Wireless World

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Second Thoughts on Television Distribution

COMPETITION in the distribution of programmes by television has been decided by democratic processes to be a good thing, and, anyway, it is no business of ours to discuss it. But competition in the technical distribution of television signals now appears to be not so good, and to make some of the natural and inevitable problems even more difficult. Rugged individualism in the choice of station sites may work well in the wide open spaces of the United States, but there is less scope for it in these small islands.

When it was first proposed last summer that the Independent Television Authority should share the B.B.C.'s masts, the idea was hailed by everyone (not excluding this journal) as technically an excellent one. A more detailed consideration of the problem now shows we were over-optimistic in thinking that co-siting of B.B.C. and I.T.A. stations would provide a solution of all the problems and would at the same time ensure an early start of the new service. As an article on another page of this issue will show, the projected Band III transmitters of the I.T.A. are not necessarily good neighbours of the existing Band I stations. Sites that are best for high-power stations working at some 50 or 60 Mc/s may be far from ideal for transmitters of necessarily lower radiated power operating at a frequency nearly four times greater. Indeed, we have in the Holme Moss station an example of highly successful siting for a Band I transmitter that would be a very bad choice for Band III.

Apart from factors arising out of the different propagation characteristics of the two bands, it now appears that insufficient thought was given to purely mechanical considerations when the idea of shared masts was first mooted. Is there sufficient space on the "standard" B.B.C. masts to support a multi-element Band III aerial of the high gain that is now thought to be essential? And, even if room could be found, would the windage of such an aerial be greater than that which the masts were designed to withstand?

In planning a Band III service for this country, we are still working very largely in the dark, from insufficient and sometimes irrelevant data. Such data as is available from the United States and the Continent relates to horizontally polarized transmissions with negative modulation. Some of the gaps in our practical knowledge will no doubt be filled in when the Belling-Lee experimental station on the I.T.A. London site starts to radiate a test pattern in April.

The original proposal that the B.B.C. should allow its competitors to share its television masts has always seemed mildly Gilbertian. But even more Gilbertian is the situation that would seemingly now arise if the best engineering principles are to be followed: the position should be reversed, and the B.B.C. should seek the hospitality of the I.T.A. for siting its projected Band III transmitters! We will leave this delicate matter by saying there seems to be a moral somewhere in favour of an integrated distribution service.

Receiver Oscillator Radiation

THE need for integration, discussed in the preceding paragraphs in relation to television transmission, spreads through the whole field of broadcasting, and, of course, affects receiver design. A case in point is the standardization of intermediate frequency for television receivers, recently agreed upon by the industry.

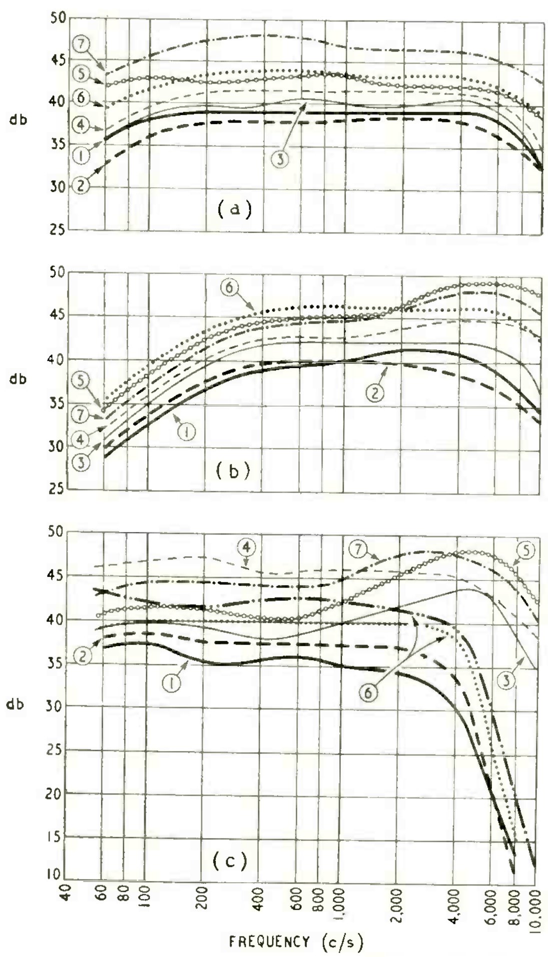
Our sister journal, *Wireless Engineer,* commenting in considerable detail on this matter in the February issue, makes the point that the choice of i.f. decided upon will give only full immunity from interference due to oscillator radiation if transmitter station channels are carefully allocated geographically. With the present uncertain position on Band III, coupled with the shortage of available channels, this is likely to be a problem of some difficulty.

The *Wireless Engineer* editorial also stresses the possibility of interference in both directions between television and f.m. sound receivers. Here prevention lies partly in the proper geographical allocation of transmitting channels and partly in the hands of receiver designers.

Does the Tape Characteristic Matter?

MOST manufacturers of tape recorders specify a given brand of tape for use with their machines. If a tape has a "characteristic" (and there can be no denying that the ratio of coercivity to remanence determines the self-demagnetizing effect and the available induction at high frequencies) this seems a not unreasonable precaution. Other factors affecting the combined performance of tape and machine could be the design of the heads and the degree of penetration of flux into the tape coating.

The results of some measurements of seven brands of tape on three different makes of recorder by Dr. Ing. M. Ulner, of the Technical University of Berlin, published in the Spanish journal *Electronica* (December, 1954) provide a useful starting point for speculation on the relative merits of tapes and machines. In reproducing these curves the machines have been labelled (a) (b) and (c) and the makes of tape are given numbers.



Courtesy *Electronica*

Clearly the different low-frequency responses are qualities of the machines and the high-frequency variations are caused by the tapes. The transposition of some of the curves on a sensitivity basis may be due to differences in the levels of the individual specimens used, but this does not explain the jump of tape 4 from fourth place on machines (a) and (b) to first place on (c) for which, incidentally, it was recommended by the makers.

If the evidence of the group of curves in (a) is to be believed, the machine is dominant and the make of tape of secondary importance. Why then does the performance at high frequencies vary so widely on machine (c), and to a lesser degree on machine (b)? One possibility is that variations of the mechanical properties of the tape (curling, flexibility, etc.) may contribute conflicting modifications of the output in the form of modulation noise and reduced sensitivity, and that these are ironed out in machine (a) by more efficient pressure pads.

Of one thing we can be sure: there is still much to be learned about "the way of a tape in a recorder" and that until more evidence of this kind is presented it is foolhardy to attempt sweeping generalizations. Nevertheless we will step in to the extent of countering the question at the head of this note with the qualification that "it depends on the machine," and of adding a rider to the effect that if a figure of merit is ever evolved it should include the mechanical as well as the magnetic qualities of the tape.

"Hansard" Magnetic Recorder

THE House of Assembly of West Nigeria will shortly have one of the most up-to-date systems for reporting the debates and the proceedings of the legislative body. As the most highly skilled shorthand writer might find it difficult to cope with the various languages and dialects employed, the Crown Agents have decided to install magnetic tape recorders.

Essential requirements of a system for a purpose like this are compactness, reliability, unskilled operation, flexibility and ease of maintenance. Equipment to meet these special needs has been designed and built by E.M.I.

A single console houses all the control equipment and the amplifiers. On the control desk are seven microphone switches positioned on an outline plan of the floor of the House and corresponding to the location of seven fixed microphones. Five spare microphone inputs are also provided to meet future needs.

The control operator, watching through a window of the soundproof room, switches on the appropriate microphone whenever a member of the Assembly rises to speak. Mixing the various microphone outputs and the control of volume are entirely automatic. Each microphone has a separate amplifier and these are mounted in a form of rack, with quick-release fittings for ease of servicing, which is assembled into one of the cubicles of the control console. From this console the speech signals go to 12 headphone sets in the Press gallery, each with a separate volume control, and also to four E.M.I. type TR50 tape recorders in a separate room, and each gives one hour's recording per reel of tape.

More About RADIO TRAINING

Technical Schools : Further Education : Specialization

In this article an official of the Ministry of Education criticizes Francis Reece's contribution "Education and Training" published in our January issue. He also outlines the plans being made to reduce the number of students who do not complete the long telecommunications courses

"CAN we be satisfied with the results achieved by our present method of technical education?" was the question posed by Francis Reece at the end of his article. Whilst there is rightly much cause for concern about the shortage of technical manpower in the radio industry the general picture is not as black as that painted in the article, which, incidentally, included a number of somewhat misleading statements.

General Education.—From the secondary modern schools the radio industry can expect to recruit its unskilled labour, a high proportion of its potential craftsmen and a large number of trainee technicians, but, contrary to Mr. Reece's claim, it will not get "many of its engineers of the future" from this source. It is the exceptional boy from the modern school who will ultimately achieve professional engineer status, through a technical college or a training scheme operated by a firm. The curricula of secondary modern schools are designed primarily for the greatest educational good of the greatest number. This rules out a policy which would make "the General Certificate of Education even in two or three subjects" a general objective for such schools. The question of suitable examinations for those leaving the modern school is being widely discussed, and some schools have instituted an extra year with, in some cases, the G.C.E. as the objective. But these are, in general, schools in large urban areas, recruiting into this final year selected children from a number of schools. This is not a solution having wide application, and the existence of only a small number of such schools is not "a deplorable fact," as Mr. Reece states, but a sober admission of what is reasonable and practicable for the type of child concerned. The best solution of the problem as it affects the radio industry will probably be the wider provision of secondary technical schools—which is proceeding—and a greater use of the mechanism of transfer between the different types of secondary school.

The secondary technical school is underrated by Mr. Reece. Almost all its students may be expected to obtain employment as trainees for skilled technical jobs in industry. Many will become craftsmen; a high proportion will qualify for technicians' posts; and the best—not just the odd one or two, but a good number—should ultimately reach professional engineer standard. On leaving a secondary technical school at 16 a boy may enter directly into the first year of the National Certificate course, whereas the ex-secondary modern school boy has to qualify for entry by taking a one- or two-year course of part-time study. Further, recommended ex-secondary technical school boys who have remained at school for a further year may enter directly into the second year of a National Certificate course, a privilege otherwise reserved for ex-secondary grammar school boys with G.C.E. Ordinary Level passes in four subjects, including mathematics and a relevant science subject.

Although, as Mr. Reece says, figures showing how many grammar school boys enter the engineering profession are not available, one very large engineering concern has given the following analysis of its craft and engineering apprentice entry. From grammar schools, 70 per cent; from technical schools, 17 per cent; from modern schools, 13 per cent. Several major engineering firms are now restricting their intake of engineering apprentices—as distinct from craft apprentices—to ex-grammar and ex-technical school boys.

Further Education.—Entrants to the radio industry may follow part-time courses leading to the various certificates in telecommunications engineering of the City and Guilds of London Institute; or they may aim at the Graduateship of the British Institution of Radio Engineers; or they may attempt the Ordinary National Certificate course in electrical engineering, followed by the Higher National Certificate course. After further study, these last students may satisfy the examination requirements for Associate Membership of the Institution of Electrical Engineers.

The figures quoted by Mr. Reece concerning these examinations are rather misleading. The "30,000 candidates" for City and Guilds Certificates should be "30,000 subject-entries." As most candidates take two or three subjects at each examination, the actual number of candidates concerned is about 12,000. Despite the high rate of failure of overseas candidates, and of those who enter without organized preparation, over 60 per cent of the 30,000 subject-entrants pass. Over three-quarters of these entries are from students taking first- and second-year subjects; and of these about 70 per cent are employees of the General Post Office, seeking to obtain the lowest qualification the G.P.O. expects of them. For many it may possibly be the maximum; for in the third year, the standard rises sharply, with a view to providing a course suitable in standard for those wishing to qualify for higher-grade employment. Many of the City and Guilds candidates taking fourth- and fifth-year subjects are university graduates in physics or electrical engineering who, having entered the radio industry, take a single-subject course as a suitable way of obtaining, fairly quickly, a knowledge of the subject in which they are going to specialize. They do not qualify for Final or Full Technological Certificates. Thus to compare the 88 who obtained a Full Technological Certificate in 1953 (67 in radio) with the 30,000 subject-entries is to ignore the fact that the vast majority of the entrants do not have the Full Technological Certificate as their objective. Indeed, relatively few are concerned with grouped course certificates at all.

Similarly, the 1,000 entries quoted for the Brit.I.R.E. examination refer to individuals taking any part of the examination, and not to those who are taking the whole examination, or such parts as, if passed, would complete the whole.

Further, both the C. & G. and Brit.I.R.E. examinations suffer from the disadvantage that they may be taken without attendance at specific courses. This inevitably leads to many hopeless entries.

Candidates for National Certificates, on the other hand, must have satisfied specific requirements in respect of attendance, classwork and homework, as well as laboratory work, before being permitted to take the examination. About 50 per cent who take the O.N.C. examination in a given year pass it; the corresponding figure for the H.N.C. is over 70 per cent. Of those at present achieving the Graduateship of the I.E.E. some 40 per cent are university graduates; and only 8 per cent qualify through the Institution's own examination.

Mr. Reece complains that few technical colleges offer Higher National Certificate courses including radio subjects, and quotes the 1950 figure of 20. This number is now 46; and this does not include those colleges providing courses which, although not specifically for radio engineers, have a considerable light current content which has to be taken by all students, whether "light" or "heavy." Also, many colleges offer electronics as an extra, either in the Higher National Certificate year, or subsequently. One cannot help wondering whether Mr. Reece's information on teachers and equipment also relates to 1950.

Reference is made to the alleged reluctance of technical colleges to provide suitable courses for radio trainees. Where a reasonable demand exists, and there is evidence that a "flow" of students can be maintained, principals of technical colleges are invariably willing to provide courses. Because of the importance of radio and electronics to our national economy and to defence, considerable latitude has been permitted to colleges in respect of small classes. In fact, if rigid considerations of economy were insisted upon, many radio and electronics classes up and down the country would be closed.

Degrees of Specialization.—Occasionally one finds that complaints of lack of special provision arise because of the impossibility of arranging in groups of economic size separate classes for those who favour early specialization, as in the City and Guilds courses, and also for those who favour a broader basis of electrical engineering, such as is provided in Ordinary National Certificate (Electrical Engineering) courses, with later specialization. The greater numbers of students are usually those wanting National Certificates; those students preferring early specialization must therefore either rest content with the National Certificate course or make arrangements to go to a neighbouring college where numbers make separate classes possible. All technical colleges cannot be all things to all men.

Mr. Reece asks if the examining bodies demand too high a standard. At one time the only way to professional engineer status was through the university. If the engineers of this country are to retain their international standing it would be unwise to reduce the standard of academic attainment in electrical subjects to below about degree level; and a comparable standard in scientific and mathematical studies is surely essential also. Hence it would appear that the Higher National Certificate course followed by those post-H.N.C. studies necessary to fulfil the I.E.E. requirements is not too high a standard to demand, if the prestige of British radio engineering qualifications is to be maintained.

The Brit.I.R.E. examinations and those of the City and Guilds both involve earlier specialization. Both reach high standards in their specialist subjects, but neither requires the stringent attendance, classwork, homework, and laboratory conditions of the National Certificate course. An examination of the advertisements for engineers in radio journals will show that most firms ask for university degrees; the commonest other qualification specified is the Higher National Certificate. This may, perhaps, indicate that employers value a qualification which implies five years of supervised and directed study more highly than others which, however high their examination standards, do not.

Mr. Reece refers to the "various bodies reconciling their differences of opinions" and suggests that if they did technical colleges would be helped in the arrangement of their courses. The advocates of early specialization, namely, the City and Guilds and the Brit.I.R.E., are sufficiently agreed for it to be possible for common courses leading to both qualifications to be organized, as is done in some colleges. The National Certificate course does not permit of early specialization. The difference here is fundamental, and a compromise appears unlikely—except perhaps in the first year. The question of whether or not early specialization is desirable is one on which opinions may reasonably differ, and it is therefore a good thing that the choice exists.

Future Development.—Although the general picture is rather brighter than Mr. Reece's article would make it appear, there is much cause for concern in the "wastage" which occurs in the courses referred to above. Whilst the examination results are reasonably good, a high proportion of the young entrants do not get as far as attempting the examinations. One reason for this is that the National Certificate and the City and Guilds courses go too far and too fast for some students; and there is as yet no less ambitious alternative. A committee representative of the interests concerned—such as Mr. Reece suggests—has existed for some time and is planning courses specifically for electrical technicians; that is, there will be no attempt to make the first three years equally suitable for both technicians and would-be professional engineers. It is possible that the first year of the technicians' courses will be similar to that of the National Certificate course so that students may progress up whichever ladder seems more appropriate in the light of their initial performance. A measure of specialization may be introduced into the technicians' courses earlier than in N.C. courses.

Another committee, acting in co-operation with the first, is considering the structure of the present City and Guilds telecommunications courses with a view to providing in the earlier years a technicians' course less arduous than the present one, whilst maintaining in later years an adequate selection of specialist and more advanced studies. The existence of these easier courses, less exacting academically than present ones, may help to close a gap in the present system. Transfers between National Certificate and these new courses may be possible at certain levels and this arrangement may do much to reduce the present "wastage." It is not possible to say when the new courses may come into being, for it is more important to get a right solution than a quick one.

WORLD OF WIRELESS

Balance of Trade • Writing Prizes • Television News

Growing Exports

LAST year's direct exports of British radio equipment were valued at over £30M—an increase of more than 12 per cent on the 1953 figure.

Two-fifths of the total (over £12.6M) came from the export of capital goods—transmitters, navigational aids and industrial electronics—an increase of over £1.4M during the year. Incidentally, the direct exports of capital goods in 1946 totalled only one million pounds. The value of last year's indirect exports, such as installations in ships and aircraft built in this country for eventual export, is estimated at £5M.

Exports of components increased from £5.3M to £6.8M, batteries and accumulators for radio from £1,6M to £2.4M and sound recording and reproducing equipment from £2.7M to £3.3M.

The receiver and valve sections of the industry again showed decreases; receivers from £3.9M to £2.6M and valves and c.r. tubes by £80,000 to £2,113,210. There was, moreover, an adverse balance of trade on valves and tubes; imports totalled £3.3M, an increase of over £1.4M during the year. Imports of all radio equipment, components and accessories totalled £7.9M compared with £5M the previous year.

Encouraging Technical Writers

THREE years ago the Radio Industry Council introduced a scheme to award annual premiums of 25 guineas each to encourage the writing for the public technical press of technical articles deserving of commendation by the radio industry. The panel of judges, now headed by Professor H. E. M. Barlow, has commended nine articles published in 1954. For the purpose of the awards some of the articles have been grouped together as they cover similar subjects.

Two premiums are to be shared by J. M. M. Pinkerton, E. J. Kaye, E. H. Lenaerts and G. R. Gibbs for three articles on LEO: Lyons' Electronic Office, which appeared in the July, August and September issues of *Electronic Engineering*. For his *Wireless World* articles on i.f. amplifiers (February and December) H. S. Jewitt receives a premium, as does A. E. Maine for two articles on high-speed magnetic amplifiers in *Electronic Engineering* (May and December). J. F. Field and D. H. Towns receive 25 guineas for their article "A Torquemeter for Testing Gas Turbine Components" (*Electronic Engineering*, November and December), and W. R. Cass and R. M. Hadfield jointly receive a premium for their article "Dip-Soldered Chassis Production" which appeared in *Wireless World* last November.

The premiums will be presented to the authors at a luncheon in London on March 10th.

Our contemporary *Research* is again organizing a "Science in Industry" essay competition to encourage scientists and technologists to take greater interest in the problem of presenting results of research work to the industrialist and the general public. Details of the competition, which is in two parts and includes awards totalling £350, are obtainable from *Research*, 436, Strand, London, W.C.2.

Television Developments

AN order has now been placed by the B.B.C. for the aerial arrays for the new London television station at the Crystal Palace. It will consist of two arrays of four bays each, with a branch feeder system. The complete aerial has 32 dipoles.

There will be two main transmission lines having outer conductors of 5in diameter. Each line will carry the combined outputs from a 15-kW vision transmitter and a 4.5-kW sound transmitter to half the aerial. If one transmitter develops a fault the station will continue to operate at reduced power.

The aerials, transmission lines, transmitters and control and monitoring equipment are being supplied by Marconi's.

Sir George Barnes, speaking at Birmingham recently, said that test transmissions on various colour television systems will be conducted by the B.B.C. this year. It is thought that the system most likely to be finally adopted will be a scaled-down version of the American N.T.S.C. system, such as that demonstrated by Marconi's last year. This uses the existing black-and-white signal with a sub-carrier of 2.66 Mc/s which is modulated by two colour-information signals in phase quadrature, one occupying a bandwidth of 1 Mc/s and the other about 0.4 Mc/s.

European V.H.F. Broadcasting

ACCORDING to figures issued by the European Broadcasting Union there were, in Europe, at the beginning of the year, 69 television stations and 177 sound broadcasting stations operating in Bands I, II and III. The distribution of the stations in the European broadcasting area is given below.

	Television Band I	Television Band III	Sound Band II
Austria	—	—	10
Belgium	2	2	1
Denmark	1	—	2
Finland	—	—	17
France	1	5	1
German Federal Republic	2	23	114
Israel	—	—	7
Italy	2	7	14
Monaco	—	1	—
Morocco	—	2	—
Netherlands	1	1	3
Norway	1	—	1
Saar	1	—	1
Sweden	1	1	1
Switzerland	2	1	1
United Kingdom ...	12	—	2
Vatican State	—	—	2
	26	43	177

During the last six months of 1953 the number of stations in Bands I, II and II increased by 53, 10 and 30 per cent. respectively.

Components on Show

ADMISSION to this year's Components Show, to be held at Grosvenor House, Park Lane, London, W.1, from April 19th to 21st, is restricted to holders of an official badge, issued only to eligible applicants who have previously filled in an application card.

The exhibition, at which there will be the record number of 142 exhibitors, is intended primarily for engineers and technicians in all the "user" industries and the Services. The list of those eligible for admission covers research and education and the manufacturing, wholesale (not retail) and export sides of the radio and electronic industries.

Application cards can be obtained by written request to the organizers, the Radio and Electronic Component Manufacturers' Federation, 22, Surrey Street, Strand, London, W.C.2.

PERSONALITIES

H.R.H. the Duke of Edinburgh has accepted the invitation of the Institution of Electrical Engineers to become an honorary member. Only once in three years is honorary membership granted to a distinguished person who is not a member of the institution.

Colonel G. W. Raby, C.B.E., M.Brit.I.R.E., has been appointed deputy director (engineering) to the research group of the Atomic Energy Authority at Harwell, of which Sir John Cockcroft is director. In 1941 Col. Raby was attached to the Ministry of Supply and as superintendent engineer assisted in the development of radar. He was later appointed chief superintendent of the Signals Research and Development Establishments at Christchurch and Woolwich.

Dr. A. R. A. Rendall, Ph.D., B.Sc., M.I.E.E., has joined the editorial advisory board of our sister journal *Wireless Engineer* in succession to **P. A. T. Bevan** who was the B.B.C. representative on the board until his appointment as chief engineer of the Independent Television Authority. Dr. Rendall, who joined the B.B.C. Lines Department in 1935, has been head of the Designs Department since 1950. Before joining the B.B.C. he was a development engineer with Standard Telephones and Cables. Other members of the board are Prof. E. B. Moullin (Cambridge University), A. H. Mumford (G.P.O.) and Dr. R. L. Smith-Rose (D.S.I.R).

W A. Turner, B.Sc., M.I.E.E., principal of the school of electronics which the Automatic Telephone and Electric Co. is establishing at Liverpool, has been head of the Electrical Engineering Department, Brighton Technical College, since 1951. He received his technical training with the B.T-H. company. From 1940-43 he was deputy head of the Services Training Department at the Rugby College of Technology and has also been a lecturer at Burnley Municipal College and Northampton Polytechnic, London.

E. N. B. Hammond, engineer-in-charge of the Norwich Home Service transmitter since 1950, is also to be responsible for the new East Anglian television transmitter. The temporary transmitter at Tacolneston, which was brought into service recently, will be replaced by a permanent 5-kW transmitter next year. Mr. Hammond was engineer-in-charge of the Home Service transmitter at Clevedon, near Bristol, from 1943-47, and had previously served as a maintenance engineer at a number of other stations since joining the B.B.C. in 1934.

K. E. Harris, Cossor's director of development, is visiting the U.S.A. at the invitation of the American Air Navigation Development Board and the Airlines Electronic Engineering Committee to discuss airborne navigation and traffic control equipment. His itinerary includes New York, Washington, Indianapolis, Chicago, and—across the Canadian border—Ottawa and Montreal.

R. H. Kelsall, B.Sc.(Eng.), Grad.I.E.E., who joined Metrovick as a college apprentice in 1939 after graduation at Manchester University, has been appointed assistant chief electrical engineer of the company's Electronic Control Department. From 1943 to 1946 he served as an electrical officer in the R.N.V.R. and after completing his training with Metrovick he joined, in 1947, the department of which he now becomes assistant chief electrical engineer.

OUR AUTHORS

O. E. Dzierzynski, contributor of the article on page 141, graduated at Warsaw Polytechnic school and was later in charge of the radio remote control section of the Institute of Telecommunications, Warsaw. He came to this country in 1939 and joined B. I. Callender's Cables condenser factory, after which he became a lecturer in radio servicing at the Polish training centres in Scotland. He has latterly been working with Sargrove Electronics and Grundig as designer of electronic measuring apparatus.

K. O. Beauchamp, who writes on spurious line scan resonances in this issue, has been on the staff of the G.E.C. television laboratory at Coventry since 1947. During the war he was a wireless mechanic in the R.A.F. and on coming out of the Service took the course for the City and Guilds Full Technological Certificate at the Coventry Technical College, where he is now teaching the C. & G. "Radio IV" class in the evenings. He is 31.

OBITUARY

Frank Murphy, who, in 1929, was co-founder with E. J. Power (the present chairman and managing director), of Murphy Radio, died in Toronto on January 26th at the age of 65. In 1936 he severed his association with Murphy Radio, of which he was managing director, and in recent years lived in Canada, where he had a business and did some lecturing. The news of his death was telegraphed to us by P. G. A. H. Voigt, now resident in Canada.

IN BRIEF

Sweden is to erect a network of Decca Navigator stations—a master and three slaves in the usual "star" formation. The stations will be brought into service next year. Six chains—three in this country and one each in France, Germany and Denmark—are already in operation; another is planned for the south of France and yet another to cover the Orkney, Shetland and Faroe area.

Submerged Repeaters for the recently laid Aberdeen-Bergen submarine coaxial cable were built and tested at the new North Woolwich factory of Standard Telephones and Cables. A brief description of them appeared in "Transatlantic Telephone Cable" in our January issue (p. 40).

Standard Sizes for "manufacturers' trade and technical literature" are laid down in B.S.1311:1955 which the British Standards Institution has issued (price 2s 6d). It is designed to facilitate the handling of instruction sheets issued by sub-contractors and suppliers of equipment and also the filing of catalogues, brochures and pamphlets.

Airborne Radar Research.—Pershore Airfield, Worcestershire, has been taken over by the Ministry of Supply for radar research. It will be used by the Radar Research Establishment for the flight testing of radar equipment.

Closed-circuit television demonstrations were provided by British manufacturers during the four-day radio and electrical exhibition held at Kampala, Uganda, at the end of January. It was organized by the recently formed Uganda Radio and Electrical Traders' Association.

Railway Radio.—According to the latest available figures the American railways are operating some 15,000 radio stations—four times as many as were in use four years ago—and nearly 2,000 carrier-telephone installations. Incidentally, the only mention of the use of radio in the British Transport Commission's report on the modernization and re-equipment of this country's railways is an oblique one—"The existing telecommunication and telephone systems must be considerably modernized and advantage taken of all available developments in telecommunications."

University Within Industry.—The five-year sandwich course now provided by the General Electric Co. in conjunction with the Birmingham College of Technology is described in the company's brochure "Professional Training in the G.E.C." as a university within industry. Designed for boys leaving public and grammar schools, it provides alternate six-monthly sessions at college and works with integrated training for an engineering diploma. College fees are met by the company and students receive a subsistence allowance during the course. The brochure, which also outlines training schemes for graduates, is available from the Education and Personnel Services, G.E.C., Magnet House, Kingsway, London, W.C.2.

End-of-the-year figures for sound and television **Receiver Production in Canada,** quoted by a correspondent of the *Financial Times*, show that 22 per cent of Canadian homes have television and 96 per cent sound receivers. With the opening of 19 new television stations, making 24 in all (seven C.B.C. and 17 privately owned) the percentage of television equipped homes doubled during last year. The percentages of homes having refrigerators, telephones and cars are 71, 69 and 55 respectively. Canada's 23 receiver manufacturers produced 612,000 television sets and 450,000 sound receivers last year.

Cumulative Figures for the production and sales of equipment during the nine years of television in the States are given in the 20th semi-annual edition of "Television Factbook." Retail sales of sets are valued at $9,000 M, components and aerials $1,500 M, tube replacements $435 M and valve replacements $518 M. It is estimated that $2,000 M has been spent on television servicing during the nine years. The 33,500,000 sets now being used by American viewers are estimated to represent an aggregate cost of $13,500 M.

Automatic Computing.—A summer school in programme design for automatic digital computors will again be held in the University mathematical laboratory at Cambridge from September 12th to 23rd. A detailed syllabus and form of application for admission may be obtained from G. F. Hickson, secretary of the Board of Extra-mural Studies, Stuart House, Cambridge.

Diversity of interest is the key-note of the 1955 **National Convention** of the American Institute of Radio Engineers, which is being held in New York from March 21st to 24th. Among the subjects to be covered by the 250 papers being presented are instrumentation, telemetering, nucleonics, ultrasonics, industrial and medical electronics, colour and monochrome TV and aerials and propagation.

The **Golden Jubilee** of the Electrical Industries' Benevolent Association will be celebrated at a luncheon in the Connaught Rooms, London, W.C.2, on April 19th. Tickets, price 1 guinea, are obtainable from the E.I.B.A., 32, Old Burlington Street, London, W.1.

R.C.E.E.A. Council.—At the annual general meeting of the Radio Communication and Electronic Engineering Association on January 28th the council was re-elected. The member-firms and, in parentheses, their representatives forming the council, are: B.T-H. (V. M. Roberts), Decca Radar (C. H. T. Johnson), E.M.I. (S. J. Preston), G.E.C. (M. M. Macqueen), Kelvin & Hughes (C. G. White), Marconi's (F. S. Mockford), Metrovick (L. H. J. Phillips), Mullard (T. E. Goldup), Murphy (K. S. Davies), Plessey (P. D. Canning), Redifon (B. St. J. Sadler) and S.T.C. (L. J. I. Nickels). The new chairman and vice-chairman are S. J. Preston and C. H. T. Johnson, respectively.

The **Soviet Union** now has six television stations—Moscow, Leningrad, Kiev, Riga, Kharkov and Omsk—according to *Soviet News*. Transmitters are also being erected at Tallinn, Baku, Tashkent, Minsk and Sverdlovsk. A booster station—the first in the U.S.S.R.—has been brought into operation at Kalinin which receives and re-radiates the Moscow transmissions.

THE LATEST in the series of engravings of "Great Men of Telecommunications" which has been published by the Internationa Telecommunication Union over the past 20 years is this one of Edwin H. Armstrong, the pioneer of frequency modulation. Measuring approximately 6in × 9in the engraving costs 3 Swiss francs and is obtainable from the I.T.U., Palais Wilson, 52, rue des Pâquis, Geneva.

