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Wireless World

# Communication by Induction

AN amendment (Statutory Instrument 1957, No. 978) to the regulations governing the issue of wireless licences by the Postmaster General makes provision for a new "Induction Communication Licence . . . to establish and use, within a specified frequency band not being above 250 kilocycles a second, sending and receiving stations for wireless telegraphy the number whereof is not limited by the licence, for the purpose of sending and receiving messages concerning the business of the licensee between stations, or between one or some of the stations and another or others of them (not being a licence authorizing the transmission of messages directly between fixed stations)."

Resentment at the imposition of this charge is being expressed in many quarters.

One view is that the P.M.G. has exceeded his powers and that induction is not wireless telegraphy within the meaning of the Act. According to this view no use is made of the free-space, self-propagating electromagnetic field which is the basis of radio communication, as generally understood, and the selective calling systems of the largest hospitals and offices are contained within the induction field of even the highest permitted frequency.

Unfortunately, this argument cannot, in our view, be pressed home. The definition of "wireless telegraphy" by the Act of 1947 is much wider than that which would be given by practising wireless engineers. The term "radiation" is avoided and we are told that "wireless telegraphy" means the emitting or receiving, over paths not provided by any material substance constructed or arranged for that purpose, of electromagnetic energy of a frequency not exceeding 3 million Mc/s for conveying messages, sound or visual images, for the determination of bearing or distance or for gaining information of the presence or absence of objects. It is not much use arguing that in a loop-coupled system one is using only the magnetic field, because to convey information one must vary this field and by so doing a disturbance is propagated with the velocity of light to the tenuous extremities of the magnetic field, and this travelling disturbance will always be accompanied by a complementary electric field. This would be just as true if the field were varied by moving the keeper on a permanent magnet as it would be by varying a current.

Proof that low frequencies are propagated electromagnetically is provided by the "whistler" atmospherics that follow a path through outer space and can be picked up by a sensitive audio amplifier connected to an elevated aerial. Incidentally, if an originating signal had a frequency of less than 2c/s the whole world would be within the induction field, and as far as the Act is concerned there is no low limit of frequency for "wireless telegraphy."

Another argument goes something like this. If the P.M.G. gets away with this induction licence what is to stop him, if he thinks fit, from demanding a licence fee for the use of transformers in communication equipment? Information is conveyed by electromagnetic energy from a transmitter (primary) to a receiver (secondary). True there may be a contrived intermediate substance (an iron core) which gives exemption under Section 19, but what happens if we use an air-cored transformer, and at what value of the coefficient of coupling does the device cease to be a transformer and become a communication system?

There is enough argument here to keep a technical committee or tribunal busy as long as funds hold out, though it would not take them long to discover that distance between source and sink of energy is the operative factor. Although all inductive communication systems are now used indoors and there is negligible outside field, in principle there is no limit to the range if power, loop area and receiver sensitivity are increased. We can vouch from experience for the fact that some magnetic measurements made a few years ago were plagued by interference from trams in a town eight miles away and had to be made at night after the last tram had gone into the depot. If a mobile service were developed on these lines would it be equitable to make no charge while still collecting from users of existing v.h.f. equipment?

Such arguments are a little far-fetched if only for the reason that adequate signal/noise ratio would be difficult to achieve at low frequencies. We bring them forward only to clear the ground before asking why a licence should be demanded so long as all calling systems are restricted to enclosed premises. The P.M.G. does not collect a revenue from house internal telephone installations; why does he insist on his legal right to do so when induction is used instead of a wire connection? If interference is caused outside the premises he could no doubt acquire the powers necesary to intervene, whether the apparatus is licensed or not.

# "SOLID CIRCUITS"

## Glimpses into the Future at Malvern Components Symposium

THE circuit designer of the future will have to be something of a sculptor and architect, as well as a physicist and engineer, if a new kind of electronic circuit described at the recent International Symposium on Electronic Components at Malvern really comes into existence. Known as a "solid circuit," it consists of a small block of semiconductor material which is specially "doped" and shaped and deposited with films of conductive, resistive and dielectric materials. This forms the equivalent of several transistors connected by resistors and capacitors into a complete functional circuit unit.

At the moment the solid circuit is little more than an idea. It is being investigated by the Royal Radar Establishment at Malvern (who organized the Symposium) in conjunction with Plessey's. A hypothetical example, described by G. W. A. Dummer of R.R.E. and displayed as a model in the Symposium exhibition, was a transistor flip-flop with two emitter-follower outputs—a total of four transistors—all contained within a tiny piece of silicon about ⅜inch square by ⅛inch thick. The semiconductor was "doped" to form a p-n-p structure and had various sections removed to leave thin bridges of material with relatively high resistances. These high-resistance paths formed the collector and emitter loads of the transistors connected to common power supply rails. Other resistors were provided by films of resistive material deposited on the surface of the silicon, while capacitors were constructed in a similar manner from thin metallic layers with insulators between.

It appears there is a possibility of incorporating inductors as well, and here the technique seems to link up with another suggested type of "solid circuit" using ferrite as the basic material. A good deal of work has already been done on printing conductors through holes in ferrite blocks to form the equivalent of cored inductors. The conjunction of these two techniques—semiconductor and ferrite—certainly offers some exciting possibilities for the future, and it was perhaps significant that a call for more work in this direction, away from conventional components, was made by John Sargrove, who designed some of the first "solid circuits" for automatic production in his ECME machine.

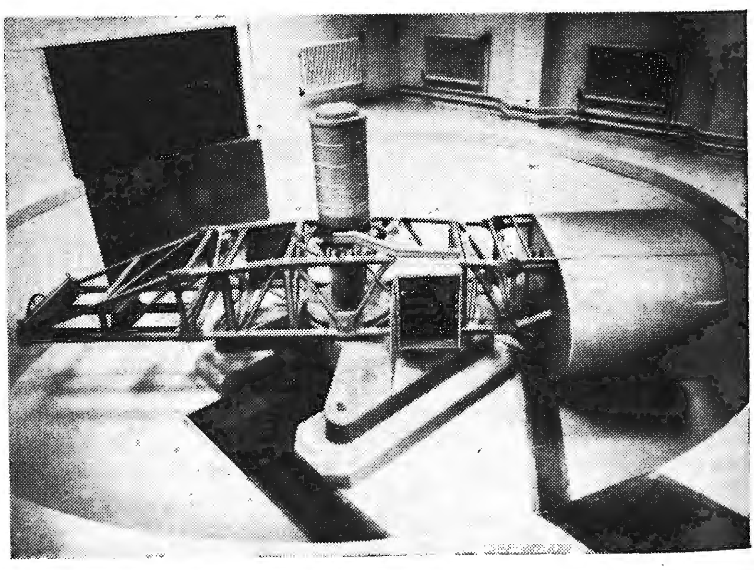
Other speakers mentioned devices already in existence which go some way towards the "solid-circuit" ideal. A. W. Rogers of the U.S. Signal Corps, for example, described piezoelectric bandpass filters in which ceramic titanate material replaces the resonant combinations of L and C used in conventional circuits. Mr. Rogers was mainly concerned with the development of new components and techniques for transistor circuits, and he stressed the need for what might again be called "solidity" in circuits—in the sense of packing as much as possible into a small space. In achieving "volumetric efficiency" in military equipment, he felt there was too much emphasis on miniaturization of individual components and not enough on the efficient utilization of space by improved methods of mounting and packaging. The overall "volumetric efficiency" for an average equipment built up from packaged units was only about 15%, but it should be possible to attain at least 50%.

