Wireless World

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B.B.C. Report

THE past year has been one of great technical development in British broadcasting, and so it is not surprising that the engineering section of the B.B.C.'s Annual Report for 1954-55* provides some interesting sidelights on the Corporation's activities. Only in one place is gloom apparent; that is in dealing with the present position on the medium waveband. Here, it is evident that things are likely to become worse rather than better, in spite of many efforts to improve the service. "It would appear that the point is now being approached at which little or no improvement in medium-wave reception can be gained by means of additional stations, so long as they must share a wavelength with an existing station."

An enterprising piece of research into v.h.f. propagation at long range over water has been undertaken by installing at Scheveningen in Holland a Band II transmitter which works in conjunction with five receiving stations on the East coast. Apparently the main purpose of this experiment is to collect data on the possibilities of long-distance interference.

A commendably realistic approach is disclosed towards the allied problems of studio acoustics and monitoring control. The Report says: "Improvements in correlating acoustic quality, as assessed by experienced listeners, with the results of laboratory measurements helped towards the improvement of studio acoustics generally. A study was also made of the effect of the acoustics of listeners' living rooms upon the quality given by a particular studio. This study led to a comparison between the conditions under which programmes are heard by listeners and the conditions under which they are heard by the B.B.C. staff in the control cubicles attached to the studios; as a result, further attention will be given to the improvement of the listening conditions in the cubicles."

That last sentence gives food for thought and may well provoke controversy. It might even be argued that the conditions in the control cubicles should be degraded rather than improved. In these matters there are two schools of thought. One contends that the monitoring loudspeaker should match the average listener's mediocre receiving equipment, so that he may be given a signal that "sounds nice" to him. The other point of view, of course, is that the output should allow full justice to be done to it by the best receiver and loudspeaker used under the best conditions.

* Cmd. 9533; H.M.S.O., 4s 6d.

Velvet Glove or Mailed Fist?

FOR well over a quarter-century there has been talk of compulsory interference suppression. As long ago as 1949 the Postmaster was given the necessary legal powers but, so far, has done little to put them into effect. Up to the present, no *user* of interfering electrical equipment has been bound to fit suppressors; compulsion has so far been applied only to *makers* of internal combustion engines.

A big change takes place on September 1st. On that day the P.M.G.'s regulation†, laid before Parliament in March, comes into force. The new order imposes an obligation on all users of small electric motors to keep radiated and conducted interference within specified limits on the bands of frequencies used for television Band I and for medium- and long-wave sound broadcasting. A second regulation (No. 292) imposes similar obligations on manufacturers and sellers of refrigerators. It should be noted that manufacturers of motors are not yet affected; this matter is still under review.

What will be the effect of the regulations just coming into force? Much depends, we believe, on the way they are administered. When they were first issued, an official statement said the Post Office would not use its new powers except when it is necessary "to insist on an appliance being put right because it causes interference and the owner will not voluntarily have a suppressor fitted." A policy of too much velvet glove and not enough mailed fist would, we believe, fail to achieve a significant reduction in the present intolerably high level of interference.

† Statutory Instrument No. 291: 1955. H.M.S.O., 6d.

Rocket Sounding in the Upper Air

Confirmation of Results Inferred from Radio Measurements

By SIR EDWARD APPLETON, F.R.S.

RECENT official announcements have made clear that rocket investigations of the upper atmosphere will be conducted by at least four countries during the International Geophysical Year 1957-58. Indeed it is evident that rocket work will provide the main new technique to be used during this year of intensive geophysical investigation, just as the radio sounding of the ionosphere was the novel technical feature introduced in the work of its predecessor, the International Polar Year of 1932-33.

American workers, with their ten years of experience with rockets, have already amply demonstrated their great value for upper air measurements *in situ*—measurements which have confirmed and extended results previously inferred from atmospheric soundings by sound and radio waves. For example, the study of the propagation of sound waves to great distances led to the conclusion that there must be a warm layer of air in the middle atmosphere; while all readers of *Wireless World* are aware that the ionosphere was discovered by experiments on radio wave reflection. Both the layer of warm air at medium levels, and the ionosphere at still higher levels have been detected in rocket soundings; and in this article I propose to deal with the underlying theory of the types of measurements in the two cases.

We naturally wonder how it is possible to measure any atmospheric characteristic during a rocket flight, since the projectile is only at rest at the top of its trajectory. The most obvious air characteristics of interest are the temperatures and pressures at various heights. But clearly the rocket compresses and heats the air through which it hurtles. However, careful experiments have shown that, just ahead of the tail fin of the rocket, there is a place where the pressure is the same as that of the undisturbed air. The recording barometer to measure air pressure can thus be placed there. The first, and basic, relation which has been the object of study by rocket sounding is, therefore, the *air pressure as a function of height* above sea level. Work of this kind has given a precision to this relationship which could not be expected from previous theoretical speculation about atmospheric characteristics. Fortunately, from the pressure-height curve, it is possible also to make a fairly accurate estimate of the temperature-height relationship in the atmosphere. By contrast, direct measurements of air temperature are difficult, if not impossible, because of the heating up of the rocket skin by air friction.

The deduction of air temperature must be made from the values of the pressures observed at two heights which are fairly close together. For example, if Δp is the pressure change over a small range of Δh, then it can be shown that

$$\frac{1}{p}\frac{\Delta p}{\Delta h} = -\frac{1}{H} \qquad (1)$$

where p is the average pressure and H is the scale height of the atmosphere at the average level in question. It is the quantity H which leads to a determination of atmospheric temperature, since, by definition,

$$H = \frac{kT}{\bar{m}g} \qquad (2)$$

where k is Boltzmann's constant, T the absolute temperature, $\bar{m}$ the mean molecular mass of the atmospheric constituents and g the acceleration due to gravity at the height in question. It will therefore be seen that to determine the temperature by this method, we have to make assumptions concerning the nature of the atmospheric gas constituents and their relative proportions.

As mentioned above, rocket soundings, made by American scientists since 1946, have confirmed the existence of the warm belt in the atmosphere, immediately above the stratosphere, the enhanced temperature of which is due to the absorption of solar ultra-violet light by atmospheric ozone. The atmospheric temperature has been shown to start to rise at a level of 30 km above the ground, reaching a maximum at a level of 50 km, thereafter falling to a minimum at 80 to 85 km, above which it rises again.

I now turn to the subject of the rocket exploration of the ionosphere, which is undoubtedly the most spectacular aspect of this fascinating field of enquiry. The ionosphere was discovered in 1924 by the method of radio sounding. One advantage of such a technique is, of course, that the phenomena investigated by radio means are not appreciably altered by the sounding mechanism. There are, it is true, two effects of such a nature, but they are trifling in practice. The beam of exploring radio waves exerts a small pressure—the pressure of radiation—on the ionosphere and pushes it upwards; also, when the radio waves travel into the ionosphere itself, they tend to warm the ionosphere (as in the Luxembourg effect). The magnitude of radio power used normally in ionospheric radio sounding is, however, so small that these two effects are inappreciable. We can therefore claim to measure things in the ionosphere by radio without changing sensibly the things we measure!

I now turn to consider the nature of the ionospheric quantities which can be measured in rocket sounding. The American method of measuring the electron density at a given height, which is, of course, the basic quantity of ionospheric interest, depends on a very elegant application of the Doppler effect. Let us assume that a radio set in the rocket is emitting a constant frequency f as the rocket climbs upwards. Then it is easy to show that the radio frequency received at ground level will be less than f by the quantity Δf, where

$$\Delta f = \frac{fv}{V} \qquad (3)$$

where v is the mechanical upward velocity of the rocket and V is the phase velocity of the radio waves *in the* *vicinity of the rocket-emitter.* Now, in un-ionized air, the phase velocity of the radio waves is c_0, the normal velocity of light in the same medium. But, when the ionization is substantial, V differs appreciably from c_0. It is, of course, the enhancement of V due to ionization which is the origin of the reflecting power of the ionosphere for radio waves.

If a very high radio frequency is employed the relation between V and the electron density N is given by

$$\frac{c^2_0}{V^2} = \left(1 - \frac{Ne^2}{\pi m f^2}\right) \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

(here e and m are, respectively, the charge and mass of the electron) so that, when V is found, using (3), N may be deduced, using (4). I am here neglecting, for simplicity, the effect of the earth's magnetic field; but equation (4) can be modified to allow for such an influence if desired.

Various elegant methods of measuring the Doppler effect from a rocket radio source travelling through the ionosphere have been developed by American scientists, by means of which the relation between electron density N, and height h, has been estimated. The N values so obtained are of the same order of magnitude as previously measured by radio sounding; but it is already clear that the new technique can supplement, in various important ways, the older radio technique. For example, in the case of the rocket experiments, it is possible to measure directly the value of N in the upper part of an ionospheric layer, whereas this quantity can only be inferred in the case of radio sounding.

A word of caution should, however, be added concerning the effect of the rocket itself on measurements of ionization density in the ionosphere. These are based on the assumption that neither the rocket nor the exuded gases affect the ionosphere over a range of one radio wavelength in the ionospheric medium. American rocket scientists feel that this condition is likely to be fulfilled in the lower part of the ionosphere—for example, below 140 km—but, at high levels, it is considered likely that gaseous products may spread out to a considerable distance from the rocket itself and so vitiate the accuracy of N determinations.

It is now known that rocket explorations of the upper air will be conducted by the United States, France, Russia, Great Britain and possibly Australia, during the International Geophysical Year. So far such exploration has been pursued mainly at one site, White Sands in New Mexico, and it is therefore most gratifying to learn of its extension to other latitudes and longitudes. Meanwhile the hourly sounding of the ionosphere by the relatively cheaper method of radio goes on constantly at many stations all over the globe, and will indeed be greatly extended in world coverage during the year 1957-58.

DIFFERENTIATING SPEECH AND MUSIC

American Design for a "Commercial Killer"

ALTHOUGH it is to be hoped that commercial announcements in I.T.A. programmes will not initiate the violent urge to get at the "off" switch that such interpolations are said to provoke in America, it is nevertheless interesting to speculate on how the differentiation between wanted and unwanted programmes might be made automatically—and, of couse, electronically.

One method, described on page 50 *et seq.* of the August 1955 issue of *Radio-Electronics,* has already reached the stage of commercial production by the Vocatrol Corporation of Cambridge, Mass., and is based on the difference in the rates of decay of the sounds in speech and music. The vowel sounds of speech are said to cut off at a rate of 400 db/sec, whereas decay rates in music are much lower.

In the "Vocatrol" a capacitance-resistance filter of suitable time constant converts the changes of level into pulses, and a diode is used to suppress those arising from rapid *rises* of level, which can occur in both speech and music. The wanted pulses pass through a potentiometer (sensitivity control) to an amplifier and thence to a parallel CR storage circuit of long time constant. A mono-stable multivibrator controlled by the voltage built up in this circuit is used to switch a large negative potential to the control grid of one of the audio stages in the receiver. A bandpass input filter and a logarithmic amplifier precede the differentiating circuit to remove hum and sibilants and to ensure that changes in general level of the programme do not affect the control.

Borderline transmissions, described in the report as "singing commercials," "patter songs" with light orchestral accompaniment, and announcers who slur their speech, may call for adjustment of the sensitivity control according to the listener's preference.

No mention is made of studio acoustics and the fact that talks and music studios have widely different reverberation times. It seems likely that most spoken "commercials" are recordings made in a damped studio or commentary cubicle, and that this would account for the difference in decay times. Would the method of control described be proof against a "live commercial" declaimed in an orchestral studio at the end of a concert?

BROADCASTING STATIONS OF THE WORLD

MANY hundreds of additions and amendments have been included in the operating details of the 2700 broadcasting stations of the world given in the latest edition of our book "Guide to Broadcasting Stations." To ensure as high a degree of accuracy as possible the tabulated information, secured from many sources, was checked against frequency measurements made at the B.B.C. receiving station at Tatsfield.

Short-wave broadcasting stations throughout the world are listed both geographically and in order of frequency (with power and call sign). The long- and medium-wave lists include only stations operating in Europe.

Details of European v.h.f. broadcasting stations and television transmitters are again included. The growth in both these spheres is shown by the fact that there are now over 300 and 130 stations respectively, compared with 160 and 40 when the last edition was prepared two years ago. Completely revised and in a new format, the 8th edition is obtainable from booksellers, price 2s 6d, or by post from this office, price 2s 8d.

WORLD OF WIRELESS

Marine V.H.F. Modulation ✦ Import-Export Ratio ✦ The T.A.C.

F.M. at Sea

TUCKED AWAY in a written reply in *Hansard* of July 28th is the announcement by the Postmaster-General that "it is the Government's intention that the United Kingdom should adopt frequency modulaion for these [v.h.f. international maritime radio] services."

Dr. Hill stated that other maritime countries in Europe and in the Commonwealth had agreed that in the interest of world-wide standardization f.m. should be used as is already done in North and South America. He added that the majority of the interested parties in this country, including all the shipping interests, are prepared to accept the change which will be made gradually.

Balance of Trade

IT WILL be seen from the following table of radio equipment exported and imported during the first six months of this year and last year that the balance of trade is becoming less favourable. Whereas exports increased by about £0.5M, imports increased by well over £2M, bringing the total imports to nearly 40% of the value of our present exports. Although these figures, extracted from the Board of Trade accounts, do not agree entirely with those issued by the Radio Industry Council, they do give a general picture of the Industry's overseas trade.

	Exports (Jan.-June) 1954	1955	Imports (Jan.-June) 1954	1955
Valves and c.r. tubes	1,040,860	1,247,740	1,776,353	1,664,494
Transmitters and nav. aids	6,373,705	6,322,315	919,792	801,483
Broadcast receivers: (sound)	1,376,410	1,393,147	}	
(radiograms) ...	216.648	283,401		
(television) ...	101,019	53,773		
Sound reproducing gear	489,351	610,263	1,161,643	3,553,258
Components ...	3,398,610	3,490,348		
Batteries	879,867	1,010,371	}	
	13,876,470	14,411,358	3,857,788	6,019,235

Television Advisory Committee

THERE have been a number of changes recently in the membership of the technical sub-committee of the Television Advisory Committee. The chair is occupied by the Post Office engineer-in-chief, now Brigadier L. H. Harris. The Post Office representative is Captain C. F. Booth (assistant engineer-in-chief), in place of H. Faulkner, and A. B. Howe, assistant head of the B.B.C. research department, now represents the Corporation in place of R. T. B. Wynn. Dr. Willis Jackson has resigned.

Three additional members have been appointed, they are L. H. Bedford (Marconi's), T. M. C. Lance (Cinema-Television) and E. P. Wethey (Kolster-Brandes).

The inclusion of Mr. Lance may be a pointer to the subject at present being studied; the terms of reference of the T.A.C. included the phrase "television for public showing in cinemas and elsewhere."

Germanium from Coal

AT THE present time one of the main sources of germanium is the flue dust from coal-fired furnaces. Only a small proportion of the available germanium is deposited and the remainder is lost to the atmosphere as fine dust.

A programme has been initiated by the Fuel Research Station of the Department of Scientific and Industrial Research to survey all possible sources and to investigate the distribution of germanium in the coke, tar and liquor by-products of coal carbonization processes. This, according to the "Report of the Fuel Research Board" (published by H.M. Stationery Office, price three shillings), will lead to the discovery of ways of modifying these processes to increase the proportion of germanium recovered.

PERSONALITIES

Sir George Nelson, Bart., is to be president of the I.E.E. for the 1955-56 session. Sir George is chairman and managing director of the English Electric group of companies, which includes Marconi's W.T., Marconi Marine, Marconi Instruments, English Electric Valve and Scanners. He was recently appointed a governor of the Imperial College of Science and Technology.

H. Stanesby, the new chairman of the Radio and Telecommunication Section of the I.E.E., has been closely associated with radio work in the Post Office since he entered the Dollis Hill laboratory as a "youth in training" in 1924. For two years he was responsible for the direction of the radio laboratory at Dollis Hill. Now staff engineer in the Radio Planning and Provision Branch, he has specialized in the development of crystal filters and cable and radio links for television. He has frequently represented this country at international conferences and is chairman of the C.C.I.R. Study Group IX concerned with general technical questions.

SIR GEORGE NELSON

H. STANESBY

Sir Gordon Radley, a deputy director general of the Post Office since last October and before that engineer-in-chief for three years, has been appointed director general and so becomes the first engineer to fill the post. Sir Gordon, who is 57, joined the Post Office as a temporary inspector in the research branch in 1920. He received his Ph.D. from London University in 1934 for a thesis on radio interference from power lines and a knighthood in 1954.

The position of deputy director general, vacated by Sir Gordon Radley, is to be filled by **R. J. P. Harvey,** who has been director of radio and accommodation for the past 18 months. Mr. Harvey, who is 50, is chairman of the Mobile Radio Committee set up by the P.M.G. to investigate the problems of clearing mobile radio users from Band III.

Captain K. H. T. Peard, who was captain of H.M.S. *Collingwood,* the naval electrical school, from 1953 until a few months ago, has been promoted Rear-Admiral and appointed director of the Naval Electrical Department at the Admiralty. He is 53. He succeeds **Rear-Admiral Sir Philip Clarke** who had held the position from 1951. Sir Philip has been president of the British Institution of Radio Engineers since last October.

Captain G. C. Turner has been appointed assistant Captain Superintendent, Admiralty Signal and Radar Establishment. He was fleet radar officer, British Pacific Fleet, at one time during the war and has since served in the radio equipment and electrical departments of the Admiralty and as executive officer at the electrical school (H.M.S. *Collingwood*).

Commander J. Forrest, who has recently been appointed to the radio equipment department of the Admiralty, has specialized in air radio matters during his naval career and it is in this field that he will be mainly concerned in his new post.

P. L. Taylor, M.A., A.M.I.E.E., who has been head of the electrical section of the College of Aeronautics, Cranfield, Bucks., since its foundation in 1946, has left the College to join the research department of Metropolitan-Vickers, at Trafford Park, Manchester. His article on servo-mechanisms appeared in our January 1952 issue.

M. R. Gavin, M.A., D.Sc., F.Inst.P., M.I.E.E., vice-principal and head of the department of physics and mathematics in the College of Technology, Birmingham, for the past five years, has been appointed professor of applied electricity at the University College of North Wales. Before going to Birmingham, Dr. Gavin, who received his doctorate from Glasgow University for work on valves for decimetre waves, was for eleven years at the G.E.C. research laboratories, Wembley. Dr. Gavin, who has contributed several articles to our sister journal, *Wireless Engineer*, was appointed an M.B.E. in 1946.

E. Lawrenson, M.A., has been appointed chief engineer of the Wireless Telephone Company, Limited, of Sheffield, a member of the Plessey group. He joined the company last year, having previously been senior engineer in the advanced development laboratory of Standard Telephones & Cables.

A. V. Krause, Grad.I.E.E. recently appointed by 20th Century Electronics, Limited, head of cathode-ray tube development, was formerly senior engineer in the vacuum tube development section of Cinema-Television, Limited. He had previously been on the staffs of Standard Telephones & Cables and Mullards.

A. V. KRAUSE

OUR AUTHORS

Professor G. H. Burchill, contributor of the article on the design of Tchebycheff filters, was a designer of synchronous machinery with the Canadian General Electric Company for five years before joining the staff of the Nova Scotia Technical College. He has been teaching for twenty-six years and since 1953 has been professor of electrical engineering at the college.

H. G. Manfield, who describes methods of making printed circuits on page 436, has been at T.R.E. (now R.R.E.), Malvern, since 1946 where for the major part of his service he has been working on printed and potted circuits. During the war he was for some time resident maintenance engineer at several radar stations.

T. K. Cowell, development engineer in the recently formed electronic development division of R. B. Pullin and Company, instrument makers of Brentford, Middlesex, describes in this issue a multi-purpose chassis for experimental work. After six years at the G.P.O. Radio Branch at Dollis Hill, which he entered as a trainee in 1948, he was with Furzehill Laboratories for a few months before joining Pullin in January this year.

S. Kannan, who discusses aerial circuit magnification on page 461, graduated from the University of Madras (India) in 1943 and joined National Ekco Radio and Engineering Company, of Bombay, as development engineer in 1948. Five years later he joined E. K. Cole, Ltd. (Southend), where he is now concerned with the design and development of broadcast receivers.

OBITUARY

Richards W. Cotton, who died recently in Portland, Maine, U.S.A., was well known in the British radio industry, having been controller of signals (communications) at the Ministry of Aircraft Production for some time during his residence in this country from 1934 to 1946. He was at one time chairman of British Rola and was a director of Philco (Overseas), Ltd. In 1952 he was appointed director of the electronics division of the American Defence Production Administration.

IN BRIEF

Television licences in the United Kingdom increased by 52,505 during June (the latest figures available). The total number of **Broadcast Receiving Licences** current in Great Britain and Northern Ireland at the end of June was 14,035,567, including 4,676,422 for television and 275,910 for car radio.

Extended Band III Tests.—Since August 2nd the transmission times of the Belling-Lee Band III experimental transmitter (G9AED) at Croydon have been extended by 17 hours a week. The times are now Monday to Friday, 9.30 to 12.30, 2.0 to 5.30 and 7.30 to 8.30; Saturday 10.0 to 1.0. Transmissions from G9AED will cease at one o'clock on September 3rd when test transmissions from the temporary I.T.A. transmitter at Croydon (opening on September 22nd) are due to start.

The **Monopolies Commission** has now appointed nine investigators to consider and report on the supply of valves and cathode-ray tubes, which was referred to the Commission last December. Written and oral evidence is now being taken and any offers to give assistance should be addressed to the Monopolies and Restrictive Practices Commission at 8, Cornwall Terrace, Regents Park, London, N.W.1.

"Inexpensive Wave Analyser." In Fig. 2 of this article (p. 361, August issue) the value of R7 should be 75kΩ, not 33kΩ.

I.E.E. Council.—Among those elected to fill the vacancies on the council of the I.E.E. at the end of September are: Sir George Nelson, president (see "Personalities"), T. E. Goldup, director of Mullards, a vice-president for the second time, Sir Hamish MacLaren, Director of Electrical Engineering, Admiralty, a vice-president, and Professors H. E. M. Barlow (University College, London) and J. Greig (King's College, London) ordinary members.

The new committee of the **I.E.E. Radio and Telecommunication Section** (note the new title), which takes office at the end of September, will be under the chairmanship of H. Stanesby (see "Personalities") with Dr. H. S. McPetrie, who is head of the Radio Department at R.A.E., Farnborough, as vice-chairman. The five vacancies among the ordinary members of the committee will be filled by F. S. Barton (principal director, electronics research and development, M.o.S.), Dr. A. J. Biggs (G.E.C. research laboratories), W. Ross (R.A.E., Farnborough), T. B. D Terroni (manager and chief engineer, transmission division, A. T. & E.) and F. Williams (senior superintendent engineer, B.B.C.).

An **Exhibition of Electrical Standards** has been opened at the Science Museum, South Kensington, and will remain open until October 31st. One of the objects is to show the origin and derivation of the various electrical units. The complete set of the original B.A. Units of Resistance, which were made in 1864 for the British Association and constitutes the oldest set of accurate electrical standards now in existence, are to be seen. The Museum is open on week-days from 10.0 to 6.0 and on Sundays from 2.30 to 6.0.

A new observatory, to be known as the **Mullard Radio-Astronomy Observatory,** is to be set up by the University of Cambridge as a result of an offer from the Mullard Company to provide £100,000 over a period of ten years for radio-astronomy research.

Brit. I.R.E.—The first meeting of the session will be held at 6.30 on September 28th, at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, when G. I. Hitchcox will deliver a paper on "Extending the limits of resistance measurement using electronic techniques."

F.M. Tuner.—Constructional details of a tuner for the v.h.f. service of the B.B.C., which will be available to 83% of the population by the end of 1956, are given in a new *Wireless World* booklet. In it are reprinted the articles by Amos and Johnstone in the April and May issues. It is obtainable from this office price 2s. (plus 2d. postage).

We regret that there is an error in the terms quoted in the bottom left hand panel of the advertisement offering complete equipment by **Stern Radio, Limited,** on page 144 of this issue. That page had gone to press before the error was discovered; the correct figures are:—

	Cash Price	Deposit	Monthly (12)
(a)	£22 19 0	£7 13 0	£1 8 1
(b)	£23 19 0	£8 0 0	£1 9 3
(c)	£28 16 6	£9 12 6	£1 15 2
(d)	£35 7 6	£11 16 0	£2 3 3
(a)	£24 9 0	£8 3 0	£1 9 11
(b)	£25 9 0	£8 10 0	£1 11 1
(c)	£30 17 0	£10 6 0	£1 17 8
(d)	£36 18 0	£12 6 0	£2 5 1

Since publishing the note in our last issue on the **Sound Reproduction Demonstration** to be given in New York, G. A. Briggs has advised us that Columbia Records Inc., and not Capitol Records Inc., will now be making the comparative recordings.

BUSINESS NOTES

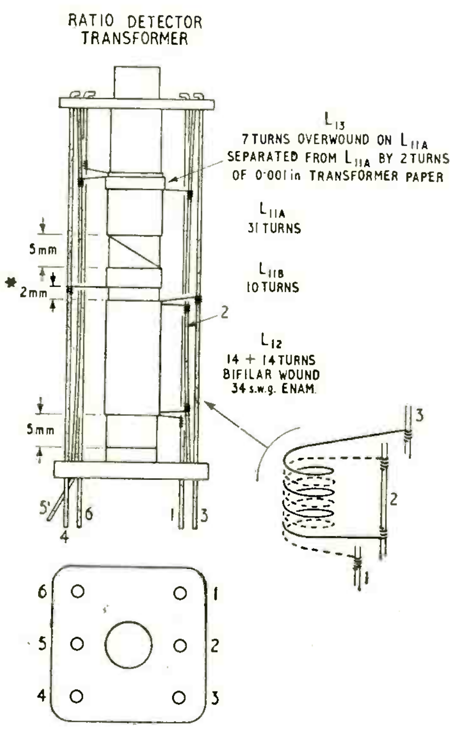
An order for the supply of twenty-three 30-kW short-wave transmitters has been placed with **Standard Telephones and Cables** by the Post Office. They are for installation at three stations and will be used for overseas point-to-point telephony and telegraphy services.

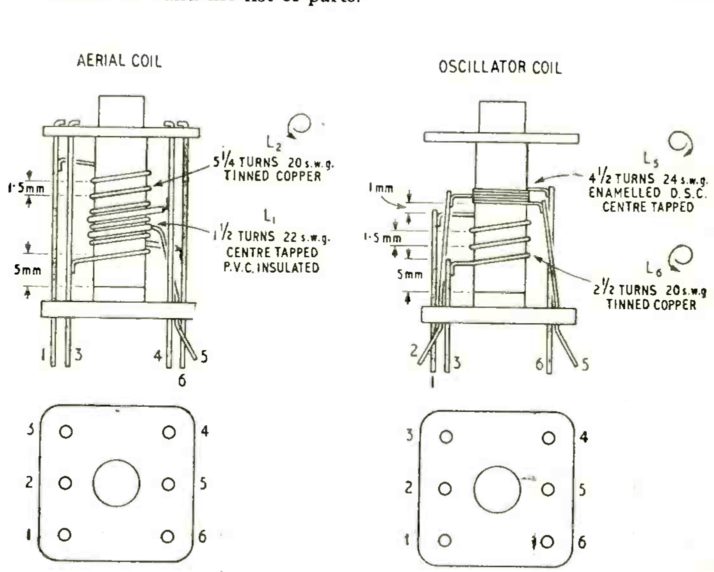
Ace Radio, Limited, receiver manufacturers of Tower Road, London, N.W.10, have opened the first of a series of new factories being built at Basildon New Town, Essex.

(*Continued on next page*)

F.M. TUNER UNIT: CORRECTIONS

IT is regretted that certain inaccuracies appeared in the drawings of the aerial coil, oscillator coil and ratio detector transformer shown on page 374 in our August issue. Correct drawings are given here together with an additional "perspective" of the bifilar-wound coil L_{12} and its connections on the ratio detector transformer. It should also be noted that C_2 is 1.8pF, not 5nF as stated in the text and the list of parts.





An acoustical advisory service has been established by **Tannoy**, of West Norwood, London, S.E.27, to deal with problems of excessive noise in factories. Acoustical treatment of existing buildings and collaboration with architects in planning new premises are the main functions of this department.

The design and manufacture of filters with Ferroxcube pot cores to customers' specifications is now undertaken by **Mullard's** Components Division.

Magnetic and Electrical Alloys, Ltd., of Burnbank, Hamilton, Scotland, producers of laminations, cores and stampings, have been acquired by the **Telegraph Construction and Maintenance Co.** J. Ancel Holden is continuing as chairman and W. Randall, a director of Telcon, has been appointed as vice-chairman and managing director. Telcon have recently formed a metals group which embraces Telcon-Magnetic Cores, Ltd., at Chapelhall, Lanarkshire, Temco, Ltd., at Lydbrook, Gloucestershire, Sankey-Telcon, Ltd., at Crawley, and Magnetic and Electrical Alloys.

Bakelite, Ltd., is to market polyethylene under an agreement with Union Carbide, Ltd., who are setting up a plant at Grangemouth, Scotland. Until the new factory comes into operation in 1957, polyethylene imported from the Union Carbide and Carbon Corporation, of America, will be available from Bakelite.

The merchandizing division of the **Solartron Electronic Group, Ltd.**, of Thames Ditton, Surrey (new telephone number Emberbrook 5522), has been appointed agent for the United Kingdom, Eire and certain parts of the British Commonwealth for the Consolidated Engineering Corporation, of Pasadena, California, and its associated companies. The Corporation manufactures a wide range of electronic and other industrial equipment.

To enable the audience to see both the live and televised performance of "The Barber of Seville" from Glyndebourne recently, 17 **H.M.V.** and **Marconiphone** receivers were installed in various parts of the theatre. The signal was taken from the B.B.C. at video frequency, passed through an amplifier and then distributed to the receivers on the vision frequency of Channel 4.

Kelvin and Hughes, Ltd., announce that they have entered the component market. Among the components listed are a magnetic record/reproduce head and sine-cosine potentiometers.

The sound reproduction equipment in the new liner *Empress of Britain* is being supplied by **Pye Marine**. In addition to the 150 loudspeakers used for the entertainment of passengers and crew, there are 35 loudspeakers associated with an emergency system with "talk-back" facilities at each speaker position.

For the demonstration of **Pye** underwater television at the recent international trade fair in Toronto, a microwave link was used to convey the underwater scenes from the ship stationed some two miles outside Toronto harbour to the receivers in the fair.

Reproducers and Amplifiers, Ltd., the well-known loudspeaker manufacturers of Wolverhampton, celebrated their silver jubilee in July. To mark the occasion a presentation was made to the founder and managing director, H. C. Willson.

Telerection, Ltd., aerial manufacturers, of Cheltenham, Glos., announce the formation of Telerection Developments, Ltd., "to co-ordinate and develop the large expansion plan on hand by the group of nine companies" which includes installation companies in six provincial centres.

Raymond E. Cooke, B.Sc. (Eng.), Grad. I.E.E., joined **Wharfedale Wireless Works, Ltd.**, of Idle, Bradford, at the beginning of August as technical manager and head of the research department.

Edwards High Vacuum, Ltd., announce the formation of an Italian subsidiary, Edwards Alto Vuoto S.p.A., with offices in Milan.

Telcon Africa (Pty.), Ltd., a subsidiary of the Telegraph Construction and Maintenance Company, Greenwich, has opened a new factory at Wadeville, Germiston, Transvaal.

Hivac Limited, manufacturers of sub-miniature valves, have transferred their registered office from Harrow to their new factory in Stonefield Way, Victoria Road, South Ruislip, Middlesex (Tel.: Ruislip 3366).

Permanoid, Ltd., formerly Associated Technical Manufacturers, Ltd., cable manufacturers, of New Islington, Manchester, have opened a Midlands branch at 558, Wolverhampton Road East, Fighting Cocks, Wolverhampton, Staffs. (Tel.: Wolverhampton 38367).

The telephone number of the **British Electric Resistance Co., Ltd.**, and the **British Power Transformer Co., Ltd.**, of Queensway, Enfield, Middlesex, is now Howard 2411.

The new telephone number of **Erie's** Great Yarmouth factories is Great Yarmouth 4911.

OVERSEAS TRADE

A further substantial order for equipment for transmitting and receiving stations of the Canadian Overseas Telecommunications Corporation has been received by **Marconi's W.T. Company** through its Canadian associate. The contract provides for the supply of six Marconi-Siemens R/T terminal equipments and ancillary gear.

Decca airfield control radar (Type 424) is being installed at Dum Dum civil airport, Calcutta, where there is already a Type 41 long-range storm warning radar.

A new overseas radio-telephone and telegraph centre for Burma is to be equipped by **Standard Telephones and Cables, Limited**, with single-sideband transmitters (4 to 40 kW), receivers, terminal equipment and beam aerials.

Another contract has been placed with **Marconi's** by the Gold Coast Posts and Telecommunications Department for the supply of radio-telephone equipment for the country's internal communication system. It provides for the installation of a twin-path, 24-channel (per path) radio communications service from Kumasi to Takoradi, via Mpraeso, Koforidua, Mampong (Akwapim), Accra, Winneba and Cape Coast. The new circuit will eventually link with one already being installed by Marconi's between Kumasi and Tamale in the north.

The New Zealand Post and Telegraph Department is calling for tenders for the supply of some **3,500 valves** and cathode-ray tubes of various types. Particulars are obtainable from the Export Services Branch, B.o.T., Lacon House, Theobalds Road, London, W.C.1 (Ref. ESB 15177/55). Closing date for tenders is September 15th.

Television in Uruguay.—The commercial department of the British Embassy in Montevideo draws the attention of U.K. manufacturers to the potential market for British receivers which will exist when the first television station in Uruguay opens shortly. It is understood that the Servicio Oficial de Difusion Radio-electrica is contemplating calling for tenders for the supply of 10,000 receivers to introduce the television service to the public. Interested manufacturers not already represented in Uruguay are invited to write to the Embassy in Montevideo.

South African Representatives.—Joseph Teer and Son (Pty.), Ltd., 5 Ulster House, Kruis Street, Johannesburg (P.O. Box 1630), wish to represent United Kingdom manufacturers of trimmer capacitors.

Saudi Arabian Market.—The firm of Suleiman Bakshwin, of Medina, have informed the British Embassy at Jidda that they are interested in receiving offers from United Kingdom suppliers of battery receivers and batteries.

National Radio Show

Stand-to-Stand Preview of Technical Exhibits

ON Wednesday, August 24th, Dr. Charles Hill, the Postmaster-General, will open the 22nd National Radio Exhibition at Earls Court; overseas visitors and invited guests are having a preview the day before.

In the following pages we give a brief stand-to-stand survey of the technical exhibits prepared from information given to us by the 121 exhibitors. Although there are bound to be some last-minute releases by manufacturers, we feel that this preview will provide visitors with a useful guide to the show and readers unable to visit Earls Court will, we hope, find the survey valuable.

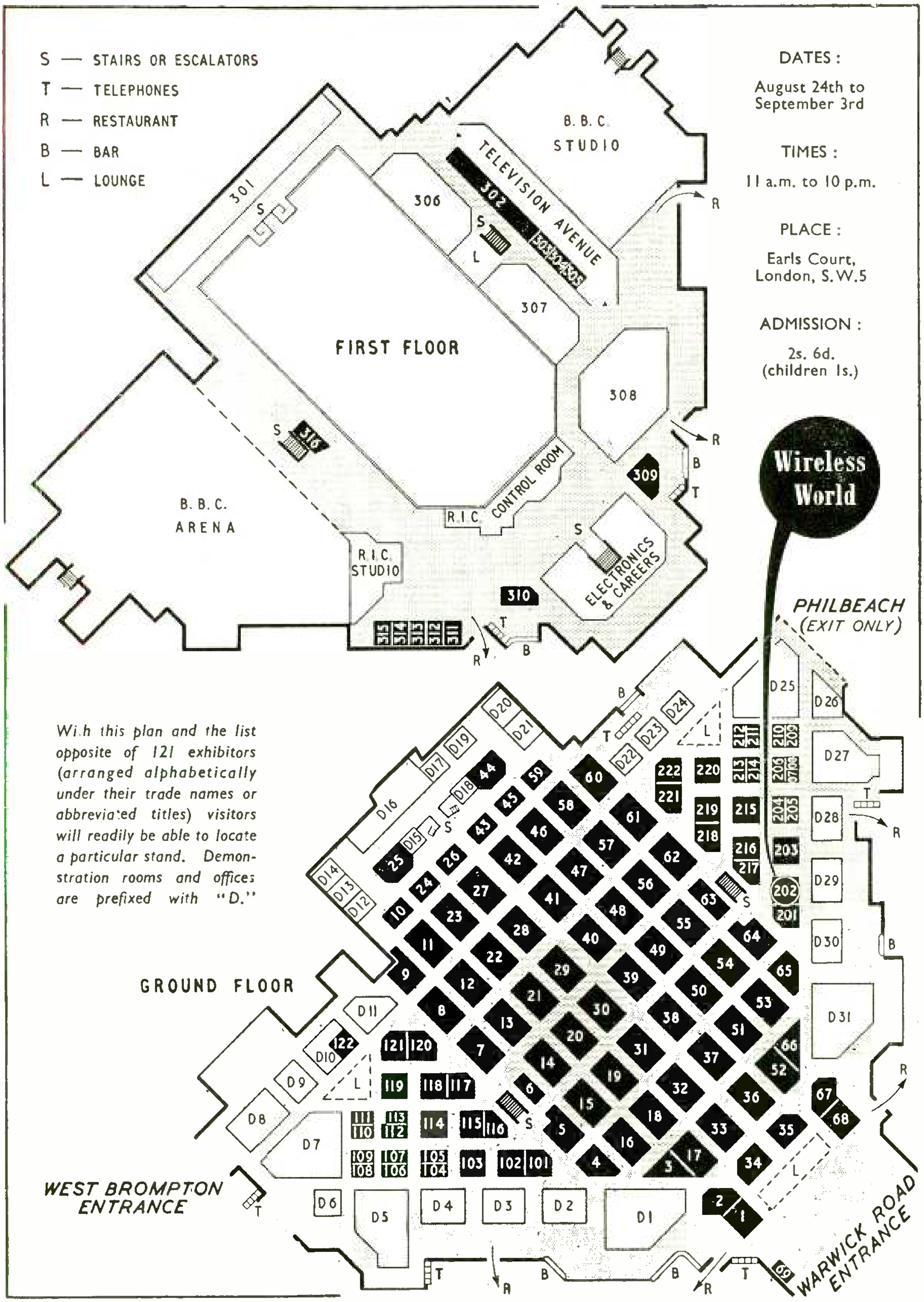
Visitors will have a foretaste of commercial television for the Radio Industry Council has offered time for short films backed by advertisements to be distributed on the network for the demonstration of Band III receivers. In Television Avenue on the first floor 28 manufacturers will be demonstrating 82 receivers, but they will operate on Band I only; Band III demonstrations are confined to the exhibitors' stands and demonstration rooms.

Instead of the collective displays of electronic equipment being set up in various odd corners of the show, as happened last year, they are this year being combined with the training display to form a large "electronics and careers" section on the first floor. It will comprise "Electronics of To-day," including examples of electronics in air and sea transport, medicine, communications, industry, etc., "Electronics of the Future" and a section devoted to careers in which visitors will have the opportunity of seeing the new I.E.E. training film "The Inquiring Mind."