Three experimental v.h.f. stations have been used by the **British Forces' Network** in Germany for some time. Now a chain of ten stations is to be brought into regular service. The first of these were opened on February 1st at Langenberg and Bonn, operating respectively on 89.1 Mc/s and 96.55 Mc/s with effective radiated powers of 60 and 3 kW. The six medium-wave stations operating on 1,214 and 1,367 kc/s at present used for the service will eventually close down.

The television service of the six broadcasting organizations in **Western Germany** are now co-ordinated. Approximately 60 per cent of West Germany's population is within the service areas of the 22 transmitters which are linked by radio.

The production of 21in **Tri-Colour Tubes** at the rate of 100 a day is announced by R.C.A. The price to set manufacturers is $175, the same as that charged for the 15in colour tube.

Instrumentation.—The third British Instrument Industries' Exhibition will be held at Earls Court from June 28th to July 9th. The Scientific Instrument Manufacurers' Association is one of the five organizations sponsoring the exhibition.

R

Snow-plough Radio.—A plan for four snow-ploughs to be fitted with radio-telephones has been approved by the Inverness-shire County Council. They will operate on the main North Road between Perth and Inverness with the control centre at Dalwhinnie.

TV and Crime.—We learn from our German contemporary *Radio Mentor* that the Dortmund police are conducting experiments with television equipment installed in patrol cars. The transmitter is installed in the police headquarters.

Transistor Bibliography.—A ten-year bibliography of semi-conducting materials and transistors including nearly 1,200 references has been prepared by N. L. Meyrick and G. Roman of the Research Department of Pye, Ltd., Cambridge. A limited number of copies are available from Pye Industrial Electronics, Ltd., of Exning Road, Newmarket, the recently formed subsidiary engaged in the manufacture of transistors.

BUSINESS NOTES

E.M.I. Electronics, Ltd., is the new title adopted by Emitron Television, Ltd. It will be concerned with the design, development and marketing of the E.M.I. group's electronic devices, other than those for the Government, and television equipment, including film scanners, microwave links, transmitting tubes, etc. It will control and co-ordinate the activities of three subsidiary companies—E.M.I. Engineering Development, E.M.I. Factories and E.M.I. Research Laboratories.

Resin Cast Transformers and chokes, which Ferranti have been developing in Edinburgh for some considerable time, have now received a Limited Type Approval Certificate from the Radio Components Standardization Committee. This range of resin cast components, which has been named the Pentland series, is stated to withstand temperatures considerably beyond the range of −40° to 110°C specified by the Services

A new grade of **P.V.C. Compound** is now being used by Associated Technical Manufacturers, Ltd., of Vincent Works, New Islington, Manchester, in the manufacture of Permanoid Grade VO insulated wire and sleeving. Diolplated p.v.c. retains its flexibility and does not suffer from "embrittlement" at temperatures ranging from −35° to 150°C.

Products of **Rothermel, Ltd.,** have been manufactured at the works of N.S.F., Ltd., at Keighley, Yorks, for some time and we learn that it has now been decided to integrate the activities of the two companies under N.S.F., Ltd. The head office of N.S.F. is at 9, Stratford Place, London, W.1 (Tel.: Mayfair 4234).

Extruded P.T.F.E.—Equipment for the extrusion in substantial quantities of p.t.f.e. (polytetrafluorethylene) rod and tube up to 4in external diameter has been installed by Crane Packing, Ltd., of Slough. In addition to the standard grade of p.t.f.e. a special high grade, possessing exceptionally good electrical properties, is available.

Metal Industries, Ltd., Universal House, 60, Buckingham Palace Road, London, S.W.1, are taking over that side of the Rheostatic Company's business relating to the manufacture and sale of unbreakable resistors. **Igranic Electric Company,** a member of the Metal Industries group, will handle the sale of resistances for the group.

Electric and Musical Industries have purchased a controlling interest in Capitol Records Inc., of California, U.S.A.

Three senior members of the staff of the **Armstrong Wireless and Television Company** have been appointed directors—A. Adams, sales manager, T. Nikolin, production manager, and G. Tillett, chief engineer. Before joining Armstrong Mr. Adams was with Masteradio, Mr. Nikolin with E.M.I. and Mr. Tillett with Pye Telecommunications.

Transistorized Telephone.—The noise-cancelling telephone handset illustrated in the note on a transistorized telephone on page 90 of our last issue is manufactured by Lustraphone, Ltd., St. George's Works, Regent's Park Road, London, N.W.1.

Crater Products, Ltd., of The Lye, St. Johns, Woking, Surrey, manufacturers of rotary and other types of switchgear, have introduced a switch mechanism which is operated by a barrel-type key and can be fitted to their existing range of rotary switches.

FOREIGN TRADE

A 5-kW **Redifon** short-wave transmitter installed in Grenada is being used to provide a broadcasting service to the four Windward Islands—Grenada, St. Lucia, St. Vincent and Dominica—strung out over a distance of some 250 miles. H.R.H. Princess Margaret performed the opening ceremony during her Caribbean tour.

In compliance with regulations for the re-organization of maritime radio beacons Portugal is duplicating its existing installations. Eight **Marconi** 20-W m.f. beacon transmitters are to be installed at four lighthouses and the single installations at these points are to be installed at other lighthouses to provide duplicate equipment there also. Designed for automatic working the RB109 beacon has a normal range of up to 75 miles.

Despite the fact that the date of the **St. Erik's Fair** (Stockholm, August 27th to September 11th) clashes with our own National Radio Show the organizers of the British Pavilion at the fair hope that the prospect of a television service starting in Sweden next year will spur manufacturers to exhibit equipment. We understand from the organizers (Thirza West Publicity, Ltd., of 141, New Bond Street, London, W.1) that no British television equipment was shown at last year's fair.

Mobile radio equipment for 50 taxis in Singapore is being supplied by **Marconi's.** The fixed station has a power of 50 W and the mobile sets 3-5 W.

Agencies for British "hi-fi" amplifiers, pickups, loudspeakers and tuners are being sought by two more American firms—Gordon Agencies, 1506 N. Western Avenue, Hollywood, 27, California, and Morris F. Taylor Company, 9431, Georgia Avenue, Silver Spring, Maryland. The latter firm is particularly interested in record changers.

Intelec, S.A., Edificio Industria, Puente Republica, Caracas, who are the **Venezuelan Representatives** for one Canadian and three American firms, are interested in representing U.K. manufacturers of radio communications equipment and radio components. Manufacturers should write direct to the company and are invited to send a copy of their initial correspondence to the British Embassy, Commercial Secretariat, Edificio Titania, Plaza Estrella, San Bernardino, Caracas, Venezuela.

CHANGES OF ADDRESS

A.W.F. Radio Products, Ltd., who manufacture chokes, transformers, loudspeaker diaphragms, etc., have moved to 10, Sackville Street, Bradford, 1 (Tel.: Bradford 24008).

The new London branch sales office of **British Insulated Callender's Cables** is 10-14, White Lion Street, N.1 (Tel.: Terminus 8696).

Radio and Electronic Engineering, of 34, Stoke Abbott Road, Beaminster, Dorset (Tel.: Beaminster 372), has opened new works at Greenham Mills, Crewkerne, Somerset.

Spurious Line Scan Resonances

Common Types and Their Remedies

By K. G. BEAUCHAMP,* A.M.Brit.I.R.E.

THE output valve used in a line scanning circuit is a non-linear power amplifier operated under pulse conditions and as a result is liable to give rise to several types of unwanted harmonic and resonance oscillations. These will be exhibited as distortion of the picture displayed on the cathode-ray tube screen, usually in the form of vertical striations of varying light intensity.

It is the purpose of this article to show how the different forms of distortion are produced and to summarize the methods that can be applied to reduce or eliminate their effect in modulating the picture information.

When these resonances are due to shock excitation of a tuned circuit the phenomenon is often known as "ringing" and this expression will be often used hereafter as a convenient identifying term.

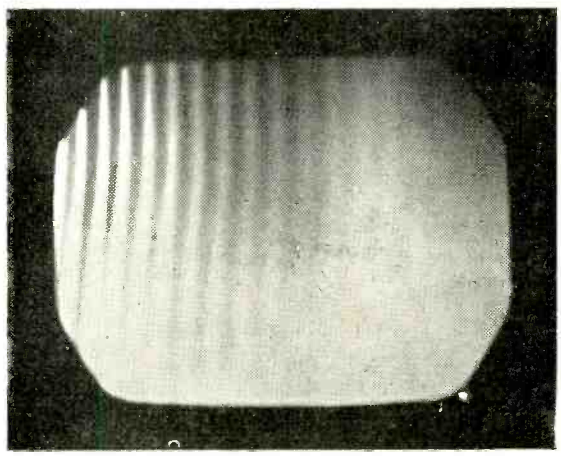
The use of resonant-return or efficiency diode line scanning circuits is now universal in domestic television apparatus and a simplified circuit of the output stage is shown in Fig. 1. Here the leakage inductances and stray capacitances associated with the transformer windings are shown as L_2 C_2, L_3 C_3, etc.

The operation of efficiency diode circuits has been fully described elsewhere[1,2,3] but a brief description of one simple mode of operation is given here in order to make the subsequent explanations intelligible to those not conversant with this type of scanning circuit.

Referring to Fig. 1, we may commence the sequence of events by assuming capacitor C to be charged and the scanning spot to be situated at the screen centre, i.e., zero current in coils L_y.

V1, previously rendered cut-off by a large negative bias applied to its grid, now commences to conduct. The potential at a point 4 will rapidly fall to the low "knee" potential for V1 and that of points 2 and 3 will fall in proportion to the transformer turns ratio. This ratio is so arranged that point 3 falls to a potential slightly in excess of V2 anode potential (h.t. volts) in order to keep the valve non-conductive during this part of the cycle. The constant potential difference between terminals 1 and 2 will cause an increase of current in L_y and the spot will move from the centre to the right-hand side of the screen. This may be termed the first part of the scanning period.

V1 is now cut-off by the negative-going excursion of the controlling grid potential and with both V1



Severe "ringing" of the line scanning circuit.

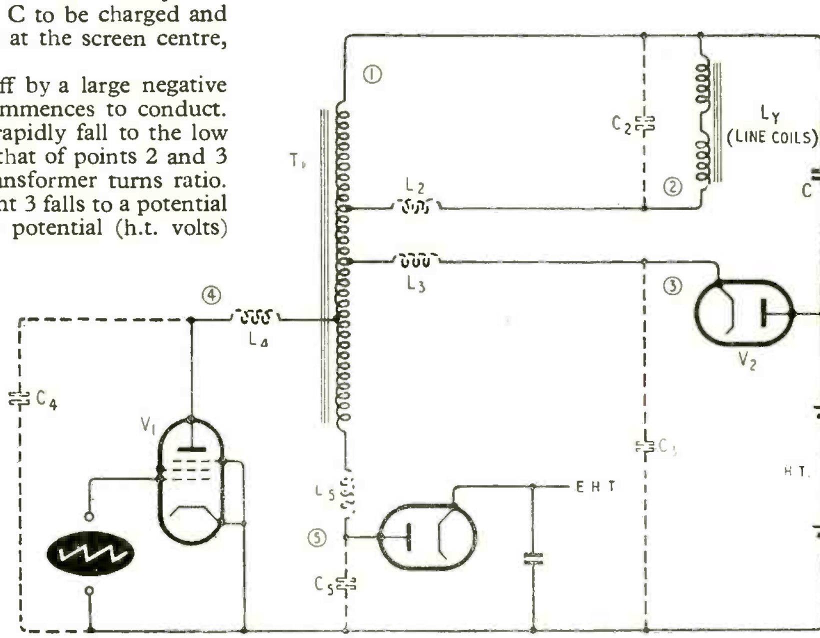


Fig. 1. Line scan output stage and transformer, showing leakage inductances and stray capacitances in broken lines.

* The General Electric Co., Radio and Television Works, Coventry

[1] E. Jones. "Scanning and E.H.T. Circuits for Wide Angle Picture Tubes." *J. Brit I.R.E.*, January, 1952.

[2] O. H. Schade. "Characteristics of High Efficiency Deflection and High Voltage Supply Systems for Kinescopes" *R.C.A. Review*, March, 1950.

[3] W. T. Cocking. "Efficiency Line Scan Circuits." *Wireless World*, August, September, and October, 1951.

and V2 cut-off the oscillatory circuit formed by L_y and C_2 becomes free to resonate at its natural resonant frequency (about 50 kc/s). During this oscillatory period the current in the magnetic system falls to zero, reverses in direction, and builds up to a maximum in the opposite sense, so that the spot travels rapidly to the left-hand side of the screen (the retrace period).

The potential at point 3 now reverses in polarity and V2 commences to conduct. This valve has a low impedance and will hold point 3 constant at about h.t. potential. The constant potential drop across terminals 1-2 will cause a linear decrease of current to take place in L_y, and with proper circuit design this will be of the same slope as the rise of current described earlier. This will cause the spot to complete the scanning cycle by travelling from the extreme left-hand side to the centre of the screen during the second half of the scanning period.

During the conduction period for V2 the boost storage capacitor C will be charged and its potential added to the h.t. supply for V1. This is an important feature enabling operation to be secured from a fairly low value of h.t. potential (180-200 volts).

The scanning circuit in Fig. 1 is capable of oscillation at several resonant frequencies simultaneously. The main magnetic flux around the circuit will resonate, during the retrace period, at a frequency of about 50 kc/s as previously described. Superimposed on this, however, will be smaller oscillations of a much higher frequency which are due to resonances between the leakage inductances and stray capacitances. These may modulate the constant potential required across L_y during the scanning period and so affect the scanning current through it.

E.H.T.-Coil Leakage Inductance

The e.h.t. winding in particular has a large number of turns, and as one of its requirements lies in having a small self-capacitance, it is usually constructed as a narrow wave-wound coil. Consequently, its leakage inductance is large, giving rise to a large storage of energy in L_5 during the retrace period. When V_2 conducts during the second half of the scanning period it should hold the potential of terminal 3 constant to enable a linear rise of current to take place in coils L_y. However, the energy previously stored in L_5 will cause oscillations to take place around the circuit C_5, L_5, L_3, V_2 and an alternating voltage is developed across L_3 which will have the effect of modulating the current in L_y.

In addition, when V1 anode current is cut-off at the commencement of the retrace period the stored energy in L_4 will flow into C_4 and cause oscillation between these two components. Oscillations between L_3 and C_3 are also possible in a similar manner when V2 is cut-off. The leakage reactance L_2 is not important as it forms part of the scanning coils resonant circuit, and will resonate with L_y and C_2 at the main resonant frequency.

As ringing is initiated by the switching action of the two valves some alleviation is possible if both valves are kept conducting during the entire scan period. This can, however, lead to inefficient modes of operation for the scanning circuit and it is better to obviate ringing by other methods.

It has been seen that the leakage inductance L_2 in series with the scanning coils plays no part in producing this velocity modulation of the scanning waveform. Consequently, by increasing the impedance of the line scanning coils until they may be placed across terminals 1-3, the leakage inductances L_2 and L_3 become coincident, and as terminal 3 (now the lower end of scanning coils 2) is held constant by V2 during the first part of the scan, irrespective of modulation of the potential across $L_2/_3$, then ringing due to this cause is avoided[1]. Unfortunately, the the voltage pulse developed across these higher inductance scanning coils, $L_y . \frac{di}{dt}$ becomes greater, and the coil insulation must be expected to withstand a peak pulse potential of some 3-4kV. Difficulties in designing scanning coils of this nature have led to other solutions to the problem being sought.

From Fig. 1 it is seen that no modulating voltage can be developed across the transformer if L_3 is not present and the diode resistance is reduced to zero during the second half of the scanning cycle, even though the current flowing around the e.h.t. circuit may be quite large. The type of valves now available for V2 have a resistance of about 100 Ω during their conduction period and unless special valves with small electrode clearances and large cathodes are used very little improvement upon this figure is possible.

However, by using auto-transformer connection and core materials of low-loss and high permeability[2] high coupling factors of the order $k = 0.998$ are now possible and leakage inductances L_3 and L_4 can be reduced to a minimum. Unfortunately, owing to the other design requirements previously mentioned, it is not possible to obtain such high coupling factors with the e.h.t. overwind, and k figures of 0.88 are often obtained. This leads to a high leakage inductance of the order of 100mH, so that with an auto-transformer design this leakage inductance will be found to be responsible for almost all the ringing experienced with the completed transformer design.

It is necessary, therefore, to investigate alternative methods of ringing suppression which allow this order of leakage inductance for L_5 to be present.

As previously stated the energy stored in L_5 during the retrace period causes a current to flow around the circuit $C_5 L_5 L_3$ V2 during the first half of the scanning period. If the impedance around this path can be increased then these current ripples will be reduced and hence their effect in modulating the steady potential set up across L_y. It will not be of any use inserting a high impedance between terminal 5 and V3 as this will not lie in the discharge path for the stray C_5.

It can be shown, however, that the e.h.t. winding 4-5 is equivalent to an infinite number of tuned circuits connected in cascade, each possessing a high mutual inductance to its neighbouring coils. If the Q of each elementary tuned circuit is reduced by introducing series resistance, then the overall Q of this winding, and hence the Q of the leakage inductance L_5, will be reduced by the same amount. This effect can be achieved by winding the e.h.t. overwind with resistance (Eureka) wire giving the completed coil a resistance of 5 to 10 Ω per turn. The Q factor can in this way be reduced by a factor of 40 to 100, which is sufficient to reduce the ringing to negligible proportions.

Although this method is quite effective it has two attendant disadvantages. First, a certain amount of power is dissipated within the high impedance e.h.t. overwind and this has the effect of reducing the overall

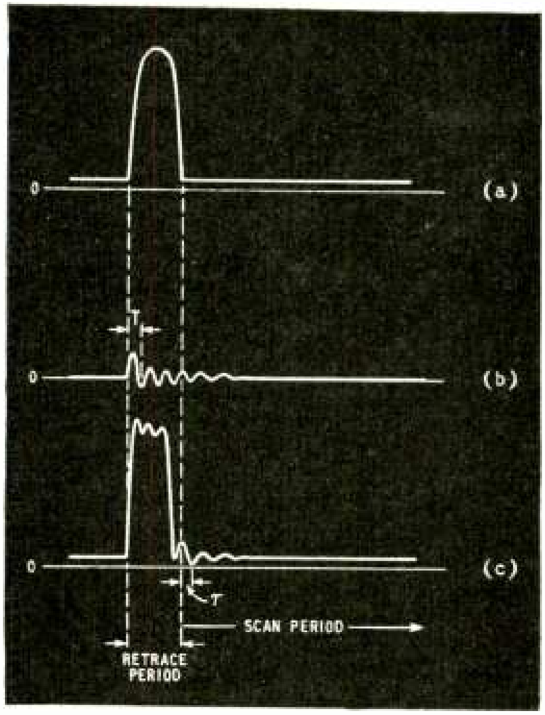


Fig. 2. Voltage waveforms in V1 anode circuit of Fig. 1: (a) potential across V1 anode transformer windings; (b) across leakage inductance L_4; (c) combined potential applied to V1 anode.

Q factor and hence efficiency of the scanning circuit. Secondly, owing to this power dissipation in the form of heat within the winding, the temperature of the coil is increased and may be sufficient to soften or even melt the protective wax covering over this winding.

Another solution to this ringing problem has been described by Telefunken[4] in which a strip of ferromagnetic material is inserted between windings 1-4 and 4-5 in a somewhat similar manner to the electrostatic copper screen often used between primary and secondary of some mains transformers. This screen should not form a complete turn of material as otherwise the shorted turn so formed will absorb a large amount of energy from the circuit. A gap of 1/16in between the two ends may be allowed in order to prevent this. As the added ferromagnetic strip will be situated within a strong magnetic field it will localize the flux near the strip and energy will be required to enable the flux within the material to go through a cycle of magnetization.

This energy is expressed by the well-known formula due to Steimetz:—

Hysteresis power loss $= n.V.f.B^{1 \cdot 6} \cdot 10^{-7}$ watts.

Where n = hysteresis coefficient and depends on the material used; V = volume of material in cubic centimetres; f = frequency in c/s. B = maximum flux density during the cycle.

Now as n also increases with frequency then the power loss becomes quite large as the frequency is raised, so that the losses at the ringing frequencies 200 to 600 kc/s will be large compared with those at the fundamental resonant frequency. As hysteresis losses can be represented by a series resistance the Q of the leakage inductances can be considered to be decreased at these higher frequencies and thus reduce the magnitude of discharge currents through them. In this way only the energy stored in the leakage inductances is dissipated as heat losses within the added magnetic strip, and as these are relatively small little loss of efficiency is obtained compared with the Eureka-wire method previously described.

The requirements for the magnetic material are bound up with the relative hysteresis losses at the fundamental and ringing frequencies, and a suitable material will be found in the range of nickel-iron alloys such as Radiometal, Rhometal, Permalloy and Mumetal, of which the last named is particularly suitable.

It may be as well to mention at this point that the reduction of resonance in the transformer winding, to a level insufficient to cause velocity modulation of the scanning current, does not mean that such resonances are entirely eliminated. With certain types of receiver layout it may be quite possible for the resonance ripples to be induced in the r.f. circuit wiring or the video lead to the cathode-ray tube from the magnetic field surrounding the transformer windings.

In order to distinguish between ringing caused by this intensity modulation and the more usual velocity modulation, it is only necessary to supply the cathode-ray tube modulation electrode directly with a source of d.c. potential enabling only the last-mentioned type of ringing to be visible on the screen.

Before dealing with other sources of ringing, mention must be made of the high frequency oscillations which are due to the presence of L_4 in series with the V1 anode circuit. As shown in Fig. 2, it is possible for the potential at the anode of V1 to become negative at the commencement of the scanning period, when the resonance of this leakage inductance is taken into account.

It has been shown elsewhere[5] that this may give rise to high frequency oscillations in one of two ways. The valve may behave as a Barkhausen oscillator. This type of v.h.f. oscillation is possible in a triode valve when operated with a positive grid and a negative anode potential. The frequency of oscillation is given by:—

$$f \simeq 10^7 \cdot \frac{\sqrt{V_g}}{d_1 + d_2} \text{ c/s}$$

where V_g = grid potential, and d_1 and d_2 are cathode-grid and anode-grid spacings.

For a typical line output valve the frequency of these oscillations will be found to be very high, and of the order of 1,000 Mc/s, so it is hardly likely that they will cause any visible effect on the picture.

A second type of high frequency oscillation may be generated if the anode voltage of V1 is modulated in such a way that the knee of the I_a-V_a characteristic is passed. The anode current will then contain high order harmonics of the modulation frequency, especially when the anode potential reaches negative values, as is shown in Fig. 2. The maximum frequency of these harmonics will be dependent on the steepness of the flanks of the modulating voltage oscillations and hence on their amplitude. With large values of modulation voltage, τ may easily become 1% of the period T of the leakage inductance resonance,

[4] Brit. Pat. No 710,629. Telefunken, 1952.

[5] G. Diemer. "Interference in Television Pictures." *Wireless Engineer*, June. 1952.

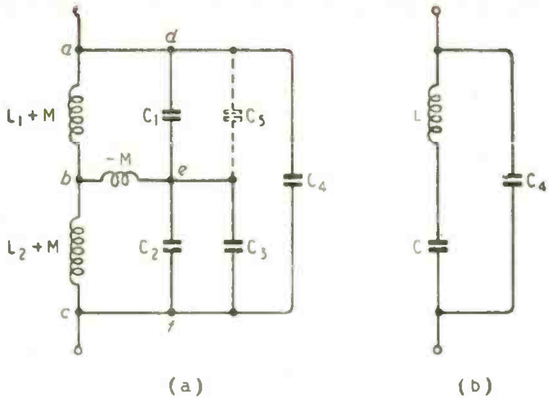


Fig. 3. Equivalent circuits of scanning coils.

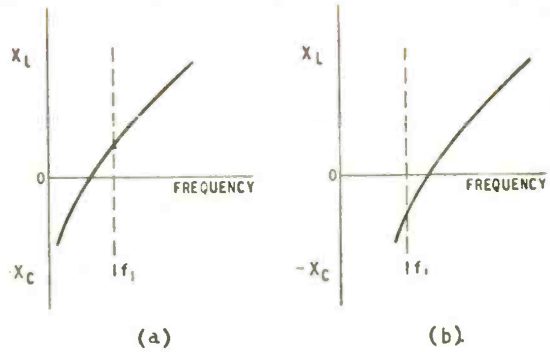


Fig. 4. Reactance sketches for equivalent circuits in Fig. 3: (a) circuit abed *and (b) circuit* bcfe.

giving rise to oscillations of the order of 50 Mc/s. These may be picked up by the r.f. section of a television receiver and become evident as vertical lines towards the left-hand side of the screen.

This form of interference will, of course, be due to intensity modulation of the cathode-ray tube electron stream as distinct from the velocity modulation of the current flowing in the scanning coils previously described.

High-order harmonics may also arise from the nature of the I_a-V_a characteristic for V1 at low anode potentials. With certain tetrodes it is possible to have a region in this characteristic where the valve behaves as a negative resistance. Dynatron oscillations will be set up with the tuned circuit L_4C_4 representing the anode load, and as the I_a-V_a characteristic is far from linear over this region considerable harmonics may be produced. These can extend into the television bands and give rise to intensity modulation indistinguishable from that described above.

Lower order oscillations can also be responsible for the "ragged edges" of vertical lines seen on the screen, due to modulation of the sawtooth scanning current by these parasitic oscillations. As this distortion will only be present whilst V1 is conducting, it is possible with efficiency-diode arrangements to find this raggedness extending only over the right-hand side of the screen, this being the portion of the scan controlled by the conduction period of V1. The effect can be readily distinguished from that of high voltage corona, which can also cause line raggedness, as with the last-mentioned line the displacement extends over the entire screen area.

Both these types of dynatron oscillations may be avoided by including a resistance, at least equal in value to the negative slope of the I_a-V_a characteristic, in series with the valve anode. A small resistor of about 100 Ω is often included in the anode circuit of V1 for this reason.

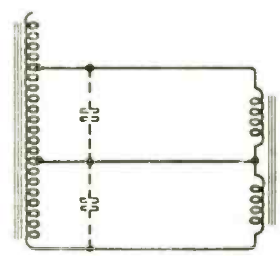
When the various sources of ringing due to the line scanning transformer have been located and either removed or minimized, some velocity modulation of the scan may remain and can be attributed to resonance within the line scanning coils. This form of ringing occurs on the extreme left-hand side of the screen at a frequency of the order of 300-800 kc/s and may be removed by tuning one of the scanning coils as shown in Figs. 7 and 8. A description of the mechanism of this type of resonance has been given by Cocking.[6]

[6] W. T. Cocking. "Simple Line Scan Circuit." *Wireless World*. August, 1952.

Consider the equivalent circuit for the scanning coils shown in Fig. 3(a). Here the leakage inductance for the two coils is shown as M whilst the stray and self capacitances are given by C_1, C_2, C_3 and C_4 respectively.

Reactance curves for the two resonant circuits *a b e d* and *b c f e* are shown in Fig. 4 and at a frequency f_1 one branch of the circuit may behave as an inductance whilst the other will be capacitive, so that the equivalent circuit may be expressed as Fig. 3(b) for this frequency. At this frequency f_1 the series

Fig. 5. Centre-tapped scanning coil connections.



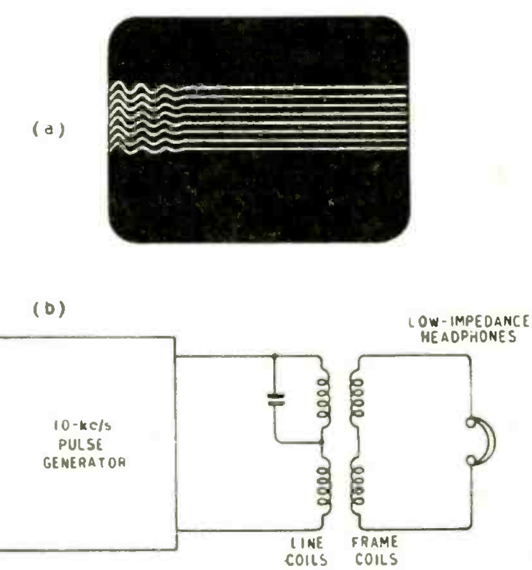


Fig. 6. At (a) is shown the effect of velocity modulation of the frame scanning current waveform, while (b) shows a method of null adjustment for minimum coupling between the line and frame coils.

tuned circuit will resonate and a variable potential will be set up across C_4 and cause the unwanted velocity modulation of the scan.

This effect may be avoided by adding an extra capacitor C_5 (shown dotted in Fig. 3(a)) across the non-earthy coil L_1. This capacitor is adjusted until the resonant frequencies of the two branches of this equivalent circuit are identical and no variation of potential occurs across C_4. In view of the high-potential pulse appearing across the scanning coils during the retrace period, C_5 will have to be designed to withstand peak potentials of up to 2 kV.

Beiser[7] has suggested a further method of obviating this ringing by connecting together the junction of the two series-connected scanning coils to a centre tape of the transformer scanning coil winding (Fig. 5). This method achieves balance by the swamping action of the added transformer capacitances and the improved top to bottom coupling, reflecting more nearly equal capacitances across each half of the scanning coil circuit. However, the electrical centre of the transformer winding is required and this is not easy to determine as the effect of any series coil such as those used for width and linearity tend to unbalance the arrangement. The effect of such unbalance is to introduce a trapezium raster distortion which can be quite serious.

Resonance of the frame scanning coils is also possible when these are magnetically coupled with the line coils. The pulse appearing across the line coils at the end of the scanning period will shock excite the frame coils at their natural resonant frequency and velocity modulation of the frame scanning waveform appears. This takes the form of a "waviness" of the horizontal picture lines at the left-hand side of the screen as shown in Fig. 6(a). To reduce this effect the coupling between line and frame coils may be reduced by orientating the pair of frame coils relative to the line ones, until a minimum voltage is induced in the former from a 10-kc/s pulse generator connected across the line coils (Fig. 6(b)).

This may not always be possible, however, or completely effective, as capacitive coupling will exist between the pairs of coils. An alternative remedy is to damp the individual frame coils with a resistor of the order of 1,000 Ω so as to increase the decrement of this resonant circuit and reduce the amplitude of oscillating potential developed across it. It is necessary to damp each frame coil individually, as a common resistor across the pair of frame coils will leave the leakage inductance relatively undamped (see Fig. 3(a)) and free to resonate.

From the remarks previously made regarding leakage reactances it will be clear that any inductive elements added to the circuit may be shock excited into resonance with their stray and self capacitances, and set up alternating potentials which may modulate the steady potential difference across the scanning coils during the scanning period. Thus the coils incorporated in the complete receiver (see Fig. 7) to provide control over picture width, L_1, and form, L_3, can give rise to resonances at the commencement of the scan.

To reduce this shock excitation of L_1 and L_3 a damping resistor may be connected across the coils. The resistor, by increasing the decrement of the tuned circuit prevents these ocillations from extending into the scan period. However, the value of resistance

[7] L. Beiser. "How to Handle Ringing in Television Design." *Electronics*, May, 1954.

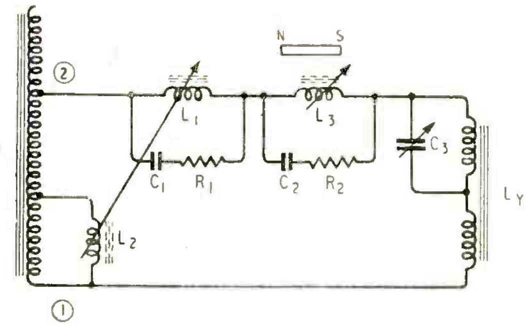


Fig. 7. Width and form controls added to scanning coil circuit.