### Heat Problems

As one might expect, a great deal of the Symposium was devoted to the design of components for operating under severe environmental conditions—extremes of heat, cold, humidity, shock, vibration and nuclear radiation. Of these, heat seems to be the major problem, and one speaker, Col. J. S. Lambert of the U.S. Air Force, said that his organization was giving its main attention to high-temperature operation because it was felt that any new techniques evolved would automatically solve some of the other problems. He was referring particularly to guided missiles, where temperatures in excess of 500°C—generated by air friction and the propulsive system—are quite common in flight.

The use of liquid cooling systems is a fairly new technique which seems to be gaining ground. One example in the R.R.E. exhibition was an experimental liquid-cooled chassis system. The components were

*Acceleration test machine for airborne electronic equipment. The acceleration range is 2-40g. Connections to the apparatus under test are made by slip rings.*



mounted on aluminium sheet containing integral ducts through which the coolant was circulated. Valves were clamped horizontally in split metal tubes fixed down to the chassis. Apart from increasing the transfer of heat beyond that normally obtained with air cooling, the system makes possible a greater thermal loading of the equipment, resulting in a saving in size and weight—even when the cooling apparatus is taken into account. The particular unit shown was dissipating 325 watts in a sealed drum 7 inches in diameter and 10 inches long, but the internal temperature was nevertheless quite safe for conventional components.

Liquid cooling is also used to some extent in individual components which lend themselves to this treatment—for example transformers and chokes mounted in containers. L. F. Kilham of Raytheon (U.S.A.) described transformers which, by the use of fluorine compounds to get the heat away quickly, could be made very much smaller in size than would be necessary with ordinary air cooling. Reductions in size and weight of about three or four times could be obtained. The liquids (which are similar to those used for refrigeration) are compatible with the materials used in transformers, are non-inflammable and non-toxic, and have a high dielectric strength and self-healing properties. Sometimes the coolant takes the form of a vapour and sometimes a boiling liquid (in which case it acts rather like a thermostat). The technique has been used for about two years in the U.S.A. and some transformers have been found to have lives of 10,000 hours or more.

### High-temperature Transformers

It is now quite possible, however, to design transformers so that they will operate at very high temperatures—in the region of 100°C to 500°C—just as successfully as they do at normal room temperatures. Various British examples were described and shown in the exhibition. Glass-insulated wire is used for windings, sometimes treated with vitreous enamel, and silicon steel for the cores. Materials like glass cloth and ceramics are pressed into service, bobbins are made of metal or porcelain, while leads have to be brazed on to terminals instead of soldered. The windings often have metal plates embedded in them, or metal clamps around them, to conduct the heat away quickly, and are sometimes enclosed in evacuated cases.

Coming straight from the atmosphere of domestic radio, it was rather surprising to hear that printed circuits have so far penetrated very little into military equipment in this country. There were, however, a great many examples of potted circuits in the exhibition—and these, of course, are yet another variant on the idea of "solid circuits." Epoxy resins are now widely used in preference to the polyester types because of their good adhesive properties and general toughness and resistance to chemicals. In addition to the conventional solid potting methods, it seems that R.R.E. are trying out a lightweight system of encapsulation in which the components are just dipped into the resin, to form a moisture barrier and prevent them from vibrating, and then the containers are sealed off with a ¼-inch layer of resin at top and bottom.

Solderless wrapped connections have come into the news again after many years of neglect (they were originally used in early telephone systems) and appear to be highly thought of by the military electronics people. The end wires of a component are wrapped around rectangular terminal posts by an automatic tool, and the resultant stress is so great that the oxide film is crushed on both wire and terminal and the tin on the wire actually diffuses into the terminal after a certain period. The result is said to be inherently more reliable than soldered joints, even though the tension in the wire does relax eventually. Examples were shown which appeared to have been in a fire or at the bottom of the sea and yet still gave perfect connections.

Operation of components and equipment under severe environmental conditions means, of course, that a great deal of testing has to be done in which these conditions are simulated. The exhibition contained, in fact, several elaborate and expensive installations for doing such work—an acceleration test machine of the centrifuge type (see picture), an automatic component testing equipment (described in our last issue, p. 483), and—most impressive of all—a stratosphere test house, looking rather like the boiler room of a ship, in which wide ranges of temperature, pressure and humidity could be obtained inside a huge 750-cu ft stainless steel chamber.

One criticism made in the Symposium was that testing for reliability tends to take so much time that sometimes the components are obsolete before the results are available. Another speaker remarked that one of the test equipments did not give results compatible with the official specifications laid down. Whether these comments are valid or not, there is no doubt that the R.R.E. work is highly respected by the commercial manufacturers and provides information of immense value in the development of new components. Government "type approval" is becoming such an "O.K." thing nowadays that, as Dr. D. H. Black, Director General of Electronics Research and Development, Ministry of Supply, remarked, firms are finding that they cannot sell their products without it!

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## B.S.R.A. COMES OF AGE

THE 9th Exhibition and Convention held at the Waldorf Hotel, London, by the British Sound Recording Association was made the occasion for celebrating the 21st anniversary of the foundation of the Association.

At the annual dinner the principal speaker was R. T. B. Wynn, chief engineer of the B.B.C., who paid tribute to the pioneers, professional and amateur, of disc and tape recording and to the part they had played in establishing the now very considerable recording resources of the B.B.C. There was still scope for originality in finding an economic solution to the problem of electrically recording television signals and he thought that amateurs could make valuable contributions, as they had in the past.

P. G. A. H. Voigt, one of the pioneers of high-quality sound reproduction, and now resident in Canada, contributed to the proceedings through the medium of tape recording.

In the competition for amateur-constructed equipment, the President's Trophy went to A. J. Harper for a four-channel mixer, the *Wireless World* Prize to W. Webber for a stroboscopic tape synchronizer for use with 8, 9.5 or 16mm film, and the Committee Prize to P. J. Baxandall for a 5-watt high-quality amplifier and equalizer unit.

# WORLD OF WIRELESS

## *B.B.C. Television Coverage*

TELEVISION is already available to 97% of the population and the B.B.C. coverage will extend to over 98% by about the end of this year, by which time it is expected that the power of the Crystal Palace station will have been increased, the temporary stations at Sandale (Cumberland) and Douglas (Isle of Man) will have been replaced by permanent stations, and the new station at Londonderry in Northern Ireland will have been completed; it is hoped also to introduce a temporary station near Dover.

The problem of serving the remaining 2% is a difficult one. Two new stations to serve about 140,000 people outside the service areas of existing B.B.C. stations are announced. One will be near Peterborough and the other in Orkney. Both stations will operate in Channel 5, the Peterborough station with horizontal polarization and the Orkney station, which will also radiate v.h.f. sound programmes, with vertical polarization.

The Norwich station, at Tacolneston, which has been operating on considerably reduced power to avoid interference with the Liége, Belgium, transmitter, will use increased power from December 1st. It will go up to its full power (varying from 1 to 10kW according to the direction) in the spring or early summer next year, when the power of the Liége transmitter will also have been increased.

## *Mobile Radio*

PRIVATE mobile radio licences in force in the United Kingdom at the end of August totalled 1,561. They covered 1,805 base stations and 13,010 mobile stations. Of the mobile stations 11,411 were in land vehicles, 901 in ships and tugs and 696 portables and transportables.

The recently revised cost of a private mobile radio licence is £3 p.a. for each of the first two stations (base and mobile) and £2 p.a. for each additional station.

Two new types of licence were recently introduced. One providing for temporary mobile radio operation for up to 28 days, costing £1, and the other covering inductive "paging" systems (£2 p.a.). Regulations regarding these two new licences are given in Statutory Instruments 1957, No. 978.