ALPHABETICAL LIST OF EXHIBITORS

	Stand
Acos	201
Aerialite	33
Airmec	108
Alba	21
Antiference	64
Argosy	35
Army	308
Arrell	111
Assimil	312
Avo	116
B.B.C.	301
B.C.C.	217
Baird	52
Barclays Bank	3
Belling-Lee	46
Bernards	314
Bowmaker	106
Brimar	1
British Radio & Television	109
British Railways	2
Brown Bros.	9
Bulgin	59
Bush	22, 57 (D24)*
Champion	62
Channel	212
Collaro	39 (D29)
Cossor	23 (D8)
Cossor Instruments	114
Decca	32 (D2)
Defiant	60 (D9)
De La Rue	214
Domain	305
Dubilier	221
Dynatron	24
E.A.P.	303
E.A.R.	216
E.M.I.	215 (D26, D28)
E.M.I. Institutes	311
Econasign	113
Ediswan	58 (D21)
Ekco	12, 121 (D7)
Electrical & Radio Trading	102
English Electric	31 (D23)
Evening News	67
Ever Ready	54
Ferguson	14, 103 (D4)
Ferranti	13, 120 (D11)
G.E.C.	37 (D31)
Garrard	47
Gibbs	209
Goodmans	20
H.M.V.	48, 49 (D25)
Hart	210
Hobday	220
Hunt	8
Invicta	53
J.B. Cabinets	219
J-Beam Aerials	104
K.B.	16
Keith Prowse	69
Kerry's	203
Labgear	204
Linguaphone	207
Lloyds Bank	115
McMichael	40
Marconiphone	50 (D27)
Masteradio	36
Midland Bank	44
Mullard	18 (D1, D30)
Multicore	63 (D18)
Murphy	29 (D3)
National Provincial Bank	68
Navy	307
Pam	61 (D22)
Pamphonic	34
Permanoid	111
Peto Scott	55
Philco	15
Philips	27, 42, 43 (D16, D17)
Pilot	56
Plessey	122 (D10)
Portogram	65
Practical Wireless	107
Pye	30 (D5)
R.A.F.	306
RCA Photophone	110 (D6)
R.G.D.	11 (D13)
R.S.G.B.	310
R.T.R.A.	302
Reflectograph	208
Regentone	38
Roberts	117
Rola Celestion	17
S.T.C.	119
Sapphire Bearings	304
Simon	10
Slingsby	112
Sobell	19
Specto	206
Spencer-West	211
Star	309
Stella	51
T.C.C.	45 (D20)
Tape Recorders	66
Taylor	6
Telequipment	105
Telerection	7
Television Society	315
Thompson, Diamond & Butcher	4
Trix	26
Ultra	41
United Appeal for the Blind	316
Valradio	118
Vidor	28 (D19)
Wearite	218
Westinghouse	101
Westminster Bank	222
Whiteley Electrical	25 (D12, D15)
Wireless & Electrical Trader	205
Wireless World and *Wireless Engineer*	202
Wolsey	5

* Demonstration rooms and offices are prefixed with "D."


S — STAIRS OR ESCALATORS
T — TELEPHONES
R — RESTAURANT
B — BAR
L — LOUNGE
DATES:
August 24th to September 3rd
TIMES:
11 a.m. to 10 p.m.
PLACE:
Earls Court, London, S.W.5
ADMISSION:
2s. 6d. (children 1s.)
Wireless World
FIRST FLOOR
B. B. C. STUDIO
TELEVISION AVENUE
B. B. C. ARENA
R.I.C. CONTROL ROOM
R.I.C. STUDIO
ELECTRONICS & CAREERS
PHILBEACH (EXIT ONLY)
With this plan and the list opposite of 121 exhibitors (arranged alphabetically under their trade names or abbreviated titles) visitors will readily be able to locate a particular stand. Demonstration rooms and offices are prefixed with "D."
GROUND FLOOR
WEST BROMPTON ENTRANCE
WARWICK ROAD ENTRANCE

National Radio Show

Guide to the Stands

ACOS (201)

Piezoelectric (crystal) pickups and microphones for every purpose are made by this firm, and attention is directed to the recently developed GP59 series of pickups for high-quality radio-gramophones and record players.

The GP59-1 is a turnover cartridge of wide frequency range and medium output, and the GP59-3 has a high output for use with amplifiers having a low overall gain. Both types are fitted with an easily replaceable cantilever stylus.

Microphones range from inexpensive hand and desk types to models suitable for studio work.

Cosmocord Ltd., 700 Great Cambridge Road, Enfield, Middlesex.

AERIALITE (33)

Folded dipoles are used in all the Band III aerials shown by this firm; they include indoor and outdoor types with from three elements upwards. Metal strip is used in many of the indoor models. There is a selection of adaptors for converting Band I aerials into dual-band systems and provision is made for orientating the Band III parasitic element, or elements, to meet the requirements where the B.B.C. and I.T.A. stations are differently sited.

There is also a good choice of f.m. aerials, aerial fittings and a range of Band III convertors.

Aerialite Ltd., Castle Works, Stalybridge, Cheshire.

AIRMEC (108)

The Televet Type 877 is a comprehensive television test set in portable form, but mains operated. It enables alignment adjustment of receivers to be carried out in the absence of a "live" broadcast on Bands I and III; a built-in wobbulator and oscilloscope (2¾-in tube) facilitate visual adjustment.

The coverage is 8 to 70 Mc/s and 168 to 230 Mc/s in two ranges with a crystal-check oscillator for ensuring accuracy. The wobbulator gives a variable sweep at 50 c/s and up to 12 Mc/s bandwidth.

Airmec Ltd., High Wycombe, Bucks.

ALBA (21)

In addition to a range of 14in, 17in and 21in table model and console television receivers with multi-band turret tuners, a Band III tuning adaptor is available for users of the older Alba models.

Two new sound broadcast receivers have been developed, both with provision for v.h.f. reception. The table Model 3211AC covers short, medium and long waves in addition to the v.h.f. range, for which a built-in aerial is provided. A high-quality output stage feeds an 8in × 5in elliptical loudspeaker. Model 6221 is a radio-gramophone version with a 10-in loudspeaker and 3-speed record changer.

A. J. Balcombe Ltd., 52-58 Tabernacle Street, London, E.C.2.

ANTIFERENCE (64)

The "Snapacitor" principle of fixing the various elements or rods of a television aerial is one of the principal features of all this firm's Bands I, II and III aerials. It eliminates actual metallic connection between the elements and the feeder, or elements and structure, and is said to eliminate most of the troubles that arise from corrosion. Greatest prominence is given to Band III aerials, both as separate items and as adaptors for existing Band I systems. The range includes indoor and outdoor types. The "Exstat" anti-interference aerial now employs high-efficiency ferrite-cored transformers.

Antiference Ltd., Bicester Road, Aylesbury, Bucks.

ARGOSY (35)

The present range of sound and vision broadcast receivers includes two recently introduced radio-gramophones with 6-watt push-pull output stages which cover four wavebands, including v.h.f. Built-in compressed dipoles are provided, but provision for external aerials for both a.m. and f.m. reception is made. There is also a table-model broadcast set covering the same ranges, with a ferrite rod aerial for long- and medium-wave reception. A new 17in table-model television receiver is being introduced.

Argosy Radiovision Ltd., Hertford Road, Barking, Essex.

ARMY (308)

Both the Royal Corps of Signals, which operates the Army communication network, and the Royal Electrical and Mechanical Engineers, responsible for the maintenance of the equipment, are participating in the Army's exhibit. Examples of the latest telecommunications equipment, test gear and electronic devices used by the Army are to be seen.

The War Office, Whitehall, London, S.W.1.

ARRELL (111)

This firm specialize in the production of television aerials and associated fittings. They have no fewer than 15 different models of Band I aerials for indoor and outdoor use and a dozen Band III models. A feature of the designs is the use of low-loss polythene insulators on all aerials.

Arrell Electrical Accessories Ltd., New Islington, Manchester, 4.

ASSIMIL (312)

This company—a division of E.M.I. Institutes—has introduced a system of language instruction by gramophone records, based on a method which was originated on the Continent many years ago. For English-speaking people, courses are offered in French, German, Italian and Russian.

Assimil (England) Ltd, 10 Pembridge Square, London, W.2.

AVO (116)

Two new signal generators covering Bands I, II and III make their debut this year. One, the "Mark III," is a moderately priced instrument covering 150 kc/s to 220 Mc/s in six bands; while the "Wide-Band AM/FM" model provides amplitude modulated signals over the band 5 to 225 Mc/s, and a frequency modulated output over 60 to 120 Mc/s. The modulating frequency is 400 c/s and the deviation ±150 kc/s. Other features include high accuracy of adjustment of the oscillator and provision for either sine-wave or square-wave modulation.

Another interesting Avo product is the Type 160 valve tester. A full range of Avometers is shown also.

Automatic Coil Winder and Electrical Equipment Co. Ltd., Winder House, Douglas Street, London, S.W.1.

B.B.C. (301)

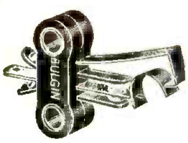
The advantages of v.h.f. broadcasting is the theme of the B.B.C. stand which incorporates a demonstration theatre, seating about a hundred people. In the theatre comparative tape recordings of reception on a v.h.f. receiver and a medium-wave set, made under varying conditions of interference, will be played over. At each demonstration an engineer will be present to answer questions.

B.B.C., Broadcasting House, London, W.1.

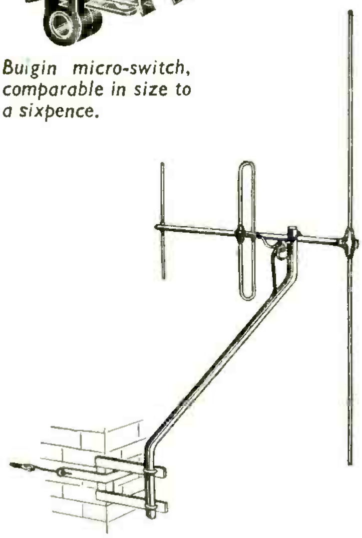
B.C.C. (217)

This firm manufacture v.h.f. radio-telephone equipment for mobile, portable and fixed-station uses. Mobile equipments are generally of 5 watts r.f. output; fixed station sets are of 5 watts and 25 watts output while portable, or pack sets, give about 120 mW output. The latest addition is a motor-cycle installation with selective calling facilities.

British Communications Corporation Ltd., Second Way, Exhibition Grounds, Wembley, Middlesex.



Bulgin micro-switch, comparable in size to a sixpence.



Aerialite Model 800 twin-band aerial.

BAIRD (52)

Television receivers with 14in and 17in tubes are shown in both table models and consoles. An unusual feature is the use of electromagnetic focus. A 12-channel tuner is included in which two channels only are initially operative.

As a console model there is a new set with a 21in tube.

Hartley Baird, Ltd., Princess Works, Brighouse, Yorks.

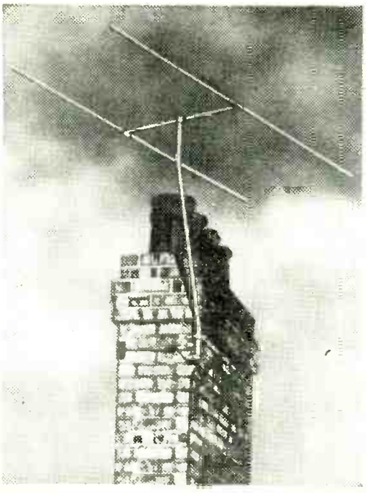
BELLING-LEE (46)

Combined aerials, separate aerials and adaptors for existing aerials are shown in profusion on this stand. An unusual combination is a Band I-Band II aerial (t.v./f.m.) which should be very satisfactory in areas of relatively high signal strength. It consists of one vertical and one horizontal dipole fitted to a single insulator and sharing a common downlead.

They have a diplexer combining unit for coupling two different (i.e. Band I and Band III) aerials into a single feeder without measurable loss in efficiency of either, or it could be used to split the output from a dual-band aerial designed for a common feeder into two output channels for separate Band I and Band III inputs at the receiver.

Their display of aerials, while physically overshadowing their other items, should not be allowed to attract all the visitors' attention. The firm make a wide range of plugs and sockets, fuse holders, connectors and interference suppressors. They are specialists in the latter business.

Belling and Lee Ltd., Cambridge Arterial Road, Enfield, Middlesex.



Belling-Lee Junior "H" FM aerial.

BRIMAR (1)

So far as valves for domestic applications are concerned, this year's exhibit concentrates attention on types introduced to meet present-day demands in the design of sets for broadcast reception in Bands II and III. Brimar television tubes are now fitted with an improved tetrode gun. A special display of transistors is to be made.

"Special quality" valves figure more prominently than in previous years. The cost of these valves has been considerably reduced, thus attracting designers to their use in wider fields of application.

New "Brimistors" include special types for insertion in valve-heater chains and for the suppression of switching surges. A miniature pattern is made for the protection of filaments in mains/battery portables.

Standard Telephones and Cables, Ltd., Footscray, Sidcup, Kent.

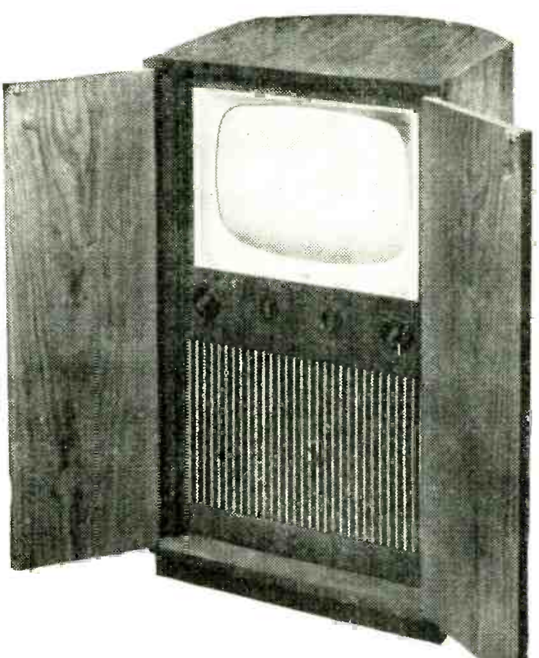
BULGIN (59)

The design and manufacture of micro-switches have been an important activity of this firm in recent years; one of the newest additions to their range takes the form of a sub-micro-switch comparable in size to a sixpence, yet which will handle 1.5 A peak current at up to 250 V a.c. or 50 V d.c. Micro-switches can be used either singly or banked for operation by a single multi-cam spindle.

The present range of miniature and standard toggle switches is very wide and most of the numerous types are available with or without insulated operating dollies.

Another important activity is the

Airmec "Televet" television receiver alignment and test equipment.



Baird TV17CD with 17in tube.

production of signal lamps; these are made in single or multiple types, large, small and Lilliputian. Sharing the same stand will be a wide range of knobs and dials, terminals, test prods and chassis fittings, including twin and multi-way connectors with floating contacts.

A. F. Bulgin and Co. Ltd., Bye Pass Road, Barking, Essex.

BUSH (22, 57)

Television sets with 12in, 14in, 17in and 21in tubes are made by this firm and all cover Bands I and III. Except in the 12in models, the tuning system comprises cam-operated slug-tuned coils, with band-switching, controlled by a multi-position knob and a clicker mechanism. A fine tuning control is provided. These sets also have a.g.c. on sound and vision, the control voltage for the latter being derived from the sync separator.

Several sound broadcast receivers equipped for f.m. reception will be on view, including a radio-gramophone. One model, the VHF54, has a magic-eye tuning indicator.

Bush Radio Ltd., Power Road, London, W.4.

CHAMPION (62)

Four new sound broadcast receivers with v.h.f. ranges form the basis of this season's programme. Another set, the Model 836 "Fidelo," is for 88-95 Mc/s only, works from a.c. or d.c. mains, gives 3 watts output into a 6in elliptical loudspeaker and costs £19 19s (including tax).

In the Model 840 console and 841 table model, two electrostatic loudspeakers are used in conjunction with a moving coil unit. Internal dipoles for v.h.f. and ferrite rod aerials for other wavebands are provided in addition to sockets for external aerials. These sets are for a.c. mains only and have three wavebands—88-95 Mc/s, 200-550 metres and 800-2,000 metres.

An additional short-wave range (15-50 metres) is included in the Model 880 table model and Model 856 radio-gramophone.

Champion Electric Corporation Ltd., Drove Road, Newhaven, Sussex.

CHANNEL (212)

A recent addition to this firm's products is a 9-channel television convertor providing one channel in Band I and eight in Band III; coils for all are included and aligned.

Other items of interest include a Band III pre-amplifier giving a gain of 24dB and a dual-band waveform generator giving a composite bar pattern and all sync pulses for alignment of a receiver in the absence of a "live" transmission.

Channel Electronic Industries Ltd., Princess St., Burnham-on-Sea, Somerset.

COLLARO (39)

The mechanical techniques of high-grade gramophone turntable design have been applied in the "Tape Transcriptor" mechanism with which Collaro have entered the magnetic tape recording field. A heavy flywheel with a ground and lapped spindle and single-ball thrust bearing ensures speed constancy, while a retractable drive to both capstan and take-up spool prevents the formation of flats on the intermediate friction wheels when the machine is switched off. The tape transport system is symmetrical with two motors and four heads (two to each track). Track changing is effected by switching heads and reversing the functions of capstan and take-up spool motors.

Items concerned with disc reproduction will include the "Studio" range of pickups, the 2010 transcription turntable, the RC54 record changer and the AC3/554 gramophone unit.

Collaro Ltd., Ripple Works, Bye-Pass Road, Barking, Essex.

COSSOR (23)

All this season's television receivers are tunable for alternative programmes: a typical specification is that of the 17in Model 937 with 21 valves. Features include turret tuning, flywheel sync, and automatic contrast control. There is also a "three-in-one" equipment embodying television, all-wave sound broadcasting and an automatic record changer.

Emphasis is placed on a.m./f.m. sound sets, of which there are three models, including a radio-gramophone.

A. C. Cossor, Ltd., Cossor House, Highbury Grove, London, N.5.

COSSOR INSTRUMENTS (AND EXPORT) (114)

This year's exhibit is concentrated largely on equipment for test and alignment of sound and vision broadcast receivers, both for use in production and maintenance. A typical instrument is the "Telecheck and Marker Generator" which, connected to a standard oscilloscope, will present the overall response curve of a television receiver. There is also an alignment generator for f.m. receivers which will be demonstrated at work.

There is also to be a comprehensive display of oscilloscopes ranging from a miniature single-beam instrument to specialized double-beam wide-band models.

A range of export receivers is to be shown.

Cossor Instruments, Ltd., Cossor House, Highbury Grove, London, N.5.

DECCA (32)

The combination of a pre-tuned three-programme f.m. receiver and a multi-channel 17in television receiver in the Model DMC/D18 gives a choice of all forms of entertainment broadcast in this country. Five Band I, three Band II and two Band III channels are provided and there are two blank positions.

In the new Models RG100 and RG103 radio-gramophones the normal short-. medium- and long-wave ranges are retained as an alternative to v.h.f. with continuous tuning over Band II. Internal resonant dipoles are provided for v.h.f. and a ferrite rod aerial for the a.m. stations. External aerials can also be used on all ranges where necessary. The RG100 has a Garrard RC111 record changer and a single pentode output valve, while the RG103 has a push-pull output stage and uses the Garrard RC80 record changer.

These new models will be supplemented by a choice of four other television receivers, four radio-gramophones and two portable record reproducers.

The Decca Record Co. Ltd., 1-3 Brixton Road, London, S.W.9.

DEFIANT (60)

A feature of the 17in television set is an electrical shift control; the 14in retains the more usual mechanical arrangement. In other respects the sets are similar. Bands I and III are covered with switch selection and trimmer; separate aerial feeders are used for the two bands.

A radio-gramophone, the RGSH-756, has a push-pull output stage and covers Band II as well as short, medium and long waves. There is a built-in Band II aerial and an internal ferrite-rod aerial for medium and long waves. This can be rotated by a panel control.

Co-operative Wholesale Society Ltd., 1, Balloon St., Manchester.

DE LA RUE (214)

The many plastic materials shown by this firm will include a range of improved insulating boards, and "Delaron Copper Clad," a composite board specially produced for the making of "printed" circuits by off-set litho, silk-screen or photographic processes. This laminate is made to withstand the etching process and subsequent dip soldering and also has good characteristics for the punching of holes.

Thomas De La Rue and Co. Ltd., 84-86 Regent Street, London, W.1.

DOMAIN (305)

This exhibit comprises display stands, tables and trucks. There are 10 models of tables for television sets. They are of tubular metal construction with a shelf.

Domain Products Ltd., Domain Works, Barnby Street, London, N.W.1.

DUBILIER (221)

The wide range of capacitors and resistors required by the radio and electronics industries today is well exemplified by the many different types displayed on this stand. Prominence is given to two types of high-voltage capacitors for use in fly-back e.h.t. circuits. Alternative types with screw terminals or soldering lugs are available. The maximum working d.c. voltage is 20 kV for a ceramic- and 30 kV for a plastic-tube type.

For v.h.f. circuitry Dubilier have a range of miniature silvered ceramic capacitors in normal, feed-through and bushing patterns.

Resistors also cover a wide field of application; one of their latest additions is a dual "Q" type with concentric spindles and mains switch.

Interference suppression is a speciality of this firm and they now have a wide range of suppressors for domestic and industrial apparatus.

Dubilier Condenser Co. (1925) Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.

DYNATRON (24)

One example of the range of elaborate apparatus being shown on this stand is the Ether Pathfinder a.m./f.m. chassis. It is a tuner covering two s.w. bands, medium and long waves and the v.h.f. band. It has an r.f. stage, frequency-changer and two i.f. stages on all bands. The output is 0.2 V r.m.s. for 40 per cent modulation and the tuner is intended for use with the (separate) LF10 a.f. amplifier. This is a four-valve amplifier with push-pull output giving 12 W for under 0.1 per cent distortion.

A television set, the Condor, has a 21in tube and a 13-channel tuner. Flywheel sync is fitted and a.g.c. is provided on both sound and vision.

Dynatron Radio Ltd., The Firs, Castle Hill, Maidenhead, Berks.

E.A.P. (303)

The portable "Elizabethan" magnetic tape recorder has a response on playback which conforms to C.C.I.R. standards and can be used for the reproduction of E.M.I. and other tape records made to these standards. The amplifier may be used independently for other purposes with a level response from 30 c/s to 15 kc/s.

A new console model and two new portable versions will also be shown.

E.A.P. (Tape Recorders) Ltd., 546 Kingsland Road, London, E.8.

E.A.R. (216)

Record reproducing equipment is the principal concern of this firm. Portable and console models range from the "Mascot Miniature" to a "High Fidelity F.M.-Gram." The "Armchair Consolette" is provided with a special stand, or it can be used as a table model.

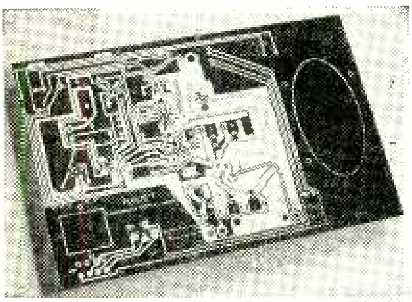
Equipment for the demonstration of gramophone records will also be exhibited.

Electric Audio Reproducers Ltd., 17, Little St. Leonards, London, S.W.14.

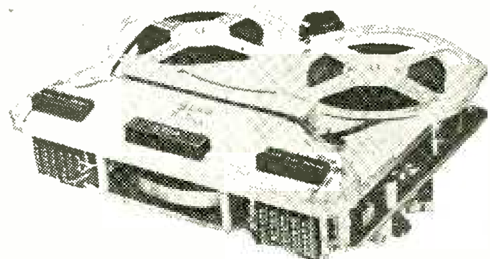
E.M.I. (215)

Equipment for tape recording at a "professional" level is to be a prominent feature of the E.M.I. exhibit. In this category is the high-quality recorder Type BTR/2, designed for record-making companies and broadcasting organizations. Different models provide for choice of tape speeds up to 30in/sec. Other recorders include a portable battery-operated model weighing only 14½lb.

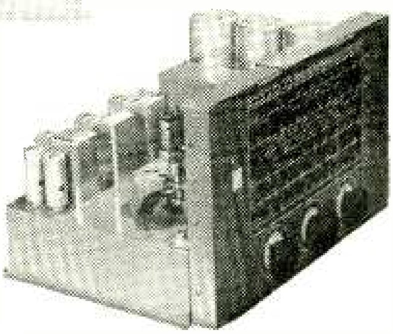
Other E.M.I. activities are also represented in the exhibit. The design and installation of relay distribution systems for both sound and vision broadcasting is undertaken, while another department deals with sound amplification for public build-



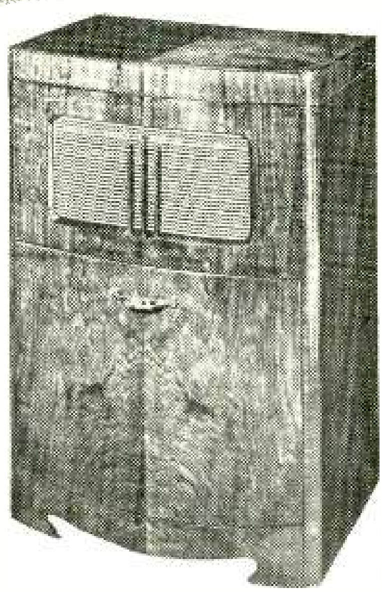
Printed circuit on De la Rue copper laminate.



Left: Collaro "Tape Transscriptor."



Right: Dynatron a.m./f.m. tuner of Ether Pathfinder.



Decca RG100 radio-gramophone with v.h.f. range.

Above: Cossor Instruments f.m. signal generator.

Left: Bush VHF54 covering long, medium and v.h.f. bands.

ings, hotels, factories and similar places.

E.M.I. Sales & Service, Ltd., Hayes, Middx.

E.M.I. INSTITUTES (311)

This institute offers home training in the various branches of applied electronics. Emphasis is on the practical side, and students are provided with experimental outfits on which to work. However, there are also courses on theoretical principles.

E.M.I. Institutes, Ltd., 10 Pembridge Square, London, W.2.

EDISWAN (58)

Broadcast receiver valves include recently introduced types for Bands II and III; among the latest productions are earthed grid triodes for both parallel and series connection. A new 12in cathode-ray tube, Type CRM124, has an ion trap tetrode gun fitted as standard. Industrial transmitting and special-purpose valves include the "Vapotron" with a novel cooling system; the valve is cooled by water vapour. Air cooling is used in a new 1-kW valve for r.f. heaters.

Among the many components and accessories shown by Ediswan will be a 12-channel turret turner for television receivers. A new co-axial television feeder has cellular polythene insulation; attenuation at 200 Mc/s is given as 3 and 3.2dB per 100ft for the rigid and flexible types respectively. Components include a number of parts moulded in high-performance fluorocarbon resins.

Edison Swan Electric Company, Ltd., 155 Charing Cross Road, London, W.C.2.

EKCO (12, 121)

Tube sizes in the television sets shown on this stand are 14in, 17in and 21in. Turret tuning is used for the two bands and some models also include provision for f.m. reception on Band II. One of these, the TC267, with a 17in tube, has spot wobble, flywheel sync and a.g.c. The 21in model (TC220) also has these features.

Quite a large number of the sound broadcast sets are now provided with facilities for Band II reception. The smallest is the U243 for a.c./d.c. operation; it has built-in aerials and a tuning indicator. The largest is a radio-gramophone, ARG256, which covers long, medium and short waves as well as Band II. There are a push-pull output stage feeding a pair of loudspeakers, a three-speed automatic record changer, bass and treble tone controls, while provision is made for feeding the radio output to a tape recorder.

Car radio sets are also on view, on stand 121.

E. K. Cole Ltd., Southend-on-Sea, Essex.

ENGLISH ELECTRIC (31)

The television sets shown on this stand are available in two forms—with and without provision for the reception of the three f.m. Band II stations. The vision side is switched off in the Band II positions of the selector switch. All sets cover Bands I and III. There are 17in table and console models and a 21in console in which the tube operates at 15 kV. Permanent-magnet focusing is used with electromagnetic deflection and flyback e.h.t. The set is designed for a.c./d.c. operation and a control barretter is fitted. The power consumption is 170 W.

The English Electric Co. Ltd., Marconi House, Strand, London, W.C.2.

EVER READY (54)

Though dry batteries for every conceivable application in the radio and allied field comprise the main Ever Ready exhibit, there is also a range of six battery-operated broadcast receivers. These comprise light- and medium-weight portables and transportables and two table models.

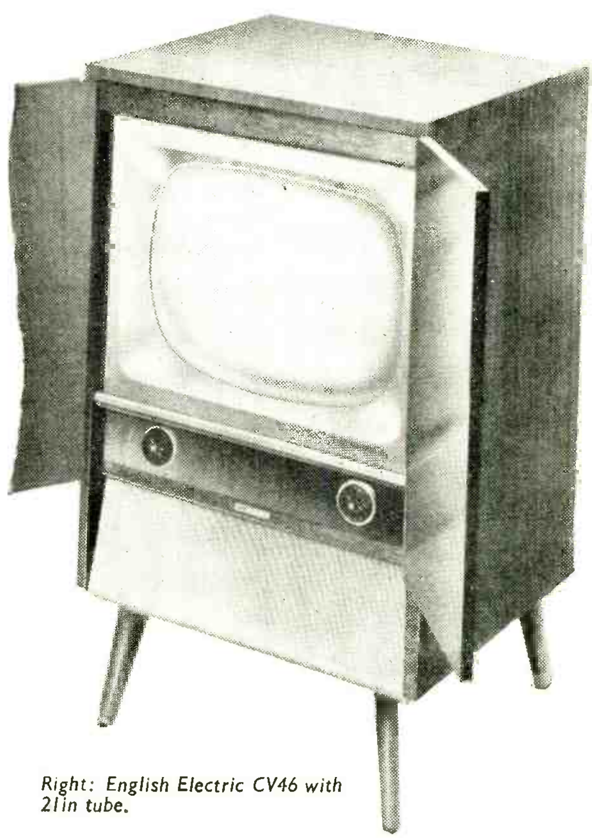
The Ever Ready Company (Great Britain) Ltd., Hercules Place, Holloway, London, N.7.

FERGUSON (14, 103)

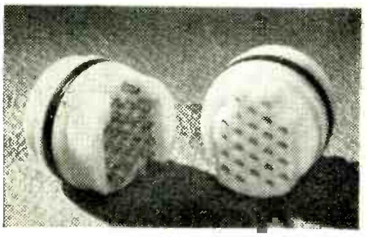
A large range of television and sound broadcast receivers is being shown. The "nine-star" television sets are fringe-area models and include an a.g.c. circuit in which the user has a choice of two time constants. The "new standard" sets are for normal

(*Continued on page* 419)

Ekco TC220 with 21in tube.

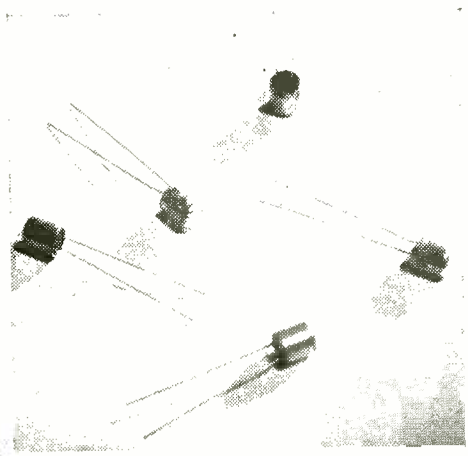


Right: English Electric CV46 with 21in tube.

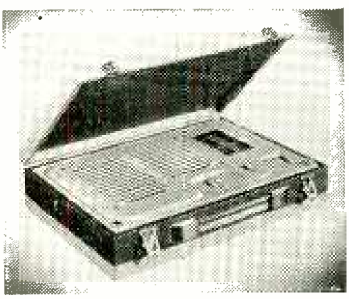


Left: Ediswan multi-way plug and socket in PTFE.

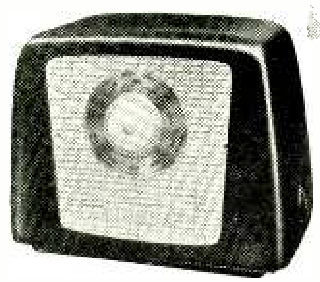
G.E.C. 25-watt general-purpose amplifier.



Ferranti silicon junction diodes.



Ever Ready "Brief Case" portable.



Ferguson 352U a.c./d.c. transportable.

reception conditions. In each range there are 14-in, 17-in and 21-in tube models, and an earlier 12-in design is retained in table-model form.

The sound receivers include the model 329A, for a.c. operation, which includes Band II f.m. reception. There is a range of radio-gramophones, some of which cover Band II. An adaptor to enable f.m. to be received with any existing Ferguson set having pick-up sockets is shown.

Ferguson Radio Corp. Ltd., 105-109 Judd Street, London, W.C.1.

FERRANTI (13 & 120)

Broadcast receiving valves specially designed for operating at around 200 Mc/s have recently been added to the Ferranti range. Cathode-ray tubes up to 21in will also be shown.

A series of silicon junction diodes have recently been introduced. These are of the hermetically sealed type with very low reverse current, designed to withstand high operating temperatures. An important part of the exhibit comprises industrial valves such as trigger tubes, miniature stabilizers, thyratrons and high-voltage rectifiers. Specialized c.r. tubes for industrial use include flying spot scanners.

A demonstration unit will present a picture on a long-afterglow c.r. tube by means of a flying spot scanner system.

Ferranti, Ltd., Hollinwood, Lancs.

G.E.C. (37)

Among the latest Osram valves is the KT55, a relatively high-power output valve for a.c./d.c. operation on restricted h.t. voltages. A range of recently introduced miniature receiver valves has been designed for operation at around 200 Mc/s. There is a new 21-in cathode-ray tube with a 90° scan angle.

Three new p-n-p junction transistors, Types EW53, EW58 and EW59 cover many different applications, including use in r.f. circuits up to about 0.5 Mc/s. Both germanium and silicon diodes are to be shown, as well as photo-electric devices and cold-cathode trigger tubes.

The present G.E.C. range of television receivers is very wide; all have switch selection of alternative programmes and fully automatic gain control. Fringe-area models are produced. Sound receivers for the present season include a table model and a radio-gramophone with provision for v.h.f. reception.

An interesting 25-watt general-purpose amplifier just produced has a wide range of application. Flexibility of control is a feature.

General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2.

GARRARD (47)

Principal interest centres on the 3-speed record changers and record players which form the foundation of many proprietary radio-gramophones. For the connoisseur there is the Model 301 "transcription" motor with minimum "wow" and flutter, and a wide range of alternative pickups and record-playing accessories.

Garrard Engineering and Manufacturing Co. Ltd., Swindon, Wilts.

GIBBS (209)

Television and radio tables and other furniture are exhibited here. Record cabinets are shown in sizes up to the U568, holding 340 records.

Herbert E. Gibbs Ltd., First Avenue, Montague Road, Edmonton, N.18.

GOODMANS (20)

Once again this stand will take the form of a demonstration theatre—this year with a seating capacity of eighty. The "Axiom" and "Audiom" high-quality loudspeakers will be shown working in a new range of enclosures (types Axiom 180, 280, 480 and 172) which have been designed to give good transient response and a smooth bass in cabinets of comparatively small size.

The Axiom 80 loudspeaker unit, which has hitherto been made for export, is now available in this country, and will be demonstrated. It has a free-edged cone with cantilever suspension, and has a fundamental resonance of 20 c/s.

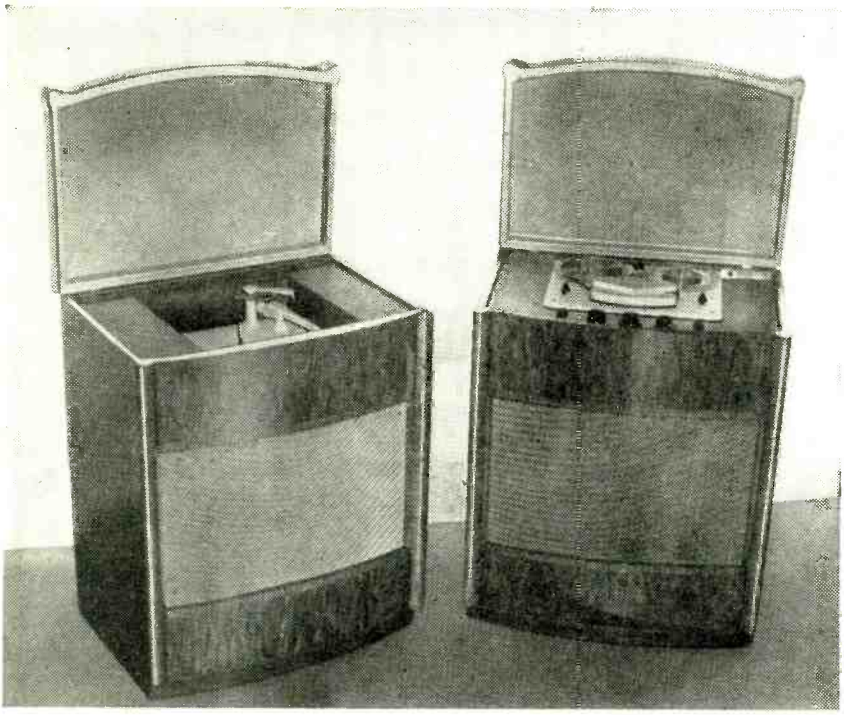
Goodmans Industries Ltd., Axiom Works, Wembley, Middlesex.

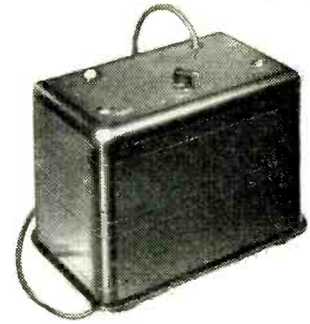
H.M.V. (48, 49)

High sensitivity and ease of tuning are design features of the new H.M.V. television receivers, which have all main controls at the front. Electrostatic focusing is used; the line scan and e.h.t. unit is completely sealed.

There is a range of sound receivers covering the long, medium and v.h.f. broadcasting bands. The Model 1252 tuner for connection to the pick-up terminals of a receiver provides reception of v.h.f. transmissions; the unit is self-contained, with its own power supply.

Equipment for the "Stereosonic" twin-channel sound reproduction system, described in *Wireless World* last May, can be heard working in the H.M.V. demonstration room. This equipment can also be used as a





Invicta Band III convertor.

Left: Twin-channel reproducers for H.M.V. "Stereosonic" system.

single-channel high-quality reproducer of tape records or discs of all characteristics.

E.M.I. Sales & Service Ltd., Hayes, Middx.

HART (210)

On this stand is to be found a wide range of record cabinets and television tables. The last are of wood construction and have shelves and castors.

Alfred Hart & Co. Ltd., 249 Upper Street, Highbury Corner, Islington, London, N.1.