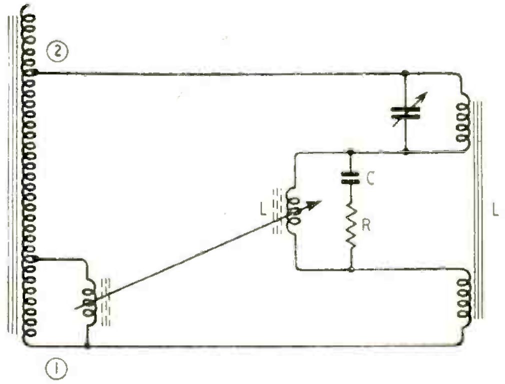


Fig. 8. Alternative position for series width coil.

required sufficiently to reduce the amplitude of ringing will usually be such that an appreciable amount of energy is dissipated within the resistor.

A better arrangement is to shunt L_1 and L_3 by a series combination of C_1R_1 and C_2R_2 as shown in Fig. 7. Such a parallel combination of CR and LR can be made aperiodic or non-resonant if the relationship $L = C.R^2$ is maintained. In practice L_1 and L_3 are usually made variable quantities so that new values of R_1 and R_2 are required for each setting of the width and form controls. As the ringing is usually most objectionable at the maximum inductance setting for L_1 and L_3 it is sufficient to adjust R_1 and R_2 for this condition.

Although an added inductive circuit may be made non-resonant in this way it will behave as a capacitance at certain frequencies of the order of 500 kc/s. This capacitance in series with leakage inductance L_2 (Fig. 1) can form a tuned circuit having this order of resonant frequency. Consequently, ringing of the series-tuned circuit so formed may become possible. A solution to the problem lies in placing the coil, together with its associated CR damping circuit, between the two line scanning coils as shown in Fig. 8. The transformer leakage inductance is now no longer directly associated with the circuit LCR and this source of ringing is obviated.

Recently a type of line scanning circuit has been developed where the transformer of Fig. 1 has been removed and scanning coils of a higher impedance than is usual with a transformer circuit are included directly in the anode circuit of V1. This circuit has become known as the direct-drive system[6, 8, 9] and one form of ringing is possible which is peculiar

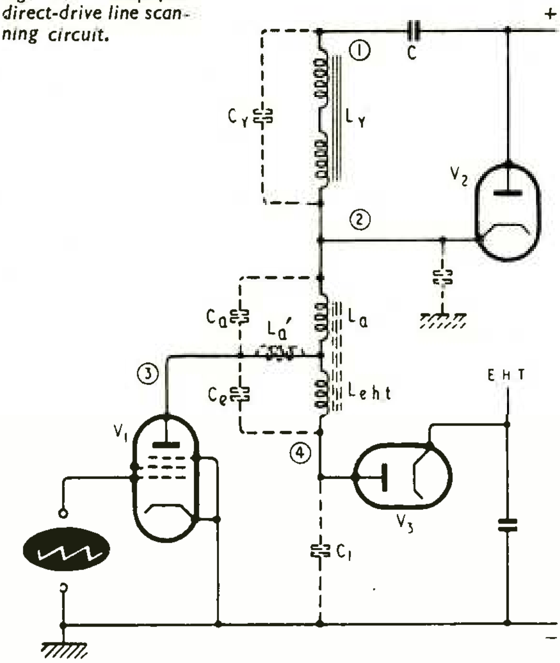


Fig. 9. Simplified direct-drive line scanning circuit.

to this circuit. This occurs towards the end of the first half of the scanning period, i.e., on the *right*-hand side of the picture.

A simplified circuit for this arrangement is shown in Fig. 9, where the stray circuit capacitances and leakage reactance of the coil L_a are shown dotted. It is a condition of normal operation with this circuit that V2 must remain conductive during the entire scan period in order to hold the potential across the scanning coils L_y constant. Should V2 cease to conduct at any point, then as the scanning coils are not magnetically coupled to the inductance L_a in the anode circuit there is nothing to prevent resonance of either L_y or L_a with their associated shunt capacitances from varying the potential across L_y and hence the scanning current through it.

It will be seen from the circuit diagram that this condition may occur if the potential at terminal 2 exceeds the h.t rail voltage. This may happen through several design maladjustments, one of the most prevalent being an excessive value of inductance for L_a compared with that of L_y, causing too great a portion of energy supplied from the h.t. supply to be stored within it. As this energy becomes greater towards the end of the scanning stroke so the potential across L_a increases in value. This may prevent V2 from conducting and resonance ripples appear towards the right-hand side of the screen.

It is now common practice in commercial television receivers to supply a blanking pulse to the cathode-ray tube such that the beam current is cut off during the period of the frame flyback. This enables the half-line pulses, present in the transmitted waveform during this period, to be placed below black level in the receiver. As a result the user is given some latitude in the setting of the brightness and contrast controls before these objectionable lines appear, and in addition it guards against the effects of variation in the black level as transmitted by the B.B.C.

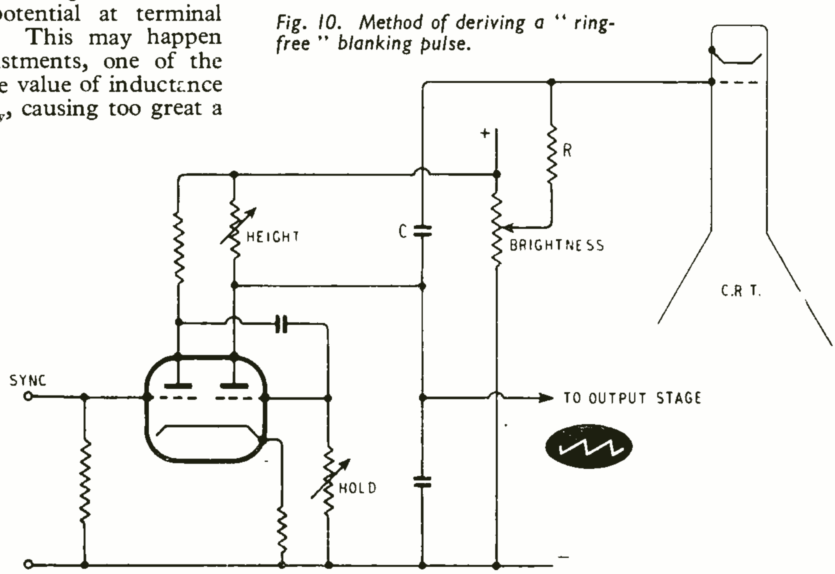
This blanking pulse is usually derived from the frame scanning circuit and, unless care is taken, can give rise during the scan period to intensity modulation of the tube at the electrode controlled for blanking purposes (usually the grid). This is especially true if the negative pulse existing across the frame scanning coils is transferred to the tube grid for this purpose.

The high frequency ringing oscillations present in the line scanning coils are induced in the frame coils by the small coupling existing between them and serve to modulate the intervals between the pulses, resulting in the intensity modulation mentioned above. Although the effect can be mitigated by the connection of a capacitor of about 0.02μF to 0.1μF across the frame coils, this can introduce an undesirable low frequency resonance in the frame scanning waveform.

A better solution is to derive the blanking pulse from the frame oscillator circuit. The sawtooth potential waveform developed by this circuit may be differentiated by a time constant of about 100μsec to produce a suitable negative blanking pulse. A circuit for this is shown in Fig. 10, where the coupling time constant is given as CR.

The preceding summary has shown some of the methods that can be applied to remove the many sources of spurious resonances inherent in modern television receiver design. A small amount of ringing can often be tolerated in a completed design, but when colour television reaches this country very stringent precautions will have to be taken to avoid unwanted velocity modulation. The colour misconvergence due to this cause should have a noticeable if not unpleasing effect!

Fig. 10. Method of deriving a "ring-free" blanking pulse.



[8] U.S. Pat. No. 255,931. C. E. Torsch.
[9] E. Jones and K. Martin. "A Direct Drive Scanning Circuit." *J. Television Society,* January/March. 1954.

Voltage-Multiplying Rectifier Circuits

"CATHODE RAY" Explains How They Work

NOT long ago* I uttered a warning about rectifier circuits always being more difficult than they look, and then proceeded to demonstrate some of the complexities of the very simplest possible rectifier circuit. So now, if I announce as the subject a class of rectifier circuits that even *look* complicated, you may perhaps suspect a very sticky session indeed and promptly remember a more important engagement. But I assure you that their very complication is going to make the lesson easier. The explanation of this paradox is that the full treatment of such circuits would be fit only for that Third Programme of radio journals, the *Wireless Engineer*, so I am bound to keep to the simple outline. In fact, all who already understand even roughly how voltage-multiplying circuits work are advised to turn to something more worthy of their intellectual status and not waste any more time here.

Voltage-multiplying circuits are all built up of the elementary circuit unit shown in Fig. 1. G is the a.c. generator (usually a transformer winding), D a rectifier (which of course may be a diode valve or alternatively copper oxide, selenium, germanium, or what have you) and C a capacitor. We shall assume throughout that G produces voltage of sine waveform, as in Fig. 2(a). And let us also assume at first that there is no load to draw off any power, and that D has zero resistance in one direction and infinite resistance in the other. So what happens is that the first quarter-cycle from G that makes the arrow-head side (or anode) of D positive passes current through it, charging up C as long as the voltage is growing. It charges it up to the peak voltage E_{max}, as shown at the beginning of Fig. 2(b). Directly the G voltage passes its peak it becomes less than the voltage of C, so the cathode of D becomes positive and D ceases to conduct. C is therefore completely isolated, so retains its full charge while G declines to zero and then performs its negative half-cycle. At the peak of its next positive half-cycle its voltage momentarily equals that of C, and D is brought to the point of conduction, but there is no excess of voltage on the G side to do any more charging. If there had been a load resistance across C things would have been different, because C would have been discharging all the time since the last peak, and each successive peak would have had some topping up to do. In practice, too, D would have some forward resistance which would prevent C from receiving its full charge in the first cycle, and several further cycles would be required to finish the job.

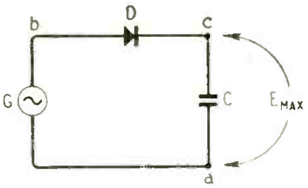


Fig. 1. The basic unit of all voltage-multiplier circuits.

We now have a steady positive voltage V_{ac} (reckoning that as the voltage from *a* to *c* so that *c* is positive with with respect to *a*). Obviously we have an equal negative voltage, V_{ca}, if we look from *c* to *a*; Fig. 2(c). And if we add this negative V_{ca} to the alternating voltage V_{ab} the result (Fig. 2(d)) is the voltage V_{cb} from *c* to *b*, that is to say across the rectifier. This voltage alternates from a displaced level, for the steady voltage across C biases the alternating voltage from G by an amount equal to E_{max}, so the peak V_{cb} (called the peak inverse voltage or p.i.v. of the rectifier) is double E_{max}. This is where we begin to see how voltage doubling can be done. Looking from *c* to *b* we have a negative voltage, so of course looking in the opposite direction, Fig. 2(e), it is positive.

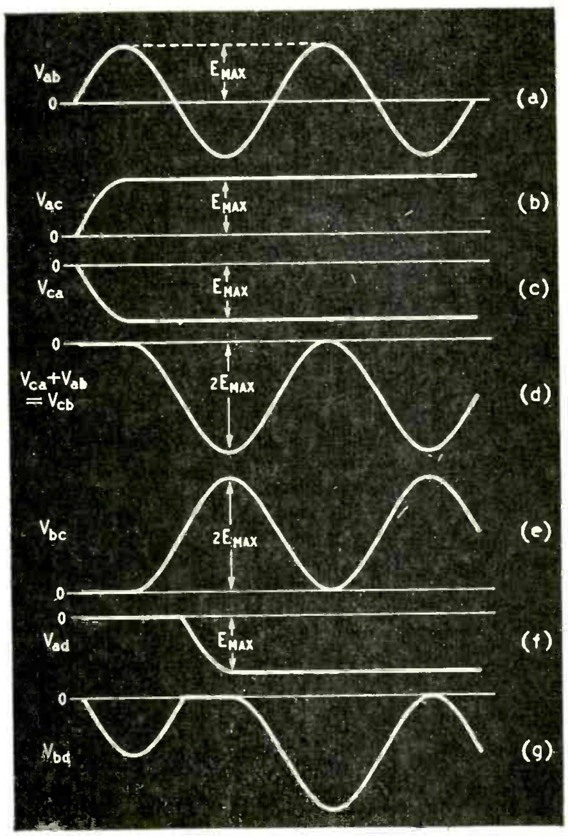


Fig. 2. Starting-up waveforms of the various voltages in Figs. 1 and 3 on no load.

* October and November 1954 issues.

If, as I hope, all this seems almost (or quite) painfully obvious, then there should be no difficulty in seeing how voltage multiplying circuits work. Before going on to these, we just pause to glance back at Fig. 1 and note that the output terminals are *a* and *c*, and the unloaded voltage between them is equal to E_{max}.

First Voltage Doubler

The first composite circuit is probably the commonest of all, being found in the power packs of many receivers and other gear. It is formed from Fig. 1 by adding another rectifier and capacitor, as in Fig. 3. To make it look a little more practical a transformer winding is shown as the generator, but the principle is the same. The important feature is that the second rectifier is connected the other way round so that, relative to *a*, *d* is negative instead of positive. Relative to either *c* or *d* these two voltages add up in series to give a steady voltage equal to twice E_{max}. This is therefore a voltage doubler. The appropriate output terminals are of course *c* and *d*.

It is easy enough to arrive at this explanation by adding together V_{ca} and V_{ad}, the steady voltages across the capacitors. V_{ca} we have in Fig. 2(c), and V_{ad} is the same, so the sum of the two is the same as Fig. 2(c) except that its voltage dimension is $2E_{max}$ instead of E_{max}. It is a universal rule that the voltage between any two points is bound to be the same whatever route is taken, and fatal curiosity may lead one to try to see how the foregoing result could be found by adding V_{bd} to V_{cb}. For both these voltages are very far from steady, yet the sum of the two must be dead smooth if it is (as it must be) the same as $V_{ca} + V_{ad}$. We already have a graph of V_{cb} (Fig. 2(d)), and it might be supposed that V_{bd} was the same and therefore V_{cd} was twice V_{cb}, which certainly has the correct *average* value ($2E_{max}$) but fluctuates violently from zero to $4E_{max}$. Can you see the fallacy? It is in assuming that because V_{ad} is the same as V_{ca}, V_{bd} must be the same as V_{cb}. Even $V_{ad} = V_{ca}$ is not *strictly* true, because during the first quarter-cycle of the generator voltage, when V_{ca} is building up, D_2 is non-conducting, so V_{ad} doesn't start building up until the second half-cycle (Fig. 2(f)). Except at the start, however, the relative phase of the two rectifier circuits makes no difference to these steady voltages; but it is otherwise with the voltages across the rectifiers, and to get at the graph of V_{bd} (Fig. 2(g)) it is necessary to add V_{ba} (Fig. 2(a) *reversed*) to V_{ad}. After the first three-quarters of a cycle needed for it to get under way, it exactly fills up the troughs in V_{cb} (Fig. 2(d)), giving a perfectly steady $2E_{max}$ as we knew it ought.

Many of us find actual typical values more helpful than symbols, so let us suppose that the alternating voltage available is 200, that being of course its r.m.s. value. The peak value is $\sqrt{2}$ (or 1.414) times as great, namely 282 volts. So the steady voltage at the output terminals is 564—getting on for three times the a.c. supply voltage.

A practical point about this circuit is that the cathodes (represented by the plain strokes in the rectifier symbols) have between them the voltage V_{bc}, which has a peak value $2E_{max}$; equal to 564 in the example just considered. If hot-cathode diodes were used, their heater-to-cathode insulation would be quite unable to stand this, so it would be necessary to use separate well-insulated heater voltage windings on the supply transformer. What in this way is awkward for vacuum rectifiers suits metal rectifiers admirably, for (as Fig. 3 shows) they point in the same direction all the way from *d* to *c*, so one " stick " of rectifier disks does for both halves of the system, only a centre-tap needing to be provided for attachment to the h.t winding. Compared with the centre-tapped h.t. winding required in the usual valve full-wave rectifier circuit, this winding is lower-voltage and higher-current, so needs fewer turns of thicker wire, and this is an economy in first cost and is less likely to break down.

But I must stop talking like a salesman and get on with the job. Before passing to the next circuit we had better just see what happens to the so-ta ideal behaviour of Figs. 1 and 3 when they get on with *their* job, which is to supply current. The thing that takes the current—the load—can be represented as a resistance joined to *ca* or *cd* as the case may be. We have seen that with the load disconnected, so that no current is drawn, the capacitors hold their full voltage

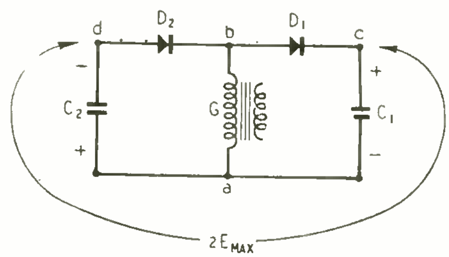


Fig. 3. First kind of voltage doubler circuit, formed by working a second rectifier unit in parallel with the same source.

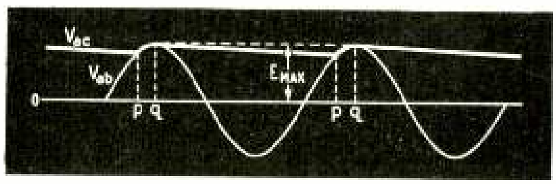


Fig. 4. Fluctuation of output voltage V_{ac} in Fig. 1 when current is drawn from C.

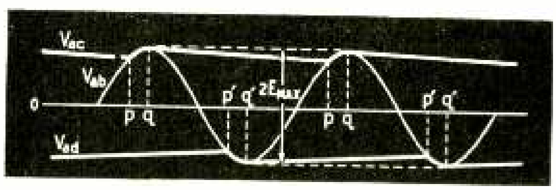


Fig. 5. Corresponding diagram to Fig. 4 for the Fig. 3 voltage doubler, with a as a zero-potential point.

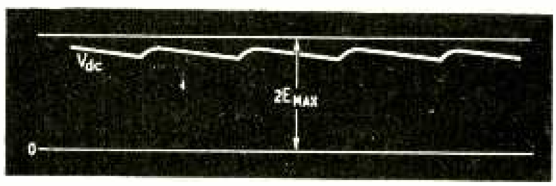


Fig. 6. The total output voltage of Fig. 3, derived from Fig. 5 but reckoned from d instead of a.

constantly, so that after the preliminary charging there is no call for G to provide any current. But that if a load resistance exists across C in Fig. 1 its voltage falls until the supply voltage meets up with it and carries it to the peak once more. This is seen more clearly when input and output voltages, V_{ab} and V_{ac}, are graphed together, as in Fig. 4, which I hope explains itself. The capacitor C supplies current almost steadily all the time, whereas current can flow from the source to replenish it only during the periods *p* to *q*, the whole process being closely analogous to the maintenance of a continuous supply of wind in playing the bagpipes. C is the bag, the load resistance is the pipes, and G is the intermittently breathing Scot. (If you didn't know before you now know how bagpipes work).

On our assumption that the rectifiers have no forward resistance, *q* coincides with the peak of V_{ab}, but in practice, owing to rectifier resistance, V_{ac} lags a little below V_{ab} and input current continues to flow a little beyond the peak. The heavier the load (i.e., the less the load resistance, so that the more current is taken) the faster V_{ac} falls and the sooner *p* occurs in the cycle. Usually we don't want V_{ac} to fall very much—not only does it mean reduced output volts, but more unsteadiness of output to be smoothed out—which means that *p* to *q* must be only a small fraction of a whole cycle, and in that fraction the input has to supply enough current to keep the output going all the time. As we saw in the November issue, this means that the peak value of current through the rectifiers is many times greater than the load current (so make sure the rectifiers can carry it without premature decease!) and the r.m.s. value is several times greater (so make sure the h.t. winding can carry it without overheating!).

All this, in relation to Fig. 1, is old stuff. Having refreshed our memories on it we can next see what happens to Fig. 3 in the same circumstances. Since D_1 and D_2 work on opposite voltage peaks, it is easy to adapt Fig. 4 to the voltage-doubler simply by chalking in V_{ad} on the lower half, as in Fig. 5. The output voltage, V_{dc}, is represented by the vertical distance between the V_{ad} and V_{ac} graphs. This would be very appropriate if the circuit were being used to supply equal positive and negative voltages, with *a* as the earthed point; but more likely *d* is the earthed point, so to show more clearly what one is getting from this arrangement V_{dc} in Fig. 5 has been redrawn in Fig. 6 with *d* at zero. Compared with the half-wave system, the voltage falls twice as fast between peaks, but the frequency is twice as great, so the ripple voltage (for equal current) is the same. Since the output voltage is doubled, the percentage ripple is halved; and with its higher frequency it is easier to smooth. Note that although (with our perfect rectifiers) the output voltage in the half-wave system reached E_{max} once every cycle, the full-wave doubler never reaches $2E_{max}$.

Second Voltage Doubler

This kind of voltage doubler, although it is very good in itself, is something of a blind-alley—it cannot be developed to give greater voltage multiplication. But there is a voltage doubler that can. Fig. 7 shows the basic circuit.

My impression is that some who have no difficulty in seeing how the first doubler works find this second one a little obscure. Perhaps the capacitor C_1 in series with the whole issue looks not quite right. One wonders how the d.c. can flow. The circuits

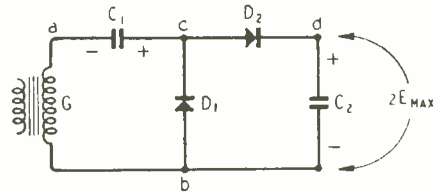


Fig. 7. Second type of voltage doubler circuit, formed by adding another rectifier unit to D_1 as generator instead of G.

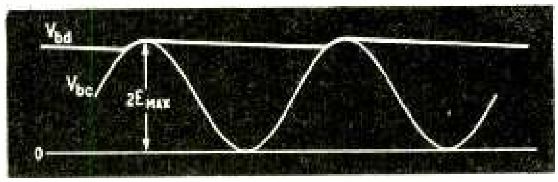


Fig. 8. Corresponding diagram to Fig. 4 for the Fig. 7 voltage doubler under load, but making the rather unjustifiable assumption that the V_{bc} waveform is the same as under no load.

we have seen so far would work after a fashion if the capacitors were entirely removed, but obviously this one couldn't. However, the first half of the system, consisting of G, D_1 and C_1, is absolutely identical with Fig. 1, and as we have studied that at length and drawn every possible voltage graph both ways up it oughtn't to hinder us now. The basic difference between the two doublers is that in Fig. 3 a second rectifier is simply added to the first, run in parallel off the same supply in such a way that the two outputs are series-assisting. They could quite well be used independently. Whereas in Fig. 7 the first rectifier doesn't contribute directly to the output at all, but only through the second. Its role is to double the peak voltage for the second.

That is why the voltage across D_1 (V_{bc}) rather than that across C_1 (V_{ac}) is used. Both contain the rectified component, equal to E_{max}; in V_{ac} it is pure, or nearly so, ready for use; in V_{bc} it is required not for direct use but to bias the alternating voltage so that the peak voltage in the direction that D_2 can use is double E_{max}—see Fig. 2(e) again. This much of the circuit takes the place of G in Fig. 1; the rest is identical, save for the doubled input peak voltage, giving doubled output. Note, as another practical point, that D_1 and D_2 can consist of a single centre-tapped stick.

We hardly need bother to draw any voltage graphs, but just to prevent any complaints of short measure Fig. 8 repeats Fig. 2(e), and then shows how V_{bd}, the output, is derived from it. To save it from complete fatuity, some load current is assumed. And that is perhaps where we may come a little unstuck. Our V_{bc} graph is one that was constructed on the assumption of no load, but obviously if the output stage (as we may aptly call it) is loaded the doubling stage must also feel this load somehow. But the loading effect differs in two respects from that experienced by Fig. 1 when a resistance is connected across C: instead of being a continuous load, it is concentrated entirely in the portion of cycle when D_2 conducts; and instead of being across C_1 it is across D_1. Perhaps you are beginning to see how we could easily get bogged down if we allowed ourselves to become involved in the

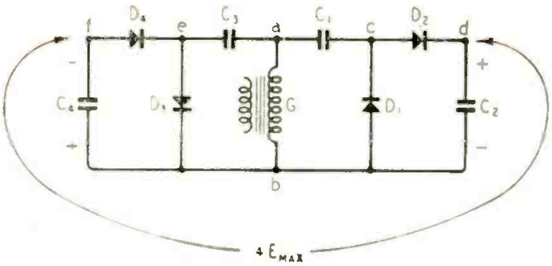


Fig. 9. Voltage quadrupler, combining the Fig. 7 and Fig. 3 techniques.

details of this type of circuit. Roughly, what is happening is that a partly discharged capacitor (C_2) is connected across D_1 every time the voltage there is near its peak. That is the middle of the time when D_1 is not conducting, so during this part of the process D_1 can be ignored. The current required to replenish C_2 must come straight from C_1 and unless its capacitance is large compared with that of C_2 its voltage will fall so much that it will be unable to raise the output voltage anywhere near $2E_{max}$. So even the peak output voltage is bound to be less than $2E_{max}$, and then there is the drop due to the discharge of C_2. Without going into involved calculations we can see that unless C_1 and C_2—especially C_1—are quite large the output voltage of this type of doubler is likely to fall rather badly as current is drawn from it.

Higher Multiplication

If we did go into those calculations we wouldn't leave time for the higher multipliers, but having seen how Fig. 7 works by considering each half separately and then putting them together let us just see if we can follow it as a whole. During the half-cycle when G makes *a* negative with respect to *b* it charges up C_1 through D_1, making *c* positive with respect to *a* (and therefore the same potential as *b*, which is natural when D_1 is conducting). The opposite half-cycle swings *a* $2E_{max}$ volts more positive than it was ($-E_{max}$) and because of C_1 *c* also becomes $2E_{max}$ volts more positive than *it* was (0 volts), charging C_2 up to that voltage, for use by the load. But the heavy current required to do this discharges C_1 to a lower voltage, so that when G swings back to its negative peak the potential of *c* becomes more negative than that of *b* and current flows through D_1 to restore the charge on C_1. And so on.

If you find this comprehensive view of Fig. 7 muddling (a working mechanical model would make it so much clearer) forget it and go back to the two-step method of looking at it, for the multiple-stage circuits will be much more muddling to visualize as wholes but just as easy step by step.

Before adding more stages to Fig. 7, however, let us note that it lends itself to Fig. 3 treatment to convert it into a voltage tripler or quadrupler. For the tripler, a third rectifier and capacitor can be run in parallel off G, in exactly the same way as Fig. 1 was developed into Fig. 3. The E_{max} output thus created is in series with the $2E_{max}$ output we already have. And instead of adding just a single stage we can add a second doubler stage of the kind we have in Fig. 7, giving an output (on no load) of $4E_{max}$ volts (e.g., 1,128 volts from our 200 r.m.s.) between *f* and *d* in Fig. 9.

Next, the two-stage Fig. 7 can be extended to more stages. In Fig. 7 we used the voltage across D_1 to drive D_2 and C_2, because its peak value is double that provided by G alone. What about the voltage across D_2?. It is not, as one might suppose without thinking, double that across D_1. The voltage provided by G alone, although it gives a peak consisting of only E_{max}, swings from $+E_{max}$ to $-E_{max}$, so has a total swing of $2E_{max}$. It is this, when biased by C_1, that gives a $2E_{max}$ peak across D_2 which is used to charge C_2 to $2E_{max}$. This voltage doesn't swing back to $-2E_{max}$ but only to 0, so its total swing, developed across D_2, is no greater than that of G. However, it can be used to charge another capacitor up to $2E_{max}$, as in Fig. 10. Unfortunately, the only way it can be arranged to do this (the way in which D_2 and C_2 were arranged relative to D_1 and C_1) puts the output (across C_3) not only not directly joining on to the previous output but in the wrong polarity, so is not particularly useful. But if we press on regardless and add yet another unit (Fig. 11) we find this comes right and gives us a total nominal output of $4E_{max}$. A third pair of units can be stuck on to D_1, just as the second was stuck on to D_2, raising the total output to $6E_{max}$; and so on. Of course the output voltage goes down directly any current is taken, and if we guess that it will go down a lot if much current is taken and the capacitances are not correspondingly large, we shall not be wrong.

The Fig. 11 quadrupler circuit is an alternative to Fig. 9. Note that the same components are used in both (one rectifier and capacitor for each E_{max} in the output); only their arrangement differs. If

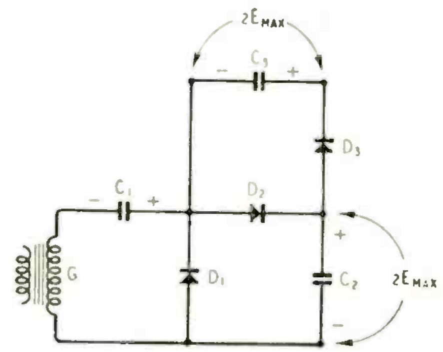


Fig. 10. First stage in the extension of the Fig. 7 technique to higher voltages on its own.

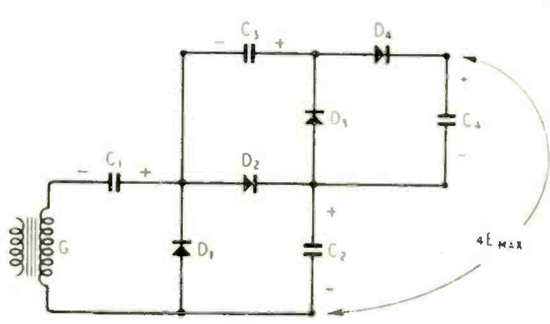
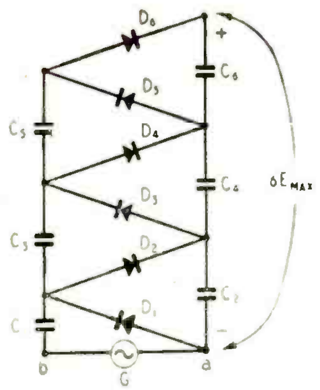
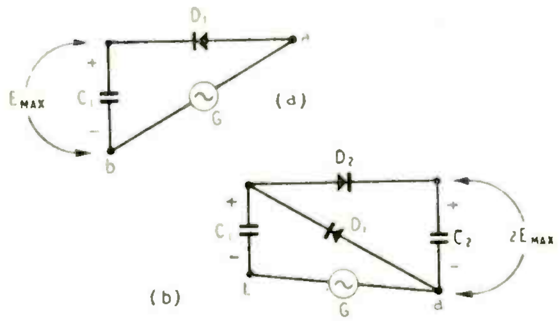


Fig. 11. Second stage in the extension of Fig. 7, completing the second kind of voltage quadrupler.

Right: Fig. 12. A voltage sextupler of the same type as Fig. 11, but in a neater style of circuit drawing.



Below: Fig. 13. The first two half cycles of operation of a "working model" based on Fig. 12.



one wants the h.t. winding to be at one end of the output, then Fig. 11 is the choice; otherwise I should vote for Fig. 9, at least if substantial current is to be drawn. For either I would use metal or crystal rectifiers, for obvious reasons.

I have drawn Fig. 11 in such a way as to bring out how the second pair of units is identical with the first, except only for using the $2E_{max}$ swing across D_2 as source instead of the total swing of $2E_{max}$ supplied by G. But it is certainly not the neatest layout; the circuit can be more tidily drawn in the form of a vertical ladder, such as Fig. 12, which shows a sextupler (I hope that is the right word!). An advantage of this form is that it can be used as a sort of working model that helps one to visualize the voltage stepping-up action, which otherwise is apt to seem rather an improbable trick like lifting oneself by one's shoe laces.