## *Valves : Prospect and Retrospect*

IN THE course of his inaugural address as president of the I.E.E. Mr. T. E. Goldup, a director of Mullard, referred to the changes which have taken place in the valve industry during the long period of his association with it. Some idea of the growth of the industry is given in these figures quoted by Mr. Goldup. In 1949 British manufacturers produced 19 million valves and 310,000 c.r. tubes; in 1956 the corresponding figures were 64 million and 2 million. The 1956 output of receiving valves in the U.K. was, however, but 9% of the world production of some 743 million, whereas the United States produced 67%.

## *Autumn Audio Fair*

OVER 30 exhibitors have taken space at the Autumn Audio Fair to be held in the Grand Hotel, Harrogate, from October 25th to 27th. They are listed below. All the exhibitors have individual demonstration rooms in addition to stands.

| | |
|---|---|
| Altobass | Lustraphone |
| Associated Electronic Eng. | M.S.S. |
| Champion | Mullard |
| C. T. Chapman | Pamphonic |
| Cosmocord | Philco |
| Dulci | Philips |
| Dynatron | Plessey |
| E.A.P. | Pye |
| E.A.R. | R.G.D. |
| E.M.I. | Sugden |
| Expert Gramophones | Tannoy |
| Garrard | Trix |
| Goldring | Vitavox |
| Grundig | W. & N. Electronics |
| *Hi-Fi News* | Whiteley |
| Jason | |

Tickets for the Fair, which is open from 11.0 to 9.0 on each of the three days, are available from exhibitors or from this office. Applications should be accompanied by a stamped addressed envelope.

## *Radio Hobbies Exhibition*

THIS year's R.S.G.B. amateur radio show has been restyled the Radio Hobbies Exhibition. It opens for four days at the Royal Horticultural Society's Old Hall, Vincent Square, London, S.W.1, on October 23rd. Admission to the exhibition, which will be open daily from 11.0 to 9.0, costs 2s.

The 22 exhibitors are:—

| | |
|---|---|
| B.I. Callender's Cables | Panda Radio |
| British Amateur Television Club | Philpott's (Metal) |
| Clyne Radio | R.A.F. |
| Cossor Instruments | R.S.G.B. |
| E.M.I. Institutes | Royal Navy |
| Enthoven Solders | S.T.C. |
| K.W. Electronics | *Short Wave Magazine* |
| Labgear | Taylor Electrical Instruments |
| London U.H.F. Group | *Wireless World* and *Electronic & Radio Engineer* |
| Measuring Instruments | Whiteley |
| Minimitter Co. | |
| Mullard | |

The B.A.T.C. is putting on a large-scale demonstration of home-constructed television equipment. On their stand will be six cameras and monitors and exhibitors will be given the opportunity of demonstrating equipment before the cameras. A television telephone link will also be demonstrated.

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**Television receiving licences** in the United Kingdom increased during August by 61,459, bringing the total to 7,331,207. The overall total for broadcasting licences at the end of August, including the above and 322,085 for car radio receivers, was 14,685,231.

**Comparisons.**—"You can buy a top-quality 21-in. console, a first-class 17-in. or 21-in. portable, a good packaged hi-fi console with a-m and f-m radio and several three-way table radios for the price of a color console. No wonder the mass market doesn't want it now." Allen DuMont, chairman of DuMont Laboratories, quoted by *Electronics* business edition.

**"Mirror in the Sky,"** the Mullard film on the work of Sir Edward Appleton on the ionosphere, was one of eleven films submitted by this country for showing at the 11th congress of the International Scientific Film Association meeting in Amsterdam.

**St. Hilary.**—Preparatory to the opening of the I.T.A. station at St. Hilary, near Cardiff, on December 17th, the stand-by transmitter will broadcast test transmissions in November, giving a much more powerful signal than that at present provided by the pilot transmitter. It is hoped to test the main transmitter, which will have an e.r.p. of 200 kW, for at least a week before programmes start. The transmitter operates in channel 10.

**Long-distance v.h.f. propagation.**—The I.E.E. Radio and Telecommunication Section is planning a symposium of papers on long-distance propagation above 30 Mc/s for January 28th. There will be two sessions at the Institution's headquarters. The first, on ionospheric forward scatter propagation, is at 2.30 and the second at 5.30 on tropospheric propagation beyond the horizon. Registration forms will be available in November. The fee for non-members will be about £1.

"**An old problem in a new industry**" is how Peter E. M. Sharp, writing in *Design*, summarizes the difficulties facing manufacturers of high-fidelity equipment in their efforts to combine appearance and functionalism. He surveys the problems which the purchaser has to face in making a united whole from the various components—tuner, amplifier, loudspeaker, turntable, and pickup.

"**E.R.A. Weekly Abstracts,**" consisting on an average of 30 abstracts taken from British and foreign journals, issued up to now only to members of the Electrical Research Association, is being made available to the public. The lists, available if required typed on one side of the paper only, cover a wide range of electrical subjects. "Weekly Abstracts" is available from E.R.A. Information Bureau, Thorncroft Manor, Dorking Road, Leatherhead, Surrey, price 5 gns. a year.

**Institute of Navigation** membership increased during the year ended June 30th by 107, bringing the total to 1,741. The annual report records that the finances of the Institute were adversely affected by the three-day conference on collisions held in June, which accounted for £580 of the £1,600 excess of expenditure over income.

**E.I.B.A.**—The radio and electronics industry is well represented in the list of donors to the funds of the Electrical Industries Benevolent Association given in the 1957 Year Book. The Radio Industry Council contributed £500 and collections at the luncheons of the Radio Industries Club totalled £350. The Association assists "any deserving and necessitous persons, but excluding manual workers, who are or have been engaged primarily in any branch of an electrical industry."

**Technical Writing.**—A course of six weekly lectures on the techniques of technical writing opened at Borough Polytechnic, Borough Road, London, S.E.1, on October 11th. The lectures are being given by G. Parr at 2.30 (fee 10s).

**I.T.A. in the N.E.**—The eighth transmitting station to be built by the I.T.A. will be at Burnhope, about five miles south-east of Consett, Durham. The station, which will have an e.r.p. of 100 kW, is expected to cover the area, roughly crescent shaped, extending from Alnwick in the north, through Middleton in Teesdale in the west and nearly to Whitby in the south. It is hoped to bring the station into service in about a year.

**International Instruments.**—The fourth international instrument show, organized by B & K Laboratories, of 57 Union Street, London, S.E.1, will be held at Caxton Hall, Westminster, London, S.W.1, from 24th to 29th March, 1958.

## FROM ABROAD

**Transistor sales** in the United States are expected to exceed 30 million units this year. Last year's figure was a little below 13M. Figures published in the business edition of *Electronics* estimate that 42% will go into "entertainment" equipment, 30% to the commercial-industrial field, and 28% into military equipment. All the transistors in the first category and all but a few in the second are germanium, but in the military equipment over a quarter are silicon.

**Home "Tele-cine."**—Cited as an attempt by American cinemas to counteract the effect of television, a cinema in Bartlesville, Oklahoma, is experimentally transmitting films by wire to television receivers in patrons' homes. The fee, according to our contemporary, *Electrical Journal*, is $9.50 a month for 13 first-feature films, plus supplementary films, music, news, etc.