HUNT (8)

With the addition of ceramics and capacitors designed especially for use in printed circuits, the range of capacitors now produced by Hunt is most comprehensive. It includes electrolytics in a wide variety of types, metallized paper, of which the W97 (Thermetic) midget has a nominal working temperature range of -100°C to $+100^{\circ}$C, metal foil and paper types, silvered mica, stacked foil and mica and ceramics.

A capacitor test set is also produced; it covers resistance measurements as well.

Printed circuits is another activity of this firm.

A. H. Hunt (Capacitors) Ltd., Bendon Valley, Garratt Lane, London, S.W.18.

INVICTA (53)

The new Type 126 television receiver with a 14-in tube, like all this year's Invicta models, has a 13-channel tuner. There is also a convertor unit for adapting Band I sets for reception of Band III.

A range of table model sound receivers and radio-gramophones providing both a.m. and f.m. reception will also be shown.

Invicta Radio, Ltd., 100 Great Portland Street, London, W.1.

J.B. CABINETS (219)

The production of radio and radio-gramophone cabinets for the trade comprises the main activities of this firm and their exhibit consists of a selection of the more interesting models produced recently.

J.B. Manufacturing Co. (Cabinets) Ltd., 86 Palmerston Road, Walthamstow, London, E.17.

J-BEAM AERIALS (104)

The television aerials made by J-Beam have always followed a very distinctive pattern, the feeder being joined, *via* a suitable matching section, to the end of the dipole in place of the more general centre connection. They have recently evolved an even more novel aerial for Band III fringe areas. It consists of a skeleton slot combined with twin yagis.

J-Beam Aerials Ltd., Cleveland Works, Weedon Road Industrial Estate, Northampton.

K.B. (16)

Although there are several 14-in tube television sets shown on this stand, in the main the new models have 17-in or 21-in tubes. They all have turret tuners for Bands I and III. Among the 17-in models there is one specially designed for fringe areas.

Many of the broadcast sets now include v.h.f., the sets in general covering medium and long waves and Band II. Radio-gramophones are also shown. The MG.30 has three loudspeakers mounted in angular planes.

Kolster-Brandes Ltd., Footscray, Sidcup, Kent.

LABGEAR (204)

The production of television aerials is a new departure for Labgear; the models shown include indoor and outdoor types and a novel design is a dual-band system comprising a single dipole for Band I and a two-element system with a fork-like attachment to the Band I dipole for Band III. A single feeder is used.

One of the Band III 4-element outdoor aerials intended for areas of poor reception (not necessarily fringe) has wide spacing between elements and it is claimed this provides a somewhat better signal than usual. A broadside array consisting of two wide-spaced 4-element yagis is said to serve for most fringe areas.

Labgear (Cambridge) Ltd., Willow Place, Cambridge.

LINGUAPHONE (207)

This company provides courses of instruction in a great number of languages; teaching is through the medium of gramophone records. Various kinds of reproducing equipment are available, including a headphone attachment enabling the student to listen without disturbance.

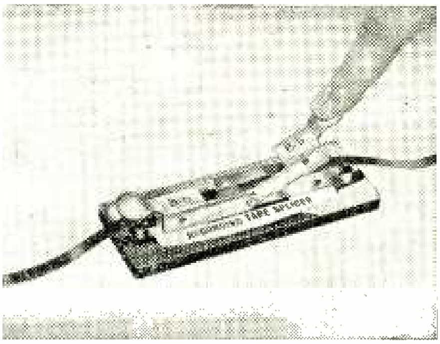
Linguaphone Institute, Ltd., 207-209 Regent Street, London, W.1.

MCMICHAEL (40)

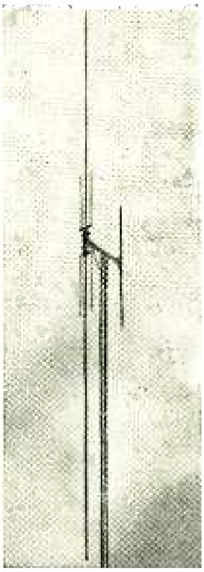
Particular attention is paid in this season's television receivers to interlace so as to ensure high-quality definition under all conditions of reception. Another feature of the new sets is the omission of a line output transformer; one reason is to eliminate one potential cause of breakdown, another is to restrict temperature rise in the set. In the absence of an output transformer e.h.t. is derived from a separate generator.

Table and console television sets with from 14-in to 17-in tubes are shown and are available with or without a radio chassis. Twelve-channel turret tuners are used throughout the McMichael range. Sound radio sets include a standard chassis for fitting to television sets and several table models, consoles and radio-gramophones.

McMichael Radio Ltd., 190 Strand, London, W.C.2.



New "Bib" (Multicore) tape splicer.



Two-band television aerial made by Labgear.

MARCONIPHONE (50)

Four new television receivers have been introduced; these give the choice between 14-in and 17-in tubes, and table or console cabinets. All are for a.c./d.c. supplies and embody switched coil tuning for 13 channels. Automatic vision gain control is fitted and a wide-range tunable filter is provided for mitigating the effects of diathermy or similar kinds of interference. An 8-channel Band III converter unit for fitting to earlier Marconiphone sets is to be shown.

Most of the new sound receivers provide for v.h.f. reception as well as for medium and long waves, and are also available as radio-gramophones.

There will be a comprehensive display of cathode-ray tubes and valves.

The Marconiphone Company, Ltd., Hayes, Middx.

MASTERADIO (36)

Without exception all Masteradio television receivers provide 13-channel tuning, embody an ion trap and are housed in cabinets designed especially for wide-angle viewing. All are superhets and, with the exception of Model TE21C, which is for a.c. mains, they operate on either a.c. or d.c. supplies. Tube sizes range from 14in to 21in.

One of this season's sound broadcast sets is an a.m./f.m. model covering four wavebands; it is known as the "Elstree" and is a table model.

Masteradio Ltd., Fitzroy Place, London, N.W.1.

MULLARD (18)

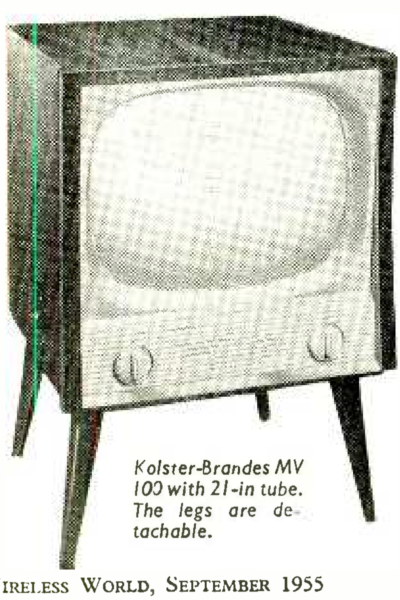
This year's exhibit aims at providing visitors with easily assimilated explanations of the functioning of various electronic devices, particularly of valves, cathode-ray tubes and transistors. There will also be a demonstration showing the advantages of f.m. broadcasting.

In one of the demonstration rooms a specimen 20-W amplifier built around the new EL34 pentode valve will be working. The design of this amplifier was discussed in detail in *Wireless World* for May and June this year. Another demonstration room will show the uses of devices intended primarily for the equipment manufactured, including picture tubes and components for 90° scanning, transistors for hearing aids, Ferroxcube ferro-magnetic cores and a new grade of Ticonal permanent magnets for loudspeakers. Some of the newer applications of transistors are also demonstrated.

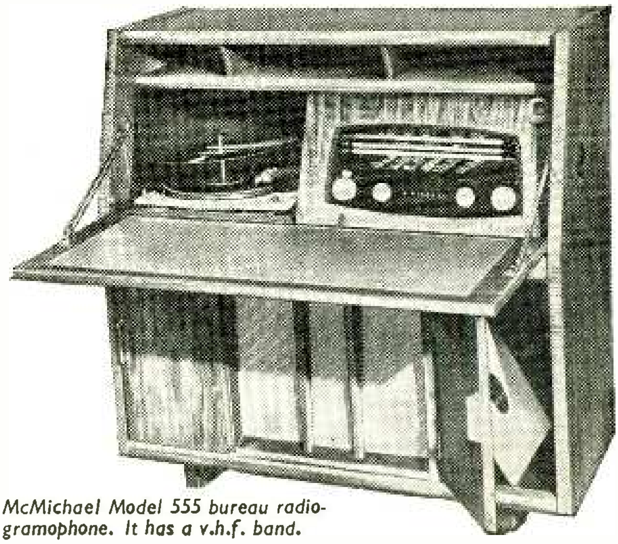
Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

MULTICORE (63)

The main exhibit here will show by practical demonstration how Ersin Multicore wire solder is used in the manufacture of radio receivers.



Kolster-Brandes MV 100 with 21-in tube. The legs are detachable.



McMichael Model 555 bureau radio-gramophone. It has a v.h.f. band.

Though most radio needs are met by six different tin-lead alloys in nine gauges, it is interesting to know that as many as 400 different specifications are available with, for example, melting points ranging from 145°C to 296°C. Another Multicore exhibit shows a complete soldering process that has been developed for printed circuit techniques of manufacture.

The Bib splicer for magnetic recording tape is now being produced in the modified form described in our February issue.

Multicore Solders, Ltd., Maylands Avenue, Hemel Hempstead, Herts.

MURPHY (29)

One of the features of this exhibit is a range of broadcast receivers which include Band II in their frequency ranges. The sets all cover medium and long waves and one short waveband and have a double-triode v.h.f. tuner in which one section acts as an earthed-grid r.f. amplifier and the other as a mixer-oscillator. There is an internal dipole for Band II and this also functions as a plate aerial on the other bands. One model, the A242R, is a radio-gramophone.

Television sets are of 14-in and 17-in types and have turret tuners with a cascode r.f. stage to cover Bands I and III. A direct-drive scanning circuit is used and the sets are available both as table models and as consoles.

Band III convertors for older Murphy sets are available.

Murphy Radio Ltd., Welwyn Garden City, Herts.

NAVY (307)

Among the examples of marine radio-communication equipment and electronic aids to navigation to be seen on this stand are the transmitter-receiver supplied to members of the Royal Naval Volunteer (Wireless) Reserve for use in their own homes and equipment for the facsimile transmission of weather maps.

The trend of progress in marine radio equipment is exemplified by replicas of the W/T office in a small ship of the 1920's and in its modern counterpart.

The Admiralty, Whitehall, London, S.W.1.

PAM (61)

Three table-models and one console comprise the television receiver range. The 17in Model 752DL is notable for its use of twin loudspeakers. All models are for a.c./d.c. operation with provision for 13 channels on Bands I and III.

The new a.m./f.m. sound receivers will be shown: Model 701 with c.r. tuning indicator in a table cabinet and Model 702RG, a radio-gramophone in a bureau cabinet.

The Pam "Pixie" portable is made by the printed circuit technique.

Pam (Radio and Television) Ltd., 295 Regent Street, London, W.1.

PAMPHONIC (34)

High-quality amplifiers, loudspeakers and microphones for both p.a. work and domestic sound reproduction will be shown, as well as magnetic tape sound delay mechanisms for sound reinforcement in large auditoriums.

One of the principal items is the "1002" 25-watt amplifier for which only 0·05% distortion at 15 watts (1 kc/s) is claimed. The pre-amplifier, in addition to a wide range of variable tone controls, gives compensation for the main groups of recording characteristics and has provision also for radio, microphone and magnetic tape inputs. The frequency range of the equipment is 2 c/s to 100 kc/s with 28 dB of negative feedback.

Among the p.a. equipment an all-weather "Loud Hailer" with self-contained rotary converter designed to run from 12-volt accumulators is well worth close inspection.

Pamphonic Reproducers Ltd., 17 Stratton Street, London, W.1.

PERMANOID (111)

Two low-loss coaxial cables suitable for use in Bands I and II fringe areas and in most areas of Band III are now manufactured by Permanoid. One, the Type 308, is largely air-spaced with a spiral of polythene cord surrounding the centre conductor. It has a loss 3.5 dB at 200 Mc/s. An even better performance is exhibited by the Type 308EP with an attenuation of only 3.3 dB at 200 Mc/s; for 100ft in every case.

Permanoid Ltd., New Islington, Manchester, 4.

PETO SCOTT (55)

Television receivers are shown on this stand in both 14-in and 17-in models, the sets being otherwise substantially the same. A turret-tuner is fitted and a form of a.g.c. is used on both sound and vision. The video amplifier has a cathode-follower output stage. The c.r. tube is operated at 14 kV.

The sets are for a.c. only and both table and console models are listed.

Peto Scott Electrical Instruments Ltd., Addlestone Road, Weybridge, Surrey.

PHILCO (15)

The range of Philco receivers for this season is wide, including as it does a.m. two- and three-band sets, portables and transportables and a.m./f.m. models. All the Philco television receivers have 13-channel tuners. Car radio receivers with push-button control are also produced.

Emphasis is placed on the comprehensive series of fully tropicalized sound receivers and car radio sets for export.

Electronic training units are also to be shown.

Philco (Overseas) Ltd., Romford Road, Chigwell, Essex.

PHILIPS (27, 42, 43)

Broadcast and sound-reproducing equipment to be shown for the first time includes a car radio receiver, a table model television set, a portable record player with built-in amplifier and automatic changer and a new record changer unit. There is also a new range of high-quality sound reproducing units.

The new television receiver has a 17-in tube and is fitted with an all-channel turret tuner. Flywheel sync and a.g.c. are included.

Among the sound receivers is an a.m./f.m. model embodying a rotatable ferrite rod aerial for long and medium wave reception and a dipole for v.h.f. Push-button controls are provided.

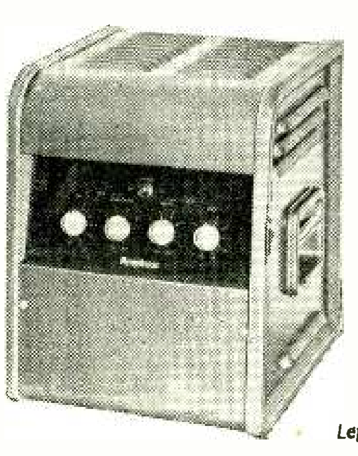
The new Philips car set is a two-unit model with separate speaker and is permeability tuned.

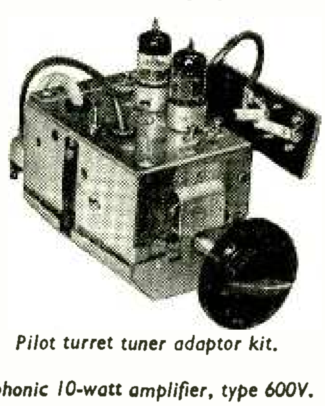
Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

PILOT (56)

This exhibit includes a new range of television receivers with 13-channel turret tuners to which coils are ready fitted for four channels in Band I and three in Band III. Automatic gain control and flywheel sync are embodied in all sets.

The range of sound receivers (*Continued on page* 423)





Pilot turret tuner adaptor kit.

Left: Pamphonic 10-watt amplifier, type 600V.

includes a mains portable with ferrite rod built-in aerial and a battery-mains set. There are also two new receivers and one radio-gramophone which cover the v.h.f. band.

Pilot Radio, Ltd., Park Royal Road, London, N.W.10.

PLESSEY (122)

This firm manufacture a very wide range of components and accessories exclusively for the radio and electronics industries. Their exhibit consists of a selection of components and parts illustrating the vast scope of their activities. Many new items are in evidence and particular attention has been given to meeting the requirements of overseas visitors.

The Plessey Co. Ltd., Vicarage Lane, Ilford, Essex.

PORTOGRAM (65)

Record reproducers of the portable type have for many years been the speciality of this firm, and a wide choice of specifications is offered.

In addition, two interesting new console reproducers have been developed. The HF65 is for record reproduction and incorporates a high quality amplifier and twin loudspeakers arranged to radiate from the sides of the cabinet to give wide sound diffusion. There is ample record storage space and provision for the addition of an f.m. feeder unit. Model TR100 is primarily a console tape recorder and reproducer with space for the inclusion of a gramophone turntable or record changer and an f.m. feeder unit. In this model a large bass-reflex enclosure is associated with the loudspeaker.

Portogram Radio Electrical Industries Ltd., Preil Works, St. Rule Street, London, S.W.8.

PYE (30)

Details of the Pye exhibit were not available at the time of going to press. In addition to the normal range of television and sound broadcast receivers a special display of high-quality sound reproducing equipment is to be staged.

Pye, Ltd, Radio Works, Cambridge.

R.A.F. (306)

Amongst the equipment being shown by the R.A.F. is the "sonobuoy" used by aircraft for the detection of submarines. The cylindrical buoy, 6 inches in diameter, houses a transmitter which is automatically switched on when dropped into the sea. All underwater noises in the vicinity of the buoy are picked up by a microphone and radiated by the aerial which is automatically erected when the transmitter is switched on.

Examples of air traffic control equipment, ground and air-borne transmitters and a pictorial display of telemetry as used in guided missiles will also be seen on this first-floor stand.

Air Ministry, Whitehall Gardens, London, S.W.1.

RCA PHOTOPHONE (110)

Inputs for magnetic and crystal pickups, radio, tape and microphone are provided in the control stages of the RCA "High Fidelity" 12-watt amplifier. The microphone input can be mixed with the radio/tape input.

Disc playback characteristics conform to the 1955 R.I.A.A. recommendations, and are supplemented by a high-pass filter (cut-off 20 c/s) and optional low-pass cut-offs at 10, 7 and 5 kc/s with slopes variable up to 35 dB/octave. Variable bass and treble controls give up to ±15 dB at 30 c/s and 15 kc/s.

The main amplifier is stated to be flat within 0.2 dB between 20 and 25,000 c/s, to have total harmonic distortion less than 0.1 per cent at 10 W, 700 c/s, and a noise level 85 dB below the rated output of 12 watts.

RCA Photophone Ltd., 36 Woodstock Grove, London, W.12.

R.G.D. (11)

Two new television receivers (1756T and 1756C) employ "Synchrolock" circuits for line timebase stability under adverse conditions of reception.

The new "Three-Fifteen" radio-gramophone includes a v.h.f. band, and this feature is also provided in the "One-Twelve" table-model receiver.

Other new models to be seen are the "Three-Twelve" console automatic radio-gramophone with 2½-watt output, and the "Five-O-Five" automatic record reproducer.

Radio Gramophone Development Co. Ltd., Eastern Avenue West, Mawneys, Romford, Essex.

R.S.G.B. (310)

Amateur television transmission, demonstrated on a closed circuit, a low-power portable transmitter, typical of those used for field days, and an automatic morse sender are features of the Society's stand.

The "R.S.G.B. Amateur Radio Call Book" and "A Guide to Amateur Radio" are among the Society's publications available on this stand.

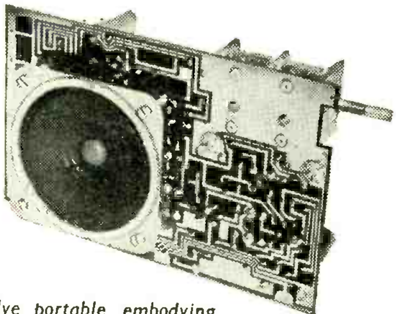
Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1.

R.T.R.A. (302)

As would be expected this stand is devoted exclusively to the requirements of the dealer. On it will be found details of the various services offered by the Association to its members; in particular the receiver maintenance-insurance scheme oper-

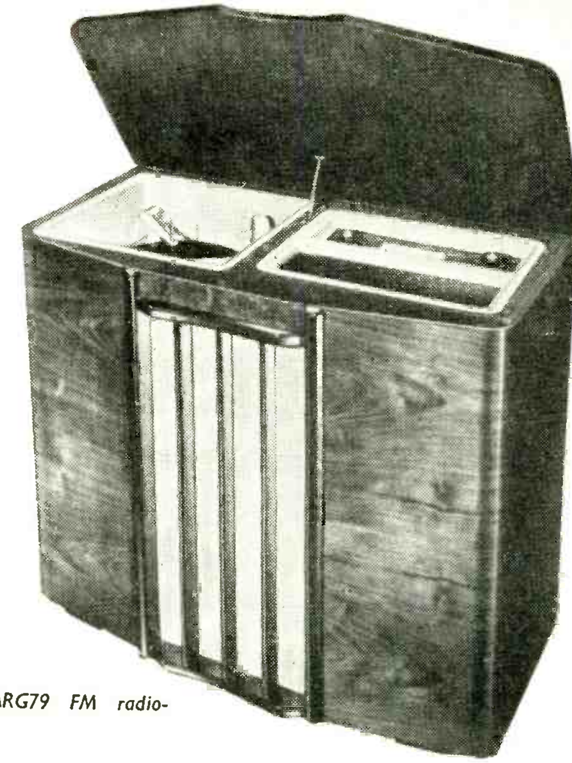
Portogram HF65 record reproducer incorporating twin loud-speakers.

R.C.A. Photophone 12-watt "High-Fidelity" amplifier.



Four-valve portable embodying T.C.C. printed-circuit element.

"Editor Super" (Tape Recorders (Electronics) Ltd.



Regentone ARG79 FM radio-gramophone.

ated by Telesurance through R.T.R.A. dealers.

Radio and Television Retailers' Association Ltd., 26 Fitzroy Square, London, W.1.

REFLECTOGRAPH (203)

In the tape mechanisms which form the basis of this firm's magnetic recorders and reproducers, a unique continuously variable speed control is employed. Models are available for industrial and scientific applications as well as for domestic high-quality sound reproduction.

The latest development is the Model RR100 which has separate amplifiers with facilities for monitoring during recording. Four transistors are employed in the playback amplifier with the object of reducing residual hum below the level possible with valves.

Rudman, Darlington (Electronics) Ltd., Wednesfield, Staffs.

REGENTONE (38)

A new table-model sound receiver (A155FM) and two radio-gramophones (ARG79FM and ARG89FM) provide facilities for v.h.f. as well as long, medium and short waves. These will be supported by a wide choice of popular models, including the ARG77 and the Multi 99 table radio-gramophone.

The established television range of five models, two table, two console and a combined television-radio-gramophone, continues unchanged.

Regentone Radio and Television Ltd., Eastern Avenue West, Romford, Essex.

ROBERTS (117)

Efficient circuitry and meticulous attention to finish and external appearance characterize the portable sound receivers made by this firm. There is a choice of types for battery, mains or mains/battery operation and more recent models are fitted with "Ferroxcube" aerials.

Roberts' Radio Co. Ltd., Creek Road, East Molesey, Surrey.

ROLA CELESTION (17)

In addition to representative examples of loudspeakers for set manufacturers, a number of special types will be shown to illustrate the versatility of the company's manufacturing resources. P.A. units for covering large areas, sources for underwater communication and flame-proof types for use in mines and oil refineries will be included in the display.

Rola Celestion Ltd., Ferry Works, Summer Road, Thames Ditton, Surrey.

S.T.C. (119)

A range of selenium rectifiers, including h.f. types, is to be shown. There will also be a series of rectifiers for sound and vision broadcast receivers as well as e.h.t. tubular rectifiers and "Q" type unistors. Three groups of high-voltage lightweight aluminium rectifiers, including types for aircraft and other uses, will also be shown, as will germanium junction power rectifiers and photo-electric cells.

A demonstration is to show the manufacture of tubular rectifiers, including electronic counting of the components used in assembly. Other displays will illustrate the use of germanium power rectifiers and servo-motor control through a photo-electric cell.

Standard Telephones & Cables, Ltd., Connaught House, 63 Aldwych, London, W.C.2.

SAPPHIRE BEARINGS (304)

As one of the industry's principal manufacturers of gramophone reproducing styli, this firm will be showing examples of "flame-fashioned" surface finish under the microscope. A modern type of shadowgraph will also demonstrate the method of checking the radius of the point to 0.0001in.

Sapphire Bearings Ltd., 96a Mount Street, London, W.1.

SIMON (10)

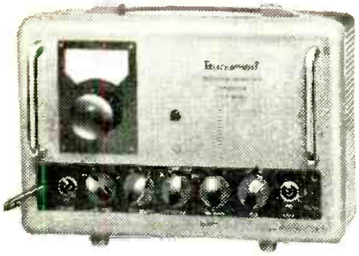
Magnetic tape recorders for domestic and professional use are represented by the recently introduced portable Model SP/2 and by a replica of the long-duration tape monitoring equipment installed in the control tower at the Royal Aircraft Establishment, Farnborough.

The Model SP/2 is notable, among other things, for the ready accessibility provided by the redesigned case, and for the fact that it includes an independently available 10-watt reproducing amplifier.

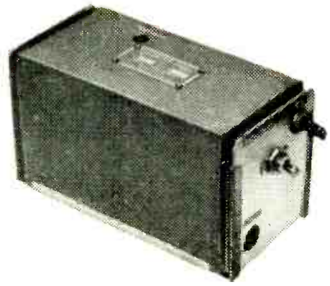
Simon Equipment Ltd., 48-50 George Street, London, W.1.

SOBELL (19)

The range of sound broadcast sets includes models covering the f.m. Band II and radio-gramophones.

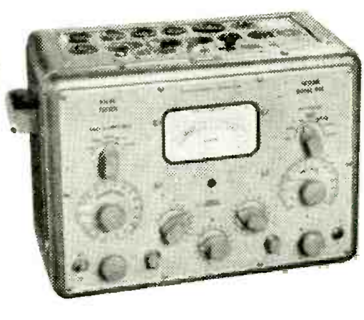


Telequipment 2-band television pattern generator, Model WG44.



Spencer-West Band III convertor.

Reflectograph Series RR100 tape recorder.



Taylor Model 45C valve test set.

Television models include 14-in and 17-in types and are for a.c./d.c. operation covering Bands I and III with turret tuning.

Radio & Allied Industries Ltd., Langley Park, Slough, Bucks.

SPECTO (206)

This firm is showing a magnetic tape reproducer for tape records having the C.C.I.R. characteristic. The output has 15 W output with a response within ±0.5 dB from 10 c/s to 20 kc/s. The harmonic distortion at 10-W output is claimed to be under 0.4% at 40 c/s and less at higher frequencies. Treble and bass tone controls are provided.

The reproducer and amplifier are available together or separately.

Specto Ltd., Vale Road, Windsor, Berks.

SPENCER-WEST (211)

In addition to pre-amplifiers for television and distribution amplifiers for Bands I, II and III, this firm is showing a range of convertors. The Type 30 is a simple model to permit reception of one station in Band I and one in Band III, while the Type 33 provides two channels in Band III. This has a neutralized-triode r.f. stage with a pentode mixer and triode oscillator. A feature of the unit is that remote switching for station selection is provided.

The "Adder" is a more elaborate convertor for 13 channels and provides an output at intermediate frequency.

Spencer-West Ltd., Quay Works, Great Yarmouth.

STELLA (51)

Models making their first appearance include a portable mains/battery broadcast receivers in a plastics case; a ferrite rod aerial is fitted. A new console radio-gramophone includes provision for v.h.f. reception, for which a built-in dipole is provided.

A new table-model television receiver, fitted with a 17in tube, is designed for use within the service areas. It embodies a.g.c. on both sound and vision and is fitted with a turret tuner.

A record player with a built-in three-valve amplifier has been introduced; this is additional to the model ST50A portable record player for use with existing amplifiers.

Stella Radio and Television Company, Ltd., Oxford House, 9-15, Oxford Street, London, W.1.

T.C.C. (45)

A special feature is made this year of capacitors designed especially for television receivers covering Band III and, with an eye to the future, Band IV also (470-585 Mc/s). These are all ceramics and consist of lead-through and stand-off bypass capacitors constructed from "Hi-k" (high dielectric constant) ceramic and small pre-set trimmers made from "Low-k" ceramic.

For circuits where high capacitance couplings are wanted in a reasonably small physical size T.C.C. have a range of "Superlitics"; these are electrolytics with leakage resistances comparable to many paper types.

A new development is a sub-miniature electrolytic of high capacitance and low-voltage rating for use in transistor circuits.

Printed circuits are becoming an important activity of T.C.C. and the many different specimens shown exemplify the various applications now found for these assemblies in radio and electronic equipments.

Telegraph Condenser Co. Ltd., Wales Farm Road, North Acton, London, W.3.

TAPE RECORDERS (66)

The "Editor" and "Playtime" series of tape recorders have been augmented by the "Editor Super Hi-Fi" and the "Playtime Plus." In the former a large-diameter loudspeaker is mounted in the detachable lid, and in the "Playtime Plus" a playback amplifier has been included. The new "Playtime Plus" weighs only 20lb.

Tape Recorders (Electronics) Ltd., 3 Fitzroy Street, London, W.1.

TAYLOR (6)

Prominent among the new pieces of test equipment introduced this year is a versatile valve tester known as the Model 45C. Valveholders to accommodate all valves in current use, English, Continental and American, are disposed about the top with the controls on the front. Charts give test conditions for over 4,000 valves.

Other items of particular interest at the present time are a signal generator covering Band III television wavelengths, a 20-kΩ/V test meter and a television/f.m. receiver alignment frequency-modulated oscillator; the range is 5 to 250 Mc/s.

Taylor Electrical Instruments Ltd., 419-424 Montrose Avenue, Slough, Bucks.

TELEQUIPMENT (105)

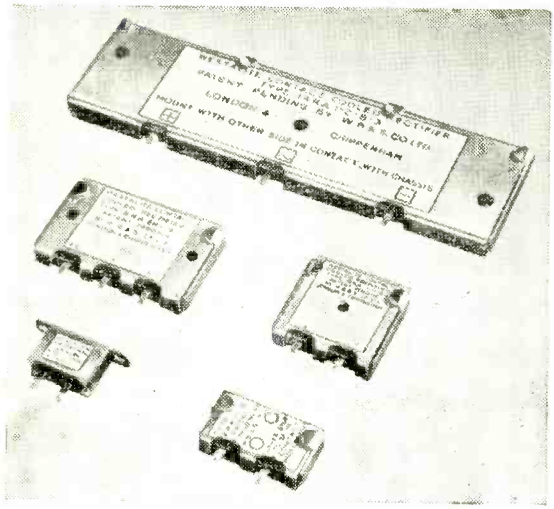
The WG44 television pattern generator made by this firm covers both the Band I and Band III television frequencies and gives the choice of several combinations of horizontal and vertical bars for testing a receiver in the absence of a "live" broadcast. They make, also, factory-type test equipment and a high-grade oscilloscope.

Telequipment Ltd., 1319a High Road, Whetstone, London, N.20.

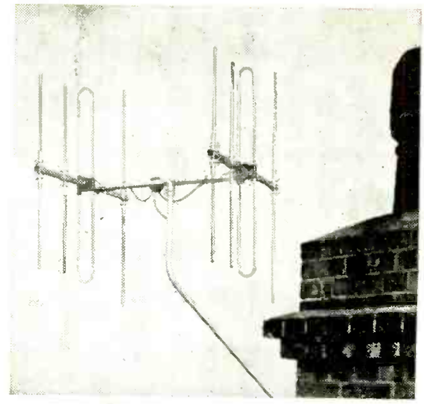
TELERECTION (7)

A distinctive feature of this firm's multi-element Band I television and f.m. aerials is that a "delta" matching system is employed for the feeder. Some aerials are also given a slight upward tilt; this is particularly noticeable in the "Multimus" series of 4-element fringe area types; which incidentally now includes one for f.m. broadcasting.

Between the fringe area types and single dipoles comes a considerable number of intermediate patterns for all three v.h.f. bands for use at various distances from the transmitters Indoor and outdoor types types are included. Fringe area



Westinghouse contact-cooled rectifiers.



Wolsey Model BAY4 Band III fringe-area television aerial.

Band III aerials are now available with six or more elements, and in general folded dipoles are used.

Telerection Ltd., Antenna Works, St. Paul's, Cheltenham, Gloucester.

TELEVISION SOCIETY (315)

In addition to providing a rendezvous for members and visitors, the stand of the Television Society also serves as an information bureau. Reprints of some of the papers read before the Society during the past year or so, including Gouriet's "Introduction to Colour Television," will be available.

Television Society, 164 Shaftesbury Avenue, London, W.C.2.

TRIX (26)

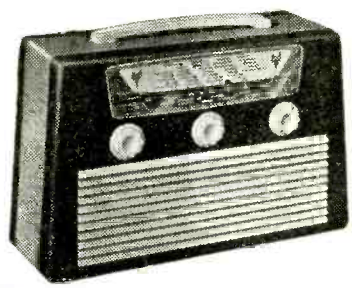
A wide variety of sound reproducing equipment for high-quality domestic and public address applications is made by this firm. The "Recital" console gramophone, which incorporates the Model T41 amplifier, has been improved in detail finish, and a new series of cases and improved amplifier performance are to be found in the "Trixette" range of portable gramophones.

For p.a. work a new 150-watt amplifier (Model T152) has been developed which can be duplicated and operated from a single drive unit (Model T152ID) to give 300 watts for large installations. A new moving-coil microphone (Model G7871) and general-purpose p.a. loudspeaker (Model G7073) are available, and for motor coaches a small, simplified battery-operated amplifier (Model B65/MX) provides an output of 5 watts.

Trix Electrical Co. Ltd., 1-5 Maple Place, London, W.1.

ULTRA (41)

Television receivers with tubes of 14in, 15in and 17in are shown by this firm and all provide for reception in Bands I and III. The



Vidor "Marquisa" all-purpose mains portable.

VT9-17 is for a.c./d.c. operation and has a.g.c. on both sound and vision.

Broadcast sets covering the f.m. Band II as well as medium and long waves are also shown. One such model forms part of a radio-gramophone in which the automatic changer can deal with 33⅓, 45 and 78 r.p.m. type records.

The "Ultra Twin," an a.c./d.c./battery portable, is now available in a cabinet with sliding doors.

Ultra Electric Ltd., Western Avenue, Acton, London, W.3.

UNITED APPEAL FOR THE BLIND (316)

At the invitation of the Radio Industry Council, the "United Appeal," which acts on behalf of a number of associations for the blind, is again staging a live demonstration to show how blind people can take their place in the radio industry side-by-side with their sighted colleagues. The equipment for the demonstration is provided by Philips Electrical.

United Appeal for the Blind, 28 Manchester Street, London, W.1.

VALRADIO (118)

The tuner produced by this firm, and used in their television receivers, provides for sound reception in Band II as well as for television in Bands I and III. It covers the range 40-100 Mc/s in four steps and 170-225 Mc/s in two steps. Continuous tuning between the steps is effected by the permeability method.

Valradio, Ltd., New Chapel Road, High Street, Feltham, Middx.

VIDOR (28)

Two new 12-channel table-model television receivers have been introduced this year; they are the Models CN4230 and CN4231; both embody the same receiver chassis, but the former has a 14-in tube and the latter a 17-in. A small but important point is that the tube protecting glass is easily removable for cleaning.

Among the many portables is a new 4-valve, 2-waveband model, the CN432. It is a very small "upright" style, all-dry battery operated with low-consumption valves, a 5-in loudspeaker and a ferrite rod aerial.

The display of receivers is supported by a full range of dry batteries, including hearing-aid types.

Vidor Ltd., Erith, Kent.

WEARITE (218)

One of the pioneers in this country in the design of tape mechanisms for magnetic recording, this firm will be showing the versatility of their "Tape Deck" as applied in industrial and Service equipment as well as in the "Ferrograph" portables for sound recording and reproduction.

The Wearite range of audio and radio components is supplemented by new coils and transformers for v.h.f./f.m. receivers.

Wright and Weaire Ltd., 131 Sloane Street, London, S.W.1.

WESTINGHOUSE (101)

Contact-cooled rectifier units in a wide choice of ratings have recently been introduced for use in television and sound broadcast receivers. These units are designed for mounting in close contact with a metal chassis, and, by dissipating their heat through it, allow a reduction in bulk, cooling fins being no longer equired. The emphasis of the Westinghcuse exhibit will be on the more specialized types of rectifiers such as germanium crystal, copper-oxide units for measuring instruments, "Westectors" and some miniature high-voltage units.

Sealed tubular rectifiers with quadruple-voltage elements are shown for providing e.h.t. for cathode-ray tubes.

Westinghouse Brake & Signal Co., Ltd., 82, York Way, London, N.1.

WHITELEY ELECTRICAL (25)

The new WB12 high-quality amplifier and feeder unit makes use of the "ultra-linear" method of connection in the output stage and has switched selection of pickup matching. A new f.m. tuner has also been developed.

A 15-in concentric duplex unit and a ready-to-assemble corner reflex cabinet kit for 10-in and 12-in units have been added to the loudspeaker range, which includes cambric cone types from 2½in to 18in in diameter.

Representative examples of the wide range of components supplied to industry and the Government departments will be shown.

Whiteley Electrical Radio Co. Ltd., Victoria Street, Mansfield, Notts.

WOLSEY (5)

This year a special feature of Wolsey Band-III television aerials is that the insulators on the aerials are made of polythene specially moulded to provide a good waterproof junction between the dipoles and the insulator.

The range of aerials has been greatly extended and, while the main emphasis is on Band-III types, both existing television requirements and v.h.f. sound are fully provided for. Pre-assembly in the factory is still one of the main features of this firm's products.

Wolsey Television Ltd., 43-45, Knight's Hill, West Norwood, London, S.E.27.

LETTERS TO THE EDITOR

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

"Tape Bookmark"

A METHOD I have been using for "finding the place" on magnetic tapes is to impose a large amplitude subsonic on the tape—about 2c/s from a dippy oscillator for 30 sec. I find about 20V into the recording amplifier, which normally requires 50mV mean, is ample. Where the recording head is fed from an output pentode via a high resistance, shunting the resistance with a 4μF paper capacitor should be effective.

On fast wind or rewind, although the tape is about ¼in from the playback head, a loud note is heard in the 100-400c/s range, according to the tape speed. By counting these markers, which are placed between each item, I can find the right place on the tape.

A simple switching circuit could be made to operate a device like the selector shown in the article by Price and Frewer in your April, 1955, issue.

The only drawback is that the indexing can only be done on one track, as, although it does not affect the adjacent track in any way, it comes through on fast rewind whichever track is in use. If difficulty is found with erasure, a permanent magnet can be used to remove the last traces of the subsonic.

Coventry. R. G. WICKER.

FOR office dictation and telephone recording, where it is only necessary to mark the interval between messages, I have found it useful to inject into the head for a second or two a small voltage at 50c/s, derived from the filament circuit, which gives a recognizable signal on fast wind.

Manchester. E. S. RUSHTON.

Magnetic Tape Characteristics

IT is refreshing to read the article "Does the tape characteristic matter?" in your March issue and still more to note the conclusions you reach. The fact that "it depends on the machine" is only too well known to tape manufacturers but not all machine manufacturers realize it as yet and very few of the users.

It is perhaps going too far to suggest that, if a tape has, in its own right, a characteristic, then so has a mu-metal stamping but the underlying idea is quite logical. There are one or two factors, in addition to those mentioned in the article, which may possibly have influenced some of the characteristics shown, such as optimum bias current (query: were all the runs on any one machine carried out with a fixed bias current?), surface smoothness and tape thickness, although this last factor is perhaps implied at the end of the first paragraph. Differences in top response between machines could, of course, be due in part to different air-gap width of the playback head.

As regards the one specific anomaly you mention, tape No. 4 may be of lower coercivity than tapes 5 and 7 and the bias field strength may be lower on machine (C) than on the other two. As a result the bias value may be nearer the optimum on machine (C) for tape 4 but too low for tapes 5 and 7. At the same time tapes 5 and 7 show good top response on machine (C) as might be expected if they were of higher coercivity and underbiased.