The idea is that distance upward is voltage positive. Point *a* is fixed, to represent zero potential. The length of each link containing a C represents the voltage to which it is charged, so, as it is drawn, the diagram represents the system giving its full $6E_{max}$ across the output terminals, every C being charged to $2E_{max}$, except C_1, which is charged to E_{max}. Current can flow through the rectifiers only in the direction of their arrow head, and as it can only flow to a lower potential (unless driven upwards by an e.m.f.) it can only flow through the rectifiers when the arrow heads are not pointing along an upward slope. In the positions shown their "doors" are all closed.

The e.m.f. of the generator is represented by the link hinging on *a*, so that *b* moves up and down a distance representing $+E_{max}$ and $-E_{max}$ respectively. At the start, all the capacitors are uncharged, so the whole structure is "deflated", with all the D links lying flat on the ground on top of G. Let us start G off on a negative half-cycle. Point *b* goes down, which starts to make D_1 tilt downwards; but directly it does current "falls" from *a* into C_1, charging it, until at the negative peak the model looks like Fig. 13(a). (As we have assumed the rectifiers to have zero forward resistance, their downward tilt when passing current is imperceptible.) Next, *b* starts pushing C_1 upwards, and this closes D_1 so C_1 cannot discharge through it, but by pushing the left-hand end of D_2 up it partially discharges through it into C_2, which thereby holds up the right-hand end of D_2 (Fig. 13(b)). During the next downward swing, C_2 partially discharges through D_3 into C_3, and C_1 is filled up again to E_{max} by G so that on the next upward swing, while C_3 is putting something into C_4, it can raise C_2 nearer $2E_{max}$. And so the ladder gradually rises, stroke by stroke, until it reaches virtually the $6E_{max}$ shown in Fig. 12. The practical limit to the voltage that can be developed in this way is chiefly the size of the capacitors, especially C_1, which bears the brunt of the work. For a given load current and resulting terminal voltage drop, reckoned as a percentage of the theoretical no-load output voltage, the required capacitance goes up as the square of the number of pairs of rectifiers.

In modified form, a sextupler like this was developed by the Westinghouse Brake & Signal Co. for providing the e.h.t. for television sets from the ordinary valve power-unit transformer. It was described fully in the May 1948 issue of *Wireless World*. Incidentally, this firm made a very cunning mechanical model to demonstrate its action—some of you may have seen it at an exhibition—with the rectifiers represented by little one-way swing doors, through which steel balls (representing current) are caused to climb up the sloping "ladder" against gravity by rocking the structure from side to side to represent the alternating e.m.f. The original idea of this kind of voltage multipler is due to Cockcroft and Walton, who invented it to produce 800,000 volts for their atomic research.

STANDARD FOR RESISTANCE WIRE

A WAR emergency standard (BS1117) was prepared in 1943 to meet the requirements for fine resistance wires with considerably closer tolerances than those prescribed in BS115, which deals in general with metallic resistance materials for electrical purposes. A revision of BS1117 has now been issued by the British Standards Institution; it covers wires of from 0.0005 to 0.012 inches in diameter and embraces four classes of metallic resistance materials based on the requirements of temperature coefficient of resistance, working temperature and non-tarnishing characteristics.

Maximum values for the temperature coefficient of resistance over given temperature ranges are specified for each of the four classes of resistance materials.

The standard does not include resistance tables but does lay down the tolerances of resistivity, resistance and uniformity of resistance. "Fine Resistance Wire for Telecommunication and Similar Purposes" (BS1117: 1955) is obtainable from the British Standards Institution, 2, Park Street, London, W.1, price 2s.

I.T.A. Transmitters

PROBLEMS OF SITING

FOR some time it has been tacitly assumed that the Independent Television Authority's Band-III television stations will be sited with the B.B.C. Band-I stations and even that its aerials will be carried by the existing B.B.C. masts. At first sight, this seems to be obviously the correct thing to do. The B.B.C., as the first in the field, has, presumably, chosen the best sites, and only if the alternative programmes are radiated from the same place is the simplest form of receiving-aerial installation practicable.

The obvious thing is not always the right thing, however, and when one examines the matter in detail it becomes plain that the use of a common site is by no means always desirable. The conditions differ so much between Bands I and III that what is a good site for one may be a bad one for the other.

As pointed out in the June 1954, *Wireless World* (p. 255), there is one definite advantage from the receiving point of view in having co-sited transmitters. At every receiver both aerials will point in the same direction and so all the aerial assemblies for a particular area can be the same, while there are some, perhaps small, possibilities of simplifying aerial construction. It may, for example, be possible to design combined aerials in which parts of the one function as certain parts of the other.

Considerable importance must be attached to anything which simplifies and cheapens the receiving side, whether it be in the aerial or in the receiver itself, because the number of receivers is so great that the total cost involved can be enormous. There are now roughly 4 million receivers in use. If only one-half are converted to Band-III operation, a saving of only 10s per aerial means a total saving to the viewing public of £1,000,000. One can do quite a lot on the transmitting side with a million pounds, but not everything.

If one makes the reasonable assumption that the use of co-sited transmitters will cheapen the receiving aerial then, from the national point of view, it may be economical to adopt such stations. This is in spite of the possibility that such transmitters may, in themselves, be more costly. Therefore, one does naturally start to consider the problems involved in the siting of the I.T.A. stations with a strong bias in favour of co-siting.

Power v. Aerial Gain

What is there against co-siting? Actually, there are a number of things which are inter-related in rather a complex way, so that it is not so easy to present as clear-cut a case against co-siting as it is for it. Nevertheless, there is quite a good case.

Most present-day Band-I transmitters have an output of 50 kW and an effective radiated power (e.r.p.) of 120 kW, which means a transmitting aerial gain of 3.8 db. On Band III, however, it is not yet practicable to build a television transmitter of more than about 10-kW output. Obtaining an e.r.p. of 120 kW on Band III thus entails using an aerial system of 10.8-db gain. Such an aerial system is, in fact, quite practicable but requires a 16-tier array, so that its physical size and weight would almost certainly be considerably more than that of the existing low-gain Band-I type of aerial.

The existing B.B.C. masts are designed to carry only the present low-gain Band-I aerials and the Band-II sound-broadcasting aerials. It seems to be accepted that they are capable of carrying, in addition, a low-gain Band-III aerial. Contrary to the view expressed in the June *Wireless World*, however, it is most unlikely that they could safely carry the load of a Band-III aerial of the high gain that now seems necessary, or that room could be found for the many elements which it would need.

If, in fact, they will not, there is no possibility of a Band-III station radiating the same effective power as a Band-I station until such time as a much higher power Band-III transmitter can be developed. This is not a thing which can be done quickly and is likely to prove more expensive than a low-power transmitter with a high-gain aerial. It seems, therefore, that the only way in which a high e.r.p. can be obtained at present is with the aid of a high-gain aerial, but this cannot be supported by the existing Band-I masts. A Band-III aerial thus needs a separate mast and such a mast could hardly be erected on an existing site without serious interaction effects. It would seem, therefore, that if the e.r.p. is to be the same on Band III as it is on Band I the use of common sites for the transmitters is impracticable.

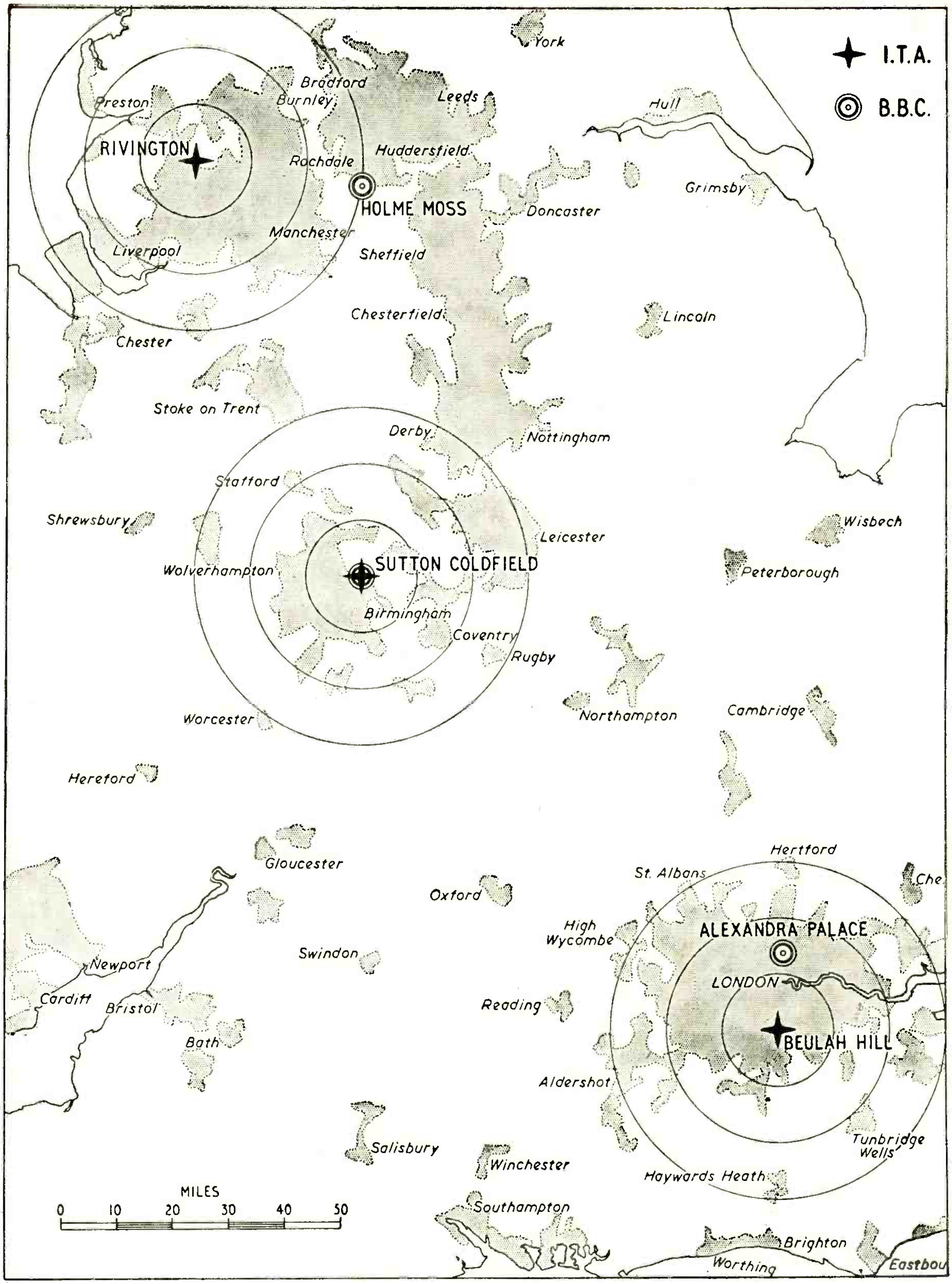
Even if the same e.r.p. could be used on the same site, the coverage of the two stations would not be the same, for the propagation conditions are different. Here we are on distinctly uncertain ground, for so little is known about propagation conditions on 200 Mc/s in this country in so far as they affect broadcasting. It is generally considered that the attenuation will be greater than on Band I, especially in built-up areas, and that much more trouble from reflections and blind spots will occur.

Receivers are unlikely to have such a high signal/noise ratio on Band III as on Band I and the aerial rods are much shorter so that the pick-up for a given field strength is less.

Of course, some of this difference can be made up at the receiving end, for it will be practicable to use higher-gain aerials on Band III than on Band I. Such aerials will inevitably cost a good deal more than a simple H or X type, however, and while they will certainly have their place, they may well be too costly for general use.

It seems certain that, for an equivalent performance, Band III will need a much higher field strength than Band I. This obviously entails a higher e.r.p. from the transmitter and, at the present time, it looks hard enough to provide even the same e.r.p.

It is, therefore, as nearly certain as anything can be, that the service area of a Band-III transmitter



This map shows some of the suggested sites for I.T.A. television stations; also B.B.C. main Band-I stations in the area. Circles 10 miles apart have been drawn around the I.T.A. stations as an indication of scale. Densely populated areas are shown shaded.

must at present be a good deal smaller than that of a Band-I station. If the I.T.A. decides that it is desirable for its transmissions to be receivable over the same area as the B.B.C. ones, therefore, it may be necessary to use more transmitters to do it.

In the initial stages of Band-III operation, at least, the important thing is to cover the most densely populated areas and it may well be possible to do this adequately from a Band-I site if an existing Band-I station is within, or on the edge of, a densely-populated area like London or Birmingham. It may then be quite satisfactory to adopt co-siting. In such cases, the Band-I signal usually extends with adequate strength well beyond the densely-populated area, and the weaker Band-III signal may cover this quite well and fail only in the relatively unimportant outside area. Although the service area of the Band-III station may be much smaller than that of Band I, it may still give a useful signal to the bulk of the population.

Matters may be very different where the Band-I station is situated in a sparsely-populated district. Holme Moss is a case in point. It is situated on the moors and serves the populated areas of Lancashire and Yorkshire which form, very roughly, a ring around the transmitter. The centre of the ring adjacent to the transmitter contains few people, and this area of high field strength is largely wasted. However, since an adequate field is maintained in the surrounding ring, it forms the most economical way of covering the populated area.

It would be very different if a co-sited Band-III transmitter were to be installed, however. Because of the reduced service area, it might well happen that the outer populated ring would not get an adequate signal and that the bulk of the useful field was wasted on the moorland centre.

Northern Area

There is a distinct possibility, if not a probability, therefore, that co-siting may be quite wrong in the case of a site like Holme Moss, but that it may be satisfactory or desirable for London and Sutton Coldfield. It does seem that one cannot enunciate, as a general principle, that co-siting is inherently good or bad; each case must be considered on its merits.

To return to the Holme Moss example, what is the alternative to co-siting? It is fairly plain that no single Band-III station can hope to cover the bulk of the population which falls in the Band-I service area. To get a good coverage, a Band-III station must be sited close to an area of dense population and it looks as though two Band-III stations, one in Lancashire and one in Yorkshire, will be needed. Even two such stations are unlikely to provide such a great coverage as that of the Holme Moss Band-I transmitter, but they would probably serve the greater part of the population.

Recent Press reports show that the I.T.A. is, in fact, thinking on these lines. It seems probable that the London and Midland stations will be at, or near, Crystal Palace and Sutton Coldfield, although little has been said to indicate whether or not the aerials will be on the B.B.C. masts. The one at Crystal Palace has not yet been erected, of course, and the I.T.A. station which is expected to open in the autumn will be only a temporary one at Beulah Hill. For the Northern area, a station at Rivington in Lancashire has been suggested, to be followed by a Yorkshire one.

If anything like full coverage of the country on Band III is considered necessary, it seems clear that it is impossible to carry it out without using more transmitters than are necessary for Band I. At present, I.T.A. has only two channels allocated, as compared with the five on Band I of the B.B.C. If more transmitters are needed, some further channels will obviously be required.

The whole matter of Band-III television is beset with difficulties and not the least of these is the time factor. Political and advertising circles press for everything quickly, without much regard for hard technical and economic facts. The choice of a suitable site takes months rather than weeks, for testing with a mobile transmitter is not a quick business. When a site has been found, its acquisition may take some months, even if it is possible at all, in these days of Town and Country Planning, etc. Not until all matters of this kind have been completed is it possible to start building and providing drainage, water and electricity supplies. Transmitters, masts and aerials all have to be designed and constructed.

One point in favour of co-siting is that it does reduce the time required in that the site is an existing one. It does not necessarily save the building time, however, for the existing buildings, water and electricity supplies may not be sufficient.

The great danger for Band-III television is that the I.T.A. will be pushed into moving too quickly and, in order to get some transmitters operating, will make too great sacrifices in performance. That is a thing which it should resist.

Even where it has a transmitter operating, it will be a considerable time before many people are able to view it. Most sets now in use will need conversion and all will need Band-III aerials. Their manufacture, supply and installation will take a long time. Many people will not, of course, consider having them installed until a Band-III transmitter is actually operating; if they do wait until then, they may have to wait another six months or a year, for the man-power available is very limited. It would be more sensible to start fitting now and give the transmitter people another year.

In conclusion, it should be pointed out that all the comments that have been made here about co-sited transmitters apply to the sharing of a site by a Band-I and a Band-III transmitter. It may be that, in the future, the B.B.C. will develop its own Band-III service. It is important to realize that the operation of two Band-III transmitters from a common site is quite a different problem. It may very well be that it is right to co-site a pair of Band-III alternative-programme stations, but not a Band I and a Band III.

MERCHANT SHIPPING R/T

WE find that the Merchant Shipping (Radio) Rules 1952 were in some respects misinterpreted in our February issue. First, they did not come into force last November but in November, 1952. There were, however, provisions covering the transitional period which ended on November 19th last.

Whilst the rules make it compulsory for cargo vessels between 500 and 1,600 gross tons (the previous minimum tonnage) to carry radio gear, it does not necessarily have to be R/T; owners may fit W/T equipment if they wish. Incidentally, fishing vessels are excluded from the provisions of these rules.

The Marconi Marine Company draws our attention to the fact that its Albatross equipment, which meets the specification prescribed in the rules, was awarded the G.P.O. Certificate of Type Approval in September, 1952.

Transistor Radio Receiver

Four-Stage Circuit with R.F. Amplifier and Push-Pull Output

By D. NAPPIN*

MANY articles have appeared on the subject of transistors and other semi-conductor devices, but most of those describing transistor circuits have involved either selected production or developmental types. The receiver described in this paper uses five GET1 or GET2 point contact transistors; four of these are production samples and only one transistor needs to be specially selected for a particular characteristic. Alternatively, a transistor with very close point spacing such as a type now being developed experimentally for high frequency use, may be employed. Some of the advantages and economics of transistor circuits became very apparent during the development of this receiver.

A block diagram of the final receiver is shown in Fig. 1. The first receiver circuit used was simply a detector followed by two audio-frequency amplifiers, but it was not possible to obtain an adequate output in the loudspeaker without exceeding the collector dissipation specified for the transistor. It was therefore decided to use a conventional push-pull output stage and to limit the h.t. supply to −22.5 volts. In this way a sufficiently high output could be obtained.

Detector. A common-base amplifier arrangement is used as a detector. The output from the r.f. amplifier stage is coupled into the emitter circuit of the detector stage by means of a matching transformer. The emitter/base circuit can be regarded as a point-contact diode. Thus when a negative voltage is applied to the emitter the diode is cut off and no appreciable current flows; as a result the collector current remains unchanged. However, when the voltage is made positive, emitter current flows; this is amplified by the transistor and hence a signal is developed at the collector of the detector stage.

The output from the collector of the detector stage is transformer coupled with the emitter of an audio-frequency amplifier stage *via* a radio-frequency filter. It is found, in this receiver, that adequate overall gain can be obtained even if the detector is coupled to the audio-frequency amplifier by an R—C coupling network.

The detector, which is known as the emitter-bend detector, is in many ways analogous to the cumulative grid detector using a thermionic valve. Thus when a radio-frequency signal is applied a positive emitter current is built up which may be compared with the building up of negative grid voltage in the cumulative grid detector.

Audio Amplifier. The audio-frequency amplifier V3 operates as a linear amplifier. The necessary positive emitter bias is easily obtained by adding resistance in series with the base lead. If this resistance, R_8 of Fig. 2, is less than the optimum value it is possible that the emitter bias current will be too low for linear amplification; if it is made higher than the optimum value, however, relaxation type oscillation can

*Research Laboratories of the General Electric Company, Ltd., Wembley, England.

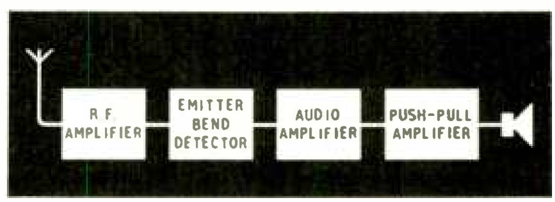


Fig. 1 Block diagram showing sequence of functions adopted

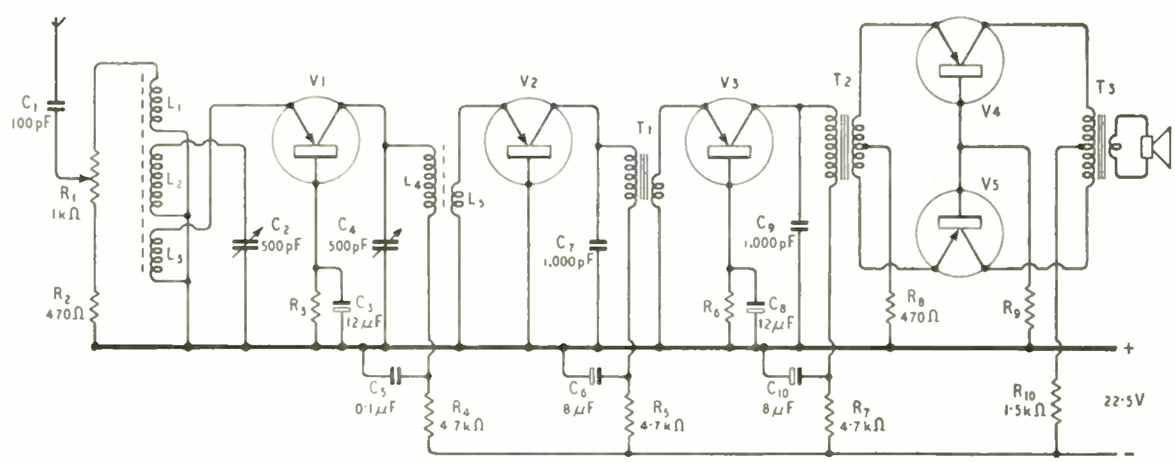


Fig. 2 Circuit diagram of transistor receiver. Details of coil and transformer windings are given in the table on the following page

COMPONENT SPECIFICATIONS

Coils Wave Wound On S34 Alladin Formers	Resistors	Transformers	Transistors
Turns (40 s.w.g., s.s.e.) L_1 50 L_2 70 L_3 50 L_4 70 L_5 20	R_1 1kΩ potentiometer Others ¼-W Carbon **Condensers** All over 25 V.W. C_4 C_2 500 pF ganged variable.	Using No. 21 M. and E.A. stampings. **Turns** (40 s.w.g., s.s.e.) T_1 P. 1,600 S. 400 T_2 P. 1,600 S. 800 centre tapped T_3 P. 1,600 centre tapped S. 28 24 s.w.g. (For 3Ω speaker)	V1-V5 G.E.C. Type GET 1

occur. The optimum value of R_6 depends upon supply voltages, transistor characteristics and circuit constants; its value is best determined empirically using a 1000-ohm variable resistor. A fixed resistor of the nearest lower preferred value is then substituted in the circuit. The adjustment is not very critical.

Push-Pull Amplifier. The collector load of the audio amplifier is that associated with the primary winding of the transformer T2. Resistance R_7, which is bypassed, is to limit the collector current that can flow. T2 steps down the output of V3 to the emitters of V4 and V5, which form a push-pull output stage. R_8 prevents the flow of excessive emitter current.

Emitter bias is derived by means of the common-base resistor R_9, while collector bias is provided via the centre-tapped output transformer T3 and the current limiting resistor R_{10}. No special precautions need be taken to balance the transistors in this circuit.

Normally no signal currents should flow in R_8, R_9 and R_{10} and they are not decoupled; it may be seen that if the circuit tends to become unbalanced, the ' unbalance current ' flows around the circuit via R_8 and R_9 in the case of the emitter circuit, and via R_9 and R_{10} in the case of the collector circuit. These resistors tend to prevent the flow of ' unbalance currents ' and thus to maintain the circuit balanced. Resistance R_9 is adjusted in a similar way to R_6.

The gain does not show a sharp maximum but increases to a certain value and then remains constant. The collector current, however, continues to increase as R_9 is increased and it is therefore not desirable to increase R_9 beyond the value corresponding to maximum gain.

Although it is possible, for example by the push-pull arrangement described by Missen†, to obtain greater powers from point-contact transistors, it was decided to use this simple push-pull amplifier because it requires only one voltage supply, is more economical on components and power consumption, and gives an adequate output for a " bedside " or " personal " type radio. The output power obtainable is about 50 milli-watts.

Radio-frequency Amplifier. This is the only stage that requires a selected transistor. The reason for this is that the band covered is 600-1500 kc/s, and most GET1 and GET2 transistors have a greatly reduced frequency response towards the upper end of this range. The transistor cut-off frequency is defined as that frequency at which the current gain has dropped to 0.7 of its low-frequency value. For existing GET1 and GET2 transistors this usually occurs at about 300-500 kc/s although about 5% of the product have cut-off frequencies greater than 1 Mc/s. A transistor now being developed experimentally has a cut-off frequency of about 10 Mc/s, and this more than adequately meets the requirements of this amplifier stage.

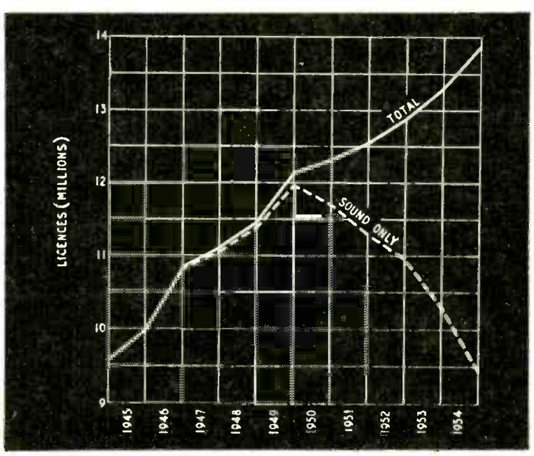
The circuit for coupling from the aerial into the low impedance input circuit of a transistor is shown in Fig. 2. L_2 C_2 provides a parallel-tuned circuit which is allowed to " float." L_1 couples the aerial into this tuned circuit, whilst L_3 provides the necessary step down from the tuned circuit to the transistor. L_1 and L_3 are disposed on opposite sides of L_2 which ensures that energy is transferred only at the resonant frequency of L_2 C_2. The emitter bias is obtained by means of a decoupled base.

† " Push-pull Transistor Amplifiers," by J. I. Missen. *Wireless World*, Oct. 1953, p. 467.

Broadcast Receiving Licences

THE steady growth in the number of television licences in the United Kingdom is shown by the divergence of these two curves. The full line plots the increase in the total number of broadcast receiving licences over the past ten years and the dotted line the number of sound-only licences. It was not until 1946 that separate licences for sound and television receivers were introduced.

The latest available figures show an increase during December of 156,365 television licences. The end-of-the-year figures were sound 9,463,475, television 4,155,989, and car radio 253,169, giving an overall total of 13,872,633.



LETTERS TO THE EDITOR

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

"*As She is Spoke*"

IN your February issue you accuse the B.B.C. of lack of zeal in its guardianship of the language of broadcasting. The B.B.C. is conscious of its responsibilities in this matter, and has set up a Committee to define terms that are widely used within the broadcasting service. This Committee, of which the writer is a member, has attempted to encourage the use of words that are clear and of untarnished lineage. There comes a point, however, in the history of a new term when resistance is useless and the earnest lexicographer must resign himself to his proper function of recording usage and give up any attempt to guide it. You, Sir, will not over-estimate the power of committees, or even of Editors, to stem the ever-advancing tide of dubious neologisms. "Television" itself is a hybrid that cannot be kept down, but our Committee is fighting a rear-guard action against "TV." It seems hardly more necessary than "TP," "TG," "TM" or "TA," but we notice that you yourself put your "TS" to your blind eye when your contributors write "TV." We share your horror at the expression "radio and television."

You refer in pejorative terms to "pre-recorded" and "telerecording." "Telerecording" seems to us to be a reasonable contraction of "television recording"; i.e., a recording of a television programme; it is a portmanteau word perfectly analagous to the established "telefilm" (=television film, i.e., a film made for television broadcasting). If you know of a better word, we should be glad to hear of it. You will be shocked to learn that a telerecording made on closed circuit is known as a "pre-telerecording."

In sound recording applied to broadcasting we have to distinguish between (1) a "live" repetition of a programme, (2) a repetition, from a recording, of a programme that has been simultaneously broadcast and recorded, (3) a repetition, from a recording, of a programme that has been recorded on closed circuit before transmission, and (4) the playing of a commercial gramophone record. We call (1) a "live repeat," (2) a broadcast from a recording, (3) a broadcast from a pre-recording and (4) the broadcasting of a record. Numbers (2) and (3) are together known as "recorded repeats." There can also be a "re-recording." Perhaps it has escaped your notice that "pre-" and "post-" each have two distinct meanings, as in (a) pre-arrange, post-date, (b) pre-war, post-graduate. "Pre-recording" is a legitimate example of (a), since it refers to a recording made before it is required for transmission.

You may still think that we are misguided or that our efforts are vain, but I hope I have refuted the charge of lack of zeal. E. L. E. PAWLEY.

Engineering Division, B.B.C., London, W.C.

TO the examples you give of the misuse of the English language for technical purposes, may I add the curious tendency to refer to a record as "a recording"? I have been unable to find any justification for this either in the dictionary or in common sense. The word "recording" surely means the process of making a record, not the record itself. Thus, if someone says he listened to a recording of so-and-so, he must either have attended an original performance while it was being recorded, or be confusing his terms (and his hearers). But perhaps "recording" sounds more impressive than "record," and I can only conjecture that its misuse springs from technical snobbery.

Bromley, Kent. M. G. SCROGGIE.

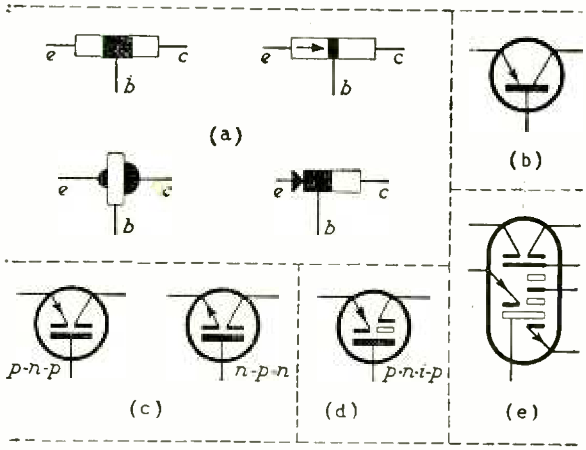
YOUR criticism of B.B.C. jargon (February issue) is out of date and rather unfair. The deplorable "pre-recorded," of which you complain, surely disappeared some time ago; at least, I have not heard it lately in programme announcements.

Judging by the current *Radio Times* (January 28th) the B.B.C.'s scribes are more successful in maintaining a reasonable terminology than most others who write on programme matters. In that issue I can find only two objects for complaint: the indefensible "telerecording" and "National *Radio* Awards." But the Awards scheme was sponsored by the *Daily Mail*; my guess is that the Corporation, left to themselves, would have chosen "Broadcasting" instead of "Radio."

Birmingham, 21. ALEX. GOLDSMITH.

Transistor Graphical Symbols

LIKE ourselves you have often commented on the wide variety of symbols used for the transistor in the technical literature (for examples see (a) in the accompanying diagram). Since these cause regrettable confusion, it occurs to us that we might get together on this matter.



The accompanying sketches put forward a proposal in which you will observe:—

(b) Symbol already adopted for point transistors.
(c) Proposed representation of junction transistors.
(d) The same as (c) with the addition of an intrinsic layer (the *p-n-i-p* transistor).
(e) Symbol for a multi-electrode junction transistor (of the year 1960. . . .).

We feel sure you will wish to participate in the advantages which would accrue from the adoption of uniform symbols by the technical press of the world.