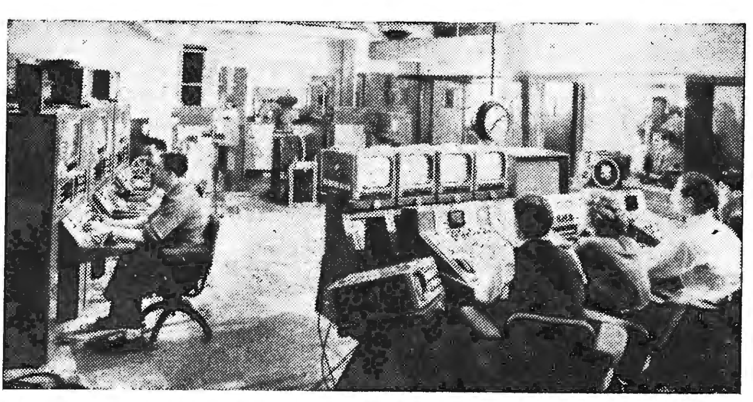
**High-power V.L.F. Station.**—The U.S. navy is to build a new high-power v.l.f. station in Washington County, Maine. It is reported that the transmitter, which it is planned to bring into service in 1961, will operate on about 15-20 kc/s with a power of 2,000kW.

**Aerial Safety.**—The first three cities or municipalities to be given power under the Canadian 1956 Radio Act, enabling them to take action against owners of receiving aerials considered to be a public danger, are announced by the Department of Transport, Ottawa. These localities have applied for and been designated as areas in which local building inspectors may enforce aerial safety regulations. These include the ability to withstand stipulated wind pressures when the aerial is covered with a half-inch of ice.

**Auckland University.**—We have been asked by Auckland University College to announce the formation of the Auckland University Engineers' Association for past and present graduates and students. There are many men who have passed through the School of Engineering since its formation in 1906 who cannot be traced. Details of the Association are obtainable from J. H. Percy, Auckland University College, Auckland, New Zealand.

**Swedish Chain** of Decca Navigator stations, officially opened on October 3rd, is the fourth to be brought into service this year. The others are Nova Scotia, Newfoundland East and Newfoundland West. A fifth—the Quebec chain—will be opened on November 5th.

**Australian V.H.F.**—An enquiry into the question of the introduction of v.h.f. broadcasting in the Commonwealth has been held by the Australian Broadcasting Control Board.



*MASTER CONTROL ROOM of the Glasgow studios of the Scottish independent television service. The film recording equipment, control racks and master control desk are all in one room, adjacent to which is the announcers' booth. All the studio and control room equipment has been supplied by Pye.*

# Personalities

**Professor H. S. W. Massey,** F.R.S., leader of the United Kingdom delegation at the I.G.Y. conference on rockets and artificial satellites held in Washington at the beginning of October is Quain professor of physics at University College, London. From 1946 to 1950 he was a member of the Radio Research Board of the D.S.I.R. For his work on the ionosphere he received the Hughes medal of the Royal Society in 1955. The other members of the delegation were: Dr. J. G. Davies, Jodrell Bank Experimental Station, W. T. Blackband, Royal Aircraft Establishment, and Alistair Anthony, British Joint Scientific Mission in the United States. Among the subjects discussed was the tracking of artificial satellites by optical and radio methods.

**Dr. M. V. Wilkes,** F.R.S., director of the Cambridge University mathematical laboratory, is the first president of the recently formed British Computer Society. Dr. Wilkes is an acknowledged authority in the field of digital computer design, in which he was a pioneer, and is well known for his book "Automatic Digital Computers."

**E. R. L. Lewis,** M.A., A.M.I.E.E., who joined Marconi's in 1950 as education and training officer and since 1955 has been manager of the education and technical personnel department, has been appointed to the newly created post of controller of education for the English Electric group, of which the Marconi companies are members. Mr. Lewis, who is 42, graduated at Trinity Hall, Cambridge, and after war service in the Royal Air Force technical signals branch, was for three years in the Signals Planning Section of the Ministry of Civil Aviation.

**Sir Ronald Nesbitt-Hawes,** who has been chief of educational administration since 1949, becomes education adviser to the English Electric group. Before joining English Electric Sir Ronald was for three years chief engineer and for nine years director-general of Posts and Telegraphs, Burma.

**R. S. Roberts,** who, as announced last month, has accepted the appointment of executive technical director to Wolsey Electronics, Ltd., is retaining his position as senior lecturer in the Northern Polytechnic's department of telecommunications. **John Gilbert,** head of the department, encourages members of his staff to maintain such connections with industry.

**F. H. Townsend** has resigned from the managing directorship of Cathodeon, Ltd., and has gone to the United States to take up an appointment with Machlett Laboratories, Inc., of Springdale, Conn. He joined Pye in 1938 and was deputy head of the vacuum laboratory until 1946, when he transferred to Cathodeon, a subsidiary, as chief vacuum engineer and manager. Before joining Pye he was in Cossor's research department for seven years. He is 46.

*DR. J. S. McPETRIE, the new chairman of the I.E.E. Radio and Telecommunication Section, whose inaugural address on "Some radio aids for high-speed aircraft" is being given on October 16th.*

**K. R. Sturley,** B.Sc., Ph.D., M.I.E.E., head of the B.B.C.'s engineering training department, is visiting the United States to study methods of training in broadcasting and radio engineering. During his stay Dr. Sturley will be presenting three papers written by members of the B.B.C. engineering division for the Audio Engineering Society's annual convention in New York and the Society of Motion Picture and Television Engineers' convention in Philadelphia.

**Harold J. Leak,** M.Brit.I.R.E., chairman and managing director of H. J. Leak & Co., is visiting North America. He was at the New York High Fidelity Fair (October 7th to 12th) and will be in Toronto for the Canadian Audio Fair (October 31st to November 2nd) where Leak equipment will be exhibited by Astral Electric Co., Ltd., of Toronto.

**K. E. Harris,** B.Sc., technical director of Cossor Radar & Electronics, Ltd., is on a five weeks' visit to North America during which he has attended the meeting of the International Civil Aviation Organization as a member of the United Kingdom delegation. He is also carrying out a survey of the evaluation trials which are being conducted on the Cossor secondary surveillance system by the Americans at Patuxent, Md. He is accompanied by **L. Perkins,** a Cossor engineer.

**D. A. Lyons,** managing director of Trix Electrical Co., succeeds **V. G. P. Weake** (Pamphonic) as chairman of the council of management of Audio Fairs, Ltd. This non-profit-making company was formed "to assume responsibility for future audio fairs in Great Britain."

**Philip M. Thompson,** who with John Bateson discusses transistor symbols in this issue, is in the transistor section of the Electronics Laboratory, Canadian Defence Research Telecommunications Establishment. He took the natural sciences tripos at Cambridge and after a short while at A.T. & E., Liverpool, returned to the Cavendish Laboratory. On leaving the laboratory he joined Salford Electrical Instruments and in 1950 emigrated to Canada. He is 31.

**John Bateson,** co-author of the article on page 525, served in the signals branch of the R.A.F. and was for some six years training "wireless trades" before his release from the Service in 1948. He then emigrated to Canada where he joined the radio propagation laboratory of what is now the Defence Research Telecommunications Establishment. He is 37 and is senior research technician in the establishment.

**H. D. Kitchin,** who describes in this issue a television frame pulse separator, rejoined Mains Radio Gramophones, Ltd., a few months ago to work on colour television and to act as technical adviser to the company, which makes sets for Radio Rentals. He was previously with the company for five years until 1955 when he became senior development engineer with Ambassador Radio & Television, Ltd. He is 29.

## OBITUARY

**L. H. Daniel,** the first director of the National Coal Board's central engineering establishment near Burton-on-Trent, who died on September 14th, aged 51, was for some years on the laboratory staff of the Electrical Research Association, where he was concerned with problems of radio interference. During the war he was temporarily engaged on investigations into magnetic mines at H.M.S. *Vernon* and from 1946 to 1954 was at the Fighting Vehicle Research Development Establishment, where he became deputy chief engineer.