What is puzzling is the pair of curves on machine (C) for tape 6. Were they taken with the tape running in opposite directions or—horrible thought—with the coating in contact and remote from the head?

Slough, Bucks. H. G. M. SPRATT.

The Cascode

"CATHODE RAY'S" statement on page 399 of your August issue that a.g.c. would be ineffective if applied to Fig. 1 is incorrect. In fact, the required voltage for any given control is roughly one half that required by Fig. 2. When the valve is used as in Fig. 1, the characteristics approach that of a "straight-mu" type and in Fig. 2 that of a "variable-mu" type.

The circuit shown in Fig. 2 is usually preferred since its cross-modulation characteristic is superior. This point is fully discussed in *RCA Review*, March, 1951, in an article "Use of new low-noise twin triode in television tuners." G. R. WOODVILLE.

M.O. Valve Company.

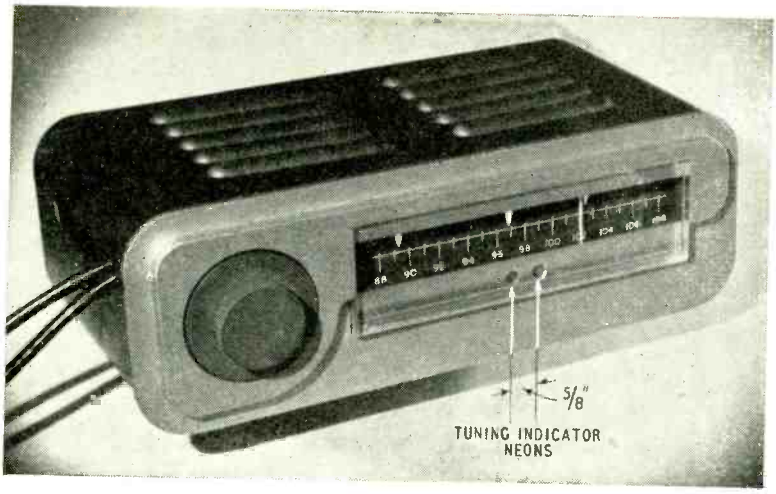
Cathode Ray writes:—My apology to readers for my misstatement about the cascode, and thanks to Mr. Woodville for correcting it.

Battery-mains Short-circuits

I HAVE had in for repair many battery-mains receivers, and in several cases filament and/or dropping resistor breakdowns have been the result of partial short-circuits due to the battery leads, where batteries are not *in situ* and mains operation is used, contacting with the metal chassis or components underneath.

Surely it would be a simple matter for manufacturers of these sets to provide dummy sockets in the cabinet material to take these leads, and thereby prevent many unnecessary breakdowns and other complaints?

Stowe, Buckingham. W. H. JARVIS.



NEON F.M. TUNING INDICATOR

By
JOHN D. COLLINSON*

High Sensitivity with Indication of + or −

TO the listener interested in high-quality sound reproduction a frequency-modulated v.h.f. broadcast system approaches the ideal. In contrast to the medium-wave a.m. service, it is difficult to design an f.m. receiver with a poor audio-frequency response. A wide frequency response in itself, however, is of little value if impulse noise is allowed to obtrude on the programme, or if non-linearity distortion in the receiver mangles the signal before application to a " $D_{tot} \leqslant 0.01\%$ " high-fidelity amplifier.

Both noise and distortion can be kept to low values in well designed and aligned receivers, but the user must play his part in getting the best performance from any given set by tuning it in correctly.

If a receiver is correctly designed and aligned so that the i.f. passband and the discriminator characteristic are symmetrical, and the i.f. signal produced by the received unmodulated carrier is exactly in the middle of the passband, impulse noise will be fully rejected.

The phase-modulated components of the noise, being evenly distributed throughout the passband, correspond to a signal whose mean frequency is that of the midpoint of the passband, so that the discriminator output is zero. If the carrier is mistuned a standing d.c. will appear at the discriminator output which reduces to zero for the duration of the noise. Thus an audio signal will appear proportional to the amount of standing d.c., which in turn is proportional to the amount by which the carrier is mistuned.

Sources of Distortion

Non-linearity distortion can arise both in the i.f. amplifier and the discriminator. If the carrier is mistuned, large deviations can swing the signal past one side of the flat top of the i.f. amplifier passband. Amplitude variations are removed in the limiter stage, but phase changes occur at the same time. When demodulated the audio signal will be asymmetrical, showing the presence of added even harmonics. The discriminator will add its quota of distortion as it is only linear over a limited range on either side of zero output, so that if the carrier is mistuned it must deviate more into the non-linear region.

From the foregoing we may conclude that in the absence of a tuning indicator, the user may resort to two stratagems:— (a) await the passage of an unsuppressed motor-car, then hurriedly tune out its ignition noise, or, (b) tune for minimum intermodulation during loud passages in the programme. With either method, the correct tuning point tends to be elusive, and some form of indicator is essential, if only to stop doubt gnawing at the mind of the technical purist.

As the negative voltage at the limiter grid is proportional to the signal strength, it would appear that it might be applied to a " Magic Eye " in the same manner as the a.g.c. voltage in an amplitude modulation receiver. Tuning for minimum shadow angle should then give the correct tuning point. However, the main requirement of an i.f. amplifier in a

* The Acoustical Manufacturing Co., Ltd.

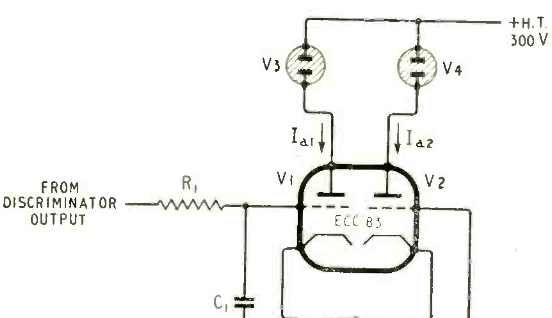


Fig. 1. Complete circuit diagram of neon tuning indicator. V3 and V4 are miniature uncapped neons (Hivac, type CC11L). These are also available with M.E.S. cap and designated CC10L.

frequency-modulation receiver is that it shall have a flat frequency response over some 200 kc/s bandwidth; thus the mid-point is indeterminate. Any attempt to get a well-defined peak at the limiter grid will degrade the phase response of the i.f. amplifier, which introduces odd-order distortion in the audio signal. It is therefore necessary to provide a separate high-Q circuit, tuned exactly to the middle of the i.f. passband, to rectify the resultant signal and to feed that to the indicator. This throws a heavy responsibility on the stability of the auxiliary tuned circuit, and such an indirect approach seems unwise.

A better method is to indicate zero d.c. output from the discriminator. Indicating nothing, however, presents its own problems. One of the best solutions is to use a centre-zero meter. This not only shows the correct tuning point, but whether the set is off-tune, and the direction in which it is off-tune, without having to alter the tuning control. It has the disadvantage that as the demodulator currents are small, a valve voltmeter circuit has to be used, which together with the cost of the meter movement itself is uneconomical, not to speak of the difficulties of finding a meter which "blends with the *décor* of one's home."

A simple and reliable circuit has been developed (Fig. 1) that gives a visual indication of the correct tuning point which may be interpreted in the same manner as a meter. It consists basically of a cathode-coupled amplifier in which one grid is taken to a reference potential, in this case zero d.c. or earth. The other grid is taken to the output of a Foster-Seeley discriminator. If both potentials are equal, then equal currents flow in both valves. If the potentials are not equal, e.g. V1 grid is positive to earth, then I_{a1} increases, making the common cathodes more positive. The negative potential between V2 grid and its cathode is increased, and I_{a2} decreases. The current flowing in each valve is indicated by the brilliance of the two miniature neon lamps in series with each anode. With the type of neon specified, the light output is approximately 0.25 lumens per mA.

The human eye is not particularly good at estimating absolute light output, but it is very much better at estimating the relative output between two lights closely spaced. This ability is aided in the circuit arrangement used, as the eye has not merely to compare the brilliance of a light against a fixed reference, but against one varying in the opposite direction (Fig. 2). Thus, by tuning the receiver until both neons are of equal brilliance, a very sensitive indication is given of zero output from the discriminator. In practice the sensitivity of the system can be such that provided *both* neons are obviously alight, the tuning error has negligible effect on the receiver performance.

The indication given by the plain neon lamps is not ideal as the glow surrounds only one of the parallel electrodes on d.c., and when viewed from the side, the random change of glow position is distracting. For this reason it has been found better to view the neons end-on via a low-loss diffusing screen. A suitable material is $\frac{1}{16}$in opal Perspex (I.C.I. Colour No. 030). When mounted close together the glow from one neon may be screened from the other by a light-coloured opaque sleeve over the body of the bulbs, the light colour helps to reflect the light forward through the diffusing screen.

The performance is determined by the choice of valve, the common cathode resistor, and the h.t. supply. The standing bias on the valve grids must be chosen so that the current through the neon is limited to about 0.7 mA in the unbalanced condition. The cathode load resistor determines the see-saw action which takes place when the receiver is mistuned. With finite values of μ and R_k the anode current changes will not be equal and opposite, but unbalance is immaterial as it reduces to zero at the working point. In practice the small current demand allows a high value of R_k to be used and this performs the dual function of bias and cathode load resistor.

The components C_1R_1, whose time constant is comparable to the period of the lowest frequency likely to be encountered, are used to filter the audio

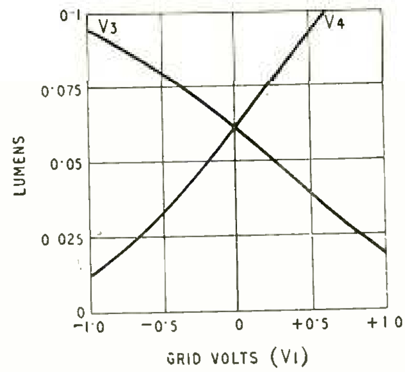


Fig. 2. Light output of neons plotted against discriminator output voltage for circuit of Fig. 1.

signal from the discriminator output. Without this filtering both neons will appear to brighten simultaneously with a heavily modulated signal, thus obscuring the d.c. component.

With the typical circuit shown in Fig. 1 connected to the output of a Foster-Seeley discriminator, there is a clear indication of the correct tuning point within ±3 kc/s. The only difficulty anticipated was the fact that as the indicators show equal brilliance in the absence of a carrier, it was thought that steps would have to be taken to suppress the indicators when the limiter grid current was low. However, this proved unnecessary as one or other indicator is extinguished before the wanted carrier is heard.

There is no reason why this indicator should not be used with a ratio detector *provided that it is of the balanced type*, but the d.c. output per kc/s of deviation will be considerably less than that of a Foster-Seeley discriminator.

"Band II F.M. Tuner Unit"

ALL the coils specified on p. 374 of this article in last month's issue can also be supplied by Wright and Weaire Ltd. The "Wearite" type numbers are:—

Aerial coil L_1, L_2	757
R.F. choke L_3	758
R.F. coil L_4	756
Oscillator coil L_5, L_6	755
Ist i.f. coil L_7, L_8	751
2nd i.f. coil L_9, L_{10}	752
Ratio detector transformer L_{11}, L_{12}, L_{13}	753
I.F. traps L_{14}, L_{15}	759

The escutcheon for the EM80 tuning indicator can be supplied by McMichael Radio Ltd.

Toronto Audio Show

Some Personal Impressions

By P. G. A. H. VOIGT,* B.Sc., A.M.I.E.E.

ON the North American continent, audio fairs tend to run to a pattern. The recipe appears to be quite simple. Take one or more floors of a suitable hotel. Give the inmates of any of the rooms accommodation elsewhere. Remove the beds and some of the other furniture. Collect several dozen manufacturers, agents, importers, distributors, wholesalers, retailers and others commercially interested in "hi-fi," and persuade them that taking space would be to their advantage. Prepare a catalogue with all appropriate information you can lay hands on, including information which the above manufacturers' agents, etc., will supply. Have a few tons printed and on hand. Advertise on the radio (including television), in the Press and by every other publicity method you can think of, and then, by opening day, you will find that you have an Audio Show on your hands.

It is a fairly safe bet that something unexpected is sure to happen, so it is well to have all routine matters under control well in advance. The Toronto Audio Show was no exception to the general rule.

That part of Canada which includes Toronto looks like the foot of Italy and sticks down into the U.S., is supplied with "the Hydro"—a rather special type of alternating-current at 25 c/s which was adopted when the hydraulic power stations were built at Niagara Falls in the early days of electricity. New sources at 60 c/s are being built rapidly, but are claimed for new outlets in an expanding economy, with the result that many parts of Toronto, including the Prince George Hotel, where the Show was held, are still on 25 cycles.

The problem was tackled by disconnecting the wiring of the two floors used for the Show at the distributing box, and connecting temporary leads to a large frequency converter hired for the purpose. Excellent, all set and the Show ready to open.

Naturally each exhibitor had to be rationed as regards the power he could draw, for every converter has its limits. For some unknown reason, however, the total demand exceeded the safe loading of the converter. Perhaps it was that some exhibitors did not count their illumination as part of the load, or their equipment took more watts than it should, according to its specification. We shall never know exactly what the cause was, but it did not take that converter long to become very hot. The result was that after running for a while, the power would shut off, stay off for five minutes or so and then come on again. The matter was coped with by the second day, but on the first one's most vivid recollection was of waiting in the dark for the power to come on again and give the equipment a chance to continue its performance!

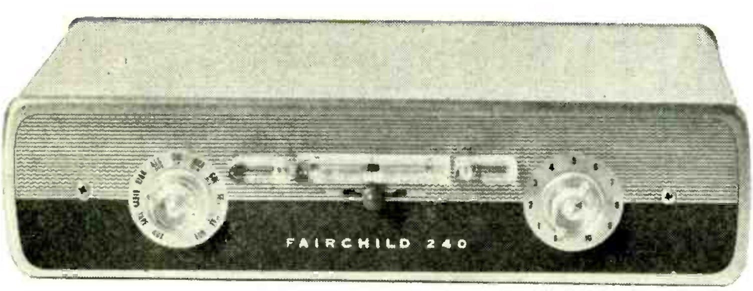
The test of the value and success of an exhibition is measured in terms of how many paid for admission, and even if some of the approximately 4,700 paid admissions represent repeat visits, it seems that on average over 1,000 new visitors came to the Show each day. For many, there can be little question but that this was the first occasion on which they heard reproduced sound of vastly better quality than that from the average radio. From this point of view alone, namely educating the public, the show must be counted a success. What the balance sheet worked out at is none of our business, what matters is that at the *first* such show in Toronto the public showed a lively interest.

Canadian "Hi-Fi"

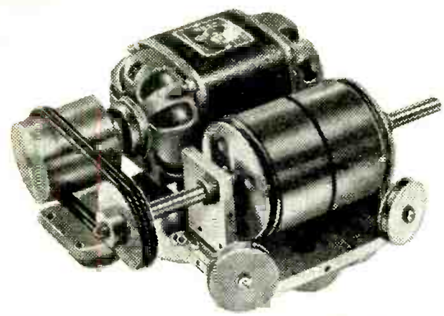
Canada, with its population of less than 1/10th that of the U.S., has, by comparison, only a small market without crossing frontiers and getting tangled up in customs complications, etc. The number of truly Canadian firms on the manufacturing side of the "hi-fi" game is consequently very small. McCurdy Radio Industries do custom work, manufacturing and installing broadcast studio control equipment, etc. Microlab Devices make transcription-type turntables for 25 and 60 c/s supplies, originally for broadcast stations, and now increasingly for "hi-fi" addicts. Dominion Electrohome Industries and the Kelton Company are attacking the domesic "hi-fi" market.

The Kelton speaker system is out of the usual rut and is described as using an acoustic bandpass at low frequencies. The low-frequency speaker has a completely enclosed cavity behind, and another cavity in front from which the sound is radiated via a number of spaced holes. The design is based on a development of the method described by J. J. Baruch and H. C. Lang of the Massachusetts Institute of Technology at a meeting of the Radio Club of America on May 22nd, 1952, and reported on page 30 of the Radio-Electronic Engineering section of *Radio and Television News* for

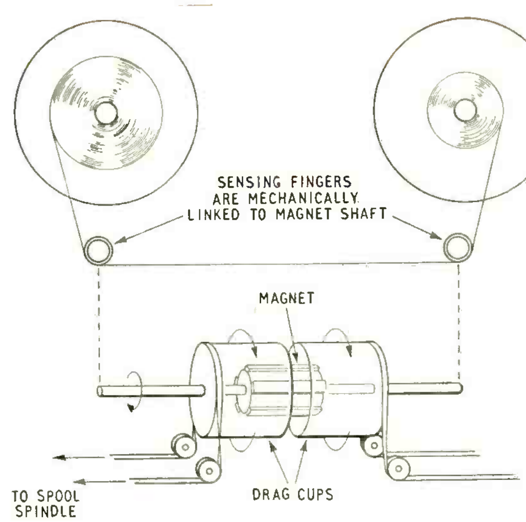
* Voigt Patents, Ltd., London, England, and Sonograph Engineering and Manufacturing Co., Ltd., Toronto, Canada.



Fairchild Model 240 pre-amplifier showing "balanced bar" tone controls.



"Isimetric" tape drive mechanism in the magnetic recorder designed by the International Scientific Industries Corporation. The sketch on the right indicates the principle of operation.



July 1952. Both the front cavity and the speaker are tuned to the same resonant frequency, and are over-coupled so as to obtain a bandpass effect. Quite a surprising amount of bass was obtained from a small volume, but it is noteworthy that in their best reproducer two of these were used together, two more speakers were used for the middle and also a tweeter, making five in all.

There is no need to discuss the many British components displayed, for *W.W.* readers will know about these already. Practically all the "hi-fi" household names, Goodmans, Wharfedale, Acoustical (Quad), Leak, Ferranti, Garrard, Connoiseur, etc., are effectively represented here. Williamson-type amplifiers, too, either according to the original circuit, or with the Hafler & Keroes† "Ultra Linear" modification are very popular.

Those readers familiar with U.S. magazines would also recognize the many U.S. "hi-fi" products which were being demonstrated. There are in Canada no currency exchange regulations which make the purchase of U.S. goods difficult; all you need is money!

The majority of U.S. manufacturers still tackle the problem of quality speakers for home use on the same basis as one tackles it for high-power p.a., namely to use different speakers for different frequency ranges. The various possible combinations of "tweeters," "woofers" and mid-range speakers that can now be put together could only be calculated with an electronic computing machine. Since, in most of the 50 or so rooms used for demonstrations, there was a variety of combinations to listen to, it will be understood that the writer came away with no very clear picture. He still remains convinced that there is more in loudspeaker design than just getting the widest possible frequency reponse.

The biggest speaker at the show was undoubtedly the U.S. Electro-Voice "Patrician IV." The writer cannot really quarrel with the idea that a speaker should be 62in high, for he designed one of exactly that height two decades ago, but this "Patrician" is 39in wide across the front! It uses one "woofer" driving a folded horn, two speakers for the next range, one for the next, and then a "tweeter," i.e., a total of five, all horn loaded. There is much that can be done with about 35 cu ft in hand. The writer can vouch for the floor-shaking ability of this speaker with suitable organ music, for he was on duty in the room set at the disposal of the Society of Music Enthusiasts, while a firm demonstrating a tape machine with organ music had one of these speakers operating in the room immediately below! Incidentally the price here, allowing for customs duties, 10 per cent sales tax, etc., is just over $1,000 or about £364 at the present rate of exchange.

† Audio Engineering, Nov. 1951.

There were speakers in all kinds of cabinets and enclosures. In some cases panel resonances were killed by damping and in some by rigidity of construction. In one case, this rigidity was achieved in a very simple manner indeed, by using a barrel with the speaker set in the side, and some internal damping material to diminish air resonances. The fact that the name of the distributor of this item is Mr. Bier is purely coincidental!

Amplifiers and pre-amps. of all kinds and with varying numbers of knobs were to be seen. In some cases, notably Quad (British), Philips (Dutch, branch plant in Toronto), National, and Fairchild (U.S.), considerable trouble had been taken to make their product look attractive and not like some piece of experimental equipment out of the lab. The Fairchild pre-amp. used an exceedingly neat way of disguising two of the knobs. Part of the decorative trim is a transparent horizontal strip divided into three parts. The two ends are attached to the bass and treble tone control spindles and the recommended procedure is to find by experiment the preferred setting for these controls, then to withdraw the levers and replace them so that they are in line with the horizontal strip. If for any reason the controls are altered, this is obvious, for they are then no longer in line, and in fact indicate the change in the response curve.

On the Philips amplifier there was also an indicator of response. It consisted of a horizontal white line behind a transparent panel. As the bass and treble control knobs were turned, the appropriate end of the line curved up or down to show how the response had changed.

New Tape Drive

Tape machines were there in great variety. With but one exception, they seemed to be along the orthodox lines. The exception, by International Scientific Industries Corporation, a U.S. organization, was not then in commercial production. The designer of this machine must, at some time, have said to himself, "I don't like the mechanics of ordinary tape machines, let us throw the book away and start again."

Most tape machines also have something which slips in the drive to the take-up reel though when this "slip" occurs in an electric motor it may not be obvious. Fundamentally the take-up reel needs a low torque, higher speed drive when empty and a higher torque, lower speed drive when full, with a smooth automatic transition from one to the other as the reel fills up. At the time when the take-up reel is empty, and the supply reel is full, the pull of the tape there acts well away from the reel axis and so exerts maximum torque. The brake also has to be stronger at this stage than later on when the reel is not so full. As the supply reel unwinds its speed increases, while the torque due to the tape tension drops. The ideal brake should adjust itself to suit these continuously varying conditions.

The "Isimetric" drive provides both the varying torque and the varying brake action in an elegantly simple way. The primary drive is a toothed permanent magnet rotor, driven from the main capstan motor. The magnet is enclosed by two "drag cups" which are coupled to the spool turntables by driving belts. Eddy currents induced in the cups tend to make them follow the rotation of the magnet, and the torque exerted depends upon the degree of overlap between cup and magnet. The position of the magnet relative to the two cups is controlled by "sensing fingers" which take up positions depending on the angle at which the tape leaves and enters the supply and take-up spools.

An additional manual control puts in extra motional "bias" of the magnet position, so that when both reels are half full one reel, the take-up reel, has more torque than that on the braked reel. To reverse the tape direction the bias is applied in the opposite direction. Torque is thus maintained all the time on both reels, but superiority of torque can be transferred from one reel to the other by moving the control. Very rapid reversals of tape direction are therefore possible without "spilling" tape all over the place; this should please those who need this facility for editing work. They will also appreciate the control over the tape by operating with the bias knob in a nearly balanced position when the tape can be made to move very slowly, the instant reversal feature still being retained.

A separate motor is used to drive the capstan, and is of "inside out" construction, in that the inner part is stationary while the outer part rotates. The motor thus acts as its own flywheel. These are the main features, but other minor ones have been worked on with equal care, in fact the writer was told that the last year has been spent on simplifying the machine. It is most certainly out of the rut, and we may wish those responsible the best of luck, for there are not enough enterprising people in this world.

"Second Thoughts on Radio Theory"

OUR contributor "Cathode Ray" needs no introduction to regular readers of *Wireless World*, for he has been writing in the journal now for over twenty years. To others it should be explained that he is an author who adopts a sympathetic and informal approach to radio theory, expounding in his own way the sort of things the textbooks either miss out altogether or deal with in a dry and stereotyped manner.

A book has now been produced containing a selection of over forty of "Cathode Ray's" articles—and many of our readers will say it has been long overdue. It constitutes an entertaining textbook for the beginner in radio and a first-class refresher course for others. The selected articles are mostly on elementary topics dealing with basic electrical ideas, circuit elements and techniques and circuit calculations; but, as the author himself says, the more elementary the subjects are, the more important it is to get clear ideas on them. Any errors or obscurities in the original articles have been removed and there are additional summaries, diagrams, cross-references, questions to work out and, of course, an index—making in all a total of 409 pages and 266 illustrations.

"Second Thoughts on Radio Theory" can be obtained from any bookseller at 25s or direct from our publishers at 25s 8d by post.

CLUB NEWS

Birmingham.—"High Fidelity Sound Equipment" is the subject of the talk to be given by C. H. Young (G2AK) to members of the Slade Radio Society on September 2nd. At the next meeting (16th), which will be held at the Aston Technical College, Ettington Road, Birmingham, 6, and for which tickets must be obtained from the secretary, the Osram 912 amplifier will be demonstrated. On September 30th Dr. P. D. Whitaker, of Birmingham University, will speak on "The Application of Electronics to Research in Nuclear Physics." Except where otherwise stated the meetings are held at 7.45 at Church House, High Street, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Bradford.—A joint meeting of the Bradford, Leeds and Spen Valley clubs will be held on September 27th at Cambridge House, Bradford, when Dr. M. J. Heavyside (G2QM) will speak on aerials for short spaces and short-waves.

Coventry.—The annual general meeting of the Coventry Amateur Radio Society will be held at 7.30 on September 26th at the Society's H.Q. at 9, Queens Road, Coventry. Sec.: J. H. Whitby (G3HDB), 24, Thornby Avenue, Kenilworth, Warwicks.

Edgware.—Meetings of the Edgware and District Radio Society are held on Wednesdays at 8 o'clock at 22, Goodwyn Avenue, Mill Hill. The next session's programme includes talks on a variety of subjects and practical evenings especially for beginners. Sec.: E. W. Taylor (G3GRT), 99, Portland Crescent, Stanmore, Middlesex.

Edinburgh.—The opening meeting of the 1955/1956 session of the Lothians Radio Society will be held at 7.30 on September 8th at 25, Charlotte Square, Edinburgh, 2. Meetings are held on alternate Thursdays. Sec.: J. Good (GM3EWL), 24, Mansionhouse Road, Edinburgh, 9.

Glasgow.—An effort is being made to start a group of the British Amateur Television Club in Glasgow. Interested readers should communicate with J. W. Bruce, 15, Dowanhill Street, Partick, Glasgow, W.1.

B.A.T.C.—As already announced, the British Amateur Television Club is holding a convention at the Bedford Corner Hotel, Tottenham Court Road, London, W.1, on October 1st. Admission is 5s. Particulars are obtainable from D. Reid, 4, Bishops Road, Chelmsford, Essex.

QRP.—The closing date for entries for the portable equipment contest, organized by the QRP Society, is September 30th. Details of the contest, which is open to non-members, are obtainable from John Whitehead, 92, Rydens Avenue, Walton-on-Thames, Surrey.

Language Translation by Electronics

Novel Application of Digital Computing Machines

By J. P. CLEAVE,* B.Sc., Grad. Brit. I.R.E., and B. ZACHAROV,* B.Sc., Grad. Inst.P.

The idea of using digital computing machines for the translation of languages was first suggested by Dr. A. D. Booth of Birkbeck College in 1946. An automatic translation project is now under way at the college research laboratory, and this article discusses the problem in the light of the experience gained so far. It illustrates the present trend towards the use of computers more for processing information than for straightforward calculation alone.

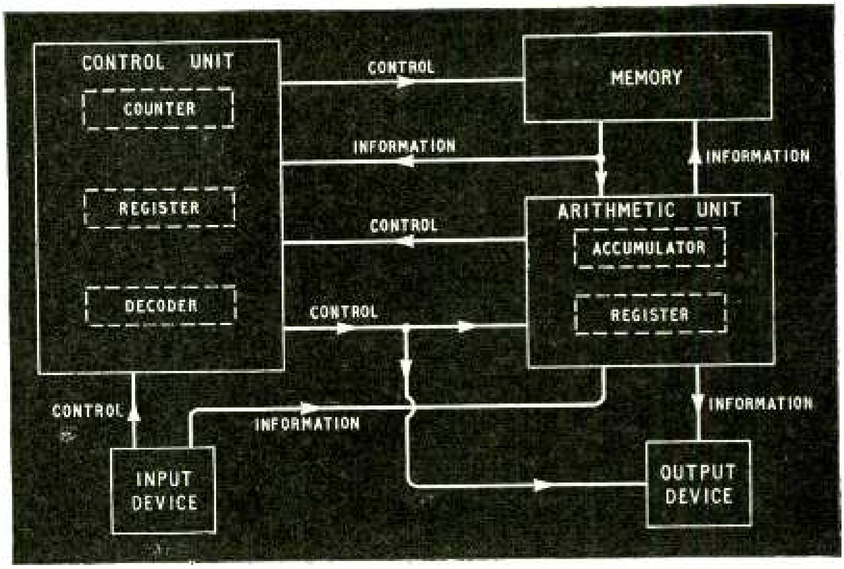
WITH the advent of mechanical calculating machines it became possible to obtain solutions of problems other than mathematical in an automatic fashion. One such problem was the automatic translation of language—the general idea being to code the words into numerical form and cause the machine to operate on these numbers in a certain routine to which the translation process can be reduced. It was only with the development of electronic digital computers, however, that results could be obtained in a reasonably short time and without excessive reference to data stored externally to the machine. In principle a computing machine is capable of automatically translating languages to any required degree of refinement, although at present there are severe limitations owing to the small amount of internal storage space for information that is generally available in the machine. The obstacles that limit the scope and refinement of electronic translation are not, however, insuperable. We can, for example, by employing a human agent to edit the material passing into and out of the machine, obtain results which could only have been obtained automatically with a more complex mode of operation or on a computer of more advanced kind than exists at the present time.

The aim of electronic translation is not to produce a literary masterpiece (though this is theoretically possible with a large enough machine) but to give a more or less semantically and syntactically correct translation of the input text, and in particular to render the vast amount of foreign scientific literature now available intelligible to the scientist. Even very rough translations can be of value here, since they allow the specialist to examine briefly the documents in his particular field of study and to pick out those of special interest. These can then be submitted to a human translator for a more exact rendering.

Restricting the aim of electronic translation to the provision of scientific information simplifies the process by removing questions of style (and so reducing the difficulties of idiom) and by limiting the size of vocabulary. The practicability of the scheme depends, first, on the extent to which the process of translation can be formalized, and secondly, on whether the formalized translation process can be adequately expressed in terms of the "orders" available for controlling the computing machine. It is necessary, in fact, to compile a complete "program" of machine instructions that will carry out sentence analysis and selection of words.

To translate a foreign language it is necessary to have a knowledge of the syntax of the foreign language, a dictionary, and a knowledge of the syntax of the "target" language (meaning, of course, English in this country). The dictionary is a list of foreign

* Birkbeck College Electronic Computer Laboratory.



Essential features of the Birkbeck College computer to be used for translation. Containing some 400 valves, it works on the serial principle and has a basic p.r.f. of 80 kc/s. Operations equivalent to addition and subtraction are done in about 400 microseconds.

language words and their "target" language equivalents, together with grammatical notes indicating possible syntactical functions of the foreign language words. It should also contain a list of contexts in which the foreign language word has a special meaning; for example, the German "unter" is entered in a standard German-English dictionary as follows:

unter (1) preposition: under, below.
~*uns:* among ourselves.
nicht ~ ein Pfund: not less than one pound.
(2) adjective: lower, under, inferior.
(3) prefix: under, among.

A knowledge of the foreign language syntax enables one to decide what are the grammatical functions of the foreign words (whether nouns, verbs, prepositions or what) and hence which blocks of words function as subject, direct object, indirect object, etc. in a sentence or clause. The knowledge of the "target" language syntax permits the rearrangement of the translated foreign words blocks into the appropriate "target" language order and the appending of necessary syntactical word endings.

Mechanized Translation Procedure

With these basic sources of information, then, it is possible to lay down in outline a definite procedure for the translation in terms of mechanical operations. First, it is necessary to determine the grammatical functions of the foreign language words. This is done by reference to the dictionary and is easy to systematize in a computer. The dictionary information about the possible grammatical functions of the word under consideration can be made to initiate an examination of a small context, say one word on either side, to resolve the ambiguity. For example, suppose "unter" (see above) occurs in a German sentence and we wish to decide whether it is an adjective or a preposition, then the words immediately following will settle the point. Thus, if following "unter" there is a group comprising an article or possessive adjective, an adjective, and a noun, with accusative or dative case endings, the "unter" is used here as a preposition.

The second part of the translation procedure is to determine the meanings of the words. Here we meet the problem of ambiguity in its largest form. It is closely connected with the problem of idiomatic usage, but this narrower difficulty is more easily disposed of, for a note in the dictionary can indicate that there is an idiomatic use of the word and thus lead to a set of operations for searching the context to see whether the conditions for the idiomatic use are present.

The next step is to identify groups of words which behave as one unit in a sentence. For instance, a noun together with its modifiers behaves as one unit. To determine these blocks of words the context of each word of the foreign language must be examined for grammatical patterns, and two blocks in juxtaposition will have to be distinguished by considering case endings. Then, with the word blocks found it is relatively simple to decide which are the clauses of the sentence on the basis of the occurrence of punctuation marks, conjunctions, etc. and also by the order of the word blocks.

Finally, the last stage of the procedure is to give the "target" language equivalents of the foreign language words in accordance with the analysis described above. This involves two things. First, adding the correct word-endings. This is a simple procedure according to the rules of the "target" language since the sentence structure and grammatical function of each foreign language word have already been determined. Secondly, arranging the "target" language word equivalents in the conventional word order of that language. This is an entirely mechanical operation once the clauses of the sentences have been identified.

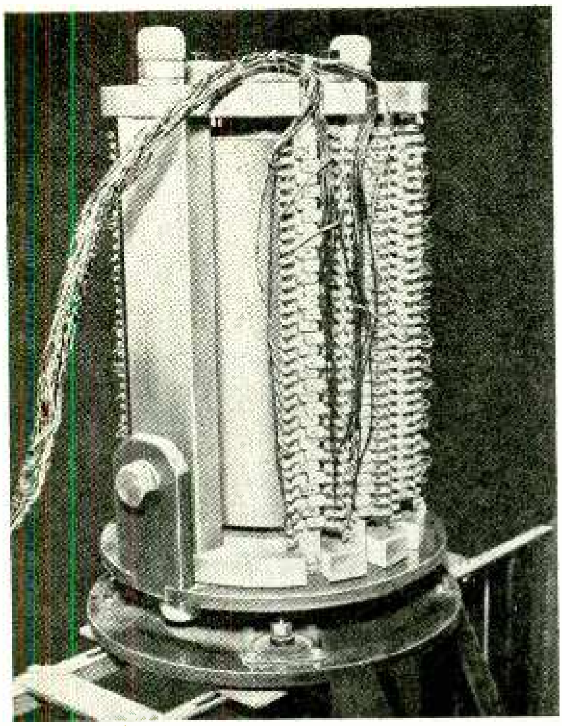
Computer Facilities

To summarize all this briefly, the basic operation involved in translation can be reduced to: (a) comparing incoming words with the dictionary entries, (b) recognizing patterns of words or characters (as in idioms, word blocks, etc.) and (c) transferring information to and from a store (as required in the operation of searching the context of a word to find the presence of the other words used in the idiom). The next question to consider is how these operations can be achieved with the facilities available in a computing machine.

Despite variations in detail, all electronic computers have the following three main types of facility: (1) information manipulation (such as the ability to shift information to and from the various storage systems), (2) arithmetic operations (such as addition and subtraction) and (3) what is known as "conditional transfer" (to be described below). These facilities are quite adequate to perform the basic operations of translation. In terms of actual "hardware," the digital computer has, in general, four distinct sections: a "memory" in which information can be stored; an arithmetic section in which operations are performed on the stored information; a control section which specifies what operation is to be performed (and, just as important, when); and terminal devices which enable data to be fed into the machine and by which the machine can display the results of its operations.

The first problem is how to code the words to be translated into numerical form and feed them into the machine. One convenient way is to deal with each letter of the words separately. It is then possible to use a teleprinter as the input device, for as each letter key is depressed it produces a pattern of holes and spaces in a paper tape corresponding to the "0" and "1" digits of a number in binary notation. The paper tape can then be fed through a "reading" device which converts the holes and spaces into corresponding sequences of pulses and blank periods suitable for use in the computer. Decoding the translated text from the output of the machine is simply the reverse of this process, and here it is possible for a "receiving" teleprinter to be operated directly from the emerging sequences of pulses.

Once having decided how the words are to be coded in numerical form it is easy to see that they can be stored as groups of binary digits in the computer "memory" system, for example as states of magnetization on oxide media or as states of operation in flip-flop devices. This "memory" can be a magnetic drum, a system of acoustic delay lines, an electrostatic store or any other device, but the major requirement is large capacity; very quick access to any word is not necessary. At the moment only one type of store, bearing in mind the question of cost, fulfils these requirements. It is the magnetic drum, and this is in fact used on the digital computer in Birkbeck College Electronic Computer Laboratory. Here approximately 8,000 words may be stored, and clearly several such



This magnetic drum storage system of the computer will contain the dictionary information necessary for translation.

drums could be used. It is this "memory" system of the computer which contains the dictionary used in translation. All the foreign language words likely to be required are stored in one set of positions on the drum while their "target" language (or English) equivalents are stored in another related set of positions. The "memory" also contains the complete set of instructions (known as the "program") for the translation process, each instruction being represented by a group of 32 digits recorded on the drum.

"Arithmetic" Operations

To see how the arithmetic unit operates in the translation process we can examine how an incoming word is compared with words stored in the dictionary incorporated in the "memory." The stored words can be fed out sequentially from the "memory" and subtracted from the incoming word. When zero is sensed from the result the incoming word is clearly coincident with the word just subtracted, and the signal so produced can be used for initiating the next part of the program, which in the simplest case is the selection of the appropriate "target" language word from the "memory" dictionary. This operation is a very easy and rapid one for a computer. Another way in which the arithmetic unit may be used is in either separating "stems" from "endings" (subtraction) or joining them. This process would be particularly useful when dealing with highly inflected languages, such as Russian and Latin, where it would be convenient to store stems and endings in the mechanized dictionary.

A very useful facility is the "conditional transfer" mentioned above. This is a control method which allows the program sequence to proceed in one of two channels, depending on whether the most significant binary digit of an incoming number is a "0" or a "1." This can be very usefully applied in translation processes in which the sequence of operations depends on recognizing any given configuration of digits in the number representing a word or part of a word. Many machines have other conditional control facilities which are similar in that they allow the sequence of operations to proceed in either of two channels provided a given condition is satisfied or not. Such a system could recognize, for example, whether a certain storage device had all "0s" or all "1s" filling it.

Specialized Dictionaries

The size of store necessary to contain the total vocabulary for a non-technical translation would be extremely large. The number of terms used in specialized branches of science, however, is considerably smaller than that required for general literature. Consequently, by limiting the automatic translation to a particular branch of science, the dictionary can be reduced to a size manageable by present techniques of storage. Besides reducing the size of vocabulary, concentration on technical literature reduces the problem of ambiguity. And by further specialization on, say, a particular branch of mathematics, ambiguity of technical terms within that branch is lessened. For technical translation, then, a mechanized dictionary must be compiled in two stages: first by collecting together the general language of mathematics, that is, the language common to all or most branches of mathematics, and secondly by assembling a glossary of all the technical words in the particular branches of mathematics. The translation of a paper, on, say group theory would thus be preceded by feeding into a computer a dictionary of the general language of mathematics and a glossary of group-theory terms.