Editor, *Toute la Radio*, Paris. E. AISBERG.

Transistor Letter Symbol

A GROWING need exists for a reference letter to represent the transistor in technical descriptions and circuit diagrams. We have V for valve, and we number the valves V1, V2, V3, etc., so that we can identify them in the tables and the text, but we have no recognized letter for the transistor.

It is important that the letter should be acceptable to all technical people, and it must not conflict with any existing references. Derivation should be recognizable, so that the symbol is easily associated with the object.

The first proposal that springs to mind is T, but that already belongs to transformer. X is another possibility, but it is used freely for so many purposes, such as Xmitter, X-ceiver. Possibly two letters might be necessary to obtain a distinctive reference; say, SC (semi-conductor), TV (transistor valve) or VT (valve transistor).

A sign of some kind is bound to evolve soon, because hardly a technical journal appears without some reference to transistors, and it must become necessary to refer to them individually, which means that they must be numbered. It would be a pity if another case developed under our very noses of the casual adoption of an inappropriate or ambiguous reference, or the general use of two or three terms, as has happened in the past. It is probable that a cross-section of the opinions held by your readers would be as good an indication as any of what reference should belong to the transistor.

London, S.E.1. E. A. W. SPREADBURY.

[The symbol V is used tentatively in an article appearing in this issue.—Ed.]

"*Anarchy in the Ether*"

THE second Editorial in your February issue touches on a matter which is vital to the future of broadcasting in Europe.

It is likely that during the next few years most of the major countries will develop f.m. networks as a supplement to their existing transmissions. Quite apart from the desire to provide interference-free reception, I imagine that many countries are keen to develop an f.m. service for security reasons.

Unless their use is reorganized, we shall then find that the medium and long wavebands are being wastefully employed. I suggest that their use should in fact be confined to the following purposes:

1.—Providing the main service in countries which are unable to use v.h.f., either because of their large area, or because they cannot afford the cost involved.

2.—Providing a service in mountainous areas, for which v.h.f. is unsuitable.

3.—For "international" services.

No. 3 requires some explanation; what I propose is that a part of the medium waveband should be reserved for international programmes, one channel being allocated to each country, with a 15-kc/s spacing and no sharing. Each channel would be used by a single high-power transmitter, carrying the pick of its country's programmes. As these should each be audible (at night) over a large part of the Continent, the ordinary listener's choice of programmes would be tremendously increased. Without some scheme of this kind, we may arrive at a situation in which few listeners ever hear anything other than their local programmes. G. H. STURGE.

Welwyn Garden City.

Vector Addition and the Slide Rule

THE following method for finding $\sqrt{(x^2+y^2)}$ with an ordinary slide rule is, I think, even quicker than that of A. G. London given in the February, 1955, issue. x is taken as the larger number, and the standard scales of the rule are called A, B, C and D from top to bottom:

1. Set the cursor to x on scale D.
2. Set either 1 or 10 of scale C opposite y on scale D.
3. Increase the reading on scale B under the cursor by 1 by moving the cursor.

The answer is now under the cursor on scale D.

London, S.W.16. G. J. PHILLIPS.

Education and Training

I SHOULD like to make some brief comments on the article by Francis Reece in your January issue. He implies that entrants to secondary technical schools are of the lowest range of ability. These schools, in fact, require a standard of intelligence and aptitude equal to that required by the grammar school and prepare boys for the General Certificate of Education at 16+ and, in a few cases in London at least, for subjects at advanced level at 18+.

Boys from these schools not only secure apprenticeships in industry leading to skilled artisan posts but also continue their education by part-time release or evening classes to Ordinary and Higher National Certificate level and to associateship or membership of professional institutions. The results obtained by part-time day release students are better than those indicated by Mr. Reece.

HAROLD C. SHEARMAN.
Vice-Chairman of the Education Committee,
County Hall, London, S.E.1.

Electronics on The Farm

MOST of the electric fencers on the market work off a standard 120-volt h.t. battery, and these are fairly big and bulky items to store away, even in so-called "portable units;" these are, as far as I can find, the highest voltage type on the market.

I have made and operated quite a few fencers on the resistance-capacitance principle, and found them very satisfactory and reliable. With neon types, one is up against snags at once. The major one is that the striking voltage is far too high for the standard battery to give any length of service; with the RC type I have still had the fence working with the battery reading 45 volts on load. The ideal is, of course, the cold-cathode trigger type, but I have only used these on mains-operated units, extensive searchings having failed to find a manufacturer who makes one that can strike or be triggered as low as 60 volts.

Incidentally, H. G. P. Taylor (your February issue) will find that a piece of grass about six inches long (if wearing boots, and shorter if in wellingtons) will only give a slight tingle in the fingers if held to the fence. Much cheaper than neons or having to walk the full length of a twenty-acre field to see if the unit is on or off.

Truro, Cornwall. D. A. BOND.

Tape Terms

AS a complete layman in electronic matters, I can confirm W. D. Arnot's warning (your February issue) of the danger of using "azimuth" to mean something that is not azimuth.

In advertisements I had noticed that certain tape-deck manufacturers advertise their products as having "azimuth adjustment." Until reading Mr. Arnot's letter I had assumed this to mean adjustment in azimuth; to wit, rotation about an axis perpendicular to the deck. The purpose or even desirability of such a movement was not clear, but that is true of most electronic gear so far as I am concerned.

Evidently the word "azimuth" was chosen because it looked and sounded well. What matter that is misleads the layman and hampers the student, who finds that the word means something quite different in electronics to what it does in geometry and navigation?

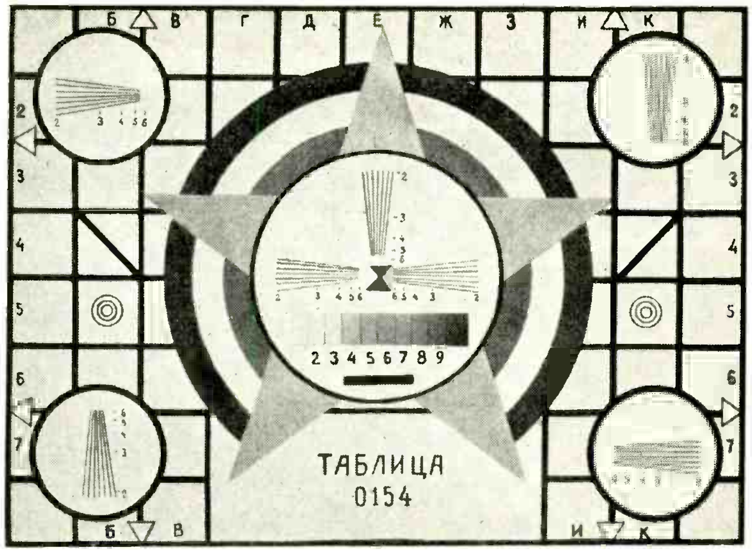
This is but one more symptom of the unpleasant and childish tendency to make everything sound more important than it is. It is not confined to electronic engineering ("Cathode Ray" very justly denounces it in the pseudo-mathematical field), but it is certainly made to feel at home there. The harm goes more deeply than is realized. Not only is the student confused by having to learn a new language as well as a new subject but the new language uses the same vocabulary, with different meanings, as the old. Thus the technical terms often call up false or misleading mental imagery which distorts insight into fundamentals. Computor jargon has many examples of this.

The achievements of electronics, during its short life, are solid enough to stand on their own feet. They need not be boosted by the undignified and illiterate methods of the huckster.

Farnborough, Hants. R. A. FAIRTHORNE.

Russian Colour Television

EXPERIMENTAL STATION IN MOSCOW



Colour test card for the experimental station. The five-pointed star is red, while the three circles are blue, yellow and green respectively. The quartered square in the middle is also made up from these four colours. (Reproduced from the Soviet journal Radio.)

THE frame-sequential system of colour television may be dead (at least from some points of view), but it is obviously not going to lie down. As reported in our last issue, transmissions on this system have recently been going out from the Moscow television centre. Rotating discs are used at both the transmitter and receiver. The name of the station is MOSTsT (formed by the initial letters, transliterated into English, of the Russian words for Moscow Experimental Colour Television Station) and it operates in the Soviet third television band of 76-88 Mc/s, which is situated roughly in the gap between our Bands I and II. (The Kiev television station is also in this band, while Moscow and Leningrad are in the equivalent of our Band I.)

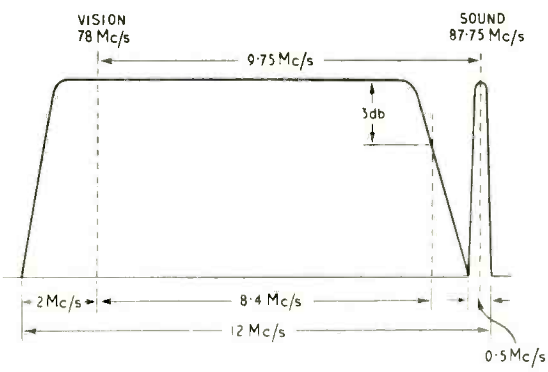


Fig. 1 (above). Idealized frequency characteristic of the transmitting channel.

As can be seen from Fig. 1, the vision carrier frequency of the experimental colour station is 78 Mc/s while the sound carrier, which is frequency modulated, is 87.75 Mc/s. The lower sideband of the vision signal is partly suppressed, giving a video bandwidth of about 8.4 Mc/s and an overall channel width of 12 Mc/s. This fairly wide bandwidth is necessary because of the high rate at which the picture information has to be transmitted, compared with a conventional black-and-white system. In fact, for every frame scan in a black-and-white system the frame-sequential colour system has to transmit three single-colour frames, red, blue and green, in the same time—or three times the amount of information.

The MOSTsT station puts out 25 complete colour pictures per second, and each picture consists of six single-colour frames, red, blue, green, red, blue, green, on alternate odd and even sets of lines—so that in the complete picture there is a full set of interlaced lines for each colour. Thus there are 150 single-colour frames per second, or three times the normal rate for black-and-white television. The number of lines adopted for the transmissions is 525 (as distinct

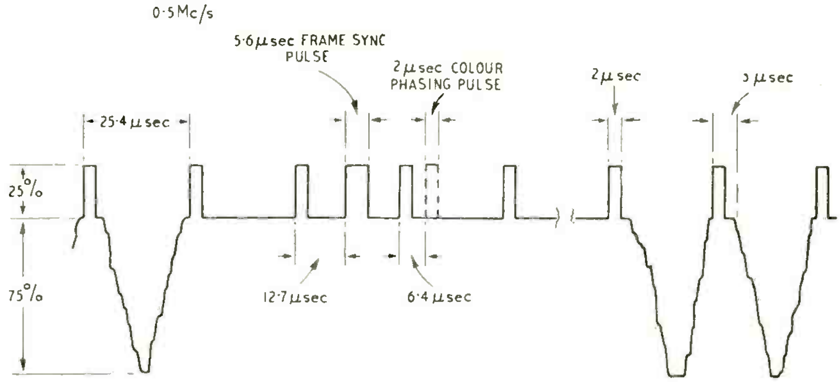


Fig. 2 (right). The transmitted waveform, showing sync pulses during an even frame. The colour phasing pulse is shown dotted as it occurs only in each red frame.

from the normal 625 lines used in Russia) so the line scan frequency works out to 39.375 kc/s, or roughly 25 microseconds per line.

The waveform of the transmitted signal is shown in Fig. 2. Negative modulation is used and the picture waveform occupies 75% of the total signal amplitude. the remaining 25% being taken by synchronizing pulses. A fairly narrow pulse is used for frame synchronizing, as can be seen, and it is intended that this shall be separated in the receiver by means of the delay-line technique. (The sync pulses are all delayed by an amount greater than the duration of a line pulse, then the delayed versions are added to the corresponding non-delayed pulses. As a result the broad frame pulses add up to twice the normal amplitude and can be separated by a "chopper" circuit while the line pulses, not being coincident, do not add at all.) The colour phasing pulse in Fig. 2 has the same duration as the line pulse but is transmitted only once per three colour frames—actually during the red frame. It appears that this colour phasing pulse may not be necessary in some receivers as the rotating colour disc can be kept in correct synchronism by being driven by a synchronous self-phasing motor working from the mains—the transmitting disc being similarly locked to the mains. If, however, the receiver is working from a different mains supply to the transmitter the phasing pulse is, of course, necessary.

Programmes for the colour transmissions originate from a studio with three cameras and an equipment for scanning colour films and slides. A special kind of film scanner has to be used because the ordinary type of equipment is useless when each film frame has to be scanned three times, once for each colour component. The studio is lighted by fluorescent lamps to give the required spectral distribution and low infra-red content (also, incidentally, reducing the working temperature inside the studio). Incandescent lamps are used, however, in conjunction with correction filters, for lighting adjustment purposes. Apart from the studio equipment. all other apparatus is installed in a central control room and here each of the three-colour component signals can be controlled separately. The vision and sound transmitters are generally similar to those used in Russia for monochrome transmissions except that the colour vision transmitter and aerial have a wider bandwidth than normal.

A typical receiver for the colour transmissions gives a picture measuring approximately 5½in × 4in (the standard aspect ratio being actually 11 : 8). The colour-filter disc has a diameter of about 15½in and rotates at 1,500 revs per minute. Six colour filters are cemented on to it, two for each colour, so that one revolution corresponds to a complete colour picture of six frames and in one second the disc revolves the 25 times corresponding to the picture repetition frequency. The colour phasing is adjusted by turning the armature of the synchronous driving motor, which can be moved through 180 degrees. The colour test chart shown at the beginning of the article is used for adjusting the receiver, and the first step, apparently, is to check that the five-pointed star comes out red!

A superhet circuit is used for the receiver, with one r.f. stage, a pentode mixer, three i.f. amplifiers, an anode-bend detector and a two-valve video output stage. There are two sound i.f. stages, an f.m. discriminator and two audio amplifier stages. Blocking oscillators are used for the scanning waveform generators. Altogether there are 23 valves, all miniature types except the power amplifiers and rectifiers, and the total power consumption is about 300 watts. The receiver has a vision channel sensitivity of about 350 μV and a pass-band of not less than 8.3 Mc/s, while the sound channel has a sensitivity of 200 μV.

Readers will note that this Russian frame-sequential system is somewhat similar to the American CBS system which was operating for a short while in the United States before the present N.T.S.C. compatible system was officially adopted. The CBS system, however, worked at a lower scanning speed, the complete colour-picture frequency being 24 per second and the colour frame frequency 144 per second, while the number of lines (for colour as distinct from black-and-white) was 405, which gave a line frequency of 29.16 kc/s. A video bandwidth of about 4 Mc/s was required and a channel width of 6 Mc/s.

The above information on the Russian experimental colour system was abstracted from recent issues of the Soviet journal *Radio* with the help of B. Zacharov.

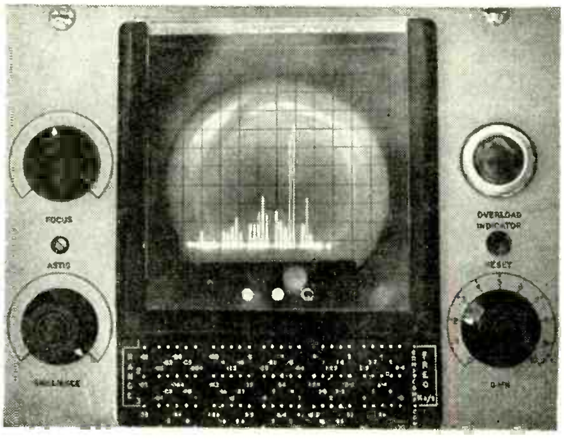
NOISE MEASUREMENT

FOR the examination of the complex noise and vibration phenomena, particularly those associated with jet engines, a wide frequency range is necessary. In general a spectrometer in which the energy in adjacent bands is displayed as a series of vertical deflections on a cathode-ray tube provides the most convenient form of instrument for use in a works, as it gives instantaneous readings which are readily interpreted.

A versatile instrument of this type has been developed by Salford Electrical Instruments in which a frequency coverage of 10 c/s to 100 kc/s is provided in three ranges (10 c/s-6.4 kc/s, 30 c/s-10 kc/s and 320 c/s-100 kc/s). The input from an appropriate transducer is amplified and applied through a cathode follower to 38 filters adjusted to cover contiguous bands each 1/3 octave wide. A mechanically driven time base is coupled to a rotary switch arranged to select each filter in turn, and to display the outputs as vertical deflections. Time-constant circuits associated with the filters provide persistences of 0.1 or 1 second according to the requirements of the work. Frequencies are conveniently identified by an engraved scale immediately below the tube face, while pilot lights show which range is in use.

A useful feature is an overload relay which disconnects the input and at the same time shows whether the overload peak is positive or negative. The relay remains in operation until the input is reduced.

The photograph shows a typical display on the 30 c/s-10 kc/s range from the exhaust of a marine diesel engine with peaks in the region of 3.2 kc/s.



THE SLOT AERIAL

By B. L. MORLEY

Its Characteristics and Relationship to the Familiar Dipole

GHOST reception is one of the serious problems encountered in TV reception and in certain parts of the country it is almost impossible to receive satisfactory pictures because of the reflections. Various methods have been devised for countering ghosts mainly by the development of the aerial system and one of the most effective forms of aerial for this purpose has been found by the writer to be a slot aerial

With the inception of Band III the ghost problem is likely to become more severe; the higher the frequency the more the radio waves behave like light waves and the greater becomes their absorption and reflection. Because of the reduced dimensions of aerials for Band III the slot becomes a practical proposition and we are likely to see some development of this form of aerial in the commercial field.

To those who are more accustomed to the normal dipole form of aerial the slot presents some interesting features, not the least of which is its polarization which is at 90° to that of the dipole. For vertically polarized transmissions the slot aerial is mounted horizontally while for horizontal polarization the slot aerial is mounted vertically.

Basic Conceptions of the Slot:—As the frequencies used in radio work become higher their behaviour becomes more like that of light waves and we find ourselves turning more and more to the optical field in the study of the behaviour of these high frequencies.

A principle of Babinet's in optics can be applied to the slot aerial as was demonstrated by Booker in his paper (*Journ. I.E.E.* Vol 93 Part IIIA No. 4, March-May 1946).

The principle may be stated by considering an array of dipoles having an electromagnetic wave incident upon it. The field around the array will be modified by the array.

Consider the array has boundaries and so forms a screen, then we shall have spaces forming the screen interrupted by the solids of the dipoles (Fig. 1).

Imagine now that the screen is replaced by a complementary screen having space where the other had solids and solids where the other had space. In this case we have a kind of metal negative, the dipoles being replaced by slots and the surrounding media by metal (Fig. 2).

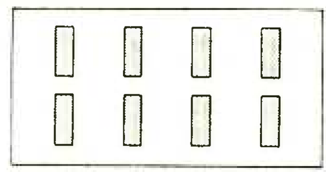
Babinet's principle suggests a definite relationship between the two; this is so; the incident wave is affected and the resultant field distribution is very similar to the previous field distribution.

A dipole may be energized by a generator connected at the centre (Fig. 3a); a slot may also be energized by a generator placed at its centre (Fig. 3b). In the case of a dipole an electric field will be built up between the two halves and in the same plane, i.e., a vertical dipole produces a vertical electric field (Fig. 4a).

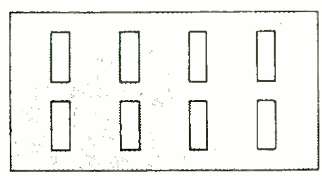
The field is not static, of course, as shown in the diagram; the diagram merely represents the field at one particular moment of time.

In a vertical slot the electric field is built up across the edges of the slot as shown in Fig. 4b. The current field in the metal surrounding the slot is shown by the thick arrows.

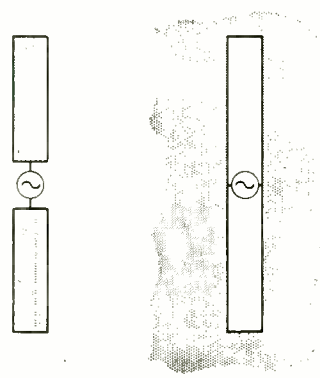
The direction of polarization of an electromagnetic field is that in which the electric field lies. It is clear



Right: Fig. 1. An array of dipoles within a finite screen.

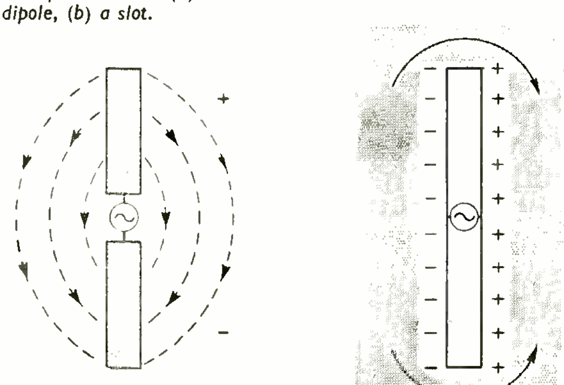


Left: Fig. 2. An array of slots in a screen complementary to Fig. 1.



(a) (b)

Right: Fig. 3. Both a dipole and a slot can be energized by a generator at its centre.



(a) (b)

Below: Fig. 4. Electric field about (a) a dipole, (b) a slot.

that while a vertical dipole produces a vertically polarized field the vertical slot produces a horizontally polarized field.

It is obvious that the electric and magnetic fields have been interchanged when changing from a dipole to a slot. For this reason the slot aerial is often referred to as a magnetic dipole.

The area of the screen surrounding the slot would be such that it is large enough to embrace the inductive and electric fields which would normally exist around the equivalent half-wave dipole in the form of a strip. The screen should extend for a minimum of $0.2\ \lambda$ around the slot.

It is not necessary for the screen surrounding the slot to be completely solid; wire mesh serves the purpose quite well.

The interchange of electric and magnetic fields makes the slot extremely useful for reception from vertically polarized transmitters where the erection of an outdoor array is not permitted. The slot, made out of wire netting, can be conveniently mounted in the loft as, being mounted horizontally, it does not require a great deal of headroom.

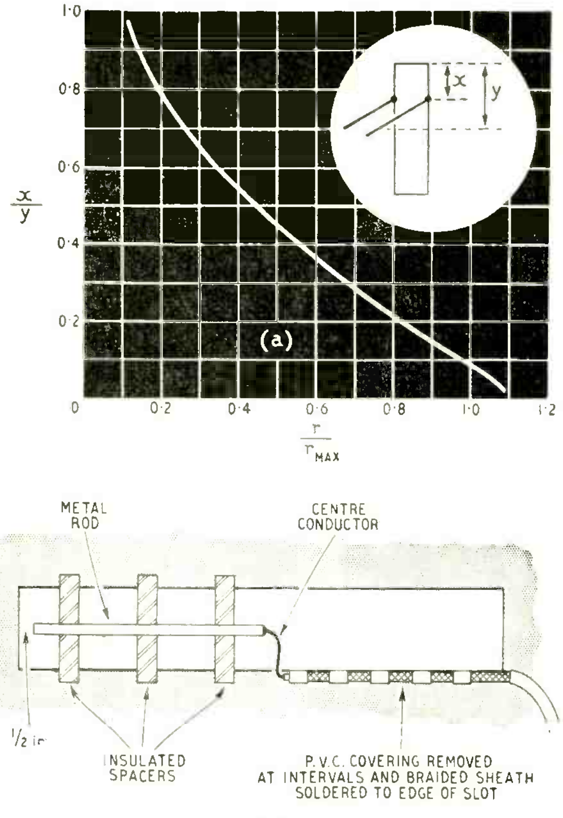


Fig. 5. Matching a low-impedance feeder to a slot, (a) by tapping down, (b) by means of a matching stub.

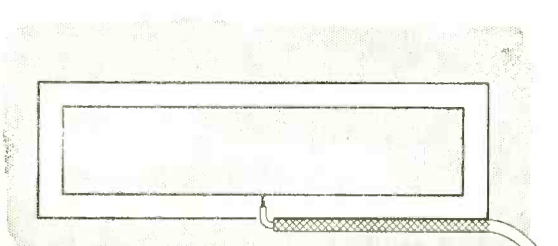


Fig. 6. Folding a slot reduces its impedance. The method of attaching a low-impedance feeder is shown here.

Impedance:—The intrinsic impedance (Z_i) of plane waves in free space may be taken as:—

$$120\ \pi \text{ ohms.}$$

For a half-wave dipole at resonance we have an impedance (Z_d) of:—

$$0.194\ Z_i \text{ ohms.}$$

The relationship between the impedance of the half-wavelength slot (Z_s) and the half-wavelength dipole may be given as:—

$$Z_d . Z_s = 0.25\ Z_i^2$$

$$\text{Therefore} \quad Z_s = \frac{0.25\ Z_i^2}{Z_d}$$

$$\text{whence} \quad Z_s = \frac{0.25\ Z_i^2}{0.194\ Z_i} = \frac{0.25 \times 120\ \pi}{0.194} = 500 \text{ ohms (approx.).}$$

From this it will be seen that the slot can be used by feeding the centre with 600-Ω line. The standing wave ratio with the slight mismatch will be very small and for practical purposes could be ignored.

Where it is desired to use 80-Ω cable, however, some method of overcoming the mismatch must be employed. A popular method is to use a matching transformer in the form of a $\lambda/4$ section of line.

To calculate the characteristic impedance of the matching section the following formula can be applied:—

$$Z_a = \sqrt{Z_b . Z_c}$$

where Z_a = impedance of the matching section
Z_b = impedance of the aerial
Z_c = impedance of the transmission line.

In this particular case we find that we shall require a $\lambda/4$-section of 200-Ω cable. This is not a convenient size but it would be reasonable to employ 150-Ω balanced twin cable.

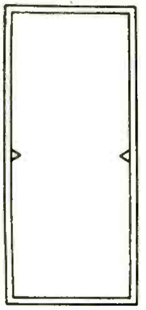
One point which must not be overlooked is that the velocity factor of the cable must be used to calculate the actual physical length, at the frequency of the aerial system. The physical length then becomes:—

$$V_o\ \lambda/4$$

where V_o is the velocity factor.

A more convenient method of matching is to utilize another property of the slot. This property is the variation of impedance along the length of the slot. In the case of the half-wavelength dipole the impedance increases from the centre to the ends; in the case of a half-wave slot, however, the reverse is the case, the impedance decreasing from the centre towards the ends of the slot. It is therefore possible to find a point along the length of the slot where the impedance will match the cable. Fig. 5a shows the relationship between the slot impedance and the point of attachment. The precise judgment of the point of attachment becomes rather tricky for an 80-Ω cable but it is perfectly practical with a 300-Ω line. The final position is best located experimentally in order to avoid the introduction

Fig. 7. The skeleton slot is derived from the slot aerial.



of any reactive component. One of the best methods of matching low-impedance cable to a slot is that shown in Fig. 5b.

The impedance of the slot can be lowered considerably by folding it (Fig. 6). This is the complementary of the folded dipole; in the latter case the impedance is stepped up by n^2 times where " n " is the number of elements in the fold. For the folded slot, however, the impedance is altered by $\frac{1}{n^2}$ times. A simple folded dipole will therefore have its impedance stepped up 4 times while a simple folded slot will have its impedance decreased by 4. The slot with a single fold will therefore have a centre impedance of $500 \times \frac{1}{4}$, or 125 Ω, which is a reasonable match to 150-Ω cable and *could* be used with an 80-Ω cable.

When a coaxial cable is used a convenient method of feeding the folded slot is to join the outer of the feeder half-way along the bottom edge of the slot and the inner conductor to the centre of the remaining half of the slot, as shown in Fig. 6. The method effects a balance-to-unbalance matching device and gives a centre impedance of about 150 Ω. With an 80-Ω cable the standing wave ratio is rather less than 2 giving a loss of only about 1 db. The system works remarkably well in practice.

Bandwidth:—In the television field we are very interested in bandwidth. With the slot aerial we have similar conditions to that existing in the half-wave-length dipole. In the latter case, increasing the ratio of diameter to length increases the bandwidth; in the case of the slot, increasing the ratio of the width of the slot to its overall length also increases the bandwidth.

Exact figures are not available but a slot width of 12 in should be adequate for the TV channels.

Adding a Reflector:—A slot has its responses at 90° to the plane of the frame and the polar diagram takes the form of a figure-of-eight in both the azimuth and the vertical planes. It can, however, be made uni-directional by the addition of a suitable reflector. This can be in the form of another slot mounted in the same plane and of equivalent half-wave reflector length, or it can be a simple screen erected vertically behind the slot. A distance of $\lambda/4$ is normally quite effective.

The most efficient method of making the slot directional is to box it in on one side. The best method is to make a cavity in the form of half a sphere, the radius being concentric around the centre of the slot.

The reflector introduces fresh matching difficulties as the centre impedance of the slot is increased. With the normal dipole, a reflector *decreases* the centre impedance of the dipole, but with a slot the reflector *increases* the centre impedance. A box reflector will raise the impedance to about 1,000 Ω.

A reasonable match to a 300-Ω line can be made by folding the slot in the manner already described, which then brings the centre impedance to just under 250 Ω.

The Cavity Resonator:—It is but a short step from a boxed slot aerial to a cavity resonator and indeed the slot so treated can be fed on similar principles, the slot being energized by the introduction of a probe; it is doubtful if such a method is of any real benefit in the TV field—at least until Band IV is opened up.

Slot aerials can also be erected in what might be termed complementary Kooman arrays, and for those interested in this aspect, reference should be made to the recent work done in this field by W. H. Watson (*The Physical Principles of Wave-guide Transmission and Antenna Systems.* Oxford University Press).

Skeleton Slots:—The skeleton slot was derived from experiments in an attempt to find the minimum dimensions of the media surrounding the slot: in the course of experiments the media were trimmed away until only the slot was left surrounded by air, yet the slot continued to exhibit the characteristics of the slot aerial! An interesting account of this work was given recently in these pages by H. B. Dent (August 1954). This type of slot may have a good future as it seems particularly suitable for Band III television.

It is clear that there is a great deal of work to be done in this field; herein lies useful work for the inventive mind!

Band III Pilot Transmitter

Vision Signals for Testing Receivers and Aerials

As reported in last month's issue Belling & Lee are erecting a temporary Band III transmitter on a site in south London for the purpose of providing a vision signal for testing aerials and receivers prior to the commencement of the regular service from the proposed I.T.A. station.

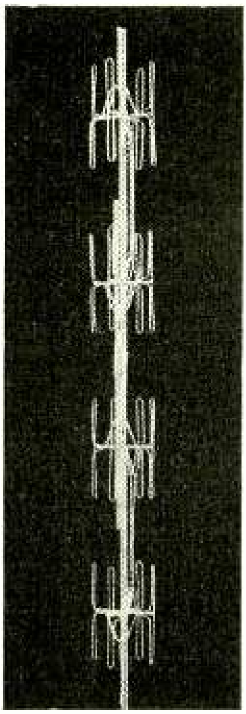
Although considerable data are available in the U.S.A. on reception conditions of 200-Mc/s signals in built-up areas using horizontally polarized waves practically nothing is known of the conditions likely to prevail with vertical polarization, which will be used largely in this country on Band III. These pilot transmissions are intended to redress for this lack of knowledge and so provide valuable data for the design of aerials for Band III.

Tall, narrow objects such as chimneys, cooling towers, cranes and possibly metal flagpoles, while not generally troublesome on Band I, may prove far from innocuous on Band III, where to the signal they look four times as large and any reflections may be expected to be four times as troublesome.

It might be found that while a simple dipole will, in a given location, provide an adequately strong signal, a more elaborate aerial system may have to be used solely to minimize pickup of reflections and the attendant interference by ghost images. The transmissions may help to decide what is a normal condition in a built-up area on Band III; is it with or without attendant ghosts? These, and many other, questions are expected to be answered before the regular I.T.A. service commences, so that manufacturers can concentrate with confidence in advance on the production of aerials for the various districts and conditions likely to be encountered.