**Major Charles E. Prince,** O.B.E., M.I.E.E., who died on September 25th at the age of 83, was for some years in the research department of Marconi's, which he joined in 1907. He was responsible for important improvements in the Bellini-Tosi d.f. system, and during the first world war developed the first aircraft radio-telephone. From 1929 to 1935 he was technical managing director of Radiovisor Parent, Ltd.

# RETURN LOSS

By THOMAS RODDAM

## I.—Standing Waves or Return Loss ?

"*Masculine will only be*
*Things that you can touch and see.*"

THOUGH excellent as a mnemonic for the student of the classics this jingle, for that is what it is in contemporary language, represents one of the great untruths of science and engineering. Too many of the elementary texts on electricity, wireless or radar, persist in the assumption that we are all plumbers at heart and cannot understand anything which isn't disguised as a system of water pipes. Currents, valves, pressures, condensers (and don't think capacitance hasn't a touch of the water works), all our terminology keeps us in the same frame of mind. This attitude was, perhaps, in order when light-current electricity was a " new thing," but now most of us find circuits much easier to understand than plumbing.

I was set off on this line of thought by the sight of a picture of a water trough intended to help the student to understand the development of standing waves. Here we have one of those happy hydraulic analogies which can so easily create more difficulties than they resolve. Do we really need standing waves?

For work in the kilo-megacycle region I suppose that there is still a great deal to be said for operating with standing wave ratios, although improvements in the directional coupler have brought us to the position where we are no longer compelled to measure standing waves. I have, however, found this to me rather repulsive concept creeping in all over the place and leaving a certain amount of confusion in its train. I think it is possible to attack many of the problems of mismatched lines more easily and more clearly without using the idea of standing waves at all.

The traditional approach to the problem of a line which is not correctly terminated usually begins with a special case, that of the open-circuited line. The voltage wave travelling along the line is shown first. The author then draws another sine wave representing the reflected wave, adds the two together, and shows the instantaneous resultant voltage distribution along the line. He then repeats the process for a slightly later time, and finishes up, in one particular example, with sixteen little drawings showing that at some points the voltage is always zero, at others the current is always zero, and that at others the voltage and current reach maximum positive and negative values. The next step, I suppose, would be to show what happens if the line is terminated, but incorrectly: the textbook I looked in apparently found this too advanced.

I'm not a student any more, but when I looked at these little drawings I wondered what happened away to the left of the picture, where the wave started. Unless the line is matched there, the reflected wave will be reflected again and it looked as though it would not be too difficult to get into rather a muddle. What is more, it seemed as though it was a rather unnecessary muddle, because it is only when asked to measure standing waves that anyone would move along a line looking at maxima and minima. I'm excluding interconnection problems in large power networks and one or two rather similar cases.

The real difficulty with the standing wave treatment of problems is that there is nothing in the ordinary simple theory to tell you whether standing waves matter, and if they do, how much. Let us consider a simple problem. From my window I can see a television aerial on a chimney stack: I suppose it is about 50 to 60 feet above ground level. The feeder wanders about rather, so I shall assume that it must be at least 20 metres long from aerial to set. Let us pretend we have carried out an experiment and found that there are standing waves along the feeder. What then?

The first conclusion we can draw is that the receiver at the bottom does not provide a perfect termination for the feeder. That means we will not get quite as much signal reaching the first grid as we might. Now we know that the standing waves originate in reflections at the receiver, but this simply means that a signal is sent back up the feeder to the aerial. There, perhaps, there is again a mismatch and the signal is re-reflected down to the receiver again. Ordinary television down-lead coaxial cable transmits signals at about 200 metres per microsecond, so that this delayed down-coming signal, after two reflections, arrives about 1/5 of a microsecond late. This means that the double echo of the white bars of the 2.5 Mc/s section of the test card will just turn up on top of the black bars. Here is something pretty practical: in this particular installation, if echoes are produced at top and bottom of the feeder this trouble will really be seen on the 2.5 Mc/s bars. Our simple standing wave test, however, doesn't help us to find out how serious this will be in our particular case.

### Determination of Return Loss

I don't know how many readers remember Appleton and Barnett's experiments on the ionosphere. They used a c.w. signal, varied the transmitting frequency, and measured the maxima and minima produced by interference between transmitted and received waves. This is a good way of proving that the ionosphere really exists, but it would take from now to Christmas to produce just one of those apparent height versus frequency curves the automatic machines turn out in the odd minute or two. The method preferred nowadays for measurements on the ionosphere is that introduced by Breit and Tuve, who used pulses to keep the echoes separate from the transmitted signal. Standing wave measurements always remind me of the Appleton-Barnett technique, so simple for indicating that something's wrong, but so awkward for finding out exactly what.

It may come as a shock to those readers who have ever had anything to do with line communications to learn that there are some living and breathing engineers who have never heard of return loss. Paddling happily in their troughs they have failed to notice that there is a much easier way of solving their problems, the method of return loss. Let us see what we mean by this.

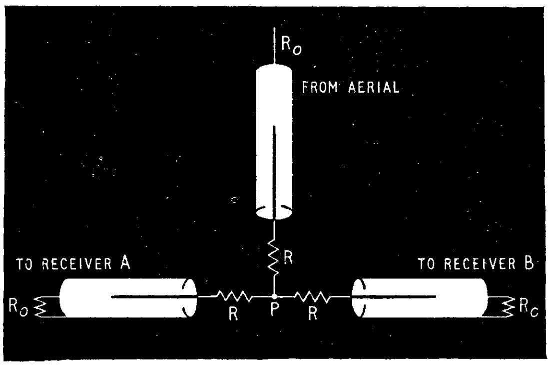



*Fig. 1. A splitting network to avoid reflections.*

Suppose we assume that we have a circuit consisting of a long line of characteristic impedance $Z_0$ and at one end, the end we can see, we terminate this line with an impedance $Z_1$. The line is, of course, quite free from all losses, because we do not want to complicate matters with irrelevant effects. At the far end we shall assume that there is a pulse generator of impedance $Z_0$ giving an open-circuit pulse voltage 2V. Each time the pulse generator delivers a pulse it operates as though the load on it were $Z_0$, because the line is assumed to be long enough for any receiving end effects to happen too late to be noticed at the sending end. Thus the generator gives out a pulse V to the line.

When we start to observe matters at our own end we carry out a special experiment putting $Z_0$ across the line (instead of $Z_1$). We then measure a pulse amplitude of V, with our given generator voltage and impedance.

There is a very important point to notice here. When we terminate the line in the impedance $Z_0$ there is no join from an electrical point of view. Nothing distinguishes the terminating impedance from a very long bit of line of the same kind so that there is no reflection at the termination.