Not every case of ambiguity with a word can be resolved simply by reducing the vocabulary or referring to a small context. For instance "Ableitung" in German means "derivative" or "deduction." The first translation occurs so frequently in many branches of mathematics that it would be safe to consider it a general mathematical term along with the second meaning. And it will not always be possible to decide by reference to the immediately preceding word which meaning is intended, for example, "zweite Ableitung" can mean "second derivative" or "second deduction" and both these phrases could occur in mathematical literature. Resolving this type of ambiguity is difficult and could possibly be done by reference to the context of the complete sentence. Failing resolution of ambiguity, all possible meanings could be printed, leaving the specialist in that particular branch of mathematics to decide the issue.

Enough has been said now to show the nature of the problem. Various projects are under way in America and in England, notably at Birkbeck College. On the engineering side research is directed towards the construction of "memories" which are large and also permit quick access to the stored data. At the same time, devices for the automatic recognition of printed and spoken material are being developed. On the linguistic side, the problems are to construct a "program" for each language to be translated into English and to build glossaries of suitable technical terms for the various interested branches of science.

Etched Foil Printed Circuits

With Particular Reference to Photomechanical Methods of Production

By H. G. MANFIELD*

FOR the production of identical circuit patterns in large quantities, printed wiring is becoming increasingly popular. At the time of writing, only wiring is being attempted; the printing of component parts, with the exception of r.f. coils and low-value capacitors, is still a long way off.

The etched foil method appears to offer more advantages than other methods, and is more easily scaled down for use in laboratories and in pilot plant production. Basically, this system uses a thin copper foil, usually between 0.001 and 0.002in thick, bonded to an insulating material; this may be practically any type of laminate but, as it needs to be machined, cut and punched, synthetic resin bonded paper (s.r.b.p.) is almost universally used. Special circuits may need either a base material suitable for use at higher temperatures than s.r.b.p. or one possessing better dielectric properties (lower permittivity and power factor). The printed circuit pattern is impressed on to the copper in acid-resisting ink (the resist) and all the unwanted copper is removed by etching in a weak acid.

Methods of Printing.—The word "printing" is used in a loose way when discussing "printed" circuits. Sometimes real printing methods are used, such as the offset-litho or the silk-screen, but photography is often used to produce the same result, and, although this is hardly "printing," the method is very similar to that used in making printing plates of the "line" or "half-tone" variety.

A few words about the non-photographic methods will show the relative merits of each.

Offset-Litho Methods.—When a large quantity of printed circuits is required, the offset-litho method is probably the most suitable way of producing them. The work is done by specialist printers using a flat-bed machine over which a roller travels from end to end. The printing plate is made by a method very similar to the one to be described in detail, but it is made on an aluminium sheet which has been lightly roughened or "grained." The prepared plate is placed on the bed of the press where it is first inked and then traversed by a blanket roller, usually of rubber, which transfers its inky pattern to the copper-clad laminate. The layer of ink transferred from the printing plate to the laminate is very thin and would not in itself stand up to the acid which is later used to remove all the unwanted copper, leaving the pattern alone on the insulated base. A layer of powdered bitumen or resin is brushed or blown on to the inky pattern and adheres to it. This is fused by heat to form a reinforced layer that will resist the acid etchant.

This process is carried out by skilled printers using standard methods and equipment, as used in the quantity production of nameplates, etc. It is not possible to scale it down to laboratory proportions.

Silk-Screen Methods.—The silk-screen method of printing is extensively used for the production of large-sized prints, e.g., posters. It is attractive for printing circuits because of its general use in the radio and electronic industry for the printing of dials, scales, etc. Circuit and nameplate printing both use non-absorbent base materials—an essential difference to printing on paper. The method of production may be scaled down for use in the laboratory and it is quite economical for the making of a few prints, but several hundred may also be made in the same way.

The silk-screen consists of a fine woven material either of silk or fine wire, which is stretched tightly over a wooden or metal frame. The pattern is made into a stencil by photographic means and this is attached to the silk, leaving holes only where the pattern is required, all the rest being blanked out. The laminate is placed under the screen, ink is poured on one end and transferred to the other by means of a square-cut rubber squeegee. In this way the ink is forced through the holes in the stencil and forms a pattern on the laminate. The inks used for silk-screen work are very viscous and, as a thick layer can be applied, they are, when dry, good acid resists.

Limitations of Offset-Litho and Silk-Screen Methods.—Apart from difficulties in production which have already been mentioned, there are technical reasons why both the methods discussed are unsuitable for certain electronic circuits. The most serious limitation is in the degree of fine detail that can be obtained by their use.

In a large number of circuits, fine detail is not necessary and it should be part of the design to eliminate unduly narrow lines and spaces, but when these cannot be avoided, or when coils must be printed, photographic printing methods must be used.

Photomechanical Methods.—Printing on metals is not done by the same means as is used in portrait or landscape photography, neither are emulsions stripped from plates and transferred to metal surfaces. The process is to deposit a photo-sensitive material on to the plate, then expose and develop it.

When making printing plates or blocks, the base material is metal and is able to withstand heating, which hardens the coating material and greatly improves its acid resistance. In addition, the etching is only carried on for a fraction of a mil (thousandth of an inch)—in the trade a "deep etch" is 0.0005in. For circuit printing, the copper must be etched right through and, as it is usually about 0.0015in thick, this may take 10-15 minutes or more, according to the density of the etchant and its temperature, and on the degree of agitation.

* Radar Research Establishment, Ministry of Supply

Numerous ways are available for producing the image. Some are wrapped in trade secrecy, others use proprietary methods—often called "cold-tops" to distinguish them from the processes where heat is required. Many of these have been tested over a period of several years and some have proved unsatisfactory; others are temperamental and require rigid control of room humidity. Two methods will be described; neither uses proprietary materials, and both have given consistently good results over a period of time.

Preparation of Drawings and Negatives.—Before printing on the laminate a negative is required, and this is made from a drawing of the circuit pattern which is to be produced. A drawing in Indian ink on white cardboard has been found reasonably satisfactory. It is made four times the size as this allows the draughtsman to draw thick lines and when working to his normal tolerance of ±0.005in, the final result will be within ±0.00125in, which is sufficiently accurate for all but the most intricate designs.

To avoid work in the drawing office a novel method of producing master prints has been developed, which is only applicable when the circuit is to be printed on a standard-sized board with terminations in fixed places. When used it enables the circuit designer to lay up a master in a short time, knowing that when photographed it will be precisely to size and that the terminations will be correctly placed. With the double-sided board, registration between opposite sides is very important and is quite difficult when using drawings, as paper and cardboards are dimensionally unstable.

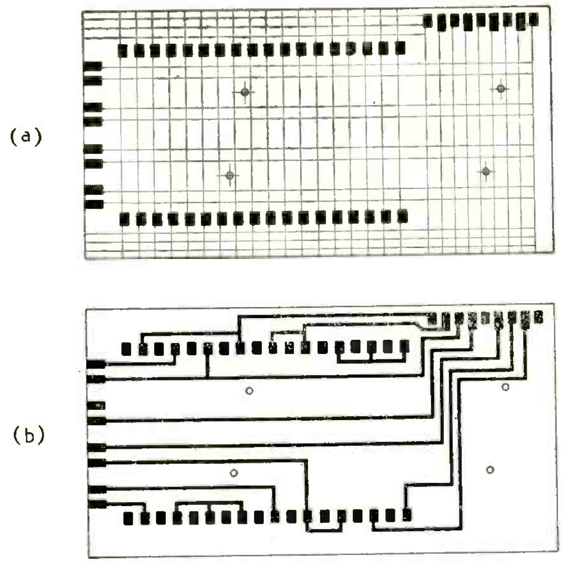


Fig. 2. Engraving sheet (a) with terminations and grid pattern cut to receive "wiring" in the form of tape strips, (b).

The circuit layout is made on a sheet of paper on which a standard basic pattern is printed by a duplicator. The lines are pencilled in, either in different colours for each side or in solid and broken lines (Fig. 1).

The system is to use engraving sheet, a three-ply laminate of a black sheet between two white or a white sheet between two blacks. The former is generally used and the standard terminations are engraved out, leaving dense black squares or circles on a white background. Surface shine is eliminated by rubbing down with fine glass paper to a matt finish. A grid pattern is marked on the surface to guide the tapes which are used to produce the wiring pattern (see Fig. 2 (a)). The whole sheet is marked out and engraved on a milling machine; the work can be done very accurately. The pattern is four times full size.

When completed, the pattern is transferred to the engraved sheet by means of adhesive cotton tape, known as photographic masking tape. This has a dull, unglazed finish that prevents shine on the photograph. It is obtained one inch wide and slit to 0.2in as the wiring is of 0.05in width, four times up in size. This tape adheres well to the engraving sheet and can be used over and over again as it retains its adhesive properties. The engraved sheet complete with its pattern of wiring is shown in Fig. 2 (b).

A circuit made by the method described is shown in Fig. 3. It consists of a double-sided laminate on which the standard components are assembled and held in turret lugs. Two double-triode wire-ended valves are fixed to the board with special clips. The whole sub-unit has been designed especially so that it can be made by semi-automatic means, and all the

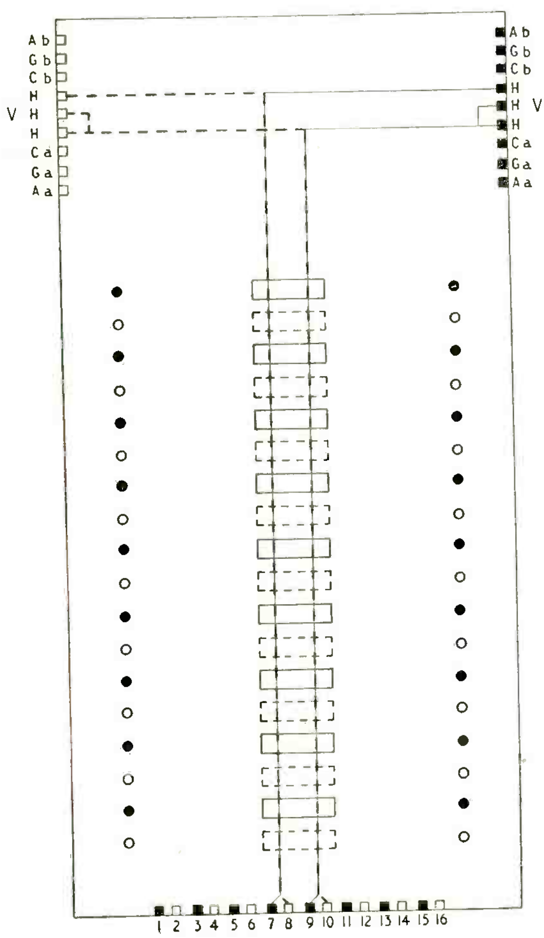


Fig. 1. Typical foundation pattern for use with white-on-black laminated paper for producing master circuits by engraving.

joints are made by dip soldering. Only the edges of the board are immersed in the solder, joining the copper foil and the components to the tags.

Photography.—The drawing on engraved sheet, when completed and checked, is mounted on an easel and photographed to correct size. This is easily done with a process or studio camera as the image is projected on to the ground glass focusing screen and measured with a ruler. If a special process camera is not available and a studio type is used, it will be important to ensure that the drawing, lens and focusing screen are all perfectly square and parallel to each other or the pattern will be distorted.

The choice of negative is limited by the need of a very "contrasty" picture giving complete transparency of the pattern on a completely opaque background. Two photographic suppliers have recently introduced a range of extremely contrasty negatives which are available in various sizes both on film and on glass. These negatives (Kodak "Kodalith" and Ilford "Formalith") are developed in special developers (known by the same name as the plates). They require a long exposure as the emulsion is very slow, but the result is ideal for photomechanical purposes as the whites are transparent and the black very dense, needing no reduction or intensifying as do most process plates and films.

The choice of plates or films is governed by the final requirements and the available equipment. For maximum stability and the maintenance of close tolerances, glass plates are preferred, but these often fail to make intimate contact with the laminate, when making the contact print. Films can be backed up close to the base and if a vacuum printing frame is available, intimate contact is made, giving the finest reproduction of the original pattern.

We will assume that the plate or film negative has been made and has been retouched where necessary to fill in any pinholes.

Printing on the Laminate.—The copper-clad laminate is usually made of paper impregnated and bonded with phenol-formaldehyde (s.r.b.p.) but it may be of glass cloth impregnated with polyester, epoxy or silicone resins. In any case, the copper foil is bonded to one or both faces by various proprietary methods, some patented by the laminators.

The poorness of the bond was largely responsible for the long delay in realizing the initial basic ideas behind etched foil. Modern materials have the copper foil bonded well enough to withstand a peel test on a 1-in strip of up to 25lb at room temperature, and stable enough to withstand dipping for 3 or 4 seconds in a bath of solder heated to 250°C.

When received from the manufacturers the copper faces are greasy and oxidized. They are cleaned either by wet abrasion with a brush, water and pumice powder or, if the surface is not pitted or porous, by chemical means with or without the passage of current (cathodic etching). The surface must be clean enough to maintain an unbroken film of water when wetted. When thoroughly clean and degreased, the board is ready for the application of the photo-sensitive coating.

Coating Solutions.—Two types of photo-sensitive coatings will be discussed. One, a single coating, requires reinforcing with ink before it becomes a sufficiently strong acid resist. The other, a double coating, stands up to the etching bath without reinforcement. Each has its advantages and disadvantages, which will be discussed later.

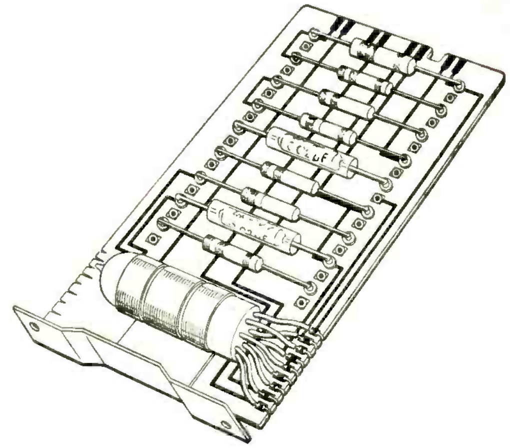


Fig. 3. Sub-unit using printed wiring and dip soldering, made from the master diagram of Fig. 2.

Single Coating Method.—The solution, which is water soluble, is made as follows: Take 70 grams of egg albumen and dissolve in 250 c.c. of warm, distilled water at about 35°C. When dissolved, add 111.5 grams of ammonium dichromate followed by 7 grams of ammonia, 0.88 specific gravity. Make up mixture with distilled water to 560 c.c. Filter through a No. 41 filter paper to remove particles.

The filtered solution is poured on to the clean copper face of the laminate and whirled until dry. The whirling may be done with a hand-operated tool like a hand drill with a rubber suction cup instead of a chuck, or on a modified gramophone motor and turntable, rotating at about 100-120 r.p.m. Commercial whirling machines are available for production quantities. The motor-driven types are best as the rotation is at a controlled and repeatable speed. If it is required to speed up the process, slightly warmed air may be applied from a hair-dryer or by other means, but it is important that the coating should not be overheated at this stage.

As there is a build-up of the coating at the edges of the plate an oversized plate is used; in other words, the pattern is smaller in size than that of the board which is being coated.

When dry the coating presents the appearance of a glossy yellow film that is even and non-tacky. It is not sensitive to any normal lighting except strong sunlight and to ultra-violet light, so the coating may be made in a well-lit room excluding sunlight.

The plate is placed in contact with the negative, emulsion to coating. Both are put in a printing frame—preferably of the vacuum type, but good work has been done with the ordinary type used to make contact prints. The exposure is made to ultra-violet light from either an arc-lamp or a high pressure mercury vapour lamp. If the negative is really opaque it is impossible to over-expose it, but as lamps produce heat, it is possible to overheat it. Four to six minutes with an arc lamp and 10 to 12 with a mercury vapour lamp are generally correct. Under-exposure must be avoided or the image will peel off during development.

On removal from the frame, the image will be seen as a dark pattern where the light has hardened the coating in those places not covered by the lines in the negative. The laminate is placed face upwards on a flat surface and a small pool of lithographic developer ink (a black, oily liquid) is poured on its centre. The ink is swabbed over the surface as quickly as possible with cotton-wool several pieces of which could be used in order to get a very thin film of ink remaining on the copper surface. The object is to remove as much ink as possible in the shortest time as it is quick-drying, and too thick a film will make the subsequent development very difficult.

The inky film is dried with warm air and thoroughly wetted under running water. Those parts of the image that were covered by the opaque parts of the negative will wash away leaving the pattern showing in the copper base. Sometimes, parts of the coating require light rubbing with cotton wool to clean up the surface, but when the process has been carried out satisfactorily the running water will suffice to develop out the image. When fully developed, the plate is dried by hot air; this time the heat is beneficial as it hardens the ink layer and so increases its acid-resisting properties.

As described, the ink layer will stand up to the etching solution long enough to remove all the unwanted copper, but as it never really dries and if both sides of a board are to be prepared for etching further initial treatment of the first side is necessary. This is quite simple, merely being the pouring over its surface of a powdered bitumin or resin (the latter known as Dragon's Blood). The powder adheres only to the sticky ink and by tapping smoothly on the side of a bench or by washing in water, all the surplus is removed from the copper. This layer of powder must be fused by heating. The resin requires about 2-5 minutes' treatment at 100°C, either in an oven or by the application of infra-red heat; the bitumen fuses at a higher temperature, which is found by experiment.

When the process is complete, the resist pattern is very hard and practically scratch-proof so the reverse side of the board may be coated and processed exactly as for the first side. When finished, the placing of the board edgewise into the etchant will remove the unwanted copper from both sides at once.

Circuits treated as described have withstood 4-5 hours in a bath of ferric chloride of 1.38 s.g. at 25°C.

Double Coating Method.—In the method already described, the single coating must be light-sensitive and also acid-resistant; this limits the choice of materials that can be used—most of them are based on a colloid such as albumen, fish glue, gelatin or gum arabic.

The separation of the light-sensitivity and acid-resistant properties allows a stronger base to be used, whilst the light-sensitive material has only to resist the solvent for attacking the base—in other words, the first layer is acid-resisting and the second is made into a stencil through which a solvent removes the underlayer where required. The process is carried out as follows:—

A cellulose nitrate lacquer is coated on the cleaned copper face of the laminate. Whirling is unnecessary as the solution, thinned to double its volume with acetone, is poured on to the centre of the plate and allowed to flow over its entire surface. It dries quickly and as it is dyed red, the smoothness of the coating is easily checked.

When dry, the plate is coated with the albumen solution exactly as used in the single-coating method. It is exposed to the arc or ultra-violet mercury vapour lamp through the negative and is developed in water after exposure, instead of being inked up as described previously. As the albumen solution is almost colourless, it is difficult to see it on the surface of the lacquer, but as it is dried with hot air the image appears, only to disappear when it is completely dry. The albumen coating solution could be dyed but the need for this has not occurred in the experience of the author.

The lacquered plate is now covered by a stencil of albumen in the circuit pattern. If a solvent is now poured on its face, all the lacquer will be removed except where it is covered by the albumen coating. Many solvents may be used—propyl alcohol is effective but most are too quick in action and some attack the stencil. A slow acting and very effective solvent is polyethylene glycol—a liquid rather like glycerine in appearance and consistency. A small quantity of this is poured on to the plate and lightly swabbed with cotton wool. All the unwanted coating comes away, leaving the image ready for acid etching. No heating is required or is desirable, as the lacquer is easily crazed by overheating.

This method is satisfactory for single-sided circuits but it is impracticable to coat one side of the laminate without getting any of the lacquer on the reverse. It provides a stable image that is non-tacky and quite tough and so able to withstand handling without being easily damaged.

Etching the Copper.—Although nitric acid has

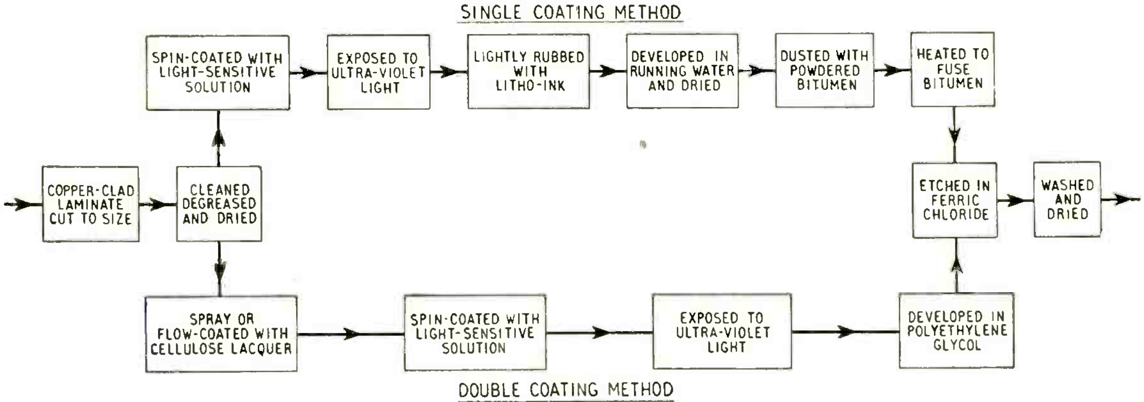


Fig. 4. Comparison of single- and double-coating photographic methods.

been used by a few people, most use ferric chloride as an etchant. Practically all workers in the printing trade use it because it gives a slower, more easily controlled etch without bubbling. When copper is attacked by nitric acid, hydrogen is liberated; this bubbling through the liquid can lift the acid-resistant pattern.

The ferric chloride may be obtained as lumps which are dissolved in water by the user or, more conveniently, as a liquid of about 1.38 s.g. When making a new bath, some 5 per cent or so of old etching fluid should be added to it as this increases its cutting speed.

Etching machines are available for large-scale work, but for laboratory purposes a photographic developing dish made of china is adequate. The single-sided board is immersed face downwards so that the copper silt which is cut away by the etchant falls to the bottom of the bath. Double-sided boards are, as already stated, placed edgewise in the bath and in each case the dish is agitated in a similar way to that used in developing a normal photographic plate.

Warming the bath to about 30-35°C speeds up the process, which can often be completed in about 7-10 minutes. Some machines will etch through 0.001in of copper in three minutes, but the resists that have been discussed are extremely durable and, when necessary, the boards may be left untouched, if the bath is at room temperature and unagitated, until the final cleaning of copper which may take about an hour.

After etching, the board is thoroughly washed in warm water to remove all traces of acid and then the resist pattern may be removed with a solvent—turpentine or white spirit for the bitumen or resin, acetone for the cellulose lacquers. Where the bitumen or resin has been well fused, abrasion of its surface, with water and scouring powder, may be necessary to clean up the exposed copper circuit. It is advisable to dry the laminate in an oven for about half an hour at 100°C to remove any water that has been absorbed during processing. This is particularly important when low-grade punching materials have been used as a base for the copper foil.

Comparison of Single- and Double-coated Methods.—It has already been stated that the double coating would be difficult to apply to double-sided boards, but apart from this fact, the following points should enable a choice to be made between the two methods.

There are more operations when using the single than when using the double coating (see Fig. 4) and it requires less manipulative skill to carry out the latter. The application of the cellulose lacquer is very simple and the albumen coating is applied in each case, so the process is common to both methods. A certain dexterity is required when inking up the albumen-coated plate; too thin a layer makes a poor acid resist and too thick a layer makes the development of the image difficult. Following up with powdered bitumen or resin is probably best done by dipping the board into the powder and washing away the surplus under a tap which, although simple, requires practice to perfect it.

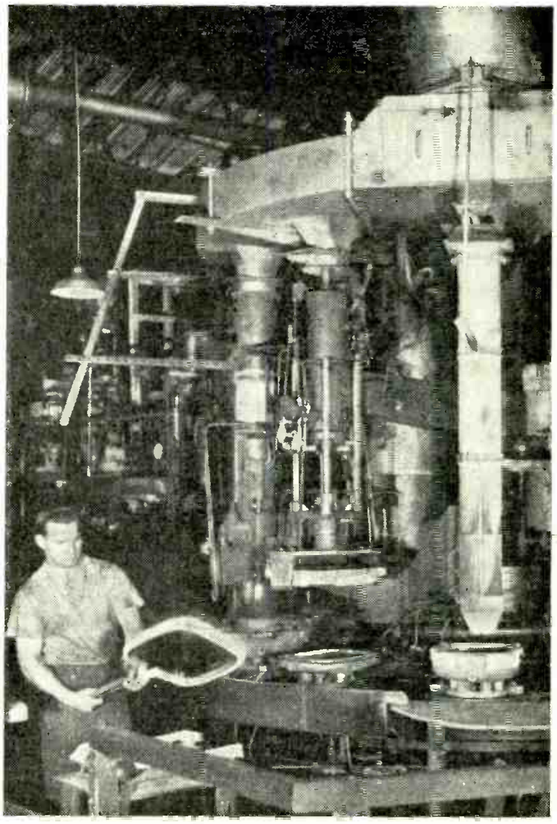
On the other hand, the thinners and solvents for the ink—white spirit or turpentine—are pleasant to use, whereas acetone as the solvent for the cellulose lacquer is unpleasant, also the red cellulose is much more difficult to remove from the skin and from clothing than the simple oily liquids.

With a little practice, the single coating with its reinforcing materials gives consistently good results under all conditions of temperature and humidity. It produces a resist pattern which is very much more durable than most cold top enamels, it is made up by the user from harmless chemicals, easily obtained. The solution, when kept in a well-stoppered coloured bottle (so that it is unaffected by light) has been used over a period of three months without deterioration.

Given a good negative, thorough cleaning of the copper, adequate exposure followed by development in cold, running water, and careful inking up of the image, very satisfactory results can be achieved with a definition that is good enough for the finest detail such as is needed on miniature circuits and coils.

Acknowledgement is made to the Printing and Allied Trades Research Association, Leatherhead, and to Kodak, Ltd., Kingsway, London, for help and advice on circuit printing over a period of five years.

Glassware for C.R. Tubes



Cathode-ray tube glass parts (cones and face-plates) are turned out at the rate of one every six seconds by a new automatic plant put into operation by Pilkington Brothers at St. Helens this year. The firm came into the business at the Government's request in 1948 and now, with the new equipment, are able to produce at least two million components a year. In this machine, large blobs of molten glass from a furnace are fed into moulds on a rotating table, and this passes under a plunger which descends and presses out the glass to the required shape. Annealing follows, then inspection, and grinding and polishing where necessary.

American Oscilloscope Technique

With Some Remarks on Anglo-American Divergencies

By A. J. REYNOLDS*

THOSE readers who were in the radio industry in pre-war days will remember the very high regard in which instruments by such American companies as General Radio, Boonton, Ferris and Measurements Corporation were held. In the early and mid 'thirties the British Instrument as we know it today hardly existed. We had, of course, famous companies such as Cambridge, Muirhead, Sullivan and Tinsley, but they were fully occupied making what can be regarded as laboratory standards, bridges of extreme precision, potentiometers and variable air capacitors of exquisite workmanship. Little was then available, British made, for those awkward characters who required to generate few microvolts at many megacycles or who cherish a notion to measure the Q of the Litz-wound glass-former inductors in their super short-waver.

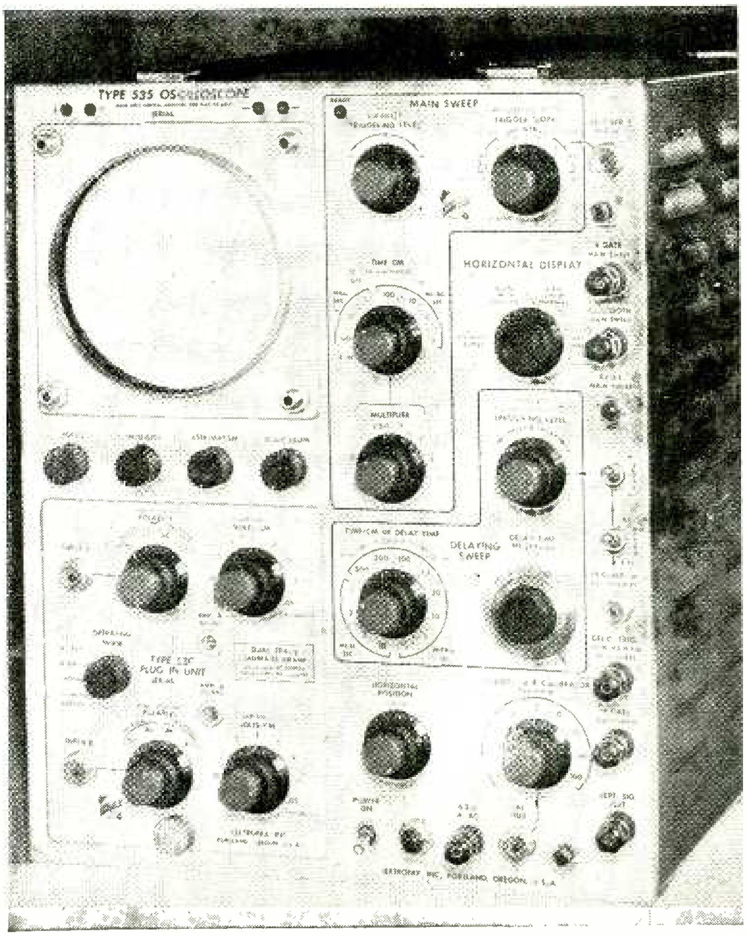
The founder member of the new brigade of instrument firms was undoubtedly Marconi-Ekco who, in the late 'thirties, began to make American-style instruments in this country. Having a relatively clear field they expanded rapidly, but when war broke out most of the serious work in British laboratories was still being done with instruments of American manufacture. During the war few American instruments found their way into the country and the small British industry expanded enormously. It had to: in pre-war days the Standard Signal Generator was an object of awe and veneration enshrined amongst the polished teak and lacquered brass binding-posts of the standards room, one per factory being about the number required. In the Services thousands were necessary, and such old favourites as the Marconi TF144 were bounced across the desert in 15-cwt trucks and dragged across the gooey mud of forward airstrips by sodden "erks."

After the war Britain found herself with a new industry—electronic instruments. New names appeared: Advance, Airmec, Cintel, Dawe, Solartron, Wayne Kerr and a whole host of others. The well-publicized dollar shortage precluded the entry of American instruments and as a result the styling, electrical and mechanical design of the products of the two countries have moved steadily apart. A somewhat similar state of affairs exists to that in the motor industries of the two countries.

Across in the States conditions were very similar to those at home. The war gave the instrument industry a tremendous fillip and while the old-established companies grew enormously, and along lines that could have been fairly easily predicted, a horde of new companies shot up overnight. (Some of them also shot down again pretty quickly.) Amongst these were two destined to become the giants of the industry. They are Hewlett-Packard, born in the garage of one Dave Packard just before the war and now the largest instrument company in the world in terms of turnover, and our heroes on this occasion Tektronix.

Company Organization

Tektronix Inc. was organized as an Oregon corporation in January, 1946, for the purpose of developing



Front panel of Tektronix oscilloscope Type 535, giving some idea of the facilities available.

* Livingston Laboratories.

and manufacturing cathode-ray oscilloscopes. The owners all had extensive wartime electronic experience in either military or civilian capacities. The president, Howard Vollum, actually worked in this country on radar development during the war.

The company and its products form a useful guinea pig for a miniature study of current American thought in light current engineering. It is a successful company; from small beginnings as late as 1946 it now dominates the American wide-band oscilloscope market and is by far the largest producer of these instruments in the world. Before going on to the instruments let us look at a few points concerning the general organization and see how they tie up with your own conception of an American company and normal British practice.

First, the president, Howard Vollum, is a distinguished engineer, completely *au fait* with the performance of his company's oscilloscopes and the designer of some of them. This is a theme constantly reiterated in the new generation of U.S. instrument companies. Bill Hewlett and Dave Packard designed all of their company's original products. Rarely is the accountant-cum-financier type of director found over there. On enquiry you will be told " You can always take an engineer and train him as a business man, but rarely does the converse apply."

Secondly, at Tektronix they are more nearly self-sufficient than any other comparable company in the world. The only bought-out components are those such as valves and resistors. When the commercially available article is not good enough there is no hesitation in setting up a department to improve on current practice. Commercial capacitors could not be bought that were sufficiently good for use in their time bases, so they wind their own to ±0.25%. Bought-out c.r. tubes were insufficiently linear for the sort of accuracy sought—so they made their own, incidentally solving a major tube manufacturing problem in the process. The new Tektronix tube uses a helical post-deflection accelerator ring that starts at the top of the tube neck and runs helically right up the flare to the screen. This, of course, is an old idea and obviously the right way to make a p.d.a. tube, but up till now no manufacturer has succeeded in holding the resistivity of his material sufficiently constant to achieve a uniform potential gradient down the tube. Hating the conventional tag-strips and group-boards, they developed and manufacture their own ceramic group-boards that contribute greatly to the internal appearance of the instruments. This may surprise those who thought, as I tended to, that the American manufacturer produced a set of drawings that were effectively a stock list enumerating the bought-out parts that merely had to be assembled in the parent works. This philosophy, once prevalent, is now regarded with disfavour by the most progressive companies.

A third feature is the generosity of the electrical performance compared with the specification. Many experienced observers in this country have been forced to apply a "transatlantic factor" to written specifications emanating from the U.S.A. It has sometimes even appeared that in the Great Democracy the output watts were larger than ours and input watts smaller. (Something to do with the size of the U.S. gallon no doubt.) Here, however, is a conservatism of claim at least equal to the best of the British firms. On the type 535 oscilloscope, for example, the claimed Y amplifier bandwidth of 10 Mc/s measures as 3 dB down at 13.5 Mc/s.

The last point, which I am sure has a sizeable bearing on the company's success, is its method of payment. Every month 22½% of the company profit is divided amongst the employees in the ratio of their salaries and a further 7½% added to the pension fund. A simple enough payment by results system, but one which ties an individual's earnings to the performance of the company as a whole. Under this system what matters to each employee is that the customer is satisfied. Surely all men should be working to please the customer rather than to put one over on an inspector three benches away!

Two Outstanding Models

As examples of the instruments themselves we have space to deal with but two, the fabulous type 517 and the latest of the line, the type 535.

The 517 is a wide-band high-voltage oscilloscope designed primarily for the observation and photographic recording of very fast rising waveforms having a low duty cycle. The use of 24 kV accelerating potential on a metallized cathode-ray tube permits photographic recording of single sweeps at the maximum writing speed allowed by the Y amplifier and sweep circuits. Distributed-type Y amplifiers provide a rise time of 7 millimicroseconds with a maximum sensitivity of 0.1 V/cm. Both amplitude and time calibrators are provided. Sufficient time delay is incorporated in the Y amplifier to permit viewing the leading edge of the waveform which triggers the sweep.

In order to provide sufficient vertical deflection voltage with a rise time as short as 7 millimicroseconds for a cathode-ray tube using 24 kV accelerating potential, a distributed amplifier is employed. This amplifier consists of five distributed stages plus a phase inverter and trigger valve. The first two stages use six 6AK5 valves each, next a stage of seven 6CB6 valves and a phase inverter of three 6CB6s. The signal then goes to a push-pull driver stage having six 6CB6s each side and finally to the output stage with twelve 6CB6s on each side.

The performance on the X axis is just as impressive. Since many fast-rising pulses are either non-repetitive or non-uniformly spaced, it is essential to have a sweep which can be triggered by the observed pulse itself. To enable the type 517 to trigger from fast rising signals of small amplitude, a wide-band, distributed amplifier is incorporated. Signals of 0.3 V amplitude with a rise time of 1 millimicrosecond will easily trigger the sweep. When using the observed signal as a trigger, any signal giving a deflection of 2 mm is adequate.

The time base on its fastest speed runs at 10 mμ sec/cm, that is, a complete sweep of 8 cm in 80 mμ sec. Although their invariable practice, and one well suited to the method of calibration, this style of specifying time base speed strikes me as slightly ludricrous. It is rather like saying "Poor old Charlie was nicked for failing to exceed 0.033 hours per mile in a built-up area." Come to think of it, they are in effect quoting the time base slowness rather than time base speed.

That then is type 517, a slightly fabulous beast in that few of us could live up to it. Owning a 517 must be rather like owning a 4½ Ferrari or being married to Marilyn Monroe. Let us examine another model, just as outstanding in its own sphere but more applicable to everyday problems, the type 535.

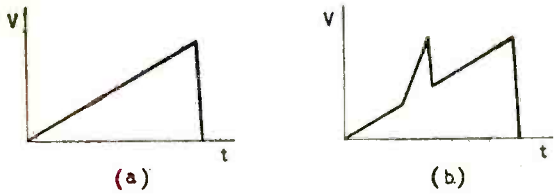


Fig. 1. Waveform of a conventional time base sweep (a) and with a second sweep superimposed on it (b).

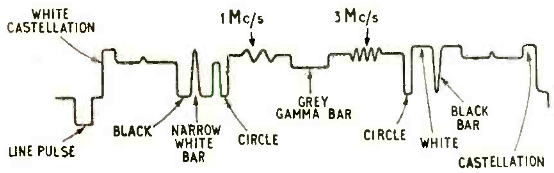


Fig. 2. Television waveform from one line of Test Card "C."

The 535 is a most unusual instrument for two reasons. First, it is the best example to date of that oft-attempted oscilloscope, the Y amplifier characteristics of which can be varied by means of a series of plug-in pre-amplifiers. The main ones of these are the 53B, with a frequency response of d.c. to 10 Mc/s and a sensitivity of 5 mV/cm, and the 53C, with a response of d.c. to 8.5 Mc/s and a sensitivity of 50 mV/cm. A double beam facility is provided by means of an electronic switching system. This beam switch can be triggered by alternate sweeps or allowed to run free at 100 kc/s. A d.c. and low frequency pre-amplifier is available, giving deflection sensitivities of 50 μV/cm. When these are allied to a time base having continuous coverage from 0.02 μsec/cm to 12 sec/cm, it will be seen that even without any other features the 535 would still be an outstanding instrument.

The second unusual facility is one that obviously springs from the firm's association with radar, as it is a well-established radar technique applied for the first time to oscilloscopes. This is the use of two time bases, one of which strobes the other. For those not familiar with this trick a word of explanation. Consider the two time bases in Fig. 1, one of which, at (a), is pictorially quite familiar. It can be so arranged that the linear rise of voltage in (a) will trigger a second time base, running much faster, at a predetermined voltage level, as shown in (b). It will be obvious that if the first sweep is triggered by a pulse, then varying the voltage at which the second sweep fires will slide this sweep up and down the slope of the first one and so provide a variable delay between the trigger pulse and the start of the second sweep. In practice no such waveform as (b) appears in the instrument, this having been simplified to establish the general principle.

Selective Observation

Let us take a practical example. We will feed into the type 535 oscilloscope a television waveform, Test Card "C" in fact, and arrange for the first sweep to be triggered by the line pulses and to have a duration of some 100μsec. The resultant display will then consist of a jumble of all 405 lines. If, however, a rudimentary sync separator, consisting of a CR network with the correct time-constant, is included in the trigger circuit, then the time base will trigger from the frame group and permit a display on one line which looks something like Fig. 2.