The pilot transmitter is to be housed in a temporary hut, 24 ft × 10 ft, in the corner of the actual site of the I.T.A. London station on Beulah Heights, South Norwood.

A self-supporting tower of at least 50 ft will carry an aerial system comprising four stacked bays each of four vertical half-wave folded dipoles spaced equidistant around a 16-ft topmast. There are thus 16 dipoles in the system, which by its design gives an all-round coverage and an anticipated power gain of four. As the transmitter power output will be of the order of 250 watts the effective radiated power will be approximately 1 kW.



Scaled-down version of the omni-directional aerial designed by Belling and Lee for the Band III pilot transmitter in South London.

The r.f. output from the transmitter is fed to the aerial by about 110 ft of 50-ohm air-spaced aluminium-sheathed coaxial cable having the exceptionally low loss at the operating frequency of about 0.3 db per 100 ft. A balun coupler converts the unbalanced feeder system to balanced output at the aerial.

The vision frequency of channel 9, which is 194.75 Mc/s, will be used and a series of static patterns will be transmitted initially, but it is envisaged that a standard type of test card and captions will ultimately be provided. No sound will accompany the vision signal except, perhaps, after the temporary service is well under way, when it may be possible to introduce some form of tone modulation.

Present plans are for morning and afternoon transmissions of two hours each on weekdays, but excluding Saturday. These periods, however, await approval and subject to the terms of the G.P.O. licence.

The pilot transmitter is being designed, built, installed and operated solely by Belling & Lee, but the project has the blessing of the Radio Industry Council and the I.T.A. as well as the Post Office, all of whom have been, we are told, most co-operative.

B.B.C. SOUND QUALITY

FEW subjects have provoked more sustained and often heated controversy than the quality of sound reproduction dispensed by the B.B.C. Since the days of 2LO there has been a steady stream of praise, blame, conjecture and correspondence.

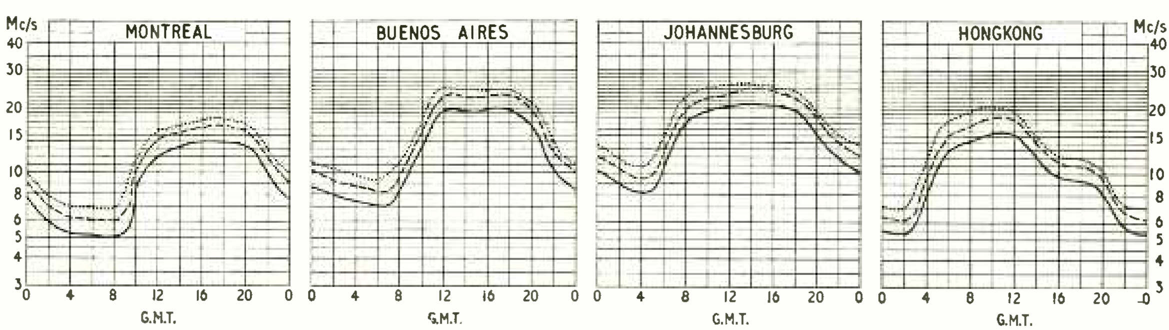
So many factors are involved and precise information has in the past been so scarce and scattered, that it is small wonder that the controversy occasionally assumes a somewhat unrealistic air. The publication of the B.B.C. Engineering Training Manual "Studio Engineering for Sound Broadcasting" should do much to bring the subject into perspective.

It is written by senior members of the B.B.C. Engineering Division and states unambiguously and in detail how the B.B.C. chooses its studio acoustics, places its microphones, amplifies and monitors the output, what characteristics are specified in hiring distribution lines from the G.P.O., the kinds of distortion that are met with and how they are corrected. For instance, it may not be generally known that the temperature of the ground has an appreciable effect on quality due to the change of capacitance as well as resistance of Post Office lines. Curves of the change of attenuation with frequency are prepared, routine measurements of temperature are made and equalization applied. There are, in fact, few details of the chain between microphone and transmitter about which there is any longer any need to guess.

Copies of this new book cost 25s (or 25s 6d by post) from our publishers, Iliffe and Sons Ltd., Dorset House, Stamford Street, London, S.E.1.

SHORT-WAVE CONDITIONS

Predictions for March



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 March.

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

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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

INTRODUCTION TO

(Concluded from p. 65 of the February issue.)

Transistor Electronics

2.—*Potential Gradients and Current Carriers in Junction and Point Transistors*

By H. K. MILWARD, B.Sc., A.M.I.E.E.

UNDER certain conditions a pair of junctions in a crystal separating the two types of impure germanium or silicon already discussed shows some very special and interesting effects. The most important condition is that the two junctions should be close together. In other words a thin layer of *p*-type material separating two portions of *n*-type material, or vice versa, constitutes such a double junction. Transistors are known as *p-n-p* or *n-p-n* according to the type of layer embodied. In this article *p-n-p* junctions are considered in detail, but the explanations given apply equally well to the other type provided that proper attention is paid to the directions of bias and current flow, and to the fact that free electrons rather than holes become the main carriers of the current.

A *p-n-p* junction is shown in Fig. 16 and the electrodes are named. The base is seen to be sandwiched between the emitter and collector electrodes.

Under conditions of thermal equilibrium, and with all electrodes disconnected, the potentials of the *p*- and *n*-layers are different, for the same reasons as was given for the single junction. This is shown in Fig. 17.

If the junctions are biased so that the base-collector junction has reverse bias and the emitter-base junction forward bias, the potential levels are altered to those shown in Fig. 18. Examination of this graph shows that because the emitter-to-base gradient is decreased the diffusion current of holes is increased, but the gradient for the base-collector junction is much increased, stopping altogether—or very nearly so—the diffusion hole current from collector to base. The generation currents, which are due mainly to thermal effects, remain much the same as before. The important point, however, is that the diffusion current of holes from the emitter crosses the junction to the base, but much of it, before it can find its way to the actual base electrode, tumbles over the "precipice" to the collector. Consequently the base current is small compared with the emitter current, the greater part of which goes to the collector. This is a most important fact when the effect of altering the base potential is considered.

The dotted line (*c*) in Fig. 18 shows the effect of reducing the base potential, that is, making it less positive; and the broken line in the same diagram

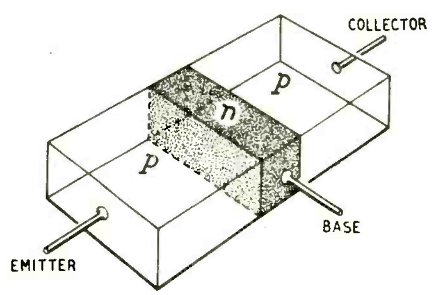


Fig. 16. Sketch of p-n-p junction transistor showing electrodes.

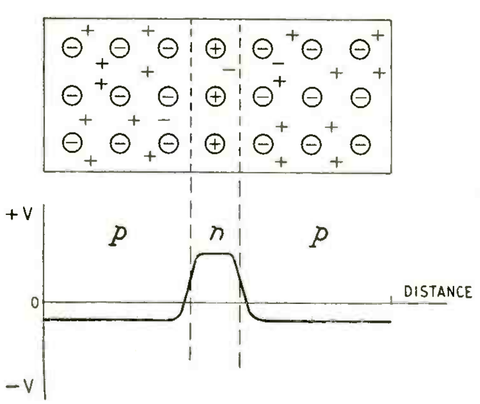


Fig. 17. In an unbiased transistor a potential difference exists between layers.

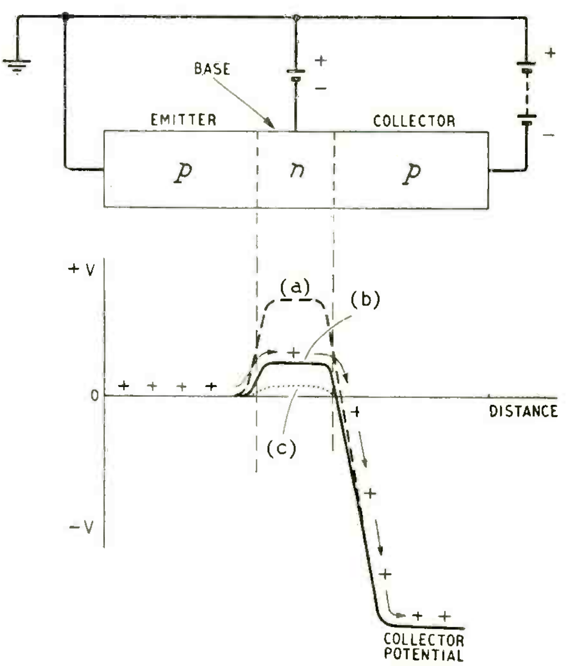


Fig. 18. Biased transistor. The full line (b) represents the normal d.c. negative bias on the base. The broken line (a) shows the effect when that bias is removed and the dotted line (c) shows what happens when the bias is increased.

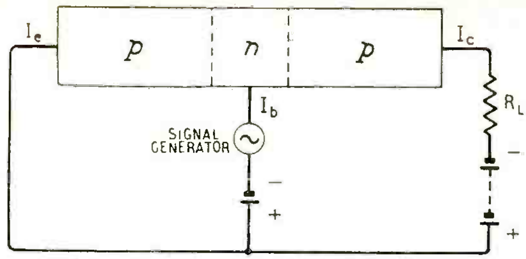


Fig. 19. Simple amplifier circuit using a p-n-p junction transistor.

represents the effect of increasing it. The + signs represent free holes, most of which are in the *p*-layers: some of these holes, however, diffuse into the centre layer, as is shown by the arrows. The effect of applying negative bias to the base is to decrease the adverse potential gradient from emitter to base, and this allows the hole diffusion current to increase. But as we have already seen only a small proportion of this current actually goes to the base electrode, most of it finishing up at the collector.

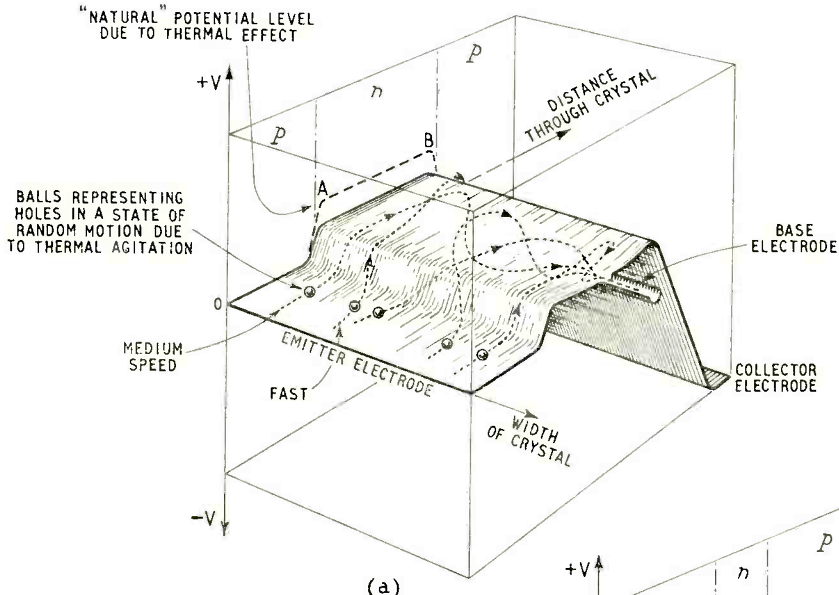
A change of base potential in the other direction increases the potential gradient, and hence reduces the emitter current. In effect, therefore, the change of base potential has much more effect upon the emitter-collector current than upon the base current. Since, too, the base-collector junction is back-biased and therefore of high resistance, the change of current through it causes a large change of potential across it. A small change of power input to the base thus causes a large change of power output from the collector. In other words there is amplification.

The current amplification ratio α may be defined as the ratio of the change of collector current to the change of base current*. This factor may be very high, particularly if the base layer is very thin. The thinner it is the greater the factor α becomes.

A fact which enhances the power gain is that the emitter-base junction is working in a forward-biased state. Its resistance is therefore low so that the power dissipated by the small base current is made still less. This means that the power gain may be considerably greater than the current gain.

An example shows this fact clearly. Fig. 19 shows a possible circuit for a junction transistor. If we assume that the resistance of the emitter-base junction is 500 ohms and that the collector-base junction is 20,000 ohms (not unusual figures), that α_{cb} is 50, and that the transistor is connected to a load of 20,000 ohms, then the power taken from the generator is $I_b^2 \times 500$ watts and that given to the load is $I_c^2 \times 20{,}000$ watts. (I_b and I_c represent alternating currents.) But since $\alpha_{cb} = 50$, $I_c = 50\ I_b$

* It is also defined as the ratio of the change of collector current to the change of emitter current, and the possibility of confusion exists. This may be avoided by using the suffixes "cb" or "ce" to denote either collector-base ratio or collector-emitter ratio, α_{ce} is always less than unity, whereas α_{cb} may be quite large: which factor is used depends upon the type of circuit.



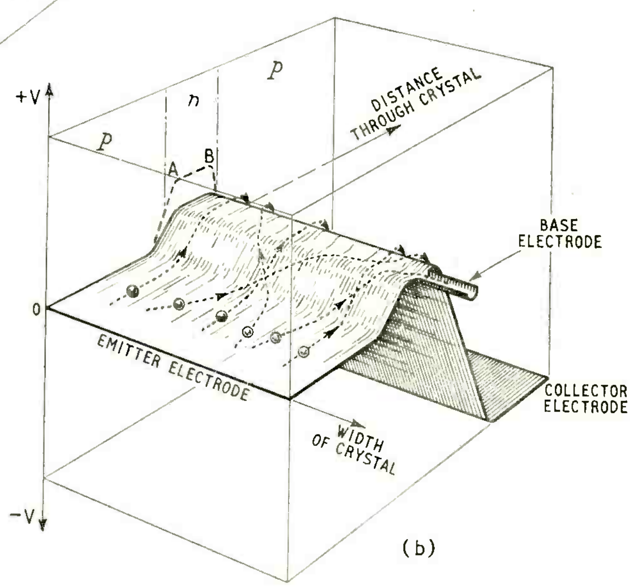


Fig. 20. Potential levels throughout the crystal represented by surfaces, the vertical dimension representing potential. In each case the unbiased potential levels for thermal equilibrium are drawn in as a broken line and marked AB. Diagram (a) shows the effect of a wide intermediate layer. The probable paths of the holes are shown and it can be seen that most of them are likely to end up at the base electrode. Diagram (b) shows the effect of a narrow layer. In this case the chance of a ball (representing a hole) arriving at the base electrode is quite small. Most, even slow ones which are able to surmount the gradient, fall over to the collector.

$$\therefore \frac{\text{Power out}}{\text{Power in}} = \frac{(50 \times I_b)^2 \times 20{,}000}{I_b^2 \times 500} = 100{,}000$$
$$= 50\text{db}$$

This simple calculation neglects the effect of feedback due to the generator internal impedance and to the common internal impedance of the transistor, and is given only as an indication of the order of gain to be expected. The detailed effects and capabilities of transistors in conjunction with their circuits do not come within the scope of the title of this article.

Now that a general idea of the working of a junction transistor has been given, it is possible to examine the reasons for the base potential having so marked an effect on the collector current. This is best done with a pictorial representation of a surface, the height of which is made to be equivalent to the potential in different portions of the crystal. This surface could be constructed as a mechanical model, using a flexible membrane supported on a solid structure.

Fig. 20 shows such a surface; the vertical dimension represents voltage and the horizontal dimensions represent the length and breadth of the crystal. The "spout" representing the base electrode can be moved up and down and this causes the whole "potential" surface of the *n*-layer to rise and fall. Being flexible the surface becomes slightly convex or concave as the spout forces it to rise above or be pushed below its natural level. Its natural level is shown dotted and marked AB, and represents the equilibrium state of the unbiased crystal. Fig. 21 shows a possible potential gradient within the intermediate *n*-layer illustrated in exactly the same way as contours on a map indicate height.

The emitter-base junction is forward biased for amplification of an a.c. signal, so that in our pictorial analogy the base "platform" is concave. This is shown in Fig. 20. In the emitter part of the crystal the holes are rushing about in a random way due to thermal agitation and the faster ones are able to surmount the slope up to the base region. The dotted lines in Fig. 20(a) show possible paths of fast holes over a wide layer. It will be seen that most of them are likely to end up at the base electrode, only the fastest being able to get up to and over the edge of the precipice into the collector region.

But this is not the whole picture. It is complicated by the fact that the probable length of path which a hole can traverse without deflection or collision is quite short. The effect of the base region being wider than this "diffusion length"† is to make it rather more likely for the holes to finish up at the base electrode.

For a narrow layer, however, the story is quite different. The platform is so narrow that the effect of the slight gradient towards the base electrode is almost negligible, and any hole having the energy to surmount the first gradient can scarcely avoid falling over the edge of steeper gradient the other side. In addition, if the width of the layer is less than the diffusion length, as is just possible, the collision effect is much less likely and the majority of holes are able to cross the platform without interference. The diffusion length may be in the region of 1 mm while the thickness of the layer can be less than this. In any case, provided that the width is not very much greater than the diffusion length a fair proportion of the emitter current still goes to the collector.

† Those with some knowledge of the kinetic theory of gases will realize the similarity of the "diffusion length" with "mean free path."

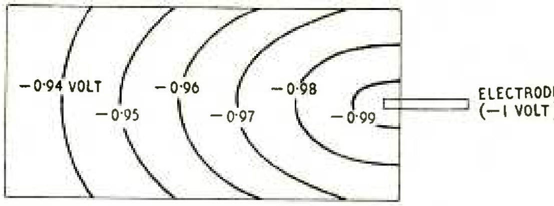


Fig. 21. Potential "contours" in a crystal layer biased negatively when the natural potential level is assumed to be positive.

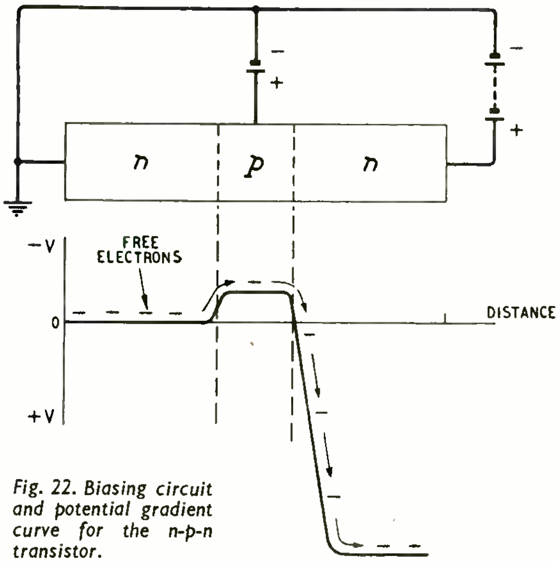


Fig. 22. Biasing circuit and potential gradient curve for the n-p-n transistor.

The width of the layer is thus a critical factor in deciding the intrinsic gain of a transistor. Control of the width of this layer to such very small dimensions is one of the most difficult problems which manufacturers have to solve.

In this pictorial analogy the generation current of holes and electrons within the *n*-type layer has been left out of the argument, but it can be included without invalidating it. It represents a steady flow of holes from the base to both collector and emitter, and provided that the gradient on both sides falls away it does not matter by how much. The effect of an a.c. signal on the base is, therefore, not interfered with by a steady d.c. flowing from base to both the other electrodes. It will be clear that the a.c. must not be too large if distortion is to be avoided.

It is as well to remember that any pictorial analogy is somewhat crude and cannot explain all the effects. It cannot, for example, deal with both hole and electron behaviour at the same time. But provided that its limitations are realized it can be helpful for an elementary understanding.

The *n-p-n* junction operates in very much the same way as *p-n-p*, except that it must be oppositely biased. As Fig. 22 shows, the potential gradient diagram is like that of Fig. 18, except that the polarity of the vertical axes is reversed. What was said of the behaviour of holes in the *p-n-p* transistor now applies to free electrons. In the *n-p-n* transistor then, the amplifying action is explained wholly in terms of free electrons.

The amplifying action may be summed up gener-

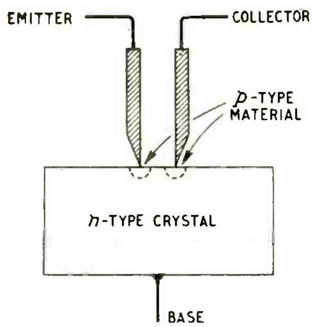


Fig. 23. Sketch of a point transistor. In practice the emitter and collector electrodes are very close together.

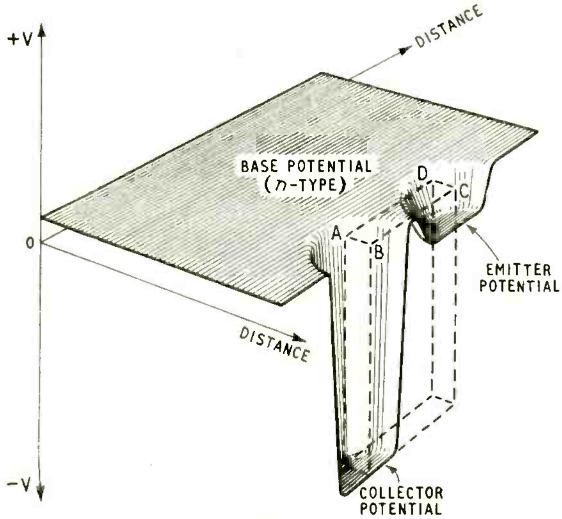


Fig. 24. A surface representing potential levels in the point transistor. Provided that the points are very close together the "barrier" between the emitter and collector is somewhat lower than the general potential level of the base as a whole. This makes it more likely for most of the emitter current to find its way to the collector.

ally by imagining the base layer to be a barrier separating the two different levels of emitter and collector, the height of which is varied by the signal. The free electrons or holes in the emitter (electrons if *n-p-n*; holes if *p-n-p*) are swirling about in a state of violent agitation. The rate at which they spill over the barrier is dependent on its height. When it is low they spill over in great quantities; when high only a few can manage it—the fast ones. The signal, therefore, in controlling the height of the barrier, effectively controls the collector current, and in doing so consumes only a fraction of the power which can be dissipated by the collector circuit. Thus there is power gain, and amplification is then possible.

Point Transistors

Junction transistors have been explained first because point transistors operate in exactly the same way, though constructed and formed differently. Fig. 23 shows a diagram of a point transistor. The two points, which are the emitter and collector, are close together, being usually only a few thousandths of an inch apart. It is possible to construct such a transistor from a germanium diode by placing a third electrode close to the original contact. If a suitable spot is found it then acts as a transistor.

In the commercial production the transistor is "formed," and this process produces a small hemisphere of *p*-type material around each point in an *n*-type crystal. This is indicated in the diagram by the dotted lines. Thus there are junctions between the different materials exactly as in the previous case. The difference here is that the junction areas are small and the effective part of them even smaller, for only those portions which are very close have an effective transistor action. It will, therefore, be realized that the power handling capacity of the point transistor is very much less than that of the junction type.

Fig. 24 shows a three-dimensional representation for the point transistor similar to that in Fig. 20 for the junction type. The action takes place mostly within the area represented by the dotted rectangle ABCD, the rest of the crystal being unnecessary. This is in effect a junction transistor in miniature.

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"Consol" Beacon Receiver

THE introduction of a compact receiver designed especially for receiving the "Consol" radio beacons in small ships focuses attention on a long-range navigational aid of which little has been heard recently. One advantage of this system is that it can be utilized by seafaring people unskilled in operating radio equipment, and in the case of this new set its operation is further simplified by employing pre-set station selection.

Consol beacons radiate rotating patterns of dots, dashes and equi-signal areas and taking a bearing merely resolves itself into counting the dots and dashes that precede the arrival of the continuous note signal. Charts then give the exact bearing, but it requires at least two stations, suitably positioned on land, to provide a position or "fix." The two giving coverage over home waters generally are Bush Mills in Northern Ireland and Stavanger in Norway. The range of a beacon is about 1,000 miles over sea and 700 miles over land in daylight and about half as far again at night. Consol is a c.w. beacon and operates in the 250-500-kc/s beacon band.

In the receiver developed by The Great Grimsby Coal, Salt and Tanning Co., Fish Dock, Grimsby, for fitting in a number of the smaller North Sea fishing craft, there are two r.f. stages, a detector/oscillator, one audio amplifier and an output tetrode embodying an audio filter.

The received c.w. signal is heterodyned by the internal oscillator and the beat note is heard in a pair of headphones. Alternatively, the signals can be read visually on a built-in milliammeter.

To meet the requirements of smaller ships the receiver is normally operated from a 12- or 24-volt d.c. supply by means of a rotary converter, but it can be supplied for other operating voltages if necessary. Apart from its use in fishing craft, it would seem to be well suited for use in private yachts and motor cruisers requiring an easy-to-operate navigational aid in the waters around these islands. The overall size of the receiver is only 13 × 9 × 9in. A 50- to 60-ft aerial, which should have as much of its length as possible vertical, is required for best results.

Information on the method of obtaining a "fix" with the Consol beacons is given in Section VI of the "Complete Weekly Edition of Admiralty Notices to Mariners" and also in the 1953 edition of the "Admiralty List of Radio Signals."

Recovering Hidden Signals

Use of Correlation Techniques

By JAMES FRANKLIN

ONE of the latest methods of analysing electrical signals—or indeed variations in time of almost any kind—is by means of a somewhat fearsome-sounding thing called the "correlation function." Actually it was invented by G. I. Taylor as long ago as 1920, but only recently has it come into real prominence and been used in a practical sort of way. This is probably due to the current interest in information theory and the modern habit of looking at signals in terms of statistics and probabilities. The correlation function is, in fact, a statistical property of a signal, and it means exactly what it says. It measures the extent by which one part of a signal is proportionately related to an earlier part—or, alternatively, the extent by which one signal is related to another signal. For example, if the signal (or time function) consists of completely random variations, like noise, there is practically no correlation between one part of it and another. One cannot say that the present fluctuations are in any way controlled by or related to those which have occurred earlier. But if the signal is periodic in nature, like a sine wave, there is a very strong relationship between present and past variations. There is, in fact, a definite law connecting them, and what happens at the present moment is completely controlled by what has happened previously.

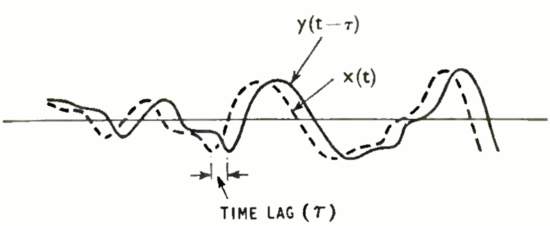


Fig. 1. Two signals with a delay time τ between them. As y(t—τ) is actually a delayed version of x(t), a comparison of values at any point is, in effect, a comparison of past and present values of x(t).

This measure of correlation is obviously of great value in making predictions. From a knowledge of how present variations in some physical phenomenon are related to earlier variations one can guess with a fair degree of certainty what will happen in the future. We all tend to use this principle intuitively for predicting the weather, and, in fact, meteorologists do the same thing, but more precisely on a numerical basis, by deriving the correlation function from data on graphs which record such things as temperature and humidity variations.

In the communication field, however, the main use of the correlation function is in analysing signals to detect periodic components which may be heavily masked by random variations or noise. If one has a signal which appears on the surface to be all random noise, but one suspects that a certain periodic component is present, then the correlation function will either confirm or deny that suspicion. Actually, the degree of correlation turns out to be a measure of the power of the periodic component.

But how does one perform the measurement of correlation in practice? One way is to tabulate values of the signals or time functions and perform a series of calculations on them. This is extremely laborious, however, and most people nowadays use an analogue computor to do the job. If the analogue computor can be made to work almost instantaneously it is possible to do away with the tabulation and feed the signal or time function into it directly. The answer, however, still comes out in the form of a slowly plotted graph. A device which responds in a completely instantaneous way to correlation in a signal is the correlation detector. This has been used in radar receivers, and it gives a steady output proportional to the power of the periodic component, rather as an a.m. detector in a conventional receiver gives an output proportional to the amplitude of an incoming carrier wave.

When correlation measurements are made to find the degree of relationship between present and past values of one particular signal, the result is known as the "auto-correlation function." When the measurements are made between two different signals which may be related it is the "cross-correlation function" that is being investigated. Thus, in practice, an "auto-correlation detector" is a device in which the incoming signal is compared with a slightly delayed version of itself, while in a "cross-correlation detector" the incoming signal is compared with a separate locally generated signal which is arranged to have the same frequency as the wanted periodic component.

In the minds of most people the idea of correlation is rather vague and imprecise. We recognize the relationship between things of similar pattern or form by an intuitive process and we are not very conscious of the mechanism by which this similarity is detected. It is therefore rather difficult to understand how correlation between physical variables can actually be measured in numerical terms. As was mentioned above, the correlation function is a measure of the extent by which the value of a signal at a time t is proportional to the value of another signal at an earlier time, t-τ. Fig. 1 shows two such signals, $x(t)$ and $y(t$-$\tau)$. They can be entirely separate signals, or, as appears from the diagram, $y(t$-$\tau)$ can be simply a delayed version of $x(t)$, which enables the correlation to be found between some present value at time t and a previous value at time t-τ of the same waveform. In what follows the symbol x will be used to denote the instantaneous value of $x(t)$ at some arbitrary instant of time while y will denote the value of $y(t$-$\tau)$ at that same instant and therefore corresponds to the value of signal $x(t)$ at a time earlier by τ. The question is then: to what extent is $x(t)$ proportional to $y(t-\tau)$, as distinct from being affected by other possible components?

One way of considering the matter is this. If $x(t)$ is really to some extent proportional to $y(t-\tau)$, when x is large the more likely it is to be related to large values of y than to be the result of other causes not connected with $y(t-\tau)$. At the same time, if y is large it is more likely to be associated with a large value of x than if it is small. Thus the two waveforms have a greater probability of being related when x and y are both large together than when x is large and y is small, or when y is large and x is small. When they are both small one can draw no conclusions.

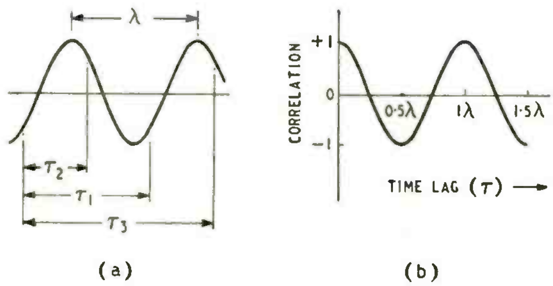


Fig. 2. At (a) is a sine wave showing possible time lag intervals for auto-correlation, while (b) is the associated auto-correlogram plotted with the time lag in terms of the sine wave period λ.

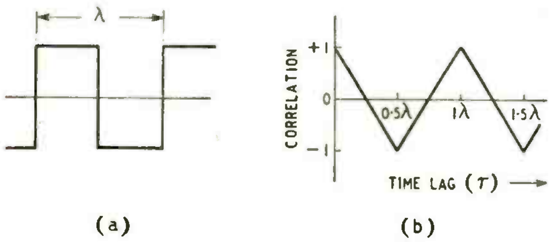


Fig. 3. At (a) is a square wave and at (b) is its auto-correlogram.

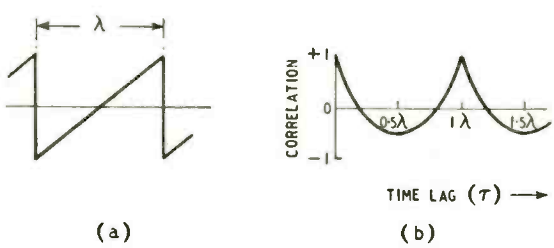


Fig. 4. Another example of auto-correlation, showing a sawtooth waveform at (a) and its auto-correlogram at (b).