Now let us put back the $Z_1$ termination. We then have a very simple circuit consisting of a generator of impedance $Z_0$ and open-circuit voltage 2V, and a load $Z_1$. Across the load, then, by Thévenin's theorem, we have

$$V_1 = \frac{Z_1}{Z_1 + Z_0} 2V$$

The generator, however, is a pulse generator and, as we have seen, operates as though the load on it were $Z_0$, so that on the line a bit back from the load the pulse amplitude is V. Suddenly, on reaching the load, the voltage has changed. Let us consider the available energy. We could deliver, in fact we are all set to deliver $V^2/Z_0$ into a load $Z_0$. Actually the pulse only delivers $V_1^2/Z_1$, that is $\frac{4V^2Z_1}{(Z_1+Z_0)^2}$ which means that an amount $\frac{V^2}{Z_0} - \frac{4V^2Z_1}{(Z_1+Z_0)^2}$ must have been rejected. It is, indeed, literally rejected, thrown back along the line as a pulse travelling back towards the source. How big is this pulse? It has energy, given by the expression above, which will all be dissipated when it reaches the impedance $Z_0$ of the generator. If the reflected pulse amplitude is $V_2$ we must have then

$$\frac{V_2^2}{Z_0} = \frac{V^2}{Z_0} - \frac{4V^2Z_1}{(Z_1+Z_0)^2}$$

$$\text{i.e.} \left(\frac{V_2}{V}\right)^2 = 1 - \frac{4Z_1Z_0}{(Z_1 + Z_0)^2} = \frac{Z_1^2 + Z_0^2 - 2Z_1Z_0}{(Z_1 + Z_0)^2}$$

$$= \frac{(Z_1 - Z_0)^2}{(Z_1 + Z_0)^2}$$

As we are only interested in amplitudes we can write

$$\left|\frac{V_2}{V}\right| = \left|\frac{Z_1 - Z_0}{Z_1 + Z_0}\right|$$

Usually we regard the operation as one providing an attenuation between the arriving and returning pulse. We work in decibels and say that

$$\text{Return Loss} = 20 \log \left|\frac{V}{V_2}\right| = 20 \log \left|\frac{Z_1 + Z_0}{Z_1 - Z_0}\right| \text{ dB.}$$

The return loss is a really useful concept. In ordinary language we say that a particular impedance has a return loss of so many decibels against 75 ohms, or 600 ohms, or whatever our standard is. Let us look quickly, before doing anything else, at my neighbour's television down-lead. We assume just for convenience, that the receiver has a return loss of 15 dB against the feeder impedance, and that the aerial has a return loss of 10 dB against the same impedance. We shall neglect the loss in the down-lead for this example. The signal, say 1 millivolt, comes down the aerial and at the set a signal of 15 dB below 1 mV is reflected back. When this reaches the aerial we have a new reflection with the echo 10 dB down on the signal moving up the feeder, so that the re-echoed signal is 25 dB below 1 mV. This, then, is the size of the delayed down-coming signal which we saw would disturb our 2.5 Mc/s bars. As you see, using return loss the mathematics is reduced to a matter of simple addition: you can hardly do better than that.

## Reflection Loss

While we have our mathematics handy, and before we go on to a further discussion of return loss, there is another important factor connected with the mis-termination of the line, the reflection loss. We have just seen that some energy was reflected back along the line. Obviously, then, we did not get as much energy into the load as we might have done. In fact the available energy was $V^2/Z_0$, and the amount not reflected was $4V^2Z_1/(Z_1 + Z_0)^2$, so that reflection

$$\text{loss} = 10 \log \frac{V^2}{Z_0} \cdot \frac{(Z_1 + Z_0)^2}{V^2.4Z_1} = 20 \log \left|\frac{Z_1 + Z_0}{2(Z_1Z_0)^{\frac{1}{2}}}\right| \text{ dB.}$$

This is usually a pretty small quantity and is difficult to measure. For example, if $Z_0 = 100$ ohms and $Z_1 = 110$ ohms then

$$\text{Return loss} = 20 \log \frac{210}{10} = 26.4 \text{ dB}$$

$$\text{Reflection loss} = 20 \log \frac{210}{2(11000)^{\frac{1}{2}}} = 20 \log \frac{105}{104.9},$$

an amount well below slide-rule errors. The return loss is much easier to deal with and, as we shall see in another article, it is the return loss combined with the time delay which makes matching important.

Now let us consider a more complicated problem to see how we can use return loss in practice. Two men, whom we will call A and B, decide that they will share a television aerial. The aerial is erected on a convenient chimney-stack, and a lead run down to a suitable point near the ground. From here, two separate leads are to run to the two receivers. Obviously, says A, we cannot just parallel up the two leads or we shall have a shocking mismatch. They therefore make up a matching network, which takes the form shown in Fig. 1. You will notice that all three resistances are equal, because if all three feeders have the same impedance the system is a symmetrical one. (Most people drawing it will, if they want to accentuate this feature, show the resistors spaced 120° apart.) To match the downcoming lead we must have $R + \frac{R + R_0}{2} = R_0$ or $3R = R_0$. At the input to this network we have a signal V. At P we have

$$V. \frac{R + R_0}{2} \Big/ \left(R + \frac{R + R_0}{2}\right),$$

and at the receiver feeder itself we have

$$\left[V. \frac{R + R_0}{2} \Big/ \left(R + \frac{R + R_0}{2}\right)\right] \cdot \frac{R_0}{R + R_0}$$

$$= V. \frac{R + R_0}{3R + R_0} \cdot \frac{R_0}{R + R_0} = V. \frac{R_0}{2R_0} = \frac{V}{2}.$$

This little pad therefore costs us 6 dB. If we hadn't worried about matching and had just paralleled up the feeders, we should have found that we got

$$2V. \frac{R_0/2}{R_0 + R_0/2} = \frac{2V. R_0}{3R_0} = \frac{2}{3}V, \text{ a loss of 4.4 dB.}$$

What reward do we get for the extra 1.6 dB? If we leave out the pad there is a bad mismatch at the junction, and the return loss at this point is

$$20 \log \frac{R_0 + R_0/2}{R_0 - R_0/2} = 20 \log 3 = 9.5 \text{ dB.}$$

Leaving out the attenuation in the cable itself, as in our previous example, we get a delayed echo 20 dB down if the aerial has a return loss of about 10 dB.

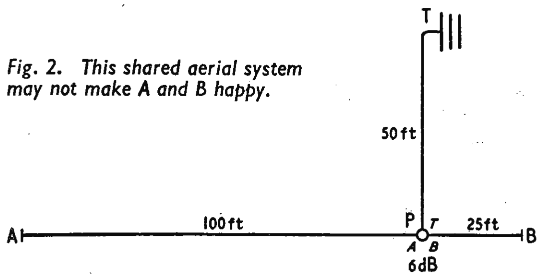



*Fig. 2. This shared aerial system may not make A and B happy.*

But now let us look more closely into the problem that A and B have set themselves and us. Fig. 2 shows a view of the sort of installation they might be sharing and I have assumed a rather large-scale affair because then we get more interesting numbers. The signal is received by the aerial at T, and we will take its level at this point as zero level. The cable used has an attenuation of 2 dB per 100 feet so that at the bottom of the downlead, $P_T$, the signal is at a level of $-1$ dB. At $P_A$ and $P_B$ it is $-7$ dB, and at A $-9$ dB, and B $-7\frac{1}{2}$ dB. So far so good; but now say that A decides to watch the other programme and in switching round his turret leaves his input a short or open-circuit to the signal B is using. (It makes no difference which of the two he does for this calculation.) The return loss at A is then zero, so that from A a signal starts to travel back at a level of $-9$ dB. At $P_A$ this signal is $-11$ dB. From $P_A$ to $P_B$ the loss is 6 dB, so the reflected signal reaches $P_B$ at $-17$ dB and goes on to B where it is $-17\frac{1}{2}$ dB, or just 10 dB below the level of the direct signal to B. In addition, the reflected signal reaches $P_T$ at $-17$ dB, goes up to T where it is down to $-18$ dB and is then reflected back at a level depending on the goodness of the aerial matching. An aerial giving 10 dB return loss will send down a new echo at $-28$ dB and this, by the time it reaches B will still be 28 dB below the direct signal.

The first echo has travelled 200′ extra, the second 300′ extra. At 200 metres/microsecond the first echo is delayed about 1/3 $\mu$sec and the second about 1/2 $\mu$sec. Just what this does to picture quality must be discussed at some other time, but you can see that when A changes programme it can show up on B's screen. We can work out something else, too. The echo from A is 10 dB down on the direct signal. This means that the echo voltage is 0.316 times the direct voltage. If the carriers are exactly in anti-phase, i.e. assuming that AP is the appropriate length, the carrier voltage received by B will drop to 0.684 times its previous value, a fall of 3.3 dB. Of course if B's receiver has a good a.g.c. system he will not notice this; but if the a.g.c. is not too good B will have a busy time with the contrast control if A can't decide which programme to watch.