Now supposing it is arranged that when the second sweep fires it applies a "bright-up" to the beam, then a portion of this display will appear brighter than the rest. The length of the bright patch can be varied by adjusting the duration of the second sweep and its position along the picture by varying the delay (point on the first sweep at which the second sweep fires). In our example we could arrange the bright portion of the trace to coincide with the 3-Mc/s bars. This done, by switching the input of the X amplifier the second sweep can be applied to the plates of the tube and a picture of the 3-Mc/s portion of one line made to occupy the whole screen, permitting detailed examination. The beauty of this system is that a complex waveform can be displayed *in toto* on the screen, a portion of it selected for detailed observation and that portion viewed on a greatly increased time scale with absolute certainty that it is the desired part of the waveform.*

This has perforce had to be a rather sketchy treatment of a complete range of instruments, but I hope it has at least shown that, during the years when American instruments have been absent from this country, oscilloscope design at any rate has been progressing along lines rather different from our own.

* * *

Since this article was written a further development of the 535 oscilloscope has taken place, bearing the type number 545. It is based on a new cathode-ray tube developed by Tektronix which has the fantastic deflection sensitivity of 7V/cm with 10kV on the p.d.a. ring. Use of this tube gives the new oscilloscope the following Y amplifier performance: frequency response, d.c. to 30 Mc/s; rise time, 12mμsec; sensitivity at full bandwidth, 50mV/cm. The amplifier is 6dB down at 45 Mc/s and 12dB down at 60 Mc/s.

* Although this example deals with the use of the type 535 as a line selecting monitor, this function is performed equally well by the simpler type 524, an oscilloscope that has been a standard instrument in American television circles for over four years.

AMATEUR COURSES

IN preparation for next year's radio amateur examination, to be held by the City & Guilds in May, a large number of educational establishments up and down the country are arranging evening courses of instruction. Among those from which we have received specific details are:—

Bradford Technical College; classes are being arranged by the Bradford Amateur Radio Society (Sec. F. J. Davies, 39, Pullan Avenue, Eccleshill, Bradford, 2).
Brentford (Middlesex) Evening Institute; Wednesdays (fee 10s).
Glasgow, Allan Glen's School; theory will be taken on Tuesdays and morse on Thursdays (fee 10s.)
Huddersfield Technical College, where the lecturer will be C. W. Oakley (G3IPD).
Holloway, Grafton School; theory on Mondays and practice on Wednesdays with morse instruction after each evening's class (fee 10s).
Ilford (Essex) Literary Institute; both theory and practical courses on Wednesdays (fees 10s per course).
South-East London Technical College; theory Wednesdays.
Wembley Evening Institute; Mondays, morse 7 to 8, theory 8 to 10.

Transistor Equivalent Circuits

3.—*Earthed-Base Transistors*

By W. T. COCKING, M.I.E.E.

SUMMARY:—Equivalent circuits for the earthed-base transistor are derived from the earthed emitter circuits of Part 2. The different forms of transistor constants are discussed and the relations between the more common ones are tabulated for easy reference.

So far, transistors have been considered only in the earthed-emitter form of connection. The published characteristics of transistors, however, are usually for the earthed-base connection rather than for the earthed-emitter. The constants of transistors are also usually quoted for the earthed-base connection.

It might be thought, therefore, that it would have been better to start in Part 2 with this arrangement and so to follow the customary practice in transistor literature. We have here deliberately avoided this, however, in order to bring out the basic similarity of the transistor and the thermionic valve, so far as external matters are concerned. If it were not for certain difficulties with the point-contact transistor, we might even take the view that the earthed-emitter circuit should be regarded as the fundamental one, just as the earthed-cathode circuit is so regarded for the valve.

A difficulty arises with the point-contact transistor, however, for it can have negative input and output resistances when its emitter is earthed. These negative resistances cause certain difficulties of measurement which can make it awkward to obtain the characteristic curves and constants. Because of this, it is much more convenient to make measurements on the point-contact transistor in the earthed-base condition than in the earthed-emitter and, for uniformity, it is

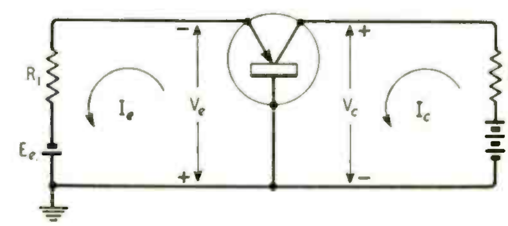


Fig. 1. Amplifier stage using an earthed-base n-p-n transistor.

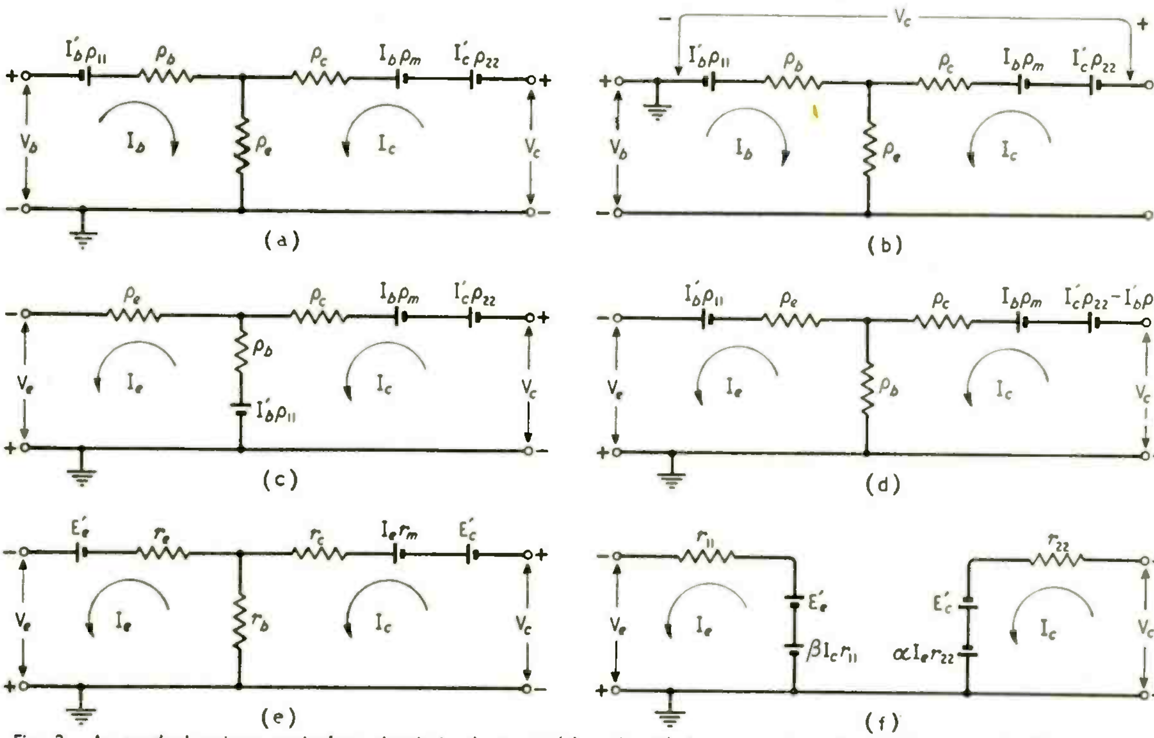


Fig. 2. An earthed-emitter equivalent circuit is shown at (a) and, with its connections altered for an earthed base, at (b). The successive transformations to an earthed-base equivalent circuit are shown at (c), (d) and (e). A two-generator form appears at (f).

customary to measure junction transistors in the same way. It seems desirable, therefore, that our final transistor constants should be ones based on this circuit.

It should not be thought that the earthed-emitter equivalent circuit developed in Part 2 has been wasted, however. So far from that, we regard it as an essential stepping-stone from the valve to the earthed-base transistor. Further, the earthed-emitter circuit is being increasingly used with junction transistors and all that is necessary to employ the equivalent circuits of Part 2 with transistor constants for the earthed-base connection is to have some conversion formulae so that ρ_b, ρ_e, ρ_c and ρ_m or ρ_{11}, ρ_{22}, a and b can be derived from them.

Our next step must be to develop an equivalent circuit for the earthed-based transistor. The circuit has the form shown in Fig. 1 for an *n-p-n* transistor. Let us first of all derive an equivalent circuit from the one for the earthed-emitter circuit Fig. 5(b) of Part 2. This is repeated in Fig. 2(a). For the earthed-base connection it becomes Fig. 2(b) which can be re-drawn as in (c). The essential change is that the collector voltage is measured between collector and base instead of between collector and emitter. There is, therefore, a change in the meaning of V_c between (a) and the other diagrams.

Fig. 2(c) can be changed to (d) by removing $I'_b\rho_{11}$ from the ρ_b arm and inserting it in both the ρ_e and ρ_c arms. In (b), (c) and (d), V_b has become V_e. The two are numerically equal but of opposite polarity, when measured from earth. In (c) and (d), too, I_b has disappeared and the path of I_c has been changed. It is plain from (a) that $I_e = I_b + I_c$, so that the currents in all the resistances are unchanged by this re-distribution and re-naming.

We now require this equivalent circuit to be brought to the form of Fig. 2(e) in which the quantities are derived from the earthed-base characteristics instead of the earthed-emitter. The relations between (d) and (e) are easily established by comparing their mesh equations. For the emitter loop

$$V_e = I_e(\rho_e + \rho_b) - I_c\rho_b - I'_b\rho_{11}$$
$$= I_e(r_e + r_b) - I_c r_b - E'_e$$

which gives us $r_e = \rho_e$, $r_b = \rho_b$ and $E'_e = I'_b\rho_{11}$.

For the collector loop we have

$$V_c = I_c(\rho_c + \rho_b) - I_e\rho_b - I'_c\rho_{22} + I'_b\rho_{11} - I_b\rho_m$$
$$= I_c(r_c + r_b) - I_e r_b - E'_c - I_e r_m.$$

Substituting $I_e = I_b + I_c$ for the coefficient of r_m in the second part

$$V_c = I_c(r_c + r_b - r_m) - I_e r_b - E'_c - I_b\rho_m.$$

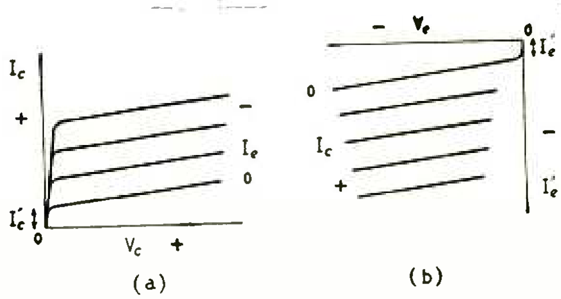


Fig. 3. General form of n-p-n transistor characteristics for the earthed-base connection.

Comparing the first and last equations for V_c, we have $r_c = \rho_c + \rho_m$, $r_m = \rho_m$ and $E'_c = I'_c\rho_{22} - I'_b\rho_{11}$.

We can now go a stage further and transform Fig. 2(e) to the form (f), which is like the equivalent circuit that we first derived for the earthed-emitter transistor. For this we have

$$V_e = I_e r_{11} - \beta I_c r_{11} - E'_e$$
$$V_c = I_c r_{22} - \alpha I_e r_{22} - E'_c$$

Comparing these with the ones for Fig. 2(e) we get $r_{11} = r_e + r_b$, $\beta r_{11} = r_b$, $r_{22} = r_c + r_b$, $\alpha r_{22} = r_b + r_m$, so $\alpha = \frac{r_b + r_m}{r_b + r_c}$ and $\beta = \frac{r_b}{r_b + r_e}$. If we remember how we derived the corresponding terms of the earthed-emitter circuit from the transistor characteristic, it is now plain that these terms have similar meanings for the earthed-base characteristics. We can say therefore, that r_{11} is the emitter a.c. resistance

$$r_{11} = \delta V_e/\delta I_e$$

for I_c constant. Also r_{22} is the collector a.c. resistance

$$r_{22} = \delta V_c/\delta I_c$$

for I_e constant.

The other terms are the current amplification factors α and β, and

$$\alpha = \delta I_c/\delta I_e$$

for V_c constant while

$$\beta = \delta I_e/\delta I_c$$

for V_e constant.

The characteristics for the earthed-base connection are shown in Fig. 3. We could have started with these and derived r_{11}, r_{22}, α and β from them in accordance with the above definitions and in exactly the same way as we did for the earthed-emitter transistor in Part 2. We should then have obtained Fig. 2(b) directly and found $E'_e = I'_e r_{11}$ and $E'_e = I'_c r_{22}$ where I'_e and I'_c are the zero-current intercepts as in Fig. 3. Following the same argument as in Part 2 we could have found Fig. 2(e) and then established the relations with the earthed-emitter circuit (d).

The relations between the values for the equivalent circuits are summarized in Table 1.

The complete equivalent circuit can be reduced to its a.c. form by omitting the d.c. parts as we did before. The result is Fig. 4. One great advantage of this form of circuit is that three of the elements r_e, r_b and r_m have the same values as their earthed-emitter

TABLE 1

Given r_{11}, r_{22}, α, β		
$r_b = \beta r_{11}$	$\rho_b = \beta r_{11}$	$\rho_{11} = r_{11}$
$r_c = r_{22} - \beta r_{11}$	$\rho_c = r_{22}(1 - \alpha)$	$\rho_{22} = r_{22}(1 - \alpha) + r_{11}(1 - \beta)$
$r_e = r_{11}(1 - \beta)$	$\rho_e = r_{11}(1 - \beta)$	$a = \frac{\alpha r_{22} - r_{11}}{r_{22}(1 - \alpha) + r_{11}(1 - \beta)}$
$r_m = \alpha r_{22} - \beta r_{11}$	$\rho_m = \alpha r_{22} - \beta r_{11}$	$b = 1 - \beta$
Given r_b, r_c, r_e, r_m		
$r_{11} = r_b + r_e$	$\rho_{11} = r_b + r_e$	$\rho_b = r_b$
$r_{22} = r_b + r_c$	$\rho_{22} = r_e + r_c - r_m$	$\rho_c = \frac{r_e - r_m}{r_b + r_e}(r_e + r_c - r_m)$
$\alpha = \frac{r_b + r_m}{r_b + r_c}$	$a = \frac{r_m - r_e}{\rho_{22}}$	$\rho_e = r_e$
$\beta = \frac{r_b}{r_b + r_e}$	$b = \frac{r_e}{r_b + r_e}$	$\rho_m = r_m$

counterparts ρ_e, ρ_b and ρ_m. It is only r_c that differs from ρ_c.

At this stage it is desirable to consider what four constants should be used to represent the transistor. So far, we have based everything upon a pair of a.c. resistances and a pair of current amplification factors because they are somewhat analogous to valve constants and are easily determined from the transistor characteristics. There are quite a lot of alternatives, however. We have already met a, b, ρ_{11} and ρ_{22} with the derived quantities ρ_b, ρ_c, ρ_e and ρ_m for the earthed-emitter connection and α, β, r_{11} and r_{22} with the derived quantities r_b, r_c, r_e and r_m for the earthed-base.

Choice of Constants

The thermionic valve operating with a negative grid requires only one family of curves to describe its characteristics and two constants, derivable from these characteristics, to describe it in a.c. equivalent circuit. Because the transistor passes current at all its three electrodes, two families of curves are needed to describe it and four constants are needed for an equivalent circuit. This raises difficulties, because neither the two families of curves nor the four constants are unique. There are four possible families of curves and twelve possible constants!

This applies to the earthed-emitter connection and there are the same number again for the earthed-base arrangement. We need only four constants out of twenty-four possible ones! In the valve we have only three—amplification factor μ, a.c. resistance r_a, and mutual conductance g_m; they are related since $\mu = g_m r_a$ so we need two only out of a possible three and, if we ever want the third, the relation is a very simple one.

In the case of the transistor, the relations between the twenty-four possible constants are much more complex and are not readily performed mentally. It is rather important, therefore, to choose the best four constants. Unfortunately, opinions differ about which are the best and different writers use different ones. This accounts for much of the difficulty of transistor literature.

We regard it as essential that whatever four constants are chosen they should be determinable from the transistor characteristics which are most readily available. This at once rules out earthed-emitter constants, for the usual characteristics are the earthed-base type. We have, therefore, to choose four out of twelve possible ones.

There are three groups of four which are particularly common in the literature and which are defined in Table 2. The symbols following the square brackets indicate which voltage or current is to be regarded as constant. The twelve constants listed are not all distinct; for example, $y_{11} = 1/h_{11}$, $r_{22} = 1/h_{22}$, $h_{12} = r_{12}/r_{22}$, $h_{21} = y_{21}/y_{11}$. There are more possibilities than are shown in Table 2, therefore.

TABLE 2

$r_{11} = \delta V_e/\delta I_e]I_c$	$y_{11} = \delta I_e/\delta V_e]V_c$	$h_{11} = \delta V_e/\delta I_e]V_c$
$r_{22} = \delta V_c/\delta I_c]I_e$	$y_{22} = \delta I_c/\delta V_c]V_e$	$h_{22} = \delta I_c/\delta V_c]I_e$
$r_{12} = \delta V_e/\delta I_c]I_e$	$y_{12} = \delta I_e/\delta V_c]V_e$	$h_{12} = \delta V_e/\delta V_c]I_e$
$r_{21} = \delta V_c/\delta I_e]I_c$	$y_{21} = \delta I_c/\delta V_e]V_c$	$h_{21} = \delta I_c/\delta I_e]V_c$
$r_b = \dfrac{h_{12}}{h_{22}}$	$= \beta r_{11}$	$= r_{12}$
$r_c = \dfrac{1 - h_{12}}{h_{22}}$	$= r_{22} - \beta r_{11}$	$= r_{22} - r_{12}$
$r_e = h_{11} - (1 + h_{21}) \dfrac{h_{12}}{h_{22}}$	$= r_{11}(1 - \beta)$	$= r_{11} - r_{12}$
$r_m = -\dfrac{h_{12} + h_{21}}{h_{22}}$	$= \alpha r_{22} - \beta r_{11}$	$= r_{21} - r_{12}$

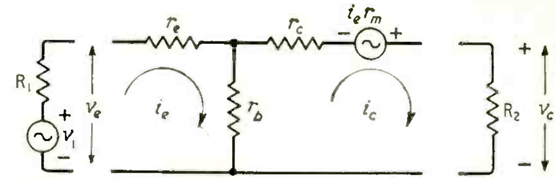


Fig. 4. A.C. equivalent circuit corresponding to Fig. 2 (e).

According to Shea[1] the h group is the most suitable, because the constants are the easiest to measure and vary less with temperature and operating point than the others. However, h_{11} and h_{12} are not obtainable readily from the ordinary characteristic curves. In fact, no single group is!

There is one serious objection to the nomenclature of the h group, which is that the same letter serves sometimes for a resistance, sometimes for a conductance and sometimes for a ratio. This is very bad practice, because it prevents the ready dimensional checking of equations It is likely to cause errors. In this respect, both the r and y groups are satisfactory, because all the r constants are resistances and all the y constants are conductances.

Measurement of Constants

When the constants are obtained by measurements on an actual transistor, some are easier to measure than others. The output resistance of a junction transistor is usually rather high, 1–2 MΩ, and it is difficult to employ a high enough external impedance to obtain constant-current conditions. It is much easier to make the impedance low and so to operate under constant-voltage conditions. It is, therefore, easier to measure quantities which need V_c kept constant than those which require I_c to be constant. At the input, the reverse applies. If the input resistance is very low, it is difficult to obtain a voltage supply of low enough internal resistance to operate under constant-voltage conditions, but it is quite easy to operate at constant current. Thus it is easier to measure quantities which need I_e kept constant than those which must have constant V_e.

The h group constants of Table 2 are thus admirably suited to the requirements of measurement.

When one wants to derive the constants from the characteristic curves, however, the h group is quite unsuitable. The most convenient ones are r_{11}, r_{22}, α and β, that we have used hitherto. They are all easily determined from the characteristic curves, which is why we selected them in the first place.

It does not seem practicable, therefore, to have a single set of primary constants which is suitable both for evaluation by measurement and from the characteristic curves. It seems best, therefore, to adopt one set for measurement purposes and another for derivation from the valve

[1] "Transistor Audio Amplifiers," by Richard F. Shea. (Chapman & Hall).

characteristics. The h group seems best for the first and, for the second, the r_{11}, r_{22}, α and β groups that we have used hitherto.

Whichever is adopted, it can be transformed to the other or to the r_e, r_b, r_c and r_m group if it is desired to use this type of equivalent circuit. This circuit is very commonly used in the literature and its outstanding advantage is that three of the four resistances are the same for both the earthed-base and the earthed-emitter connection. Only one needs to have its value altered.

Transformation of Constants

For general use in circuit work, no single equivalent circuit is necessarily always the best. Often, a particular form best suits a given problem. It is, therefore, very necessary to be able to pass readily from one form to another and Table 1 enables this to be done. Sometimes, the transistor constants are quoted somewhat differently; instead of having r_{11}, r_{22}, α, β or r_b, r_c, r_e and r_m, for instance, one might have r_b, r_c, r_e and α. The quickest way of finding r_m is then to find r_{11}, r_{22} and β from the relations in the first column of the second group of transformations in Table 1 and then to compute r_m from the equation in the first group. It works out at $r_m = \alpha\,(r_b + r_c) - r_b$.

Table 2 gives the definitions of the r, y (or g) and h groups of constants which are found in the literature. In addition, it gives a transformation from the h group to the r_b, r_c, r_e and r_m form so that, with the aid of Table 1, a transformation to any other group can be effected. The transformation from the r group to the r_b, r_c, r_e and r_m form is also included, since this is also commonly found in the literature. The derivation of the r group is treated in the Appendix.

One or two comments on the relations of Table 1 may be helpful. In the first place, some of the relations can be simplified in practice with negligible error; for example, r_b is often very small compared with r_c and can be neglected in comparison. Secondly, the relation for a, the current amplification factor for the earthed-emitter transistor, is different from the one usually quoted, which is $a = \alpha/(1 - \alpha)$. The equation given reduces to this simple form when $r_{11} \ll \alpha r_{22}$ and $r_{11}\,(1 - \beta) \ll r_{22}\,(1 - \alpha)$, which is usually the case.

Before we conclude this part, it may be helpful to quote some actual figures for transistors to get an idea of the order of magnitude of the quantities involved and how the transformations are effected. Turning to the *Wireless World* "Radio Valve Data", we find the Mullard OC70 listed as having $r_b = 750\,\Omega$, $r_c = 1.5\,M\Omega$, $r_e = 35\ \Omega$ and $\alpha = 0.97$, so

$$r_m = 0.97 \times 1.5 = 1.455\,M\Omega$$

since r_b is negligibly small in comparison with r_c. For the earthed-base connection we have (see Table 1):— $\rho_b = 750\ \Omega$, $\rho_e = 35\ \Omega$, $\rho_m = 1.455\,M\Omega$ and

$$\rho_c = \frac{1.5 - 1.455}{1.5} = \frac{0.045}{1.5} = 0.03\,M\Omega = 30\,k\Omega.$$

For the two-generator earthed-base equivalent circuit we have:—

$$r_{11} = 750 + 35 = 785\ \Omega$$
$$r_{22} = 1.5\,M\Omega$$
$$\alpha = 0.97$$
$$\beta = \frac{750}{785} = 0.956$$

while for the two-generator earthed-emitter circuit we get:—

$$\rho_{11} = 785\ \Omega$$
$$\rho_{22} = 1.5 - 1.455 = 0.03\,M\Omega = 30\,k\Omega$$
$$a = \frac{1.455}{0.03} = 48.5$$
$$b = \frac{35}{785} = 0.0446$$

Using Table 2, we can evaluate the quantities in terms of the r and h group and we get:—

$$r_{11} = 785\ \Omega$$
$$r_{12} = 750\ \Omega$$
$$r_{21} = 1.455\,M\Omega$$
$$r_{22} = 1.5\,M\Omega$$

and
$$h_{11} = r_e + r_b\frac{r_c - r_m}{r_c + r_b} = 35 + 750\,\frac{1.5 - 1.455}{1.5}$$
$$= 35 + 750\,\frac{0.045}{1.5}$$
$$= 35 + 750 \times 0.03 = 35 + 22.5 = 57.5\ \Omega$$
$$h_{12} = \frac{r_b}{r_b + r_c} = \frac{750}{1{,}500{,}000} = 0.0005$$
$$h_{21} = -\frac{r_m}{r_c} = -\frac{1.455}{1.5} = -0.97$$
$$h_{22} = \frac{1}{r_c} = \frac{1}{1.5 \times 10^6} = 0.66 \times 10^{-6}\ \text{mhos}$$

Point-contact Transistor

For a point-contact transistor, the values are quite different. Krugman[2] quotes:— $r_{11} = 250\,\Omega$, $r_{12} = 100\,\Omega$, $r_{21} = 24\,k\Omega$, $r_{22} = 12\,k\Omega$. From Table 2 we then have:—

$$r_b = 100\ \Omega$$
$$r_c = 11.9\,k\Omega$$
$$r_e = 150\ \Omega$$
$$r_m = 23.9\,k\Omega$$

From Table 1, $r_{11} = 250\,\Omega$, $r_{22} = 12\,k\Omega$, $\alpha = 24/12 = 2$ and $\beta = 100/250 = 0.4$. Notice particularly that α is greater than unity. This is typical of a point-contact transistor; with the junction type, α is always less than unity. Proceeding, we have $\rho_{11} = 250\ \Omega$, $\rho_{22} = 0.15 + 11.9 - 23.9 = -10.85\,k\Omega$, $a = (23.9 - 0.15)/(-10.85) = -21.8$, $b = 150/250 = 0.4$. Notice that ρ_{22} and a are both negative for the point-contact transistor in the earthed-emitter circuit. Taking the remaining form we have,

$$\rho_b = 100\ \Omega,\ \rho_e = 150\ \Omega,\ \rho_m = 23.9\,k\Omega,$$
$$\rho_c = \frac{11.9 - 23.9}{12}(12.05 - 23.9) = -10.85\,k\Omega.$$

What is the meaning of α greater than unity? In terms of a.c., we have defined it as i_c/i_e and we have $i_e = i_b + i_c$. If α is greater than unity, it means that the collector current is greater than the sum of the base and collector currents and, in turn, this means that the base current must be in the opposite direction to the collector current. We derived our equivalent circuit for the junction transistor and took the positive directions of current flow as the actual directions. With the point-contact transistor, however, one of these is reversed. We cannot yet say which.

However, we find ρ_{22} is negative and this means that i_e is reversed compared with the junction transistor.

[2] "Fundamentals of Transistors," by Leonard M. Krugman. (Chapman & Hall).

We can say, therefore, that in the two types i_b flows in the same direction but i_c in the opposite and we have the curious result that the emitter current of a point-contact transistor is smaller than the collector current.

(To be concluded)

APPENDIX

IN American literature, the equivalent circuit of a transistor is usually derived from the arrangement of Fig. 5. The transistor is represented as a box with four terminals 1, 1 and 2, 2, two of which are internally joined. The voltages v_1 and v_2 are applied externally and, as a result, the currents i_1 and i_2 flow with the directions shown. Four resistances are named arbitrarily r_{11}, r_{12}, r_{21}, r_{22} and the following equations are written:—

$$\begin{aligned} v_1 &= i_1 r_{11} + i_2 r_{12} \\ v_2 &= i_2 r_{22} + i_1 r_{21} \end{aligned} \qquad \text{(A1)}$$

The meaning of the four resistances is then determined by putting the currents each in turn equal to zero. Thus,

$$\begin{aligned} r_{11} &= v_1/i_1 \text{ for } i_2 = 0 \\ r_{21} &= v_2/i_1 \text{ for } i_2 = 0 \\ r_{12} &= v_1/i_2 \text{ for } i_1 = 0 \\ r_{22} &= v_2/i_2 \text{ for } i_1 = 0 \end{aligned} \qquad \text{(A2)}$$

The equivalent circuit of Fig. 6 is then drawn with $v_e = v_1$, $i_e = i_1$, $v_c = v_2$, $i_c = i_1$ for the earthed-base transistor and the same current directions as for Fig. 5. The equations for Fig. 6 are:—

$$\begin{aligned} v_e &= i_e(r_e + r_b) + i_c r_b \\ v_c &= i_c(r_c + r_b) + i_e(r_b + r_m) \end{aligned} \qquad \text{(A3)}$$

Comparing these with (A1), we have

$$\begin{aligned} r_{11} &= r_e + r_b \\ r_{12} &= r_b \\ r_{21} &= r_b + r_m \\ r_{22} &= r_c + r_b \end{aligned} \qquad \text{(A4)}$$

If we write $v_c = 0$ in (A3) any current in the collector circuit flows as a result of v_e. Then

$$i_c = - i_b \frac{r_b + r_m}{r_b + r_c}$$

and the minus sign indicates that the current i_c flows in the opposite direction to that shown in Figs. 5 and 6. In our derivation in the text, we assumed this opposite direction of current flow from the start and our v_c was a voltage developed by i_c in a load resistance even if this was not always specifically shown. Here v_c is an externally applied voltage.

The current amplification factor is

$$\alpha = \frac{r_b + r_m}{r_b + r_c}$$

$= - i_c/i_e$ in the American convention.

We defined α in relation to the static characteristics of the valve as $\delta I_c/\delta I_e$, which is equivalent to i_c/i_e in terms of alternating current. The minus sign arises in the American definition because they have assumed i_c to flow the other way round. There is no real difference in the meaning of α.

The backward current amplification factor, which we are calling β, is defined in American literature as

$$\beta = - i_e/i_c \text{ for } v_e = 0$$
$$= \frac{r_b}{r_e + r_b}$$

from (A3).

We originally defined b as $- \delta I_b/\delta I_c$ and later obtained β as $1 - b$ or $1 + \delta I_b/\delta I_c = (\delta I_b + \delta I_c)/\delta I_c = \delta I_e/\delta I_c$ which is i_e/i_c in terms of alternating current. Again, there is a difference of sign in the definition which is again brought about by the different direction of current flow assumed initially. Again, there is no difference in the real meaning of β.

The American derivation of the equivalent circuit is simpler than ours and leads to the same result, but it is intellectually less satisfying, because the initial constants r_{11}, r_{12}, r_{21}, r_{22} are obtained in an apparently arbitrary manner. Our constants r_{11}, r_{22}, α, β are derived directly from the characteristic curves and have an obvious physical meaning.

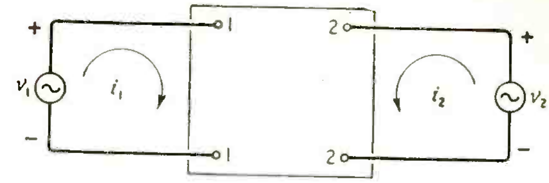


Fig. 5

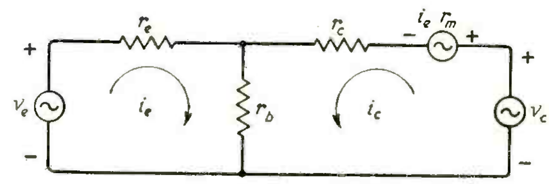


Fig. 6

BOOKS RECEIVED

Linear Feedback Analysis by J. G. Thomason, B.Sc. Treatise covering basic principles and their application in electronic circuits and servo-mechanisms, with special reference to the causes of instability and methods of stabilization, with practical illustrative examples. Pp. 355+x; Figs. 236. Price 55s. Pergamon Press, Ltd., 4-5, Fitzroy Square, London, S.W.1.

Powder Metallurgy. Report of Technical Assistance Mission No. 141 on European and American manufacturing techniques. Pp. 309; Figs. 15. Price 20s. Organization for European Economic Co-operation, 2 rue André-Pascal, Paris, 16.

Thermionic Valves, 1904-1954. Souvenir reprint of the lectures and photographs of the exhibits at the celebrations to mark the jubilee of the thermionic valve (16th November, 1954). Pp. 69. Price 9s. The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Practical Wireless Servicing Manual by F. J. Camm. Revised tenth edition, including additional chapters on the construction of test instruments. Pp. 284; Figs. 221. Price 17s 6d. George Newnes, Ltd., Southampton Street, London, W.C.2.

Points on Pickups by F. Wilson. Replacement guide to stylus types and cartridges, illustrated for ready identification. Pp. 34. Price 3s. A. C. Farnell, Ltd., 15, Park Place, Leeds, 1.

Théorie des Réseaux de Kirchhoff by M. Bayard. Analysis and synthesis of linear networks under sinusoidal conditions. Pp. 414+xv; Figs. 315. Price F.fr. 3,200. Editions de la Revue d'Optique, 3 et 5, Boulevard Pasteur, Paris, 15.

Cours de Radioélectricité Générale. Volume 4 Propagation des Ondes by Pierre David. General survey of radio wave propagation. The influence of the ground, the troposphere and the ionosphere. Applications to the selection of wavelengths for long-distance communication. Pp. 223. Editions Eyrolles, 61, Boulevard Saint-Germain, Paris, 5.

A Guide to Electricity by J. H. M. Sykes, Assoc.I.E.E. Elementary treatise on everyday electrical engineering practice for the general reader. Pp. 275; Figs. 90. Price 21s. Hutchinson's Scientific and Technical Publications, Stratford Place, London, W.1.

Design of Tchebycheff Filters

Experimental Verification of the Basic Formulæ

By G. H. BURCHILL,* B.Sc.

THE following notes are offered as a corollary to the series of articles on filter design by Thomas Roddam (*Wireless World*, Aug., Sept., Nov., Dec. 1954). Filters of the third order will be discussed and the results given of measurements on experimental filters.

Data for constructing Tchebycheff third-order (π-section) filters are given by Fig. 1, and the configurations and characteristics of these filters are shown by Fig. 2. Curves are plotted for the case where source and load resistances R_1 and R_2 are equal, and for the case where R_2 is infinite. The curves were calculated on the assumption that losses in the filter components could be neglected.

These filters have relatively high insertion loss beyond cut-off, but they also have appreciable loss at certain frequencies in the pass band. The loss is to some extent under the control of the designer, and depends on the value chosen for the factor "t" in the Tchebycheff polynomial which describes the insertion loss characteristic. As indicated by Fig. 1, the greater the value of t the greater the loss beyond cut-off; but also the greater the loss at some frequencies in the pass band. Thus with reference to Fig. 2, the greater the value of t the greater the slope of the insertion loss curve beyond cut-off, and also the more pronounced the "ripple" in the pass band.

To design a filter it is first necessary to choose a value of t. The choice may be made either by consideration of the allowable loss in the pass band, or of the desirable loss beyond cut-off. The lower "db"

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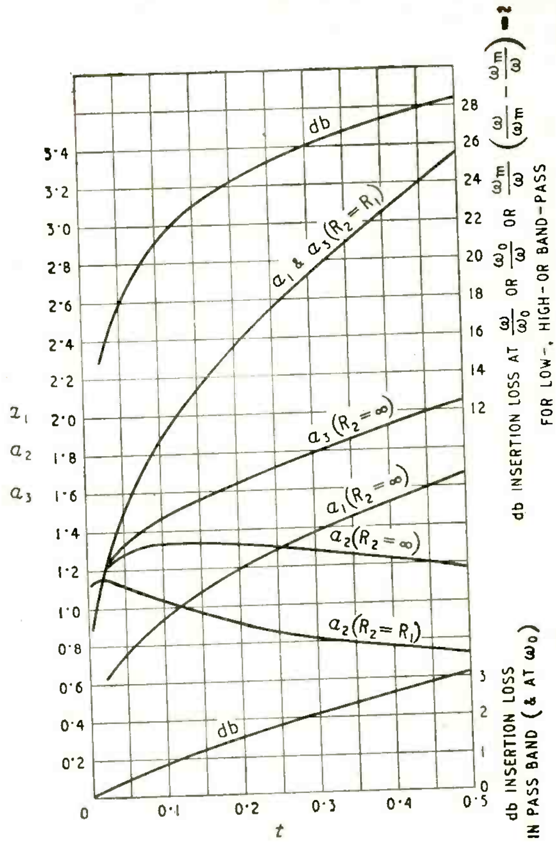
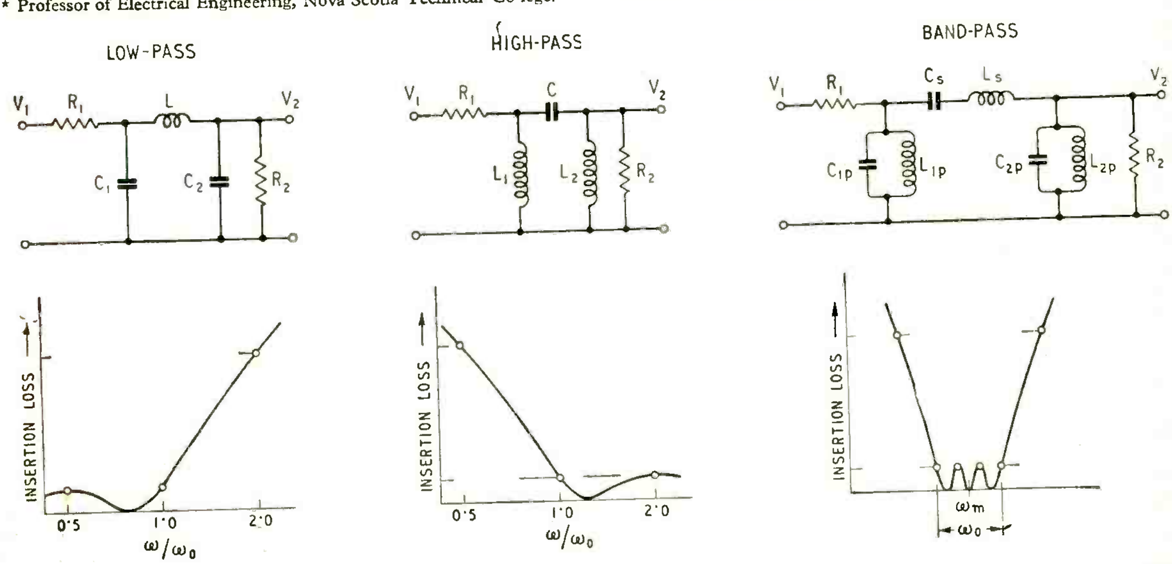


Fig. 1. Basic data for use in design formulæ.