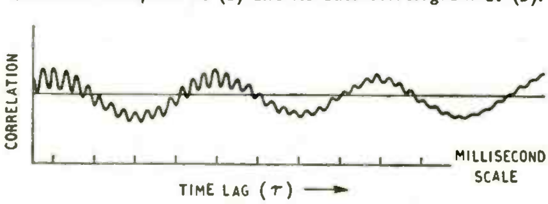


Fig. 5. Auto-correlogram of a speech waveform produced by a male speaker saying "ee" as in "feed." The two main periodicities are at 250 c/s and 3.5 kc/s.

Thus, one can say that the correlation at any single point is proportional to the product of x and y, which is only large and positive when both x and y are large (either positive or negative) together. It is necessary, however, to take the average of a large number of such products to be able to decide the degree of correlation between the complete waveforms. Thus the correlation function finally turns out to be the average of the product $x(t).y(t-\tau)$, and it is expressed mathematically as

$$\frac{1}{2T}\int_{-T}^{+T} x(t)\,.\,y(t-\tau)\,dt$$

In principle the averaging should be performed over all time, but in practice it is only necessary for the averaging time to be large compared with the period of the slowest variations in $x(t)$ and $y(t-\tau)$ or lowest frequency components.

When expressed in this way the value of the correlation function is obviously affected by the amplitude of either of the two signals, although the form of the relationship between x and y is not changed. It would clearly be better to express the function in a form which depends only on the shape of $x(t)$ and $y(t)$ and not on the amplitude of either signal. Correlation between many different types of signal could then be measured on the same scale. This can, in fact, be done by replacing $x(t)$ and $y(t-\tau)$ in the formula by the ratios $x(t)/\sqrt{\overline{x^2}}$ and $y(t-\tau)/\sqrt{\overline{y^2}}$, in other words, by dividing both signals by their r.m.s. values. The result is then known as the "normalized correlation function" and its values always lie between the limits -1 and $+1$. If the normalized value is $+1$ then $y(t-\tau)$ is exactly proportional to $x(t)$. If it is -1 then $y(t-\tau)$ is proportional to $-x(t)$. If the normalized value is zero, there is no linear relationship between $x(t)$ and $y(t-\tau)$ for that value of τ or time lag.

The extent of the time lag is, of course, important in determining the correlation values, and to get a complete picture or "correlogram" the measurements have to be made with a large number of values of τ. For example, supposing we are finding the auto-correlation function of the sine wave in Fig. 2 (a), the time lag τ_1 will clearly give maximum correlation $(+1)$ because it corresponds to the period of the sine wave. A time lag of either τ_2 or τ_3, however, will give maximum negative correlation (-1) because here the points compared are 180° out of phase.

If the amount of correlation (in normalized values) is plotted for a large number of different values of time lag τ the result comes out as shown in Fig. 2(b) which is the "auto-correlogram." It can be seen that the auto-correlogram is a sine wave like the original signal, and, in fact, it is a general rule that where the signal is periodic the correlogram is too. Some other examples of signals with their auto-correlograms are shown at Figs. 3 and 4. It will be noted that where the time lag τ is zero the signal is being compared with itself, so that obviously the correlation must be a maximum.

When the auto-correlation function is measured for more complex signals, but which contain various periodic components, the result is usually something like Fig. 5, which shows an analysis of an audio signal produced by the continuous sound "ee" as spoken by a man. From this auto-correlogram it is possible to do a frequency analysis. It will be noticed, for example,

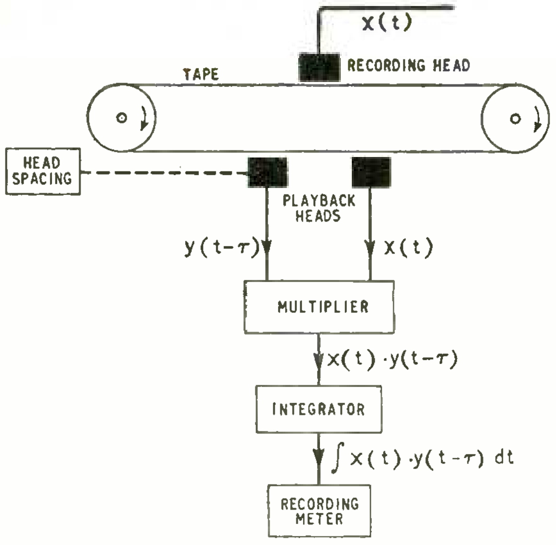


Fig. 6. Simplified schematic of an auto-correlation analogue computor using a magnetic tape system to obtain the necessary time lags. The recording meter prints the values of successive integrals (one for each time lag) as a series of vertical lines of varying height.

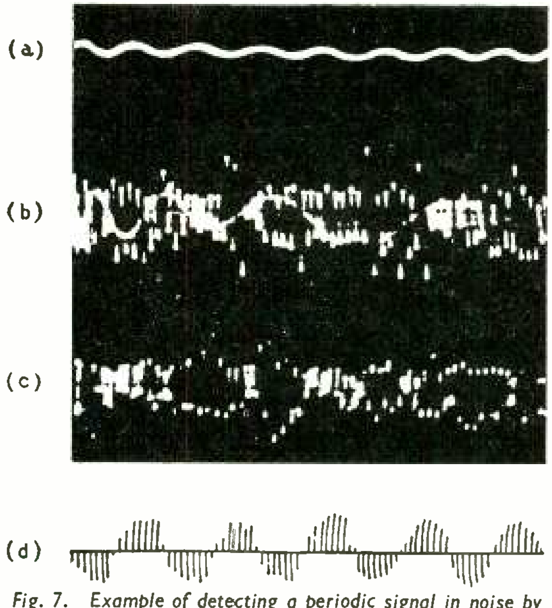


Fig. 7. Example of detecting a periodic signal in noise by means of an auto-correlation computor. At (a) is the signal while (b) is the noise and (c) the mixture of signal and noise. The auto-correlogram, indicating the periodicity, is shown at (d), the line heights being proportional to the values of successive integrals as the time lag τ increases in steps along the horizontal axis. (Courtesy E.E.G. Journal.)

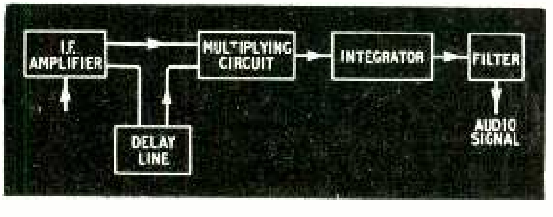


Fig. 8. Block diagram of an auto-correlation detector.

that the principal maxima are produced with a time lag, τ, of 4 milliseconds, and this period corresponds to a frequency of 250 c/s. One might argue that this type of measurement does not give any more information than an ordinary spectrum analysis, which is quite true. The form of presentation does, however, bring out the less obvious relationships and periodicities which would not be shown up by other means. For this reason correlation techniques have been used on complex signals such as speech waveforms, television signals and electrical brain rhythms in an effort to discover any significant relationships which are not normally apparent.

It was mentioned earlier that an analogue computor could be used to calculate the correlation function automatically. One example of such a device is shown in Fig. 6 in very simplified form. Supposing we are concerned with auto-correlation for the moment, the necessary delayed version of the signal is obtained by recording the waveform on magnetic tape and then taking it off by two playback heads, one displaced slightly from the other. The first head to encounter the signal then gives $x(t)$ while the second one gives the delayed version $y(t-\tau)$. These two signals are multiplied by an electronic circuit to give $x(t).y(t-\tau)$ and finally integrated by another circuit to give $\int x(t).y(t-\tau)dt$. The time lag τ is varied in steps by an automatic mechanism which alters the distance between the playback heads for each successive revolution of the tape, and for each particular value of τ the value of the averaged product is plotted by a recording meter.

With cross-correlation between two separate signals it is necessary to use two recording heads, one for each signal, working on adjacent tracks on the tape. The two pick-up heads are similarly arranged with one on each track.

As was mentioned earlier, one of the important applications of correlation techniques is in recovering signals from noisy backgrounds. Fig. 7 is an example of what can be done in this direction with an auto-correlation computor (such as in Fig. 6) indicating the periodicity by its plotted measurements. The original periodic signal is shown at (a) while (b) is the noise—very much greater in amplitude—and (c) is the mixture of signal and noise. It is almost impossible to detect the presence of the signal in (c) by ordinary methods, but the auto-correlation computor gives the result of (d). This shows that the periodic component has been correlated but the random fluctuations of the noise have not. Thus the auto-correlation computor operates in the time domain to achieve a result that only an extremely narrow-bandwidth filter could give in the frequency domain, and in certain applications this can be a definite advantage. Moreover, the computor is not restricted to working at one particular signal frequency whereas the filter is.

For producing an instantaneous output signal there is (as was mentioned above) another device—the correlation detector. A typical arrangement for one working on the auto-correlation principle is shown in Fig. 8. From the i.f. amplifier of the receiver two identical output signals are obtained, one of them being passed through a delay line. The i.f. signal and its delayed version are then applied to the two grids of a multiplying valve, which gives an output proportional to the product. This is then integrated in a capacitor over a sampling interval which is short compared with one half-cycle of the highest modulation frequency but long compared with the carrier frequency. The capacitor is discharged at the end of each sampling interval, so the waveform across it consists of a series of sawteeth rising to different amplitudes—which represent successive integrations corresponding to the lines of varying height in Fig. 7 (d). The sawteeth are then passed through a filter and the original modulating frequency is recovered.

The auto-correlation function is often quoted as being "the Fourier transform of the power spectrum." This means that if one does a frequency analysis of $x(t)$ and the normalized correlation function one finds that they both have exactly the same frequency components, but that the amplitudes of the components of the correlation function are proportional to the power of the corresponding components of $x(t)$, that is, proportional to the squares of the amplitudes. One might expect from this that it would be no easier to frequency analyse a signal from the correlation function than from $x(t)$ itself, but it is easier in fact because in $x(t)$ the frequency components have widely differing phase relationships, whereas in the normalized correlation function they are all in phase when $\tau = 0$.

To end on a practical note, one interesting example of correlation techniques being applied to industrial purposes occurs in the textile industry. An auto-correlogram computor has been developed by the British Rayon Research Association for analysing periodic components in the irregularities which occur in the cross-section of yarn. These periodic components can produce highly objectionable patterning in a fabric when it is woven at cloth widths bearing some relationship to the wavelength of the component. In order to characterize the yarn output from a set of spindles it is necessary to take a large number of yarn samples, so a comparatively cheap computor is needed to analyse the output signal from a yarn irregularity measuring instrument in as short a time as possible.

The computor used actually works on the principle shown in Fig. 6. The electrical signal corresponding to the variations in yarn cross-section is obtained from a Fielden-Walker yarn-irregularity tester, and is recorded on the tape in the form of frequency variations. Two demodulators following the playback heads then convert the frequency variations back into amplitude variations before they are applied to the computing circuits.

Commercial Literature

Band I/Band III Television Aerials, for chimney mounting, with both aerials consisting of a dipole and reflector and feeding into a single 70-Ω downlead. Performance figures given on a leaflet from Wolsey Television, 43-45, Knight's Hill, West Norwood, London, S.E.27. Also a leaflet discussing the reception problems created by Band-III stations which are not co-sited with Band-I stations.

R.F. Cables; coaxial solid and air-spaced types for general purposes and various types of twin and coaxial for television feeders and transmission lines. Tables of characteristics in an illustrated catalogue from W. T. Henley's Telegraph Works Company, 51-53, Hatton Garden, London, E.C.1.

Coil-winding Bobbins of synthetic resin-bonded paper for use with standard laminations and "C" type cores. Booklet giving types, dimensions and prices from Associated Electronic Engineers, Dalston Gardens, Stanmore, Middlesex.

"Silver Plating," a booklet describing in a practical manner the various processes involved in preparing the work, plating and finishing, from Johnson, Matthey & Co., Hatton Garden, London, E.C.1.

Carbonyl Iron Powders; their properties, manufacture, testing and use in magnetic cores and waveguides described in a well-produced illustrated booklet from The Mond Nickel Company, Sunderland House, Curzon Street, London, W.1.

Sonic and Ultrasonic Testing. Determination of elasticity, compressive strength and porosity of materials and detection of flaws; methods and electronic equipment described in a booklet from A. E. Cawkell, 6-7, Victory Arcade, The Broadway, Southall, Middlesex.

Miniature Stud Switches (Painton Winkler), one- to four-pole and one to six banks operated from common shaft. Various numbers of positions are available up to 29 and the action can be make-before-break or break-before-make. Leaflet from Painton & Co., Kingsthorpe, Northampton.

Miniature Transistor Transformers; a range of two input, one output and two interstage types, all measuring (in Mumetal screening cans) $\frac{9}{16}$in × $\frac{1}{2}$in × $\frac{25}{64}$in. Leaflet giving impedance ratios, d.c. resistances and frequency responses from John Bell & Croyden, 117, High Street, Oxford.

Audio Amplifier with output power of 25 watts and frequency response of ±1db between 10c/s and 100kc/s. Distortion at 26 watts output less than 0.2 per cent. Specification and test report from Southampton University on a leaflet from Cape Electrophonics, 43-45, Shirley High Street, Southampton.

Printed Circuit Preservative. A liquid which can be sprayed or brushed on to printed circuits to prevent oxidation during storage and also to act as a flux for dip soldering. Descriptive leaflet from Multicore Solders, Multicore Works, Hemel Hempstead, Herts.

Anti-corrision Bolts; made of Monel alloy to prevent corrosion of threads under nuts. Mentioned in a bulletin "Wiggin Nickel Alloys" from Henry Wiggin & Co., Wiggin Street, Birmingham, 16.

Silicone Insulated Transformers (power types) with resistance to fire and moisture. There is little change in the dielectric strength of the insulant over a period of time at temperatures in the 200-250°C range. Brochure from Brentford Transformers, Kidbrooke Park Road, Kidbrooke, London, S.E.3.

Point-to-point Communications Station consisting of transmitter and receiver working on frequencies between 1.6 and 14 Mc/s. The 60-watt transmitter is a crystal-controlled, four-channel type with push-button channel selection, and the receiver also has four pre-set crystal controlled channels. Leaflet from Pye Telecommunications, Newmarket Road, Cambridge.

Portable Wheatstone Bridge with measuring range of 0.01Ω to 1MΩ, using internal battery and galvanometer, and an accuracy of ±0.1Ω. Leaflet from the Croydon Precision Instrument Co., 116, Windmill Road, Croydon, Surrey.

Solderless Connections; a system for attaching tags, pins and other connectors to wires and cables by a crimping process. Booklet describing the process and various crimping tools from The Plessey Company, Ilford, Essex.

Printed Circuits; application to various equipments such as audio amplifiers, power supplies, television i.f. amplifiers and filters, with notes on dip soldering, discussed in a bulletin from The Telegraph Condenser Co., Special Products Division, North Acton, London, W.3.

Wide-range Oscilloscope (for testing advanced equipment) with provision for incorporating sub-units for specialized requirements. Includes facilities for instantaneous voltage and time measurement, sweep delay (with respect to sync) and control of tube e.h.t. and bias, while the Y amplifier can be switched to high gain and 9Mc/s bandwidth or low gain and 25Mc/s width. Leaflet from E.M.I. Factories, Hayes, Middlesex.

Combined Television Tester, covering Bands I and III and incorporating a pattern generator, wobbulator, a.m. signal generator, l.f. oscillator, oscilloscope, e.h.t. voltmeter and a.c. and d.c. valve voltmeter. Portable instrument measuring 15½in × 9½in × 8½in and weighing 25lb described in a leaflet from Airmec, High Wycombe, Bucks.

Airfield Radio Communications, for traffic control, and public address equipment; their application described briefly in an illustrated booklet "Airport Electrification" from The General Electric Company, Magnet House, Kingsway, London, W.C.2.

Direct-Reading Capacitance Tester

Range 10pF to 1,000 μF with Insulation Resistance 0.3 to 2,000 MΩ

By O. E. DZIERZYNSKI

THE conventional method of measuring capacitance is to compare the unknown with a standard in a bridge circuit. The method is accurate and provides a wide range of measurement. It is simple and inexpensive. When large numbers of capacitors of different values require checking, however, the time taken in setting and balancing the bridge is a disadvantage, and a direct-reading method is much to be preferred.

The instrument to be described, gives direct readings of capacitance on a moving-coil milliammeter. The scale is linear (1 to 10) and gives readings from 10pF to 1,000 μF in eight decades. Insulation tests can also be carried out at voltages close, in most cases, to the rated working voltages of the capacitors. Three overlapping ranges give direct readings of resistance from 2,000 MΩ to 0.3 MΩ the scale calibration law is similar to that of the conventional ohmmeter.

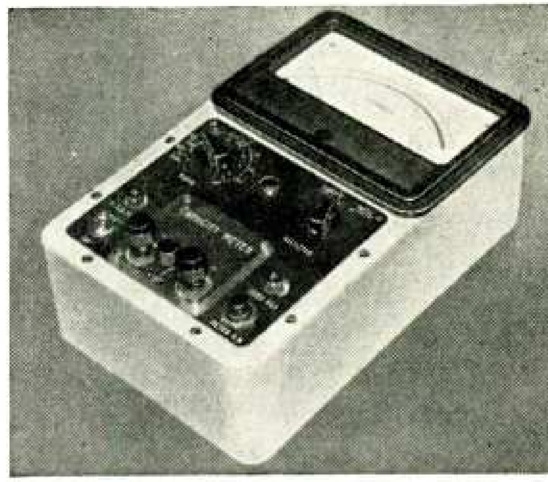
Capacitance Circuit.—The basic circuit for measuring capacitance is given in Fig. 1. A 50-c/s source drives a current through C_x and R in series. Provided that the reactance of C_x is at least 10 times greater than R, the current is almost proportional to the value of C_x when decreasing from $C_x$max to the minimum value $\frac{C_x\text{max.}}{10}$

The voltage developed across R will be

$$V = IR \approx V_0 \Big/ \frac{1}{\omega C} R = V_0 R \omega C$$

As V (as will be discussed later) is of the order of a fraction of a volt, amplifier A is necessary between V and the linear-scale a.c. instrument. Consequently, the reading of the instrument is $V_1 = k\,V_0\,R2\pi fC$, where k is the gain of amplifier A.

In the above formula k, V_0, R and f are constant, hence instrument readings in a.c. volts are proportional to the capacity C. An important fact to emphasize



Direct-reading capacitance and insulation meter made by Sargrove Electronics Ltd.

here is, that the voltage V_0 must be sinusoidal, and the maximum permissible distortion should be less than 5%.

Capacitance Ranges.—From the last formula, the capacitance reading can be expressed as:

$$C = \frac{V_1}{kV_0 R2\pi f}$$

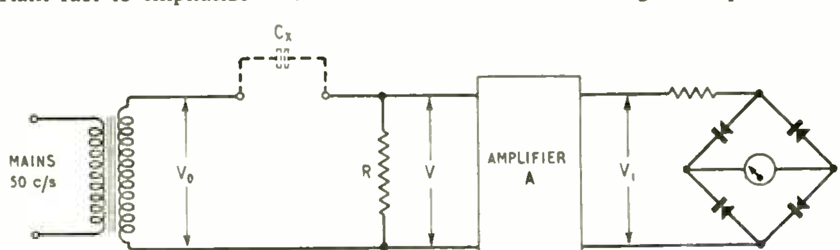
The values of k and V_0 are normally constant, irrespective of range (with the exception of highest and lowest range—see later in text), the frequency (50 c/s) is constant; so the range of the instrument can be varied only by the value of R.

On the second range (100-1,000 pF) the impedance of the capacitance under test varies from about 3 to 30 MΩ, so the resistance R should be of the order of 300 kΩ. For the following five ranges (0.001-0.01μF, 0.01-01μF, 0.1-1μF, 1-10μF and 10-100μF) the value of R is successively divided by 10 for each range.

The input voltage V_0 was chosen to give a maximum voltage across R of 250 mV. The output meter gave full-scale deflection for 25 volts a.c. input, so the required gain in the amplifier was 100. This could be comfortably provided by an ECC81 double triode connected as an R-C coupled cascade amplifier with negative feedback (Fig. 2).

The highest range (100-1,000μF), which is used primarily for electrolytic condensers, must be given separate treatment. The impedance of 1,000-μF at 50 c/s is about 3 ohms, and with the standard input a current of the order of 1 ampere would flow, with detrimental results not only to the condenser, but to the stability of the input voltage. The value of R is therefore reduced on this range. In practice the

Fig. 1. Basic circuit for capacitance measurement.



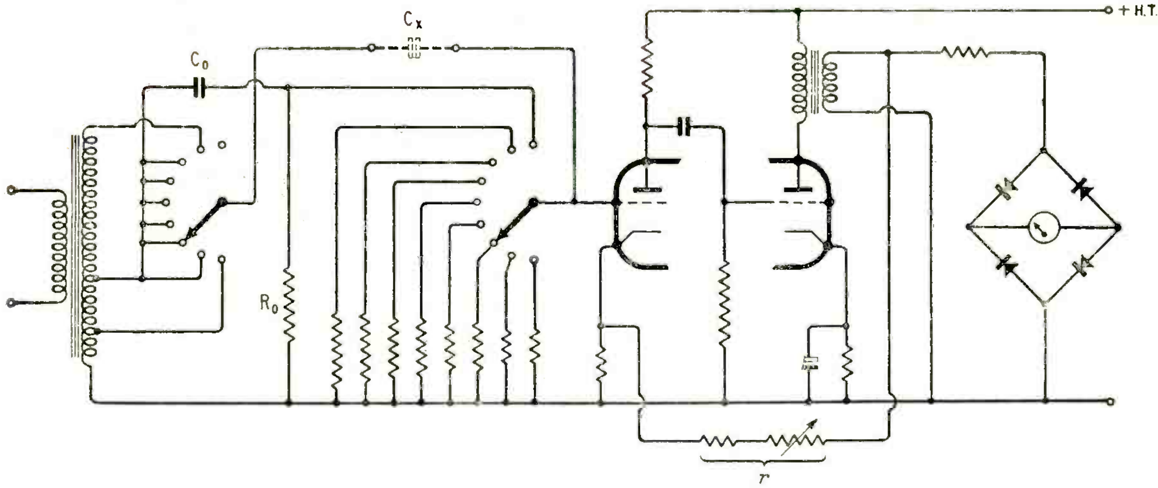


Fig. 2. Capacitance range switching and amplifier circuit.

use of raw a.c. for testing electrolytics proved to be quite successful.

On the first range (10-100pF), the impedance of the condensers under test are of a very high order (approximately 300-30 MΩ respectively) and resistor R should be 2 MΩ. For practical reasons (hum pick-up, stray capacitances, etc.) it is advisable to keep R as low as possible. Consequently, on this range V_0 was increased 10 times with R remaining the same as in the 100-1,000 pF range.

Amplifier.—The R-C coupled amplifier incorporates negative feedback derived from the secondary of the output transformer and applied through *r* to the cathode of the first stage. Part of resistor *r* is variable and in this way it is possible to control the gain of the amplifier. This control is used only when the calibration of the instrument is being checked.

The amplifier—owing to considerable negative feedback (approximately 10 db) has good stability and the principal reason to introduce control of gain is to compensate for the effects of mains supply voltage variations on the input voltage V_0.

When the range switch is set to the first (calibration) position, the standard condenser C_0 (0.001μF) combined with resistor R_0 (of the same value as R on the range 100-1,000 pF) is connected in the normal way for capacity measurement. Exactly full-scale deflection should be then obtained, and if not, resistance *r* controlling the gain of the amplifier must be adjusted accordingly.

Accuracy.—In general this should be better than 5% with good and medium quality condensers. Condensers with excessive leakage should give higher readings for capacity, as the effective impedance would fall and larger currents would appear in resistor R. To keep readings correct on range 10-100 pF requires not only good internal insulation of condenser, but also that outside dirt, and particularly moisture around the terminals and on the body of the condenser, should be reduced to the minimum. A series of tests and measurements has been carried out on this subject and the results obtained are summarized in Fig. 3. Assuming that errors should not exceed 5%, values of maximum permissible leakage have been determined, depending on the value of capacity.

This curve shows that leakage in the very great majority of tested condensers would not affect the capacity reading. The normal insulation resistance of a 0.1 μF condenser, for instance, is of the order of at least hundreds of megohms. Generally speaking, normal insulation in the first three ranges is of the order of 1,000 MΩ and moisture and dirt on the body of the capacitor, or poor insulation in the meter itself are more likely to be the limiting factors.

Insulation Measurement—Fig. 4 gives a general

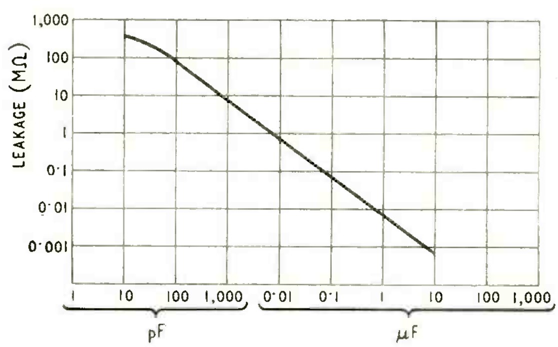


Fig. 3. Permissible leakage resistance for reading accuracy up to ±5% in capacitors of different values.

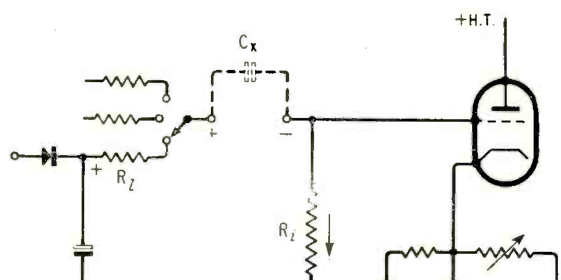


Fig. 4. Basic circuit for insulation test.

idea of the circuit used in the insulation test. To the condenser C_x under test a voltage of the same order as the rating of condenser is applied in series with resistances R_l and R_i. Leakage in the condenser would produce a voltage drop in resistor R_i which would apply a positive potential to the grid of the valve, causing an increase of anode current, measured by meter M (0-1 mA).

Resistor R_l serves to limit this voltage drop in the case of very low insulation or a short circuit between the condenser terminals; also to improve the calibration law. Meter M is connected in a simple backing-off circuit. Initial anode current is approximately 3 mA and this current is reduced to zero in the meter by means of the 1.5-V battery. Under these conditions an ECC81 valve will still work on the linear part of its characteristic, and, with negligible load in the anode circuit, maximum sensitivity is obtained (theoretically equivalent to the mutual conductance).

Insulation Ranges.—Three ranges have been employed: 2,000—30 MΩ, 200—3 MΩ and 20—0.3 MΩ. Test voltages and limiting resistance have been chosen so that for simplicity of calibration, 2,000, 200 and 20 MΩ on the various ranges are approximately 1/10 of full-scale deflection (same spot) and 30, 3 and 3 MΩ are at about 85% of f.s.d. The calibration law is similar to that of an ordinary ohmmeter with this difference, that no f.s.d. adjustment is necessary (ranges are also much more spread than in an ohmmeter).

Owing to the fact that the current in the meter is compensated, the initial zero indication has to be adjusted.

When testing a condenser for insulation the initial surge current could be quite considerable (particularly in electrolytics) and to prevent overloading the meter, provision has been made to reduce sensitivity 10 times (while switch S remains closed).

Test voltages (according to range) are 500V, 50V or 5V d.c.; limiting resistances range from several megohms to a fraction of a megohm. Resistor R_i is fixed and incidentally is equal to R in capacity measurement circuit (second range).

Insulation Precautions.—When testing high insulation, particularly in the low-capacitance range, special precautions must be taken, not only to prevent leakage across terminals, but also leakage from the positive terminal to earth. Leakage to earth would bypass the tested condenser and resistor R_i, decreasing the reading considerably. Consequently the positive terminal and associated components (such as switches) must be very well insulated from earth (ceramic wafers); also kept in dry, warm conditions.

The condenser itself, during the test should not be touched, being suspended between terminals or resting on a special insulating base (see photograph).

High accuracy of insulation measurement is not normally required, but in this system $\pm 10\%$ can be achieved. From time to time, using an external standard, say 20 MΩ, calibration should be checked, as, if the valve emission deteriorates, readings become high, and this cannot be compensated, as it is by feedback in the a.c amplifier in the capacity meter.

Constructional Notes.—When developing the final circuit and layout of components, several factors had to be taken into consideration. Regarding the circuit itself, switching over from insulation to capacity test and *vice versa* presented the main problem. This was solved by using an 8-way, 2-position ceramic selector switch.

In the insulation position, the first section of the ECC81 works as the d.c amplifier, the second section being disconnected.

The range switch is of the 3-way, 9-position type, also with ceramic wafers.

Important factors when designing the mechanical layout were:

1. Negligible hum pick-up from internal and external sources.
2. Low internal capacitance and good insulation between terminals and between associated components.
3. Compactness.
4. Necessary controls on front panel.
5. Easy access for servicing.
6. Layout convenient for wiring in sub-assemblies.
7. Provision for testing condensers *in situ*.

An interesting details in the design is that the negative return is connected to the chassis through 0.1 μF. Laboratory tests of residual capacity between terminals gave a figure less than 0.5pF, and consequently capacitors of the order of 1—10pF could be tested on this equipment after extending the range by increasing the parameter V_oR ten times with reference to the first range (0.0001 μF f.s.d.).

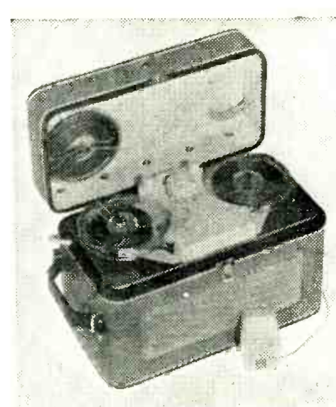
The photograph shows the two switches (selector and range), two small pre-set knobs for adjusting zero and f.s.d. when setting for insulation and capacity tests respectively, main switch and meter switch—the latter chiefly for use when testing electrolytic condensers (to prevent overloading of the meter by the first surge). As, on the capacity test position, a.c. voltages are exposed between the live terminals and earth (middle terminal connected to the negative return), the appropriate circuits are protected by fuses in the event of an accidental short circuit. Fuses are located on the underside of the case.

Compact Tape Recorder

A SINGLE tape speed of $3\frac{3}{4}$ in/sec has been adopted in the new Philips "Recordergram" Model AG8105, which, with twin tracks on 600 ft (5-inch) reels, gives one hour's playing time. The circuit employs a single ECC83 double triode, followed by an EL84 which functions alternatively as output valve or h.f. oscillator; the level indicator is the new DM71 with "dot and line" display. There are separate volume controls for recording and reproduction in addition to the main function-control knob.

A crystal microphone is supplied and there are facilities for using the amplifier for disc record reproduction.

The dimensions of the case are $13\frac{3}{4}$ in × 10 in × 7 in, the weight is 21 lb and the price £36 15s.