We can carry out the same calculations of the effect at A's set assuming that B keeps altering the termination. The echo from B will be less delayed, but the possibility of change of level is somewhat greater—I'm not going through the whole analysis here. There is a solution of the problem we have created which is also worthwhile analysing. Attenuators placed in the two feeders A-$P_A$ and B-$P_B$ will each protect the other receiver. An attenuator of 6 dB at A will improve the echo effect by 12 dB for B, and an attenuator of 6 dB at B will improve the echo effect by 12 dB for A. As you can see, the total signal attenuation is 12 dB, so that we have a very simple theorem "Protection equals loss". Obviously neither A nor B will put in an attenuator unless the other does, so we can expect the two attenuations to be equal, and their sum is equal to the protection afforded to either of the receivers.

The protection equals loss theorem is a useful one to remember if you ever have anything to do with what the telephone transmission people call two-wire/four-wire circuits. As you know, the ordinary local telephone system is a two-wire system, with speech travelling in both directions on the same pair of wires. Two-wire repeaters, and, more important, all carrier telephone systems, are four-wire systems in which the go-circuit is different, either in frequency band or in wire-pair, from the return-circuit. At the junction of 4-wire and 2-wire circuits something has to be done to prevent the incoming speech on the 4-wire circuit from going back along the out-going 4-wire circuit. A bridge network of some kind is used, and on the balance of this bridge depends the level of the echo which is sent back to the speaker. This is a very important part of the circuit, because in a normal carrier system there may be, and in a two-wire repeater there certainly will be, enough gain for the echo to arrive back at a higher level than the original signal. The goodness of balance is expressed as the return loss of the 2-wire line against the balancing network in the bridge. At regular intervals someone has the bright idea of putting a pad in the two-wire line to improve its impedance characteristic. However, after you have increased the gain in both go and return circuits to make up for the loss of the pad you are back where you started.

The only other thing for which we now have space this month is a rather useful expression for the return loss caused by bridging an impedance across a line. This crops up in problems of what the Americans call "Community Antenna Systems". Of course you can just work out the load provided by the ongoing feeder in parallel with the bridged load and then go on to calculate the return loss. It is useful, however, to have a separate expression for this. Let us write $Y_0 = 1/Z_0$ and let G be the admittance bridged across the line. The return loss is produced by the termination $G + Y_0$ (admittance), so that it is

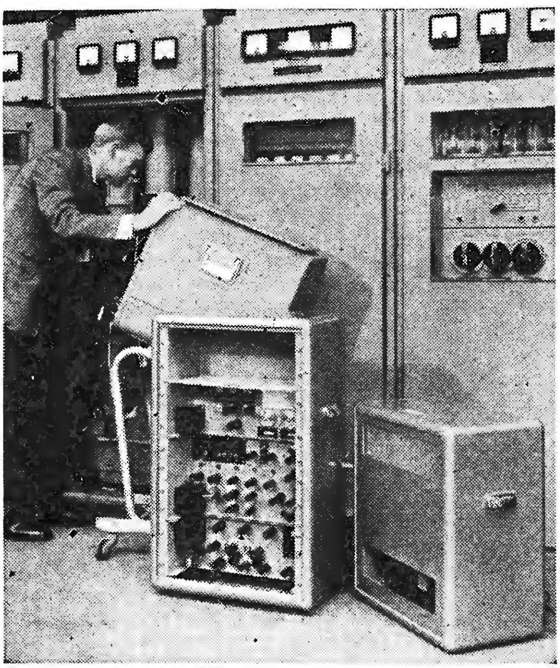
$$20 \log \left|\frac{Z_0 + Z_1}{Z_0 - Z_1}\right| = 20 \log \left|\frac{1 + Z_1/Z_0}{1 - Z_1/Z_0}\right| = 20 \log \left|\frac{1 + Y_0/Y_1}{1 - Y_0/Y_1}\right| = 20 \log \left|\frac{2Y_0 + G}{G}\right| \text{ dB}$$

In most practical cases this will be near enough equal to 20 log $|2Y_0/G|$, or, since we usually think in impedances, 20 log $|2Z/Z_0|$. As an example, a 750-ohm resistor bridged across a 75-ohm line will produce an echo 26 dB down.

I think that I have made a case for the use of return loss as a basic design concept. Two topics remain to be discussed: how can we measure return loss, and what sort of values should we hope to get. I hope to be able to deal with these soon.

# Television Transmitter Sideband Analyser

TEST and adjustments carried out on television transmitters when in service are often tedious, and in some cases unreliable. By means of a new Marconi Instruments equipment called a sideband analyser this kind of work can be done in a very much shorter time than is possible by existing methods. The instrument displays the overall response of any Band-I or Band-III transmitter using 405-, 525-, or 625-line standards. It does this by providing a sweep signal for modulating the transmitter, and by scanning the resultant r.f. output signal in such a way as to display the upper or lower sideband response, either separately or both together, in their correct amplitude and frequency relationship to the carrier. In addition, the response of a complete transmitter modulator chain, or any part of it, can be measured. The test signal is actually a composite signal. The normal television waveforms are combined with the video test signal, and the transmitter operates on test at any level in the grey scale, under the same conditions as in normal service. The effect on the transmitted spectrum of any adjustment to the transmitter is immediately visible to the operator.



*Television sideband analyser (Marconi Type OA 1241).*

Test signals are generated in the following manner. The video sweep signal is derived from two oscillators, one fixed and the other swept, to provide either a sweeping difference signal from a lower limit of 100 kc/s to any frequency up to a maximum of about 20 Mc/s, or a sweep symmetrical about zero frequency and extending to a maximum of not less than 7 Mc/s each way The output level is held to within ±0.1 dB throughout the sweep. Line and field blanking and sync pulses are applied to the analyser from a standard source, and are combined with the sweep signal.

This output can be applied to (a) the video stages under test, the output of which is detected by a circuit in which the detector is immobilized during the period while the sync and blanking are present, and applied to the display for measurement; or (b) as modulation for the transmitter In this last-mentioned condition, one of the two sidebands produced at any instant decreases in frequency at the same rate as the output frequency of the swept oscillator. By mixing the outputs of the transmitter and swept oscillator, a constant-frequency signal is produced, whose amplitude is directly proportional to the sideband amplitude. This constant-frequency signal is fed to a narrow-band amplifier whose output, after detection, is applied to the display unit. Markers, which occur at 1-Mc/s intervals, are available on the display for reference purposes.

# Semiconductor Symbols

## Logical System for Diodes, Transistors and Other Junction Devices

**By P. M. THOMPSON* and J. BATESON***

THE number of articles written on the subject of transistor symbols is growing at an alarming rate. If, indeed, the present rate of production is maintained it will soon be reasonable for the Editor of *Wireless World* to introduce a symbol representing an article on transistor symbols. In view of the foregoing the reader might be forgiven for asking why we are adding to the alarm. The answer would be that this article is not only about transistor symbols; what we have developed and would like to present here is a logical, self-consistent, graphical nomenclature which can be used to depict any device depending for its action upon p-n junctions. Thus, by means of this nomenclature one may represent, and distinguish between, junction transistors; junction diodes, both of the common-or-rectifier type and the Zener type; photo-diodes and -transistors; solar batteries and the like.