Below: Fig. 2. Third-order (π-section) Tchebycheff filters and their characteristics.

curve is used in the first case, the upper " db " curve in the second. When a value of t has been chosen the corresponding values of a_1, a_2 and a_3 are read from their respective curves for the specified termination, $R_2 = R_1$ or $R_2 = \infty$. The filter components are then calculated as follows:

For a low-pass filter with cut-off angular frequency ω_0

$$C_1 = a_1/\omega_0 R_1 \qquad L = a_2 R_1/\omega_0 \qquad C_2 = a_3/\omega_0 R_1$$

For a high-pass filter with cut-off angular frequency ω_0

$$L_1 = R_1/a_1\omega_0 \qquad C = 1/a_2\omega_0 R_1 \qquad L_2 = R_1/a_3\omega_0.$$

For a band-pass filter of band width ω_0 and mean angular frequency ω_m

$$C_{1p} = a_1/\omega_0 R_1 \qquad L_s = a_2 R_1/\omega_0 \qquad C_{2p} = a_3/\omega_0 R_1$$

$$L_{1p} = 11\omega_m{}^2 C_{1p} \qquad C_s = 1/\omega_m{}^2 L_s \qquad L_{2p} = 1/\omega_m{}^2 C_{2p}$$

The curves were plotted after a number of filters had been designed and tested. The method of design was based on the articles " Filters without Fears " by Thomas Roddam in the August and September 1954 issues of *Wireless World.* The filter components were determined from cut-and-try solutions of the Tchebycheff filter equations, for which Mr. Roddam did not give a solution. Following Mr. Roddam's method, but in more general form, the desired insertion loss characteristic for the low-pass case, based on the appropriate Tchebycheff polynomial, is:

$$\text{db} = 10 \log [1 + 18t(\omega/\omega_0)^2 - 48t(\omega/\omega_0)^4 + 32t(\omega/\omega_0)^6]$$

The expression in brackets may also be derived in terms of the filter components, as explained by Roddam. When $R_1 = R_2$ it is:

$$1 + \omega^2\left\{\left[(C_1 + C_2)\frac{R_1}{2} + \frac{L}{2R_1}\right]^2 - L(C_1 + C_2)\right\}$$

$$+ \omega^4\left\{\frac{L^2(C_1 + C_2)^2}{4} - 2LC_1C_2\left[(C_1 + C_2)R_1 + \frac{L}{R_1}\right]\frac{R_1}{4}\right\}$$

$$+ \omega^6 L^2 C_1{}^2 C_2{}^2 \frac{R_1{}^2}{4}$$

Writing $C_1 = a_1/\omega_0 R_1 \quad L = a_2 R_1/\omega_0 \quad C_2 = a_3/\omega_0 R_1$ and equating the two expressions term by term gives:

$$\frac{(a_1 + a_2 + a_3)^2}{4} - a_2(a_1 + a_3) = 18t$$

$$\frac{a_1 a_2 a_3}{2}(a_1 + a_2 + a_3) - \frac{a_2{}^2(a_1 + a_3)^2}{4} = 48t$$

$$a_1{}^2 a_2{}^2 a_3{}^2 = 128t$$

The first equation may be simplified to $a_1 + a_3 = \sqrt{72t} + a_2$ and the third to $a_1 a_2 a_3 = \sqrt{128t}$

If these are substituted in the second equation there results $a_2{}^3 + 2\sqrt{72t}\, a_2{}^2 + 72ta_2 - 8\sqrt{32t} = 0$

Values of a_2 for particular values of t were obtained from this equation. The corresponding values of a_1 and a_3 were then obtained from the simplified forms of the first and third equations.

When $R_2 = \infty$ the filter equations become:

$$\omega^2(C_1 + C_2)^2 R_1{}^2 - 2\omega^2 LC_2 = 18t(\omega/\omega_0)^2$$

$$2\omega^4 LC_1C_2(C_1 + C_2)R_1{}^2 - \omega^4 L^2 C_2{}^2 = 48t(\omega/\omega_0)^4$$

$$\omega^6 L^2 C_1{}^2 C_2{}^2 R_1{}^2 = 32t(\omega/\omega_0)^6$$

Substitution of a_1 etc. gives.

$$(a_1 + a_3)^2 - 2a_2a_3 = 18t$$

$$2a_1a_2a_3(a_1 + a_3) - a_2{}^2a_3{}^2 = 48t$$

$$a_1{}^2a_2{}^2a_3{}^2 = 32t$$

further manipulation leads to:

$$a_3 = \frac{\sqrt{32t}}{2a_1{}^2} + \frac{48t}{2\sqrt{32t}} - a_1$$

$$a_2 = \frac{(a_1 + a_3)^2 - 18t}{2a_3}$$

$$a_1a_2a_3 = \sqrt{32t}$$

These were solved for particular values of t, using a slide-rule and systematic computing form, by trying values of a_1, finding the resulting values of a_3 and a_2, and comparing $a_1a_2a_3$ with $\sqrt{32t}$. About six trials usually gave the solution.

In *Wireless World*, December 1954, Mr. Roddam explained the transformations which give high-pass and band-pass filter designs from low-pass calculations. The examples he gave were second-order filters, but the expressions he derived were general, and apply also to third-order filters. The high-pass and band-pass design formulæ given above were obtained by writing these expressions in terms of R_1, a_1, a_2 and a_3.

A comparison with other types of filter is interesting. Mr. Roddam gives the solution for Butterworth response, low-pass, with $R_2 = \infty$. For our purpose it may be written $C_1 = 1/2\omega_0 R_1$, $L = 4R_1/3\omega_0$, $C_2 = 3/2\omega_0 R_1$. Evidently in this case $a_1 = 0.5$, $a_2 = 1.33$, $a_3 = 1.5$. The insertion loss at $\omega = \omega_0$, 3 db, is the same as that of a Tchebycheff filter having $t = 0.5$, but the Butterworth filter does not have the 3-db loss at $\omega = 0.5\omega_0$ and it has about 10 db less insertion loss at $\omega = 2\omega_0$. If $R_2 = R_1$ a Butterworth filter has $a_1 = 1$, $a_2 = 2$, and $a_3 = 1$, giving the same component values as the conventional image-impedance method.

When $R_2 = R_1$, $a_3 = a_1$, and $C_2 = C_1$, there is no obvious difference between the proportions of Tchebycheff and Butterworth filters. It is therefore instructive to determine the conditions that lead to these different types of response. If the low-pass design equations are multiplied together, there results:

$$LC = \frac{a_2R_1}{\omega_0}\cdot\frac{a_1}{\omega_0 R_1} = \frac{a_1a_2}{\omega_0{}^2}; \text{ or } \omega_0{}^2 = \frac{a_1a_2}{LC}$$

and if they are divided:

$$\frac{L}{C} = \frac{a_2R_1}{\omega_0}\cdot\frac{\omega_0R_1}{a_1} = \frac{a_2}{a_1}R_1{}^2; \text{ or } R_1{}^2 = \frac{a_1}{a_2}\cdot\frac{L}{C}$$

Evidently it is possible to operate a given filter, having fixed values of L and C, at any value of the Tchebycheff factor t, and the corresponding values of a_1 and a_2, if the resulting values of ω_0 and R_1 are acceptable. Further, it is possible to operate with $a_1 = 1$ and $a_2 = 2$ to obtain Butterworth response. As an example, a filter made up of a 46-millihenry inductor and two 0.1-microfarad capacitors operates

(a) Butterworth, with $f_0 = 3320$ c/s, if $R_1 = R_2 = 480$ ohms.

(b) Tchebycheff, $t = 0.125$, with $f_0 = 3320$ c/s, if $R_1 = R_2 = 960$ ohms.

(c) Tchebycheff, $t = 0.5$, with $f_0 = 3650$ c/s, if $R_1 = R_2 = 1460$ ohms.

There is another mode of operation which is useful at radio frequencies. If t is chosen as 0.0185, $a_1 = a_2 = a_3 = 1.15$. If a filter having these proportions is operated at the frequency $\omega = 0.866\omega_0$, so that $a_1\omega/\omega_0 = 1$ (etc.) the reactances of all its components become numerically equal to R_1. Then if it is terminated with an arbitrary load resistance R_L the rather complicated general expression for the input impedance becomes simply R_1^2/R_L. The value of R_1 may be chosen to make this input resistance any desired value, so the circuit can act as an impedance-matching network, as well as reducing harmonic radiation. The low-frequency filter of the previous example operates in this fashion if $R_1 = 680$ ohms. When tested between a 340-ohm source and a 1360-ohm load (or vice versa) it showed a response resembling the Tchebycheff, but with insertion gain in the region near $0.866\omega_0$ (2350 c/s). The measured gain was slightly less than 1.9 db, the theoretical value for perfect matching.

Measurements have been made on a number of experimental filters, of the three types, some designed for $R_2 = R_1$ and some for $R_2 = \infty$. Two r.f. filters were also set up and tested in the equivalent lattice form for matching balanced to unbalanced lines. In general the agreement between measurements and calculations was close. The greatest discrepancy occurred in the pass band where the calculated insertion loss was zero or very small. In this region typical high- and low-pass filters showed 1- or 2-db loss, and band-pass filters (with three coils) as much as 5-db loss. The discrepancy is presumably due to the neglect of component losses in calculations. The loss has the effect of reducing the ripple in the pass band, and several band-pass filters designed with $t = 0.5$ showed only 1- or 2-db variation over the pass band, instead of the expected 3-db. One filter, designed for $R_2 = \infty$ and with $t = 0.41$ was tested with a value of $R_2 = 5000$ ohms ($R_2 = 10R_1$). It showed about 0.6 db more insertion loss in the pass band than it had without the resistor, and no measurable difference in loss outside the pass band. Evidently R_2 need not be extremely high to be considered "infinite."

Simplified GCA

A NEW precision approach radar known as SPAR has been developed in the U.S.A. which provides all the facilities of a full-scale ground controlled approach (GCA) system for landing aircraft in poor visibility and at the same time is simple to operate and can if required be moved quickly from one site to another. The total weight is under one ton and the various parts break down into conveniently sized units for handling and for transport by aircraft if necessary. The whole equipment can be dismantled in six man-hours and re-erected in the same time.

The illustration shows the type and arrangement of the aerials; each measures 8ft × 2ft and they scan mechanically in azimuth and in elevation respectively, the former over an arc of 30° and the latter 10° (−1° to +9°).

What is thought to be a unique feature of this GCA is that both glide and approach paths (elevation and azimuth information) are displayed on a single 17in extra-long-persistence c.r. tube. "B" scans are used in both cases with glide path information shown on the top half of the tube and approach path information below. A logarithmic scale of range is employed, which is appropriate since it gives the greatest expansion of the trace at the most critical stage of the talk-down descent; just before the actual touch-down.

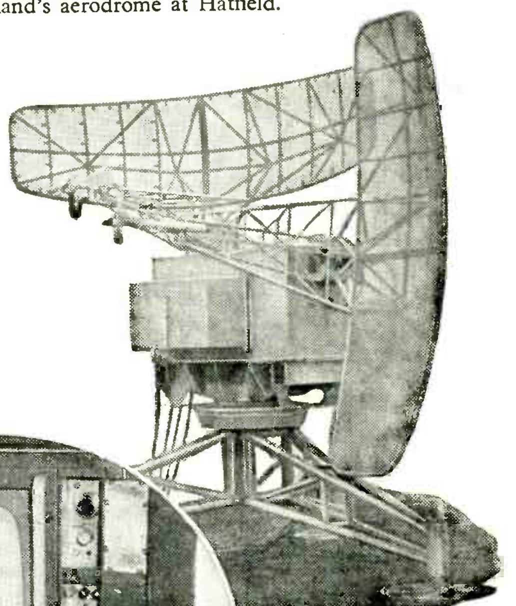
Predetermined glide and approach paths are applied electronically to the screen of the tube and it is only necessary for the controller to keep the two elongated echoes astride these displayed paths to bring the aircraft down safely. Relevant flying instructions are passed by v.h.f. radio-telephone.

A high degree of accuracy is claimed for this system; ±20ft at touch-down, just before which the pilot takes over for a visual landing, and 0.5% of the range are the figures given.

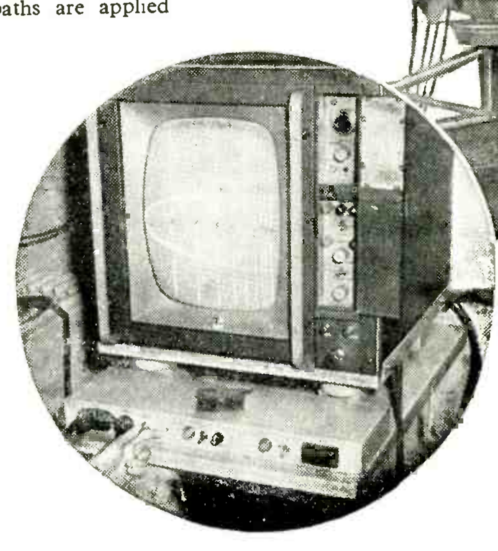
The aerial unit can be positioned either on the centre line of the runway or to one side of it, the maximum displacement off centre being 1,000ft.

Brief technical details of the installation are as follows: operating frequency, 9,080 Mc/s ±1%; pulse width, 0.5 μsec; peak power 50 kW; range, 10 nautical miles; aerial scan rate, 2 per sec azimuth and elevation. Provision is made for optional circular polarization to combat any clutter or degradation of the system by rain droplets. The power input required is 3.5 kVA at 115/230 V a.c. 50/60 c/s single phase.

The equipment is a Bendix product and is handled in the U.K. by Elliott Bros., Century Works, Lewisham, London, S.E.13, who recently demonstrated it on De Havilland's aerodrome at Hatfield.



Aerial system of the new 3-cm SPAR GCA shown on mobile mounting.



SPAR control unit with elevation and azimuth information displayed on a single extra-long persistence c.r. tube.

Vertical Pattern of V.H.F. Aerials

New Method of Measurement Dispensing with the Need for High Towers

By E. G. HAMER,* B.Sc.(Eng.) Hons., A.M.I.E.E.

THE increasing use of v.h.f. equipment for mobile services, both of the business radio and public utility types, has called for intensive development to improve the performance of all the various units involved. In the case of the transmitter the maximum power output is restricted by regulations laid down by the local licencing authorities, and to some extent by the economic maximum power consumption of the mobile equipment. The output signal-to-noise ratio of modern receivers is controlled mainly by the noise factor of the input circuits when the thermal noise is predominant. The noise factor varies between individual designs but is usually as low as 4 db up to 100 Mc/s, and 6 db up to 180 Mc/s. The main items which remain, and which could possibly give improved performance are the aerial systems and feeders. A small improvement say 1 to 2 db could be made by using low-loss air-spaced feeders, but this improvement would be outweighed by the large increase in initial cost of the improved feeder cable.

Many types of aerials have been used in the past both for the fixed and mobile stations, and each system designer has had his own particular favourite. The performance of several types of aerials has been suspect in the past, their failings becoming apparent during the course of trials or demonstrations. This in many cases has led to conflicting opinions on the suitability of various types of aerials for different uses, and it has not been possible to recommend on technical grounds the best aerial for various types of service. It has been thought for some time that the vertical polar diagram of the various types of aerial varied considerably, and it is possible that the diagram changes rapidly with small changes of frequency, this being of importance where double frequency working, or common aerials are in use (Ref. [1,2]). The lack of information in the past has been due to the practical difficulties involved in the measurement of the true vertical polar diagram of an aerial, as even with the use of a high tower only part of the diagram can be measured. To some extent the vertical polar diagram of an aerial will depend upon its location and method of mounting, so that any measurements made will only apply to the particular equipment used, or some idealized case, say that of free space. In most aerials used for mobile services the desirable factor of a low standing-wave ratio, and lack of energy fed back down the outside of the feeder are sacrificed in the interests of low initial cost; and a " live feeder can have a pronounced effect on a vertical polar diagram, or on the symmetry of both the horizontal and vertical diagram, usually giving a degradation of performance in the required directions.

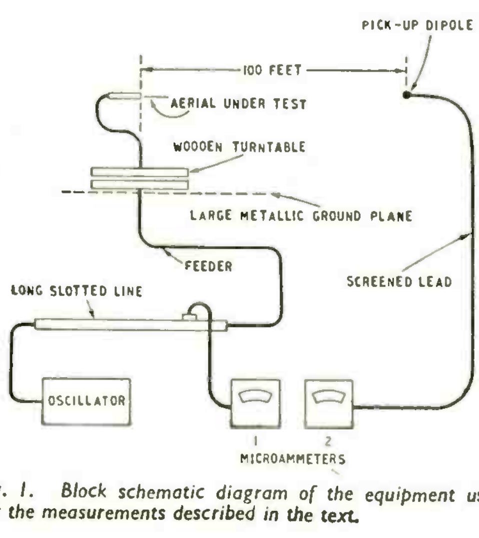


Fig. 1. Block schematic diagram of the equipment used for the measurements described in the text.

With a view to checking this last unknown factor of system performance (i.e. the aerial) it was decided to measure the approximate vertical polar diagram of various types of aerial. It has been shown in the past that the vertical polar diagram of simple aerials comprised only of vertical elements could be obtained by laying the aerial horizontally above a large ground plane and either rotating the aerial itself, or moving the receiving test aerial around at a fixed radial distance from the aerial being measured. But this method has not been justified in the past for more complex aerials consisting of mixtures of horizontal and vertical elements. The techniques used have been discussed in a previous paper (Ref. [5]) and provided certain precautions are taken reasonably accurate results will be obtained. The results obtained compare favourably with part diagrams taken when using a high tower to move the receiving aerial in a vertical direction. This to some extent may be fortuitous as the measured true vertical diagram will vary according to the height at which the aerial under test is mounted and also to the surrounding terrain.

Fig. 1 shows a block schematic diagram of the equipment used; the aerial under test was mounted on a wooden turntable which itself was set on a large metallic ground plane laid on the roof of a wooden hut. The aerial was connected by a suitable feeder to an oscillator through a long slotted line. The pick-up dipole was mounted 100 feet away and connected to a bridge rectifier, the resulting direct current being fed by a screened lead to microammeter 2. When measurements were made the radio frequency power into the aerial from the oscillator was adjusted to give a constant field strength at the pick-up dipole as measured by microammeter 2, and the power fed to the aerial measured by use of the long slotted line and microammeter 1. Fig. 2 is a sketch of the pick-up dipole head, a resonant circuit with the centre earthed was

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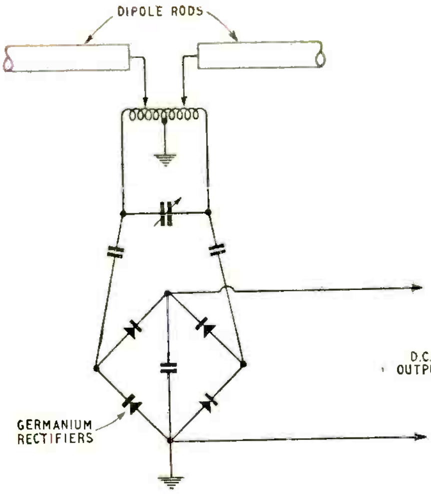

Fig. 2. Pick-up dipole head.

used to eliminate stray and unwanted pick up from powerful medium wave stations. A bridge formed of four germanium rectifiers was tapped on to the coil *via* isolating capacitors. A pick-up circuit of this kind, although insensitive, has the advantage of long-term stability, and requires no returning or power supplies; it was mounted at the top of a plywood telescopic mast on a level with the aerial under test. By plotting the inverse of the power fed into the aerial under test to give a constant field strength at the pick-up aerial the polar diagram of the aerial was obtained.

The product of the maximum and minimum relative voltages as measured by the long slotted line is directly proportional to the power being fed into the aerial (Ref. [3]), and by obtaining this product at various positions the polar diagram is obtained. For any given aerial setting as the standing-wave ratio is constant the aerial power is proportional to V_{max}^2 and the field strength at the pick-up aerial to V_{max} where V_{max} is the relative voltage at a maximum position along the slotted line. It is convenient only to measure V_{max} and V_{min} at a few positions to obtain the standing-wave ratio, and at all other positions only to measure V_{max}. This obviates the need to keep moving the probe of the slotted line, thus reducing the time taken to make a series of measurements, which in itself tends to increase the accuracy as the effect of drift of measuring equipment is minimized.

The average time to take a complete polar diagram of an aerial with a mechanically driven turntable, and with 10-deg intervals is thus reduced to 10 to 15 min. These individual diagrams are rescaled to a basis of equal radiated power, and hence direct comparisons of the performance of various types of aerials tested may be made (Ref. [5]).

Figs. 3, 4 and 5 are photographs of some of the aerials tested and Fig. 6 shows a comparison of the performance of various types of aerial when radiating the same power, and plotted on a basis of relative field strength. The Aerial Table shows the relative gain of the various types of aerial in a horizontal direction when compared with the equivalent omni-directional source.

It will be noted that in the case of asymmetric

AERIAL TABLE

Type of Aerial	Gain over Omni-directional Source
Standard Dipole	2.2 db (theoretical 2.15 db)
Sleeve Dipole	1.5 db
Ground Plane	−0.5 db
Wide band Ground Plane	−0.4 db
Simple "J"	2.6 to 2.9 db depending on direction
Ground Plane "J" λ/4 rods)	0.5 to 1.5 db depending on direction
Ground Plane "J" λ/2 rods)	1 to 2.5 db depending on direction

Gain of various types of aerial in the horizontal plane.

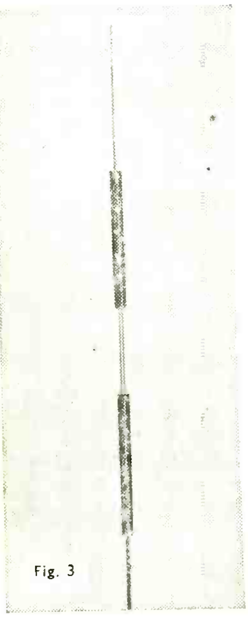
Fig. 3

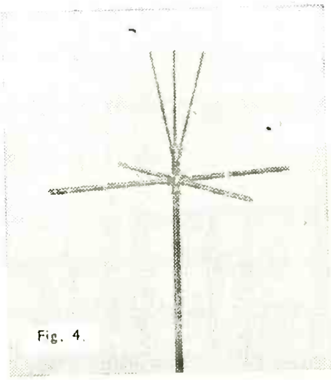
Fig. 4

Fig. 3. Type of standard dipole used.

Fig. 4. Details of the wide-band ground-plane aerial.

Fig. 5. The ground-plane "J" aerial employed in the tests.

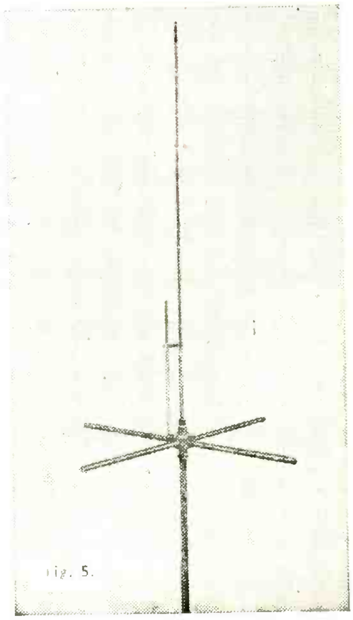
Fig. 5.

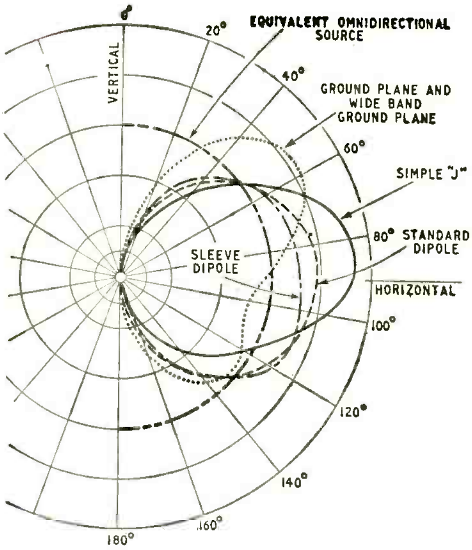

Fig. 6. Comparison of various aerials.

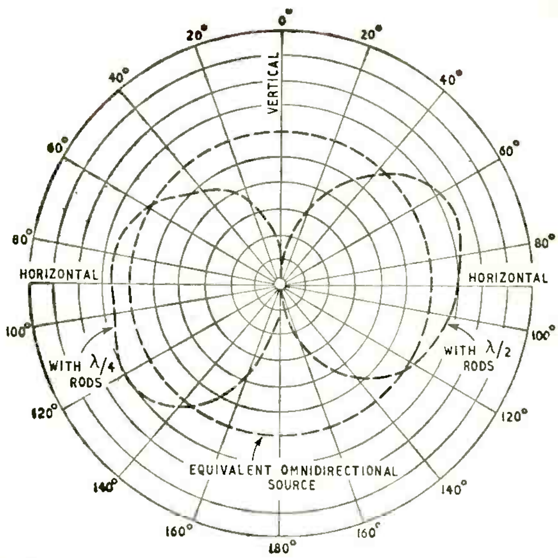

Fig. 7. Average polar diagrams of ground-plane "J" aerials.

aerials the gain varies according to the actual direction in the horizontal plane; also although in Fig. 6 the ground-plane aerial and wide-band ground plane are shown as having the same diagram small differences do exist and these account for the variation of horizontal gain as shown in the Aerial Table. Fig. 7 shows the average vertical polar diagram of the ground plane "J" aerials. These aerials are asymmetric and the polar diagram depends upon the actual direction of measurement. These average figures are taken by combining the diagrams taken in various planes so as to give a representative answer. This effect is also shown in the Table where the horizontal gain is seen to vary according to the direction of measurement.

In the case of aerials which are asymmetric in both horizontal and vertical planes, the average of the "Rousseau" diagram (Ref. [4]) in several directions should be taken. By applying this construction to the results obtained for the different aerials under test, they may all be scaled to have the same mean spherical intensity, and hence directly compared. This is probably the most accurate method but in the case of complex aerials where the mean of many "Rousseau" diagrams would have to be taken; the actual relative power fed to an aerial can be quickly obtained by dividing the V_{max}^2 reading by the standing-wave ratio as measured at the slotted line. For any given aerial the standing-wave ratio will be constant and hence need only be measured once.

This is seen to be true as

$$\text{Relative Power to aerial} = V_{max} \times V_{min} = V_{max}^2 \times \frac{V_{min}}{V_{max}} = \frac{V_{max}^2}{\text{s.w.r.}}$$

The reciprocal of this value is plotted, as the pick-up voltage has been kept constant.

The comparative power at the pick-up dipole if the radiated power is kept constant is proportional to

$$\frac{\text{s.w.r.}}{V_{max}^2}$$

and the field strength at the pick-up dipole if the radiated power is kept constant is proportional to

$$\frac{\sqrt{\text{s.w.r.}}}{V_{max}}$$

This method is of course subject to errors due to drift of the measuring equipment, and other errors of measurement.

For normal communication services it would appear that the best aerial to use is the simple "J" aerial, or dipole aerial with or without sleeve suppressor. The ground-plane "J" aerials offer little if no technical advantage despite their additional complications. Ground-plane aerials would appear definitely unsuitable for land mobile services, although they would have an advantage if used in mobile services to aircraft. These conclusions are based on tests conducted at a single frequency and where the aerials are to be used for multiple frequency working this may not be true. It is possible that an aerial which at a single frequency gives a slightly inferior performance, may hold this performance over a wide band of frequencies; whilst another initially superior aerial may have its performance seriously degraded by slight changes of frequency. This will probably be shown very markedly in special types of stacked aerials used to give omnidirectional gain in the horizontal plane.

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[3] E. G. Hamer, "Slotted Line Techniques," *Electronic Engineering*, Dec. 1951.

[4] E. W. Golding, "Electrical Measurements and Measuring Instruments" (Sir Isaac Pitman & Sons, Ltd., Third Edition, 1948), page 406.

[5] E. G. Hamer, "V.H.F. Aerial Radiation Pattern Measurements." *Electronic Engineering*, October 1953, Vol. 25, pp. 427-431.

FOURIER—Fact or Fiction?

Why Sine Waves?

By "CATHODE RAY"

YEARS ago—around 1930 if I remember rightly—there arose a great public controversy, the like of which, regrettably, never emerges nowadays to gladden our dull lives. Everybody has become too sophisticated to proclaim, with any show of authority, that mathematicians are wrong, or that the earth is flat, or television is a hallucination. But at the time I mentioned there were a number of persons well known in the radio world, including no less an authority than the late Sir Ambrose (Valve) Fleming, who said—and stuck to it—that sidebands were imaginary; a mere mathematical fiction. The dispute reached such a pitch that actually a Government-sponsored Committee was appointed to go into the thing, and the result was Special Report No. 12 of the Radio Research Board, published by H.M. Stationery Office in 1932. But by then the subject had gone cold.

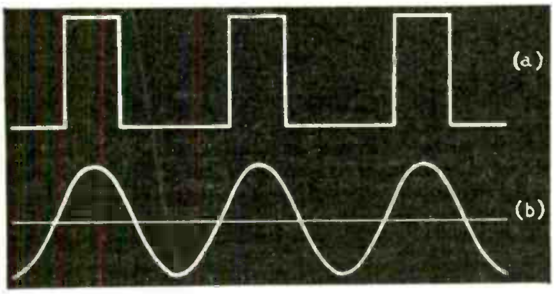


Fig. 1. Is it true that waveforms such as (a) are really and inevitably made up waveform (b) at various frequencies ?

The same kind of doubts about the reality of what is represented by mathematical processes must often visit the minds of students faced with the Fourier theorem—the one that says that periodic waves of any and every shape can be regarded as made up exclusively of pure sine waves having frequencies that are whole-number multiples of the fundamental frequency of the wave. It certainly is difficult to believe that waveform (a) in Fig. 1 can be constructed entirely from smooth waves of form (b). There is some excuse for the feeling that this can be no more than a "mathematical fiction"—an ingenious device to help with calculations, but not a physical reality.

Other questions may well be asked. What is it about waves of the particular shape (b) that they and they alone have only one frequency? How did they come to have the special privilege of being the sole ingredients of all other waveforms? Did Fourier confer it, or is it an immutable law of Nature? Is there any other waveform that could be substituted?

When I started looking up a few books to see what they said on such questions, I found that they didn't even ask, much less answer them. They just took for granted that a single-frequency wave must be a sine wave*, and that Fourier has no competitors. A more thorough search revealed some clues, but not much that could be considered to be crisp answers. Perhaps you would like to try answering the above questions yourself before reading on.

Fundamental Frequency

To clear the ground, I would remind you that the Fourier theorem applies only to *periodic* waveforms; i.e., those that repeat exactly and for ever. In practice, "for ever" can be interpreted rather freely, without making a great deal of difference, as "a considerable number of periods" (or cycles, as they are more often called). One period is the shortest time required for a showing of the complete programme, before it starts to repeat. Fig. 1 shows three identical copies of each waveform; and if what it shows occurred during one-thousandth of a second the fundamental frequency would be 3kc/s. In (a) there would be (according to Fourier) other frequencies, whole-number multiples of 3 kc/s; but (b) being a sine waveform has (it is generally assumed) no other frequency.

Look now at Fig. 2, which is the kind of thing

* Throughout here, "sine wave" includes the cosine wave, which is the same thing advanced quarter of a cycle in phase.

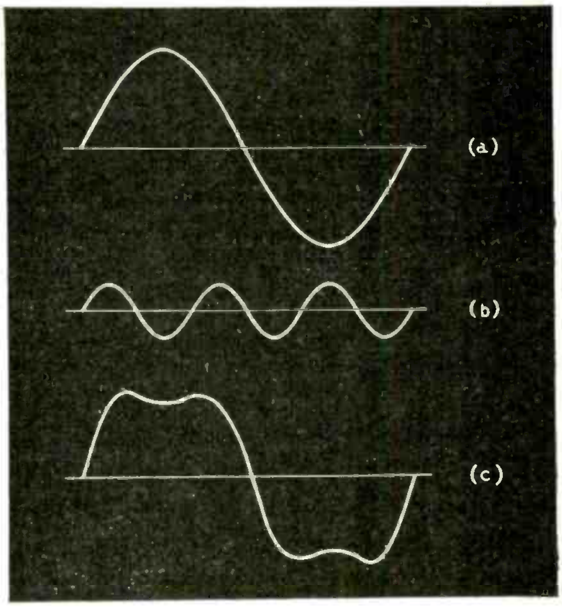


Fig. 2. Example of how a fundamental sine wave (a) and a harmonic (b) add up to a different waveform (c).

commonly used to demonstrate Fourier. First, at (a), is one cycle of sine waveform. Next (b), three cycles of the same form in the same time and therefore three times the frequency. If (b) is added to (a), its first and second positive half-cycles augment the lower slopes of the positive half-cycle of (a), and its first negative half-cycle flattens the positive peak of (a), so the result is something like (c). Among other things, this demonstration is supposed to convince everybody that (c) is necessarily a composite wave, made up of a fundamental (a) and third harmonic (b), both of these of course being of sine form.

But what if somebody, just to be awkward, comes along and draws Fig. 3 showing that adding together the non-sine waves (a) and (b) gives a sine wave (c), so (c) must be a composite wave, made up of a fundamental and third harmonic? Would you be able to explain why Fig. 2 must be accepted rather than Fig. 3?

Credentials in Doubt ?

Of course, if some mathematician should chip in with a neat proof that a perfect sine wave cannot in fact be constructed in this way from any one other waveform, it would give us some ground for believing that the sine waveform had a special claim. (I have failed to find any such proof, and would be glad to receive offers.) Still more would the prestige of the sine wave be boosted if a Fourier series (of sine waves) could be shown to be the *only* one that can be used for constructing other wave forms. There, at least, I have authoritative mathematical guidance, and it is to the effect that waveforms *can* be constructed from series other than sine. So the sine wave is still, as it were, confined in our mental guardroom, unable so far to produce complete evidence of its intitlement to the very special status commonly granted to it.

Thinking over the thing, I eventually arrived at several reasons why the sine should be selected in preference to all others, but nothing to rule all other

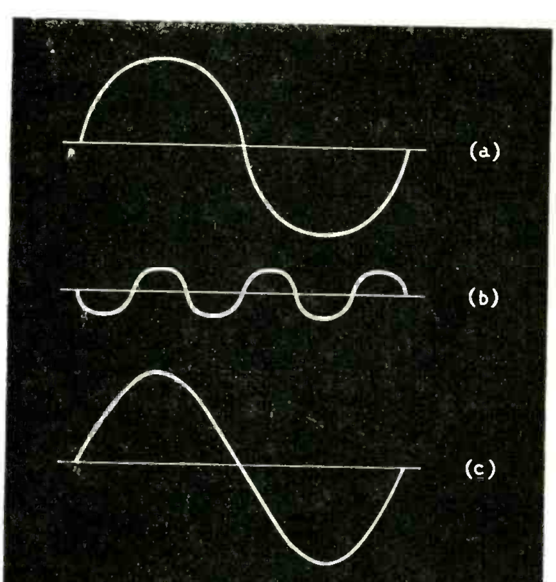


Fig. 3. Here, a non-sine waveform (a) and its harmonic (b) add up to a sine wave (c).

forms completely out on principle. The further book search I mentioned tended to support these reasons, so here they are.

They can be divided into two lots: mathematical and physical. Suppose we were to start absolutely from scratch to choose some function of time that would make the most suitable basis for expressing repetitive events. The simplest for this purpose would be something that goes on continuously at a steady rate and yet repeats itself identically in definite periods. Nothing that I—or apparently anybody else—can think of fits this description so simply and well as what in the physical world appears as steady rotation. Mathematically, it is change of angle at a constant rate. Suppose OA in Fig. 4 is a fixed line to mark the start of an angle, and the angle between it and OB (labelled θ) increases at a constant rate. When the angle has changed by one whole revolution, or 360°, or 2π radians (all of which are the same thing), the position is exactly the same as at the start, and what happens during the next 2π radians is exactly the same as during the last. So it fits perfectly with the definition of "periodic." Call the number of periods or cycles or revolutions per second f. The angle traced out per cycle is 2π radians, so the angle traced out per second is $2\pi f$, written ω for short; and consequently the angle between OA and OB (i.e., θ) at t seconds from the start (when $t=0$) is ωt. So we have

$$\theta = \omega t$$

Now for many purposes (as we shall see) the significant thing about this circular motion is the height of B above the horizontal (OA). That height, in relation to the maximum it can attain—obviously equal to the length OB—has been named the sine of the angle AOB, abbreviated to $\sin\theta$. It is what the length OB has to be multiplied by to give the height of B above OA. When $\theta=0$ (or 180°), $\sin\theta$ is obviously 0; when θ is 90° it is 1, and when θ is 270° it is -1. Plotting $\sin\theta$ against θ from 0 to 360° (or 2π radians) we get the familiar curve of Fig. 2(a). Suppose the maximum height, equal to the length of OB, is denoted by H. Then the height at any time t must be $H\sin\omega t$. So if we plotted height against time we would get a curve just the same shape as Fig. 2(a), of maximum or peak height H, and with f complete waves per second. Mathematically, there is nothing to equal this for simplicity and clearness in expressing uniform periodic motion or change. But from our point of view the more important thing is that it ties up perfectly with so many of the technicalities to which *Wireless World* is devoted.

Elementary A.C.

Take, for example, the generation of alternating current by the most elementary arrangement we can think of—a loop of wire rotated at constant rate in a uniform magnetic field. The vertical lines in Fig. 5 represent the direction of the field, and B is an end view of one of the two horizontal parts of a square loop of wire rotated about O. When the loop is horizontal, the wire is all moving along the field, so has no e.m.f. generated in it. When vertical, the wire B is cutting directly across the field, so e.m.f. is a maximum. At all positions, the e.m.f. is proportional to the sine of the angle, so the waveform of the e.m.f. is a sine waveform.

A still more significant thing is what happens when

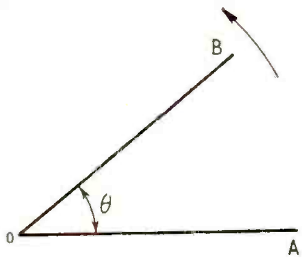


Fig. 4. How a sine wave is derived from a steadily increasing angle.

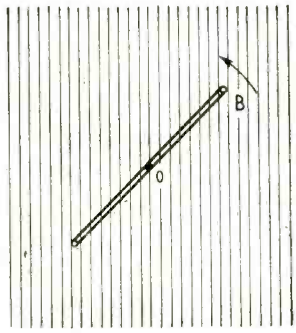


Fig. 5. Side view of an elementary a.c. generator consisting of a square loop of wire rotating about O in a uniform magnetic field.

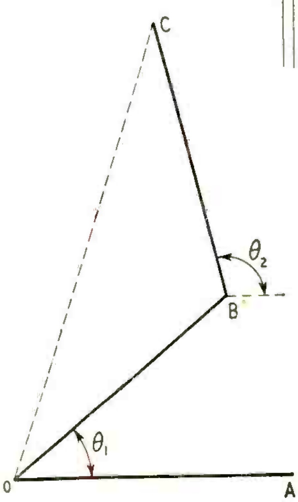


Fig. 6. If to B rotating steadily around O is added C rotating at the same speed around B, then the angle CBO remains constant, so C also rotates steadily in a circle around O. This shows that if two sine waves of equal frequency are added together the total is also a sine wave.

we use this sine-wave e.m.f. to drive current through a circuit. No matter how complicated the circuit—provided only that it is linear—the waveform of the current is the same. It may be shifted backwards or forwards relative to the voltage wave, but the shape is identical. This is not true of any other waveform. Lord Rayleigh put it rather nicely in his *Theory of Sound*: he said that a simple tone (by which he meant one having sine waveform) "is the only one capable of preserving its integrity among the vicissitudes it may have to undergo. Any other kind is liable to a sort of physical analysis, one part being differently affected from another."