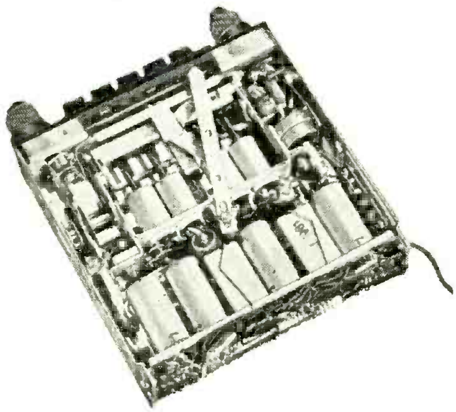
Philips portable tape recorder Model AG8105.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Car Radio Units

AN entirely new range of car radio sets has been introduced by Radiomobile to replace the units brought out in 1950. The new sets are again made in three separate units; a control unit, an amplifier and a loudspeaker system. But in the new models much re-arrangement of parts and circuit has been effected, with the result that greater sensitivity is afforded, the electrical link between units offers greater freedom from external interference and the power output is increased.



Inside of the new de luxe Radiomobile control unit, model 200X. Note the compactness and orderly layout.

The four basic units comprise a standard radio control unit (model 220X), containing the first three valves of a superhet receiver, a standard amplifier with 2 valves, one of which is a rectifier; a *de luxe* amplifier with 2 valves plus a metal rectifier. The standard amplifier operates one loudspeaker while the *de luxe* model gives sufficient output for two speakers.

Push-button selection of five stations plus free-tuning facilities are provided by the *de luxe* radio control unit, but the standard unit has free-tuning provision only. The makers claim that the new standard model is some four times more sensitive than the old one.

Prices of the new sets are: model 220X, £24 9s 1d; model 200XA with standard amplifier, £30 3s or with the *de luxe* amplifier (200XB) £33 10s. Inclusive of U.K. purchase tax and loudspeaker.

The makers are S. Smith & Sons (Radiomobile), Ltd., Goodwood Works, North Circular Road, London, N.W.2.

"Cascap" Capacitors

RECENTLY introduced by Plessey is a new range of miniature ceramic capacitors known as "Cascaps" for working voltages up to 500 d.c. or 300 a.c. They are suitable for use over a wide temperature range and are especially applicable where precision of capacitance value is not of primary importance.

"Cascaps" are made in two basic types, one for purposes such as r.f. by-passing and decoupling and the other for use in radio interference suppressors.

The normal types are in capacitances ranging from 0.0005 to 0.01 μF and made in the form of small discs. A 0.003-μF "Cascap" for example measures 0.5in only in diameter and is about $\frac{1}{16}$in thick. The breakdown voltage is 4,000 d.c. and the insulation resistance of the order of 10^{11} ohms. In general the suppressor types are a fraction larger than the normal variety and comply fully with BSS613 for this class of component.

The capacitors are distinguished by their protective coating of a specially developed green paint having very high insulation resistance and being impervious to moisture.

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

Record Cleaning Material

THE strong electrical charges which attract dust to the surface of vinyl long-playing records are effectively dissipated by the application of minute traces of a chemical cleaning liquid compounded by E.M.I. Sales and Service Ltd., Hayes, Middlesex. To ensure that the liquid is sparingly used it is supplied as an impregnant in a cleaning "cloth" of folded crepe paper which will be known as "Emitex." Each cloth, which costs 1s 6d, will treat an average of 100 record sides.

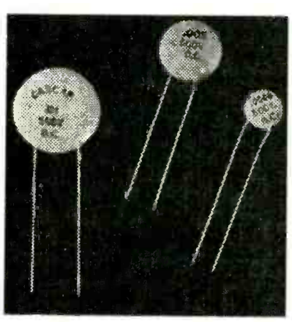
A single application was found to be sufficient to disperse deliberately induced charges which were strong enough to lift the record envelope off the table. Some curious effects were noticed during the cleaning process, due to uneven distribution of the charge, a few particles appearing actually to be repelled by the disc. When the film has penetrated to the bottoms of the grooves, the surface becomes electrically inactive and this process is usually complete after a single playing. Thereafter the treatment should not require to be repeated for several months.

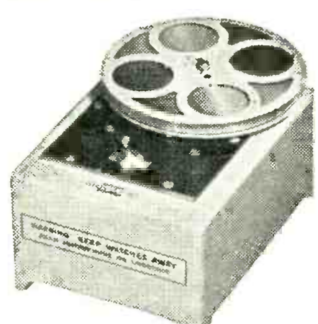
The makers state that the treated surface reduces the friction between stylus and groove by about 20 per cent.

Tape Eraser

PROVISION for erasure is often omitted from small portable tape recorders in the interest of battery economy, and there are many office dictating machines using small spools for which a separate eraser would be convenient.

To meet this demand Leevers-Rich Equipment Ltd., 78 Hampstead Road, London, N.W.1, have introduced a "Junior" version of their bulk eraser in which a strong 50-c/s alternating field is used to bring the tape back to a magnetically neutral state as the spool is rotated over an electro-magnet in the base. The new model is designed to take spools up to 5 in diameter and can be operated from any a.c. lighting point (consumption approximately 1.5 A at 200-250 V). The price is £6 5s.





Plessey "Cascap" miniature ceramic capacitors and (right) Leevers-Rich bulk eraser for small magnetic tape reels.

TWO-VALVE SUPERHET

Simplicity and Economy Without Sacrifice of Performance

By R. C. LEVER*

IN the design of a new type radio receiver, the designer has many problems to overcome, possibly most important of all being the total cost of the finished product. To-day the cheapest domestic receiver available on the open market resolves itself into the popular t.r.f. type. This receiver, which no doubt justly fulfills its obligations in sensitivity, invariably falls by the way when judged from the aspects of selectivity and ease of manipulation. It is for this reason then that the standard four- or five-valve superhet receiver with all the advantages of selectivity and sensitivity is generally favoured. However, the cost of this type usually exceeds that of the t.r.f. receiver. With economy the overriding factor the author decided to combine some of the advantages of both the t.r.f. and superheterodyne receiver principles.

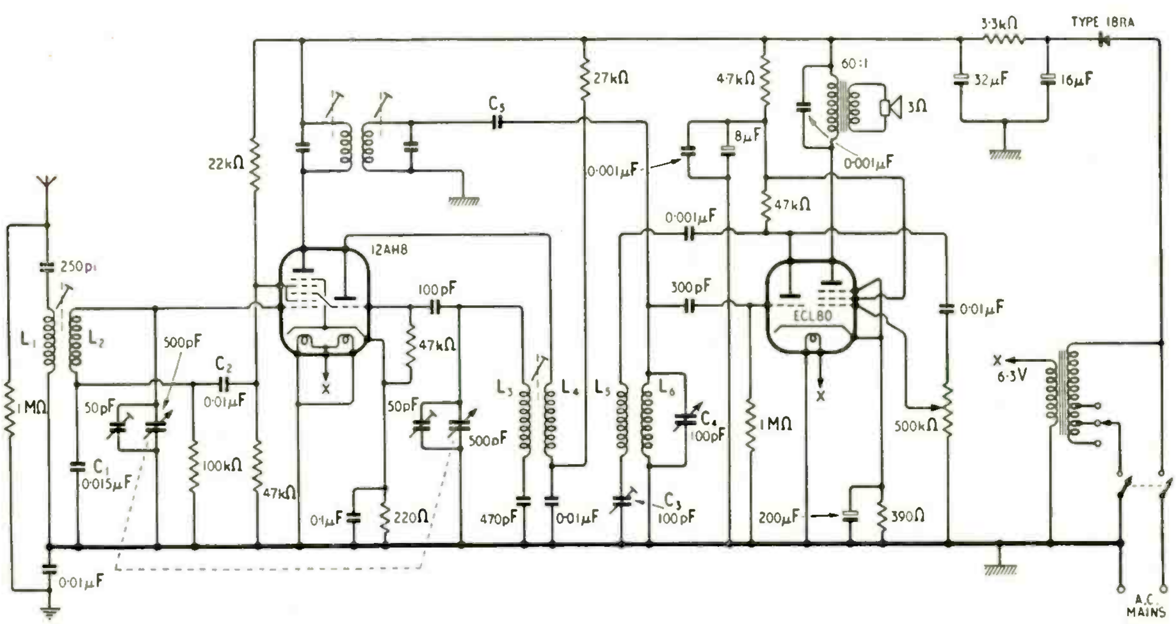
Inspection of the circuit reveals that two valves only are used, a 12AH8 triode-heptode as frequency changer and an ECL80 triode-pentode as detector and audio amplifier. It will be noticed that the normal conventional i.f. amplifier has been omitted, the i.f. output being fed directly into the triode section of the ECL80 which is acting as a leaky grid detector, tuned to the i.f. frequency by L_6C_4.

To overcome the obvious loss in gain due to the omission of an i.f. amplifier stage, regeneration is applied to the grid detector by L_5C_3, the amount of feed-back being adjusted by C_3. The adjustment of this circuit certainly goes a long way to overcome loss of gain and at the same time the selectivity can be made very sharp, again depending on the amount of feed-back. However, it was found that the receiver was still below par as far as sensitivity was concerned and it was decided to look further into this matter.

It is possible to use controlled regeneration in a frequency converter stage to give improved gain, image rejection and signal-to-noise ratio. It will be seen that the screen by-pass condenser, C_2, is returned to ground through the 0.015-μF condenser C_1. The signal-frequency voltage from the screen circuit developed across C_1 is injected into the grid circuit in the correct phase to give positive feed-back at signal frequencies.

Regeneration obtained with this arrangement is proportional to the reactance of C_1 and is, therefore, inversely proportional to frequency. An improvement of about 4 db in sensitivity and image ratio and 2 db in signal-to-noise ratio is obtained at the low frequency end of the broadcast band. At the high frequency end of the band these figures do not hold good but considerable and useful gain is still experienced. C_1 has a critical value; a reduction in its value will result in possible self oscillation of the mixer at the lower frequencies, and conversely if C_1 is increased the overall regeneration is reduced, resulting

* The Trevor-Johnstone Co., Ltd.



Circuit diagram of the 2-valve Superheterodyne receiver described in the text. C_5 is a small capacitor to be found experimentally.

in loss of gain. The value of C_1 (0.015 μF) seems to be the best choice for operation on the medium-wave band; it will have to be increased if the receiver is intended to be used on long waves.

Regeneration always has the disadvantages that variations in gain, e.g., with different valves, are emphasized, but this need not be serious so long as moderate amounts of regeneration are used, sufficient, for instance, to give an improvement of the order outlined above.

The aerial, oscillator coils and i.f. transformer are standard types; in the original receiver Osmor coils were used very successfully, their type QA8 as aerial coil and QO8 as oscillator. For the detector coils L_5L_6, an Osmor long-wave coil type QA12 is used, the iron dust core being removed and the normal aerial coupling coil included in the grid circuit, and the normal grid winding used as the feed-back coil. This arrangement produces the smoothest controllable regeneration, with the grid circuit tuning nicely between 450 and 480 kc/s.

For the d.c. supply a Westalite contact cooled rectifier is used, and as the name suggests dissipates its heat by conduction to the chassis on which it is mounted. The maximum current available from the Westalite type 18RA.1-1-16-1 is 60 mA. In view of the fact that the total d.c. current of the receiver is no more than 32 mA this unit is most suitable, and due to its very small size can be located at any convenient point on the chassis.

The sensitivity of the receiver is approximately 100 μV at the signal grid for 50 mW output.

Although no form of a.g.c. is used, no severe overloading of the detector occurs even on strong local stations. However, no difficulty should be experienced in arranging some form of a.g.c. if it is required.

The circuit shown caters only for medium-wave reception, but the inclusion of a long-wave band is quite straightforward, the only alteration required would be to increase C_1 in value, as already stated, and, of course, fit the appropriate coils and switching in the mixer and oscillator circuits.

BOOKS RECEIVED

Mass Spectrometry by A. J. B. Robertson, M.A., Ph.D. Introduction to the method of analysis in which atoms and molecules are identified and their quantities measured by the position and strength of positive ion beams, after deflection by a magnetic field. Pp. 135 + vi; Figs. 30. Price 8s 6d. Methuen and Company, Ltd., 36, Essex Street, London, W.C.2.

Fundamentals of Radar by Stephen A. Knight. Revised second edition of textbook introducing radar circuit principles as an extension of ordinary radio techniques. Pp. 150 + ix; Figs. 113. Price 15s. Sir Isaac Pitman & Sons, Parker Street, London, W.C.2.

Unit Constructed TV Receivers by E. N. Bradley. Circuits and wiring plans of units from which a variety of specifications for receivers of different sensitivity and picture size can be met. Pp. 92; Figs. 42. Price 6s. Norman Price (Publishers), Ltd., 283, City Road, London, E.C.1.

Circuits Electroniques by J. P. Œhmichen. Description of typical waveforms, their generation, amplification, measurement and application in selected practical problems. Pp. 256; Figs. 195. Price 1,200 fr. Société des Editions Radio, 9 rue Jacob, Paris 6.

Picture Book of TV Troubles; Vol. 1, Horizontal AFC-oscillator Circuits. Typical faults and their associated circuit waveform and picture distortions. Pp. 80; Figs. 50. Price $1.35. John F. Rider Publisher, 480, Canal Street, New York 13.

How to Use Test Probes by Alfred A. Gerhardi and Robert G. Middleton. Auxiliary probes for use in conjunction with meters, oscilloscopes and valve voltmeters for fault tracing in television and other electronic circuits. Pp. 176; Figs. 127. Price $2.90. John F. Rider Publisher, 480, Canal Street, New York 13.

The Inventor of the Valve by J. T. MacGregor-Morris, D.Sc. (Eng.), M.I.E.E.—A biography of Sir Ambrose Fleming against the background of electrical history, with many personal anecdotes by his contemporaries. Pp. 141; Figs. 22. Price 7s 6d. The Television Society, 164, Shaftesbury Avenue, London, W.C.2.

World Radio-Television Handbook. Edited by O. Lund Johansen.—1955 edition of this directory of broadcasting stations, their wavelengths, interval signals, times of transmission, etc. Pp. 160 with numerous illustrations. Price 9s 6d. Surridge Dawson and Co., Ltd., 136, New Kent Road, London, S.E.1.

Table of the Gamma Function for Complex Arguments.—National Bureau of Standards Applied Mathematics Series 34. Including an introduction on the properties of the gamma function and methods of interpolation, and a bibliography. Pp. 105. Price $2. Government Printing Office, Washington 25, D.C., U.S.A.

Magnetic Alloys and Ferrites.—Survey of recent developments, contributed by six authors and edited by M. G. Say, Ph.D., M.Sc., M.I.E.E. Sections deal with ferromagnetic theory, soft and hard materials and alloys, permanent-magnet ferrites, powder cores, non-magnetic ferrous and magnetic compensating alloys, recording materials and magnetostrictive alloys. Pp. 200 + vii; Figs. 115. Price 21s. George Newnes, Ltd., Souhampton Street, London, W.C.2.

Basic Television; Principles and Servicing by Bernard Grob.—Revised second edition of a descriptive analysis of television circuits written by an instructor at the R.C.A. Institutes. Chapters are included on the principal colour television systems and on "trouble-shooting" techniques. Pp. 660 + xv; Figs. 462. Price 64s. McGraw-Hill Publishing Co., Ltd., 95, Farringdon Street, London, E.C.4.

Test Scope Traces, by John F. Rider.—Waveforms and their interpretation; circuits and test procedure for use in the production and maintenance of electronic equipment. Pp. 186 + v; Figs. 186. Price $2.40. John F. Rider Publisher, 480, Canal Street, New York, 13.

TV Manufacturers Receiver Trouble Cures, Volume 6, in a series dealing with receivers of American origin. Pp. 120 + viii; Figs. 75. Price $1.80. John F. Rider Publisher, 480, Canal Street, New York, 13.

TV Field Service Manual with Tube Locations. Edited by Harold Alsberg.—Volume 3 of a series giving typical faults and the components most likely to be involved. This issue deals with American Emerson and Fada receivers. Pp. 120 + vi; Figs. 53. Price $2.10. John F. Rider Publisher, 480, Canal Street, New York, 13.

Advanced Television Servicing Techniques by the teaching staff of the Radio, Electronics, Television Manufacturers' Association pilot training course. Prepared with the participation of the American radio industry, to improve the skill and proficiency of service technicians. Pp. 163 + xi; Figs. 123. Price $3.60. Complementary *Laboratory Workbook*. Pp. 46 including work sheets. Price $0.95. John F. Rider Publisher, 480, Canal Street, New York, 13.

MARCH MEETINGS

Institution of Electrical Engineers

London.—March 2nd. "Some Comparative Directional Measurements on Short Radio Waves over different Transmission Paths" by E. N. Bramley; "Some Aspects of the Rapid Directional Fluctuations of Short Radio Waves reflected at the Ionosphere" by E. N. Bramley; "On the Rapidity of Fluctuations in Continuous Wave Radio Bearings at High Frequencies" by Dr. W. C. Bain; and "Sources of Error in U-Adcock High-Frequency Direction Finding" by K. C. Bowen.

March 9th. "Artificial Reverberation" by Dr. P. E. Axon, C. L. S. Gilford and D. E. L. Shorter.

March 21st. Discussion "Materials for Valves" opened by Dr. R. O. Jenkins.

All the above meetings will be held at 5.30 at Savoy Place, W.C.2.

North-Eastern Radio and Measurements Group.—March 7th. "Standard Frequency Transmissions" by Dr. L. Essen; "The Standard Frequency Monitor at the National Physical Laboratory" by J. McA. Steele; and "Standard Frequency Transmission Equipment at Rugby Radio Station" by H. B. Law at 6.15 at King's College, Newcastle-upon-Tyne.

North Midland Centre.—March 15th. "Colour Television" by Dr. G. N. Patchett at 6.30 at the Technical College, Bradford.

North-Western Centre.—March 16th. "Artificial Reverberation" by Dr. P. E. Axon, C. L. S. Gilford and D. E. L. Shorter at 6.45 at the Engineers' Club, Albert Square, Manchester.

March 22nd. Discussion on "The Servicing of Electronic Measuring Instruments and its Effect on their Design" opened by Dr. Denis Taylor at 6.15 at the Engineers' Club, Albert Square, Manchester.

South-East Scotland Sub-Centre.—March 15th. "The Genesis of the Thermionic Valve" by Professor G. W. O. Howe; "Thermionic Devices from the Development of the Triode up to 1939" by Sir Edward Appleton, F.R.S.; and "Developments in Thermionic Devices since 1939" by Dr. J. Thomson at 6.30 at the Carlton Hotel, North Bridge, Edinburgh.

March 22nd. Faraday Lecture "Courier to Carrier in Communications" by T. B. D. Terroni at 7.0 at the Central Halls, Edinburgh.

South Midland Radio Group.—March 28th. "Plastics for the Radio Engineer" by M. Jones at 6.0 at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Rugby Sub-Centre. — March 2nd. "Developments in Thermionic Devices since 1939" by Dr. J. Thomson at 6.30 at the Rugby College of Technology.

Southern Centre.—March 9th. "The Manchester-Kirk o' Shotts Television Radio Relay System" by G. Dawson, L. L. Hall, K. G. Hodgson, R. A. Meers and J. H. H. Merriman at 6.30 at the College of Technology, Portsmouth.

Oxford District.—March 9th. "Some Aspects of the Design of V.H.F. Mobile Radio Systems" by E. P. Fairbairn at 7.0 at the Electricity Demonstration Room, George Street, Oxford.

London Students' Section.—March 28th. "An Introduction to the Transistor" by A. V. Bryant at 6.30 at Savoy Place, W.C.2.

British Institution of Radio Engineers

London.—March 30th. Discussion on "The Maintainability of Service Equipment" by Capt. (L) A. J. B. Naish R.N., Maj. R. B. Brenchley, R.E.M.E., Wing Commander G. C. Godfrey, Technical Signals Branch, R.A.F., and G. W. A. Dummer, R.R.E. Malvern, at 6.30 at the School of Hygiene and Tropical Medicine, Keppel Street, W.C.2.

West Midlands Section.—March 9th. "Electrical Standards in Electronics" by P. M. Clifford at 7.15 at the Wolverhampton and Staffs. Technical College, Wulfruna Street, Wolverhampton.

North-Eastern Section.—March 9th. "The Application of Negative Feedback to Electrical Measuring Instruments" by F. J. U. Ritson at 6.0 at Neville Hall, Westgate Road, Newcastle-upon-Tyne.

Merseyside Section. — March 3rd. Symposium on "Electronics in Industry" at 7.15 at the College of Technology, Byrom Street, Liverpool, 3.

North-Western Section.—March 3rd. "Computing Circuits in Flight Simulators" by Dr. A. E. Cutler at 7.0 at the College of Technology, Manchester.

March 31st. "Industrial Applications of Electronic Control" by J. A. Sargrove at 7.0 at the Reynolds Hall, College of Technology, Manchester.

Scottish Section. — March 10th. "Computing Circuits in Flight Simulators" by R. A. Marvin at 7.0 at the Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow.

British Sound Recording Association

London. — March 25th. "High Fidelity Reproduction in the Home Using the Metal-Cone Loudspeaker" by F. H. Brittain at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

Manchester Centre.—March 14th. "Piezo-Electric Crystals" by J. N. Adams at 7.30 at the Engineers' Club, Albert Square, Manchester.

Television Society

London.—March 10th. "Distributed Amplifiers" by W. S. Percival (E.M.I. Research) at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

North-Western Centre.—March 30th. "The Television Coverage of Gt. Britain" by R. A. Rowden (B.B.C. Research) at 7.30 at the College of Technology, Sackville Street, Manchester.

Radio Society of Great Britain

London.—March 25th. "The Historical Development of Wireless Communication" by Maurice Child at 6.30 at the I.E.E., Savoy Place, W.C.2.

Royal Society of Arts

March 23rd. "Radio Astronomy" by Professor A. C. B. Lovell at 2.30 at John Adam Street, London W.C.2.

Society of Instrument Technology

London.—March 10th. "Information, Feedback and the Human Senses" by Dr. E. C. Cherry at 7.0 at Manson House, Portland Place, W.1.

March 29th. "Design and Applications of an Electronic Simulator for Control Systems," Part 1, Design, by H. H. Idzerda and L. Ensing; Part 2, Application, by J. M. D. Janssen and R. F. Offereins at 7.0 at Manson House, Portland Place, W.1.

RANDOM RADIATIONS

By "DIALLIST"

Erect in Haste, Repent at Leisure?

QUITE a few people, eager not to lose a moment of the I.T.A. programmes, are hastening to order Band III aerials to be put up as soon as the job can be done. The usual reason they give, if you ask them why, is that there will be such a rush as the opening day draws nearer that dealers will be snowed under and some of their customers may have to wait for weeks. I, personally, prefer to wait. When a Band III test signal is available in London manufacturers will be able to verify the effectiveness of their products and servicemen will have a proper chance of finding out by actual trials what kind of array is needed in their particular locality. One of the biggest problems is likely to be "ghosting," which may often make it necessary to use much more elaborate aerial systems than many had expected.

Ghost-Laying

Speaking of ghosts reminds me that there's a simple and quite useful way of getting some idea as to whether a directional aerial array is likely to be able to lay them and, if so, roughly what degree of directivity will be needed. The scanning time for the "active" part of each line on the screen is 83.5 microsecs. Thus with a 17-inch tube giving a picture about 12 inches wide the speed of the spot, if we neglect imperfections in linearity, is approximately 6.9 microsecs per inch. Suppose that the ghost is displaced a quarter of an inch from the main image; then the reflection causing the ghost takes approximately 1.72 microsecs longer than the wanted signal to make the journey from transmitting to receiving aerial. The speed of wireless waves through air being 5.4 microsecs per mile, that quarter-inch displacement means that the path of the reflected signal is longer by 0.32 mile than that of the wanted signal. The distance between transmitting and receiving aerials being known approximately, a rough idea can be formed of how far the reflecting object is from the receiving aerial. The more distant it is the more likely is a directional aerial of some kind to be successful in eliminating it but ghosts cannot always be laid as easily as that. There are many factors to be considered, as Cocking points out in "Television Receiving Equipment."

Anglo-French Vision

IT'S GOOD NEWS that we shall soon have a permanent television link with France. Considering how much of a makeshift the whole thing has so far had to be, the results obtained in relaying programmes from France, Italy, Switzerland and other European countries, have been astonishingly good. Once the permanent link between London and Cassel is completed good and reliable two-way transmissions between this country and France should be ensured. There is already an extensive network of co-axial cable connections between most of the European capital cities but they were installed primarily for telephone services, and are not suitable for TV. The temporary links used so far have been by radio, but television will no doubt have its own system of inter-capital links before long. And there seems to be no particular reason why we shouldn't reach out much farther afield as time goes on. When Baird produced his first scanning-disk televisor there was what then seemed wild talk about our being able to watch test matches played in Australia. Well, some who read this paragraph may live to see that come true.

North Hessary Tor

THE B.B.C.'s estimate of the service area of the temporary low-power television station at North Hessary Tor, S. Devon, has proved in the event to have been very much on the conservative side. A number of my friends in the West Country who live outside those parts of Devon and Cornwall which the B.B.C. had expected the station to cover have reported good, steady pictures. Perhaps the most surprising case is that of one who lives near Liskeard. Expecting nothing, and purely for the fun of it, he retuned his receiver to Channel 2 and turned his 4-element channel-5 aerial array towards N. Hessary Tor. To his entire astonishment he received an excellent picture, far better than he had ever had from Wenvoe. Many people, I'm told, who live within the Tor's predicted service area are finding that their Wenvoe aerials give them as good a picture as they want. If the signal is strong, the dimensions and spacing of the aerial elements don't seem to matter all that much.

Too Many Valve Types

SOME YEARS AGO an attempt was made to reduce the number of thermionic valve types to reasonable size, for it was felt (and rightly) that the thousand kinds of receiving valves then on the market were several hundred too many. The attempt wasn't successful. How many types there now are I don't know, for I gave up some time ago the hopeless struggle to keep pace with them. It seems a pity that equipment manufacturers and the B.V.A. can't get together and agree on doing some ruthless pruning of the lists. The vast number of types that we now have is utterly uneconomical, for it must prevent those long runs which mean good profits to manufacturers and low prices to the public. One of the very first steps should be to cut the number of different kinds of valve base, for this has now reached fantastic proportions.

Exploring Band III

I EXPECT some of you wondered, when you read my note in the last issue, why the B.B.C. should be using an I.T.A. frequency for its experimental square-wave transmissions from Sutton Coldfield. Mr. Pawley, head of the B.B.C.'s Engineering Services Group, tells me that the frequency is actually 180.4 Mc/s, which is below Channel 8 allocated to the I.T.A. for its Midland Service. These test transmissions are being radiated for the purpose of making propagation measurements both within and beyond the range corresponding to the service area of an actual station.

CLUB NEWS

Barnsley.—At the meeting of the Barnsley and District Amateur Radio Club on March 25th, J. Ward (G4JJ) will speak on "Transistor Transmitting." The club meets in the King George Hotel, Peel Street, Barnsley, at 7.0 on the 2nd and 4th Fridays of each month. Sec.: P. Carbutt (G2AFV), 33, Woodstock Road, Barnsley, Yorks.

Birmingham.—Meetings of the Birmingham and District Short Wave Society continue to be held on the 2nd Monday of the month at 7.45 at the Y.M.C.A., 20, Soho Road, Hockley, Birmingham, 19. At the March meeting H. Burdett will deal with power supplies. Sec.: R. Yates, 28, Daimler Road, Yardley Wood, Birmingham, 14.

UNBIASED

By FREE GRID

Hi-Pri Hi-Fi

NOW that so-called "hi-fi" receiving and reproducing equipment is being supplied by more and more manufacturers people will have the opportunity of discovering what poor quality they have been putting up with all these years.

I shall, however, be extremely surprised if the revelation leads to such a mad rush to the local dealers that people get their clothes torn off their backs as I had the misfortune to do a few weeks ago; I accidentally got caught up in a queue of struggling women fighting their way in to one of the January sales.

I hold this opinion because, for one thing, "hi-fi" is rather "hi-pri" although it will probably get cheaper as the demand increases. But my main reason is that the average listener has not a very high musical standard—and I say this despite the demand for seats at the Festival Hall for May 21st. The ordinary set really gives him all he wants in the way of quality.

The state of affairs in the world of wireless is, so far as fidelity is concerned, much the same as it is in the world of amateur photography where the seaside and wedding snapshotter is quite content with his miserable-looking, under-exposed,

"Caught up in the January sales"

badly-posed and out-of-focus efforts. There are, of course, the elite of amateur photographers with their "hi-fi" and "hi-pri" cameras, and they certainly produce marvellous results. But the ordinary soot-and-whitewash snapshotter still remains the backbone of the photographic industry and I think the "mellow bellow" type of listener will always fulfil the same role in our own industry. This is another way of saying that in my opinion, "hi-fi" reproduction, whether it be gramo., radio or photo, will always be for the elite and, therefore, "hi-pri." I sincerely hope time will prove me wrong.

Vive La Manx

A KINDLY READER, evidently guessing my catholic tastes in literature, has sent me a copy of *Islam A. E. F.*, a journal having its offices in Brazzaville, the capital of French Equatorial Africa. I only wish I were permitted to tell you of the many interesting things to be found therein, ranging from an intriguing article entitled "La Femme dans L'Islam" ("Elles sont si délicieuses que nous les gardons jalousement pour nous!" says the author) to a lively account of the modern way of doing the pilgrimage to Mecca, namely, by plane.

I must remember, however, that this is *Wireless World* and so confine myself to that part of *Islam A. E. F.* dealing with radio matters. My interest was at once aroused when I saw that the same problem exists there as it does here, namely, the deliberate ignoring of minority languages. In this sun-baked corner of Africa broadcasting is carried on in French and in six native tongues, all these latter being important ones in the sense that collectively they cover the majority of the population.

There is, however, a "couldn't-care-less" attitude about minority languages which the editor of *Islam A. E. F.* deplores. That is exactly the state of affairs existing over here where the majority of people speak English, or so-called English. There are, however, four other languages in use in the United Kingdom, two of which, Welsh and Gaelic, are extensively spoken, and the two others, Manx and Cornish, less so. We do, of course, get some Welsh and Gaelic from the B.B.C., but of the others absolutely nothing.

I feel particularly sore about Cornish, as Cornwall, the home of the pioneering Poldhu and of the Marconi memorial at Mullion Cove, is really the cradle of long-distance wireless. The home of the originator of the famous directories has a rather more nebulous link with radio, but the P.M.G. and *W.W.* are both focal points of liaison (work that one out).

If anyone is with me in this I would ask them to write a strongly worded letter to the Editor, and I will use all my influence to get him to find space for it; it should, of course, be written in Cornish or Manx, as the case may be.

"La femme dans l'Islam"

The Editor demands an illustration for this item, and I have, therefore, dug out an old photograph of two Islamic maidens which I took many years ago in A.F. but not A.E.F.

As She is Spoke

IN the February issue the Editor quite rightly took to task the general public for jungle-izing Shakespeare by using such strange and uncouth expressions as "the wireless"; he also had a tilt at the B.B.C. for indulging in similar barbarities.

I do, however, feel that those of us who are outside the pale of the oxonocantabrigian educational atmosphere which prevails at Broadcasting House have been rather harshly dealt with. It is a long time since some of us were at school, and we look to the B.B.C. to correct our faulty pronunciation; in this it has failed us lamentably.

We are a little bewildered when one B.B.C. pronouncer speaks of "fine-ants" with the accent on the "fine" and another shortens the first vowel and puts the stress on the second syllable. This is but one of many instances where announcers differ, but on the pronunciation of one word they never fail to agree. Although they, with their "eddication," ought to know better, all the announcers continue to turn my hair as grey as the word "polio" by pronouncing it as though it rhymed with "folio"; yet they never try to manhandle in this way polygamy, polytechnic, politics or police, all of which like "polio" are of Greek derivation and have an omicron and not an omega in their first syllables. Perhaps the announcers think that two omicra make one omega, for, of course, unlike the other words I have quoted, "polio" does have two omicra in it.