This is bound up closely with the very significant and important fact that electrical and mechanical arrangements that give rise to periodical or to-and-fro or wave motion, called oscillation or vibration, tend, when conditions are reduced to the simplest or ideal, to cause the waveform to be of the sine pattern. The "arrangements" referred to include, as the essential minimum, capacitance and inductance in the electrical systems, and their analogues, compliance and inertia, in the mechanical systems. Now our electrical theory teaches us that while the current through a linear resistance is proportional to the e.m.f. across it (Ohm's law), the current through a capacitance is proportional to the rate of change or "differential" (nothing to do with engine drivers or motor cars) of the e.m.f., and the current through an inductance is proportional to the opposite of the differential—the "integral"—of the e.m.f. The differential of a curve on a graph is represented by the slope of the curve, and if you draw a graph of the slope of a sine wave you find that it has exactly the same waveform as the sine wave, subject to a phase advance of quarter of a cycle. So obviously if you perform the reverse operation—draw the integral curve, the graph of whose slope is a sine wave—you get another sine wave, shifted quarter of a cycle the other way. The sine waveform is the only one of which that is true, and it accounts for the fact that the current waveform in capacitive and inductive circuits, as well as resistive, is only the same as the voltage waveform when that has the sine shape. It accounts for a lot of other things, too, such as the tendency for oscillation to have a sine waveform, the more nearly the conditions that cause it are reduced to simple inductance-and-capacitance.

Another interesting point is that the wave formed by adding together any number of sine-wave variables of equal frequency but different phase has itself a sine form. So if there are two or more sine-wave currents flowing in the same circuit, even if they are out of phase with one another, the total current has sine waveform. This may not be obvious if you draw the separate waveforms, and it is laborious to add them up point-by-point on a graph; one can much more easily see it by slightly elaborating Fig. 4—adding another "vector" line like OB, but at a different angle (Fig. 6), and then noting that the tip of it (C) performs a circular motion around O, just as if it were the tip of a single vector OC representing the total of the other two. But if you try adding together any other out-of-phase waveforms you will find that the total has a different form. So if electrical engineering (for example) were based on any other waveform, the whole thing would be unbearably complicated and difficult.

A Tricky Question

Even without detailing all the significant consequences of the foregoing significant facts about sine waves (which could easily take up thousands of pages) the most sceptical reader may be willing by now to concede that the sine wave has the best claim to its proud position in science. But besides the question of the realities of harmonics (which we shall have to leave till next month), we still have the question of why only sine waves have a single frequency. It would not do, however, to start a murder trial by asking the accused *why* he murdered his wife. His lawyer would be very quick to object that it had not been established that he *had* murdered his wife. We have not yet established as a fact that the waveform of a single-frequency oscillation is necessarily sine.

Your first reaction may be that this is a frivolous question—of *course* a sine wave has only a single frequency and is the only single-frequency waveform; if it weren't the Fourier theorem would be complete nonsense, and so would most—anyway, a lot—of our basic theory. Yes; we may be quite sure it is true, but can we prove it? Obviously if it can be proved that a single-frequency waveform is *necessarily* a sine waveform, it will be a still more decisive fact with which to justify our enthronement of the sine wave. But let me point out that the Fourier theorem doesn't prove it; it only shows that any waveform can be regarded as made up of sine waves having frequencies that are 1, 2, 3, 4, etc., times the fundamental frequency. It doesn't prove that there is no other waveform of which this is true.

Of course, all hinges on what we mean by "frequency." Are we not—perhaps unconsciously—relying on the admittedly strong status of the sine wave to define the frequency of any waveform as the frequency of the sine waves into which Fourier analyses it? Are we not, in fact, committing the logical fallacy called (don't ask me why) "begging the question," i.e., basing a "proof" of something on the assumption of that something? Have we any absolutely independent scientific ground for saying that if an oscillation occurs at only one frequency its waveform must be sine? Is "frequency" a basic characteristic of Nature that we are bound to accept, or is it one of those things, like "offside," that could mean different things, and can only be made to mean one thing alone by people agreeing to accept an arbitrary definition? If we define frequency as (for example) the rate at which identical events occur, can we show why Fig. 1 (b) has been chosen, rather than (a)—or any other of a variety of waveforms—as having only a single frequency?

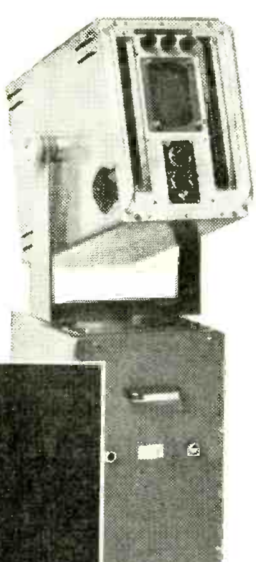
I suppose you will say at once that it can be perfectly easily demonstrated; if a transmitter puts out a pure sine waveform it can be picked up on only one frequency—the fundamental—but if it has any other waveform it can be tuned in on harmonic frequencies. What more proof could one want?

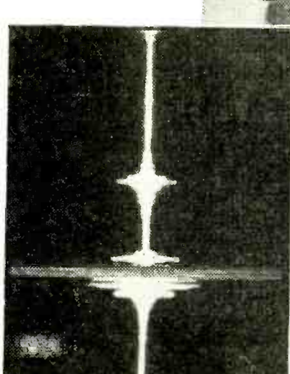
Well, I may be a bit awkward, but I must point out that the tuning-in is done by an arrangement that by its nature responds to sine waves. But in a single cycle of a pure sine wave, the variable attains 70.7% of its peak value four times, at evenly spaced intervals, and if some device responded to this condition it would respond four times per cycle and would reckon the frequency accordingly. It might be that a system could be devised that would respond to square waves only at their fundamental frequency, and would interpret sine waves as composed of an infinite series of harmonic square waves. That may sound rather fantastic, and anyway, I am not proposing that in practice our usual concept of frequency based on sine waves should be abandoned; but it is an interesting thing to consider whether we can prove that frequency is necessarily and inevitably based on sine waves, or whether that is merely a matter of convenience, because it fits in with the way tuning circuits and ears happen to work.

Next month we shall consider whether all non-sine waves are really composed of sine waves, or only mathematically; and how square waves, sawteeth, etc., are analysed, and what they contain.

Ultrasonic Fish Detection

Depth Sounding Equipment Based on Radar Technique





Complete equipment (right) with typical response from a concentration of herring off Denmark (below).

A NEW echo-sounding device recently introduced by Pye Marine as an aid to trawler fishing is notable for being all-electronic in operation and is claimed to be more sensitive than previous equipments of this kind. The transmitter consists of a 30-kc/s oscillator working into a magnetostriction transducer which sends pulses of ultrasonic energy from the bottom of the fishing vessel towards the sea bed. Reflections from shoals of fish and the sea bed are received by another transducer and, after amplification, are applied to the deflection plates of a c.r.t. display system. They appear on the screen as horizontal deflections on either side of a vertical timebase which represents the depth to which the equipment is sounding (see picture).

The speed of the timebase can be varied by a control knob which also moves a pointer on a calibrated scale showing the depth corresponding to the finish of the trace. (Depth, of course, determining the transit time of the ultrasonic pulse.) This ensures that as the sounded depth is decreased the trace is expanded to increase its scale. The variable timebase actually provides the means of triggering the transmitted pulse. Thus, as the timebase speed is increased for decreased sounding depth so also is the p.r.f. of the transmission, to the maximum possible for that depth. Successive echoes combine to form a steady picture as soon as the p.r.f. is high enough and in practice this occurs at depths less than 100 fathoms.

Another control knob calibrated in depth enables a marker to be moved up and down the trace. This actually deflects a portion of the trace, equivalent to a depth of seven fathoms, bodily to the right, and it can be placed over any echo that one wishes to investigate. By means of a secondary timebase the selected seven fathoms can then be expanded to fill the whole screen for examination in detail. In the circuit this secondary time base and the marker are both triggered from the start of the main timebase through a variable delay circuit, the control knob of which carries the depth calibration.

The design has taken into account the variations present in ships' power supplies, and a 10% voltage change is permissible.

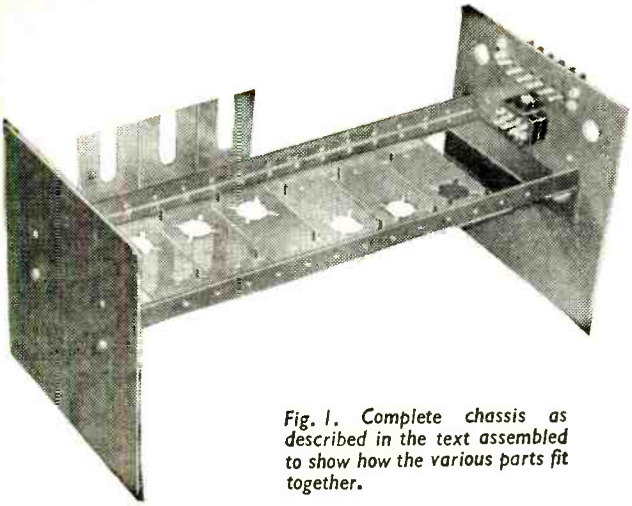


Fig. 1. Complete chassis as described in the text assembled to show how the various parts fit together.

Standard Chassis

Versatile System for the Experimenter and the Development Laboratory

By T. K. COWELL*

FOR some years, the author has been concerned with the construction and development of various small experimental units up to the prototype stage. The units usually embodied not more than half a dozen valves and their associated components and in general, the chassis, panels, etc, used for one job were not suitable for further use. Accordingly, they were either scrapped, or put in a cupboard and forgotten until the next "open day" when they would be hastily stripped of components and crushed into a bulging scrap metal bin.

It was with a view to reducing this wastage of time and material that the author set about devising a chassis that would possess the often conflicting features of simplicity and versatility.

It was felt that the chassis should provide the following facilities:—

(1) Be capable of assembly for a particular need from a small number of "standard parts."

(2) Be capable of accepting a circuit containing up to six valves of B7G or B9A type, a lesser number of valves with somewhat larger bases, or a mixture of any such types in any order.

(3) Positions of valves, potentiometers, switches, etc, should be capable of alteration without difficulty.

(4) Assembly should be capable of standing upright (i.e., with the valves base downwards) or inverted to facilitate wiring, alterations, voltage checking, etc.

(5) Be possible to join one chassis to another for larger layouts, without reducing the flexibility of the system.

Dimensions of Parts

As bench supplies of h.t. and l.t. are usually available in development and research establishments, it was felt that a plug and socket connection would suffice together with simple facilities for switching and metering. The chassis described here fulfils the requirements outlined and the dimensions given in the sketches have been found to be satisfactory in practice.

* R. B. Pullin and Co., Ltd.

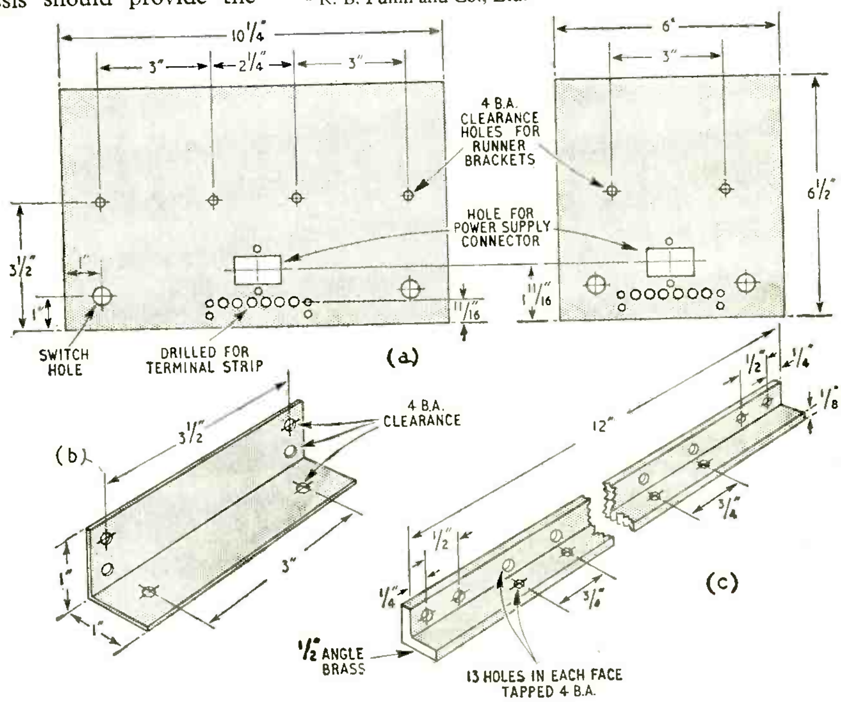


Fig. 2. Details of two alternative end plate are given in (a) while (b) shows the end-plate bracket and (c) one of the long runners.

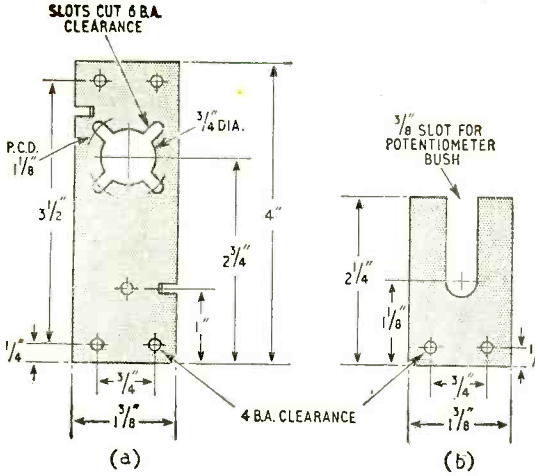


Fig. 3. Details of (a) the valveholder plate and (b) the potentiometer plate.

Reference to Fig. 1 will show that the chassis is made up of component plates (for valveholders, potentiometers, etc.) mounted on two rails, or runners. The runners are supported by a pair of end plates. One of the end plates carries a power supply connector, switches and a terminal strip to facilitate supply metering and control. The runners are fixed to the end plates by a simple bracket, Fig. 2 (b), which ensures adequate rigidity.

As illustrated in Fig. 2 (a) the end plates are made in two sizes, so that a simple doubling of chassis width is possible, using the standard runners and component plates.

One of each pair of end plates is drilled and cut to accept two small toggle switches, an eight-way chassis mounting plug, and a terminal strip. The other plate of each pair is left plain, except for the fixing holes for the runner bracket.

Only one runner is shown in Fig. 2 (c) as the two are identical. By making the component plate fixing hole spacing equal to $\frac{3}{4}$in, it is possible to mount long tag-strips of either the miniature type ($\frac{1}{4}$in spacing), or the larger type with $\frac{3}{8}$in spacing, along the runners.

Component Plates

The plates illustrated in Fig. 3 are those found to have been most generally useful, and may be very easily fabricated. The valveholder plate, Fig. 3 (a), is capable of accepting either B7G or B9A holders in any one of four positions. Also, as the hole is positioned towards one end of the plate, the latter may be fitted to the runners in two ways.

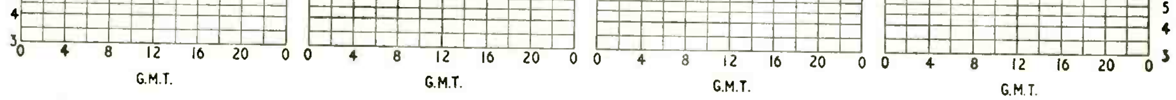
To save time and trouble in fitting earthing tags, a pair of saw-slots are made in either side of the plate, leaving a tag that may be bent up. One 4-BA clear hole is drilled in the plate to facilitate fitting a small tag-strip, or stand-off terminal, if required.

The potentiometer plate, Fig. 3 (b) needs little explanation beyond the fact that it is slotted for easy removal of potentiometers, rotary switches, etc. The distance between adjacent shaft centres is normally $1\frac{1}{2}$in, but the slot permits the vertical staggering of components whose diameter somewhat exceeds this figure.

Input and output terminations may be made on small, single screw fixing stand-off terminals, but tag-strip would do equally well. In cases where screened input and/or output leads are necessary, suitable sockets could be mounted on the appropriate component plate.

The valveholder plates are made of brass to facilitate soldering, but aluminium alloy is satisfactory for the other parts, provided that earthing points on individual valve plates are bonded together. For work usually involving large components it would probably be convenient to scale-up the whole system, but the author has found that a chassis of the size illustrated is a fair compromise for the majority of experimental applications.

SHORT-WAVE CONDITIONS *Predictions for September*



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

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

Aerial Circuit Magnification

Notes on Capacitive Bottom Coupling for Medium- and Long-wave Receivers

By S. KANNAN,* B.Sc., Assoc.Brit.I.R.E.

INPUT circuits with bottom capacitive coupling are commonly encountered in commercial broadcast receivers. A typical arrangement is that shown in Fig. 1, in which C represents the lumped capacitance (including any trimmer, gang or fixed capacitor, valve input capacitance and all strays); C_c is the coupling capacitor shunted by R whose value is chosen to be much greater than the reactance of C_c at the lowest radio frequency to which the receiver tunes and much smaller than the reactance of C_c at supply mains frequency so as to minimize any hum pick-up by the aerial; and L is the aerial coil. For medium and long waves, the equivalent circuit of Fig. 1 is given in

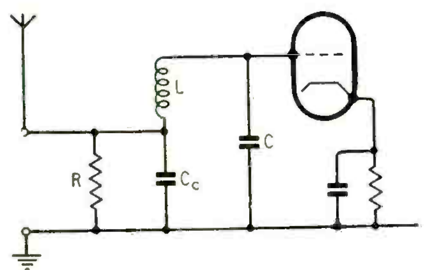


Fig. 1. Typical aerial input circuit with capacitive bottom coupling.

Fig. 2, where, for simplicity, R and the valve input resistance have been neglected, C_a represents the internal impedance of the aerial (mainly capacitive) and $r = \dfrac{\omega L}{Q}$

Fig. 2 is transformed, by Thévenin's theorem, into Fig. 3, where at any resonant frequency $f\left(=\dfrac{\omega}{2\pi}\right)$ of the aerial input circuit, the total circuit impedance $= r$.

$$\therefore E_o = E_a \cdot \frac{C_a}{C_a + C_c} \cdot \frac{1}{\omega C r} \quad \ldots \quad \ldots \quad (1)$$

Since the Q of the circuit

$$= \frac{\omega L}{r} = \frac{C + C_a + C_c}{\omega C r (C_a + C_c)}$$

equation (1) can be rewritten:

$$E_o = E_a \cdot \frac{Q\,C_a}{C + C_a + C_c} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$\therefore \text{Aerial circuit gain}\dagger = \frac{Q\,C_a}{C + C_a + C_c} \quad \ldots \quad (3)$$

This generalized equation (3) can now be applied to the two commonly encountered types of aerial tuned circuits:

(a) *Variable Capacitor Tuned Circuit:* as shown in Fig. 4, where C_s denotes the sum of all strays and valve input capacity, C_t = trimmer capacity, C_v = aerial tuning capacitance and $C_t + C_v + C_s = C$ of Fig. 1.

Due to C_v (usually one section of a ganged condenser), the value of C varies over the band, and hence, as shown in equation (3), the aerial gain also varies over the band. However, in order that the disturbance of the tuning by changes in aerial capacitance (C_a) be kept at a minimum (and in some cases in order also that the aerial circuit frequency coverage be not unduly restricted), C_c is usually much greater than C_a. In a typical medium-wave circuit, with C_a = 200pF, C_c = 4,700 pF, R = 10 kΩ, $C_c + C_s$ = 70 pF, C_v = 13 to 528 pF, the aerial gain at the l.f. end of the band will be $= \dfrac{200.Q}{5498}$, while the gain at the h.f. end will be $= \dfrac{200.Q}{4983}$.

Hence, if the Q of the circuit remains fairly constant

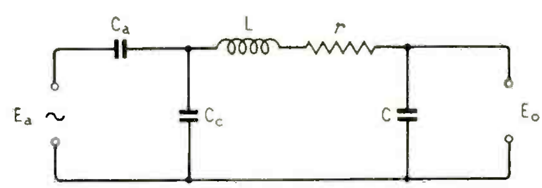


Fig. 2. Equivalent circuit of Fig. 1.

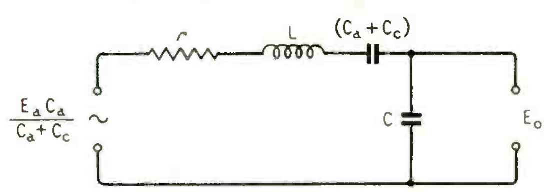


Fig. 3. Thévenin transformation of the equivalent circuit of Fig. 2.

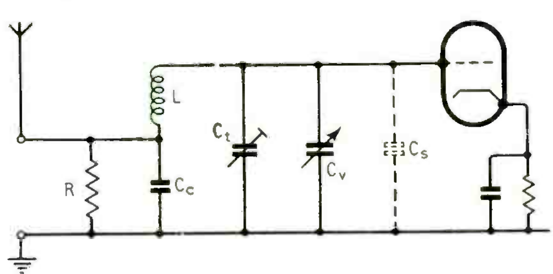


Fig. 4. Variable capacitance tuning.

*Development and Engineering Dept., E. K. Cole Ltd.

†The terms "input circuit magnification", "aerial circuit gain" and "aerial step-up" are used synonymously to mean the ratio of E_o to E_a.

over the band, the gain at one end of the band will be $\frac{5498}{4983} = 1.1$ times that at the other end, the gains at intermediate frequencies falling between these limits. Thus, with such a coupling, one desired feature of aerial circuit design is achieved, viz., fairly constant aerial gain over the band. Another desired feature, viz., a high enough aerial gain, will not be achieved with this method of aerial coupling unless the Q of the circuit is fairly high. Perhaps this explains why this method of coupling was not popular with designers in the days before ferrite-cored aerial coils, when the Q of air-cored and dust-cored aerial coils of normal dimensions rarely exceeded 50 and consequently more aerial gain could be obtained with other forms of aerial coupling. With the advent of ferrite cores, however, Q's of the order of 180 are easily held fairly constant over the band and, even allowing for a reduction of this Q by 50% due to valve input and other circuit damping, adequate gains are still obtainable.

Equation (3) also shows that, provided the circuit Q is constant over the band, the r.f. input sensitivity at aerial input must needs vary over the band by not more than the ratio indicated, viz.

$$(C_a + C_c + C_t + C_s + C_{v-max}) \text{ to } (C_a + C_c + C_t + C_s + C_{v-min}).$$

Hence, if in a receiver where circuit Q is nearly constant over the band, the aerial sensitivity figures vary by an abnormal ratio (e.g., 100 μV, to 10μV, over the band, which is not borne out by equation (3), the designer would do well to look elsewhere for the trouble, e.g., inconstant oscillator performance, wide tracking or ganging errors, etc.

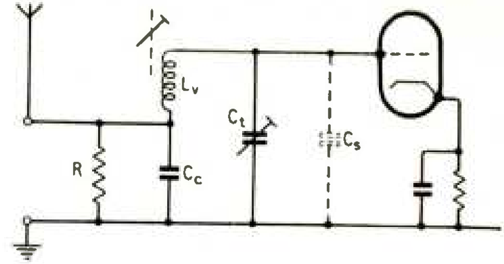


Fig. 5. Permeability-tuned aerial circuit.

(b) *Permeability-tuned Circuits:* Equation (3) also shows why this coupling system is especially suited for many applications of permeability-tuned aerial input circuits. One example is a car-radio design where an efficient coupling of the rather inefficient car-aerial was carried out by this method (see Fig. 5). With $C_a = 68$ pF, $C_c = 90$ pF, $C_t + C_s = C = 100$ pF, and the circuit Q varying between 20 and 40 over the band, the aerial step-up over the band was between 5.35 and 7.9. Thus with permeability-tuned circuits, and especially in applications (e.g., car-aerial installations) where the designer need not provide for much possible variation in C_a, a low value of C_c can be used to obtain good aerial gains even with low-Q aerial coils. It should be noted, however, that in mobile installations the equivalent series resistance of the aerial can, in some cases, become an important limiting factor in the determination of maximum obtainable aerial circuit gain.

COMMERCIAL LITERATURE

Colloidal Graphite Dispersions; a list of technical data, including solids content, density, flash point, diluent and typical applications, on 23 "dag" products arranged in convenient tabular form, from Acheson Colloids, 18, Pall Mall, London, S.W.1.

Silver Brazing Paste consisting of finely divided metal powder and flux in a liquid medium, which can be painted on the work, described in a leaflet "Easy-flo Paint" from Johnson, Matthey & Co., 73-83, Hatton Garden, London, E.C.1.

Books on Radio, television, electronics and other engineering subjects. A classified catalogue with descriptive notes from Cleaver-Hume Press, 31 Wright's Lane, Kensington, London, W.8.

Equipment Cases, racks, consoles, chassis, panels, etc. listed in an illustrated catalogue giving dimensions and enclosing a price list, from Alfred Imhof, 112-116 New Oxford Street, London, W.C.1.

Continuous Terminal Strip (to be cut up into pieces as required); cable cleating and strapping; sleeving; mouldings; grommets and other products described in an illustrated catalogue with tables of dimensions from Creators, Plansel Works, Sheerwater, Woking, Surrey.

Harmonic Distortion Meter Kit for an instrument covering 20 c/s-20 kc/s with an accuracy of ± 5 per cent of f.s. reading plus 0.1 per cent distortion. Specification of this "Heathkit" from Rocke International Corporation, 13 East 40th Street, New York 16, N.Y., U.S.A.

Tantalum Electrolytic Capacitors claimed to have greater reliability and longer shelf-life than conventional aluminium types. Technical bulletin giving capacitances, sizes, etc. from The Telegraph Condenser Co., North Acton, London, W.3.

Vibration Generators and power oscillators for driving them. Concise descriptions and specifications of a complete range of equipment on a leaflet from Goodmans Industries, Axiom Works, Wembley, Middlesex.

Switches and Signal Lamps. An illustrated catalogue containing ten new products and notable for its "blueprint" drawings of constructions and mechanisms (with dimensions). From Arcolectric Switches, Central Avenue, West Molesey, Surrey.

High Stability Resistors (wire-wound) ranging from 0.1Ω to 1MΩ with resistance tolerance of 0.1 per cent and temperature coefficient of only 0.002 per cent per degree C. Leaflet from Electrothermal Engineering, 270 Neville Road, London, N.7.

Small Electrolytic Capacitors by T.C.C. referred to in our June issue do not, of course, have a "paper dielectric construction" but the electrical advantages associated with such a construction, combined with the high capacitance values given by electrolytic operation. Apologies to the makers.

Oscilloscopes, oscillators, amplifiers, pulse generators and other test equipment. A short leaflet catalogue from the Solartron Electronic Group, Solartron Works, Thames Ditton, Surrey. Also a leaflet on a transfer function analyser, comprising l.f. decade oscillator and phase sensitive voltmeter, for testing servo systems.

Amateur Transmitter Valves. A valve line-up chart, "Headliners for Hams," giving operating conditions for class C amplifier and oscillator, modulator and frequency-multiplier service and also s.s.b. valve data. From the Radio Corporation of America, Tube Division, Harrison, New Jersey, U.S.A.

"V.H.F. Broadcasting Starts"

An error occurred on page 252, of our June, 1955, issue, where it was said that a transmitter fault could produce merely a 3-dB drop in signal strength. The figure should be 6dB, since if one transmitter fails one half of the aerial is also inoperative and the aerial gain is halved.

Rugby Radio Extension

Control and Supervision from a Central Point

TWENTY-EIGHT modern 30-kW transmitters have been installed in a new building on a 700-acre extension of the long-range Post Office radio station at Rugby. Eventually the new building will be surrounded by about 100 aerials of one kind or another radiating telephony and telegraphy signals to all parts of the world on frequencies between 4 and 27.5 Mc/s. About 60 aerials, mostly rhombics, are at present in use; these are multi-wire types and being non-resonant work over a wide range of frequencies. Were resonant aerials employed far more than the 100 legislated for would be needed to maintain the service envisaged for the new extension.

The aerials are connected by open-wire transmission lines to switching units inside the building; these are twin coaxial systems providing complete interchange of connections between transmitters and aerials. There are two such switching units installed, each serving 14 transmitters and giving each transmitter the choice of any one of six different aerials by remote control. On the roof of the transmitting building the twin coaxial feeders are transformer-matched, by four open-wire lines, to the main twin-wire outdoor transmission line systems.

For telephony each transmitter accepts an input on about 3 Mc/s and, by mixing with an internal crystal-controlled oscillator, converts this to the required output frequency. Linear amplifiers are employed throughout with considerable negative feedback and suppression of harmonic and intermodulation components.

When supplied with two separate telephony (or audio) inputs between 100 and 6,000 c/s, the drive equipment provides two independent sideband outputs or, if required, a double sideband output. It is also capable of providing an output of four telephony speech channels 300 to 3,000 c/s wide for operating the main transmitter as a four-channel independent sideband system.

The frequency-shift system is generally favoured for telegraphy whenever suitable facilities exist at the receiving end. The output of this drive unit is on a fixed frequency between 4 and 27.5 Mc/s and can be normal single-channel FSK, single-channel FSK with frequency modulation, two-channel FSK or on-off keying.

Control of all the 28 transmitters is effected from a central operating position taking the form of a curved control desk as shown in the illustration. On it are assembled separate control panels for each transmitter with switches for on-off, monitor, local or distant operation of the transmitters and indicating lamps to give warning of a fault in any of the transmitters.

The transmitters, drive units, aerial switching system and much of the associated equipment were supplied by Marconi's Wireless Telegraph Company and installation was carried out in co-operation with the Post Office.

The heart of the new extension to the G.P.O.'s station at Rugby is shown here. From it the engineers in charge can start up or close down any one of 28 transmitters, monitor their operation and change frequency and aerials by remote control. The transmitting hall is visible in the background.

RANDOM RADIATIONS

By "DIALLIST"

Penny Plain, Tuppence Coloured

A GOOD MANY readers living in the service area of the Alexandra Palace transmitter will probably take the opportunity of seeing something of the B.B.C.'s experimental transmissions of colour television in the autumn. The vast majority of them, I imagine, will have to content themselves with the penny plain version and will only be able to make guesses about the tuppence coloured pictures. But even that is well worth while: for they will be able to discover whether or not the system being tested is genuinely compatible; whether, in other words, the colour transmission gives an acceptable monochrome picture. That's going to be a very important point. We're not far from the time when there'll be 5,000,000 monochrome sets in use in this country and, whatever happens about colour, a good service for them has to be provided for years to come. There'd be an outcry if their owners thought that they were being sacrificed on the altar of colour television.

Making the Change

The number of black-and-white television sets in the homes of this country may well be doubled by the time a completely satisfactory colour system has been developed. And that, I believe, is one of the reasons why neither the B.B.C. nor the I.T.A. are likely to be in any particular hurry to develop it. It's highly improbable that it will be feasible to convert or adapt existing sets for colour; those who want the tuppenny version will have to buy new receivers, which seem likely to be a good deal more costly than those of to-day. Unless, in fact revolutionary new processes of transmission and reception are developed, the stage seems hardly to be set for a boom in colour television. It's much more probable that when good compatible transmissions are regularly on the air a gradual, rather than a spectacular, increase in the number of domestic colour receivers will take place. People will buy them when the time comes to replace their existing sets.

Festina Lente

Hasten slowly is a sound watchword in such matters as the development of colour TV. It's no use, as our good friends on the other side of the Pond have found, going off at half-cock. And I don't think we're in danger of doing that. The P.M.G. won't sanction the adoption of any system until his advisers are completely satisfied that it's the goods; and I'm sure that the B.B.C. and the I.T.A. will be just as hard to please. The radio industry itself provides another staunch safeguard. It certainly wouldn't support the kind of colour television system that could be guaranteed to give passable pictures only if users were prepared to pay £300 for a receiver and to employ a whole-time resident serviceman! Please don't imagine that I want the development of colour TV to be delayed: I certainly don't. But there must be no ifs or buts about the system we launch.

Divis Starts Well

AS I write, there are splendid reports of the coverage disclosed by the initial transmissions from the new Belfast television station at Divis. Reception has been good over a larger area of Northern Ireland than was forecast by the B.B.C., and excellent pictures have been obtained much farther afield than that. In fact, they've left little to be desired in much of the area round Dublin as well as in other parts of Southern Ireland. It's unlikely that Southern Ireland will be able, at all events in the near future, to finance a television service of its own. I don't think, though, that we need worry if some of its folk can pull in the Divis programmes free, gratis and for nothing so far as licence fees are concerned. To do so they'll have to buy receivers made in this country, and that's good business for us. Actually there are already quite a few enthusiasts in that part of the world who have been eager to spend money on rather chancy reception of Wenvoe and Holme Moss. Divis has also been well received in many parts of N.W. England and S.W. Scotland, in which it has hitherto not been possible to rely on getting good, steady pictures from stations on the mainland. Altogether a very satisfactory show, on which all concerned deserve warm congratulations.

A Spot of Bother

RATHER an interesting fault cropped up recently in my television receiver. It had been right up to the mark when previously used; but now, after the usual warming-up period, the brightness of the picture was a good deal below its normal level. As the sound was unaffected and the height and width of the picture were as they should be, it seemed that the h.t. line was beyond suspicion. The picture was clear and steady enough; just dim. Tests disclosed a weak signal at the video amplifier, and, moving forward, the trouble was eventually found to be at the input to the second vision i.f. stage. The cause was, in fact, a defective i.f. transformer. When a new one had been obtained and connected up reception was again as good as ever. The reason why I describe this fault is that the symptoms were rather misleading. More often perhaps than not a poor signal from the video amplifier means an unsteady picture; with maybe line break-up and vertical rolling, the reason being that the sync pulses aren't good enough to take proper charge of the time bases.

Present Help in Time of Trouble

IT'S a bit surprising, I think, that dealers and service technicians don't make more general use of the oscilloscope. Many of them, of course, are fully cognisant of its virtues as an aid both to fault-finding and to correct alignment; but there are lots who never give it a thought. Simple oscilloscopes suitable for the jobs in question aren't all that expensive. It certainly takes a bit of practice and of common sense to use them effectively; but this instrument does so speed up the work, once its use has become familiar, that I'm sure it must quickly pay for itself in a busy repair shop. Myself, I wouldn't care to undertake the job of lining up the superhet stages of a high-quality sound or television receiver without being able to see what's going on by means of the oscilloscope screen. Perhaps the coming of v.h.f. sound broadcasting with frequency modulation will give the oscilloscope a boost, for it's the most reliable of all means of checking up f.m. receivers.

Lining 'em Up

THE South Wales Electricity Board is to spend a tidy bit of money during the next 18 months on getting rid of d.c. supplies and standardizing those that are already a.c. but with some odd voltage or frequency. I only hope that other Boards will take a leaf out of their book. It's a job that should be pressed forward, for the different forms of mains power supply now still often to be found in the same town—or even on different sides of the same street—are more than a nuisance to domestic and other users. If, for instance, you come to move house, you may well find that quite a number of your existing appliances won't be of any use in the new abode.

UNBIASED

By FREE GRID

A New Menace

WE are, I hope, all trying hard nowadays to avoid causing interference to radio reception and to that end have fitted suppressors to all electrical apparatus under our control. I have long ago put my own house in order in this respect but Mrs. Free Grid arrived home recently from one of her infernal shopping expeditions with an entirely new piece of electrical apparatus which has so far defied all my efforts to suppress it. I am wondering, therefore, if any of you with specialized technical knowledge in the matter of suppression can let me have a word of advice.

The apparatus calls itself a magnetic broom and claims quite rightly that unlike ordinary brooms it does not raise a cloud of dust when you use it, as the polystyrene bristles become electrified by friction with the carpet or floor. All dust particles thus cling to the bristles. Its very virtues are its greatest drawback from the point of view of listeners and lookers as the friction between bristles and carpet, which brings into being the static charge, causes an inferno of crackles and snowstorms. I have tried earthing the bristles but this merely converts the sweeper into an ordinary broom. Is there any solution at all?—beyond the obvious one, of course.

Communal TV Aerials

ANYONE taking a train from any of the great London termini cannot help being struck by the large and ever-increasing number of TV aerials that adorn the chimney pots. As the train gets farther afield and passes through country towns the number of elements on each aerial steadily increases until the skyline of distant towns seems ornamented with a lot of elevated xylophones.

When taking such a journey the other day I could not help wondering whether some of the xylophone owners would not have laid out their money to better advantage if they had invested in a really tall mast instead of in a family of directors. Here and there I did notice that somebody had been thinking on somewhat the same lines as myself and had put their ideas into practice; I'll warrant that such people get better reception than do their xylophonic neighbours.

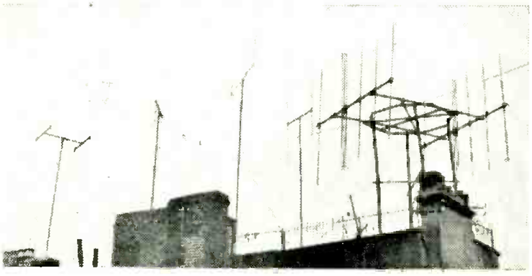
However, a tall mast needs careful staying and if everybody erected one the general effect would be far from beautiful. At the same time, if TV aerials continue to grow at their present rate the skyline of a densely populated district will look even uglier than it does to-day.

I have been wondering, therefore, if it would not be possible for streets to co-operate as they did for fire-watching during the war and contribute to the erection of a really high and well-stayed mast to carry a communal aerial which would feed signals to subscribing houses by means of a coaxial cable.

An aerial pre-amplifier would, of course, be needed and possibly others at intervals along the distribution cable.

The mast could carry aerial arrays for B.B.C. and I.T.A. television and also for f.m. The advantage of such an arrangement would be increased signal strength, greater freedom from interference and greater beauty of skyline. Also the cost of maintaining the mast and aerial arrays would work out less per subscriber than the present cost of keeping individual aerials up to the mark.

I quite expect to be told that this is already done in some areas; in fact, the other day I noticed a TV mast towering above a building outside Wandsworth Town station which was such a fine piece of work that I suspect it to be a communal effort.



Could anything be uglier?

Hi-Fi-Li

A CORRESPONDENT has sent me a copy of the Toronto *Telegram* in which appears an advertisement for what is called Hi-Fi make-up. I can only suppose that the vendors of this cosmetic or the composers of their advertisement have no knowledge of feminine psychology.

Hi-Fi in radio, or anything else, virtually means "the same as the original" or at any rate a close approach to the original. Therefore the girl who uses this cosmetic may expect to look as Nature made her; a thought which would send a shudder through even the most tempting torso. Surely, the whole object of using cosmetics is to make some improvement upon Nature's handiwork, or in other words to obtain a result which is as lo-fi as possible.

Improving upon Nature!

Have the people responsible for this advertisement never heard that—

"A little touch of powder,
A little dab of paint,
Can make the female features
Look like what they ain't"?

As Others See Us

DURING May I took the opportunity of visiting the "Photo Fair" not so much because of an interest in photography as to see how another great industry went to work in putting itself over to its customers, and to find out if we radio people could pick up a few valuable ideas.

I took Mrs. Free Grid along as she and people like her with their "snaps" of repulsive-looking people on the beach or in the garden and of babies in their baths are the very backbone of the photographic industry. Their cameras are only in the crystal-set class and yet they use more films and paper and so bring more grist to the mills of the big photographic manufacturers than do the owners of the lordly Leica and such-like instruments.

To my astonishment this numerically great class of prosperity-bringers was almost totally ignored by the exhibition. It made me wonder if we are making a similar mistake at the annual radio show. Honestly I don't think we are, for at Earls Court is to be found the true democratic spirit with something for all the listening and looking public. Nobody is ignored, but all the same I should like to read a photographer's criticism of the Radio Show.