Since the days of Archimedes mankind has been attracted to the idea of getting, or only apparently getting, something for nothing, and the transistor showed such promise in this direction that many people were led to consider it the only significant device to come out of the field of semi-conductor research. One result of this has been that symbols proposed to represent "the" transistor have tended to be unique and incapable of extension to related semiconductor devices. The Bell (Telephone Laboratories) symbol has historical significance since it is a depiction of the earliest point contact transistors. However, it is noteworthy that the early and also pictorially derived symbols for valves gave way to symbols which could be helpful in explaining the action of a valve. This could be interpreted as indicating that the symbol, for any device, which finally becomes universally accepted is that which proves most helpful to the student.

Engineers coming upon the transistor late in their training, or in post-training years, would be expected to incline towards adoption of a valve-like symbol since they tend to explain the action of a transistor (at least to themselves) in terms of a valve amplifier. However, it is interesting to speculate upon the symbol that would be adopted (or invented) by the student who, familiar with semiconductor amplifiers, or, perhaps magnetic amplifiers, was then introduced to the valve as an amplifier. We feel it is not improbable that in future training courses students will be introduced to transistor amplifiers before going on to consider the less elegant evacuated bottles of metal and mica which are variously known as valves or vacuum tubes.

Historically and technically the junction transistor evolved from a successful attempt to create a continuous, tetravalent crystal lattice which contained, in adjacent regions, precisely controlled amounts of an impurity selected from the group III or group V elements. Two such regions with their different "doping" but with similar conductivity gave us the p-n junction rectifier. The creation, then, between two like-doped, relatively high conductive regions of a physically and conductively slender, other-doped region gave us a device that would amplify small currents.

We feel, therefore, both that the bond between the junction diode and the junction transistor is one that is logically not easily broken and that there is no real reason for trying to break it. We do not, then, propose a special system of symbols so much as a philosophy of an integrated and self-consistent system. Being self-confessed traditionalists we have accepted the traditional rectifier symbol and have extended it to fit related devices in this new field. It was this philosophy that led to the "Canadian system" and what follows has been abstracted from a memorandum which is used as an approved guide by the research laboratories of the Canadian Government.

The purpose of a semiconductor symbol is to represent the semiconductor device in a schematic diagram. In order to do this it should suggest to the reader the characteristics of the device; it should be easily recognizable, and easily distinguishable, from other parts of the diagram. Other important requirements for the symbols are that they should be easy to draw, easy to remember, and adaptable to any new semiconductor device.

Since there are many devices to be represented and since each has its own symbol, if the symbols are to be easy to remember the system of nomenclature must be based on the logical development of a few simple rules. Furthermore the system should be capable of remaining accurate when used in part, in whole, or just approximately. Although based on only a few rules, it should not be necessary for a user to know the whole system to use but part of it.

It was with all of these considerations in mind that the following system was developed.

**Fundamentals.**—Semiconductor devices such as diodes and transistors consist of p-n junctions. In this system of nomenclature there are symbols for the various types of junctions, and the devices are represented as combinations of these junctions.

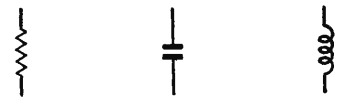
The junctions are distinguished as to the direction of essential current flow. If the current flows from *p* to *n* (in the forward direction) as in a transistor emitter, the junction is shaded. Where the current flows from *n* to *p*, as in a transistor collector or a Zener diode, the junction remains unshaded.

A second connection to a region, such as in a transverse field junction tetrode, is indicated by displacing the connection or by a dot. There are

* Defence Research Telecommunications Establishment, Ottawa, Canada.

distinctive symbols to indicate special sensitivity to light or heat, or the presence of an intrinsic layer. Any semiconductor device, which consists of points, junctions or both will have a logical symbol within the system.

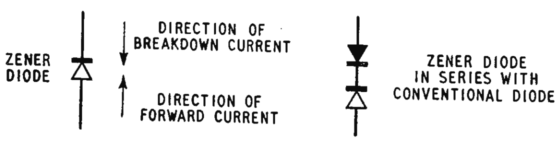
**The Standard Symbols.**—In order to indicate the size of the symbols for semiconductor devices with relation to the other circuit components, a resistor, capacitor, and inductor are drawn.



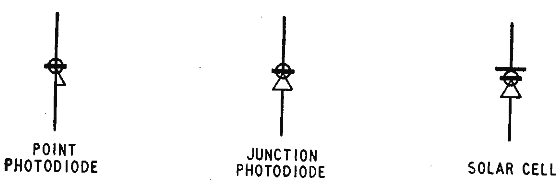
The photoresistive device and the thermistor indicate the symbols for light and heat sensitivity respectively.


Among the single junction devices there are several types of diode and "field effect transistor." Point and junction diodes have distinctive symbols. They are shown shaded because the essential current flow is from *p* to *n*.


In a Zener diode the breakdown current flows in the reverse direction, so it is shown as an unshaded junction diode.

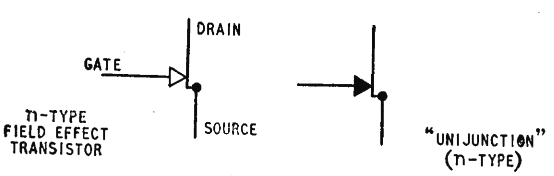



In photodiodes reverse current flows when light falls upon the junction, so they are shown as unshaded diodes with the circle to indicate sensitivity to light. For a solar cell the "battery" symbol can be added.



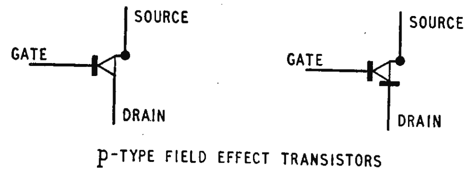

An *n*-type field effect, unipolar, or analogue transistor would have its gate shown unshaded, and the source shown as a second connection to the base. (This bears some similarity to the bias connection in a junction tetrode.)

"Unijunctions" or "double base diodes" are similar to the last-mentioned types, except that they are operated with a forward current through the junction.

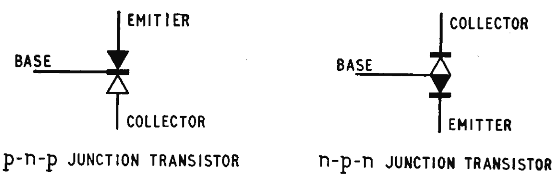



A field effect transistor with injecting drain has the normal drain connection replaced by a junction.

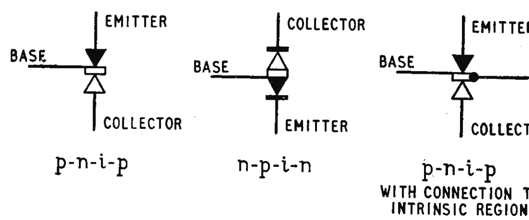

The complementary *p*-type field effect transistors will be shown as follows.




Triode junction transistors, both p-n-p and n-p-n, consist of two junctions. The current flows in the forward direction through the emitter and in the reverse direction through the collector junction. The emitter is therefore shaded.



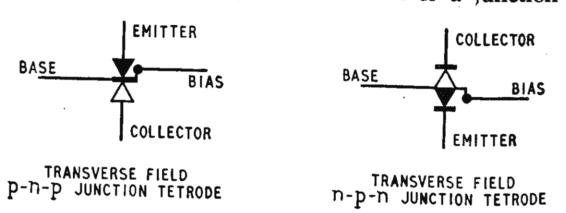

There are several types of junction triode referred to as alloyed, fused, surface barrier, grown, rate grown, diffused base, etc. Although all have their own particular characteristics they do not differ electrically sufficiently to warrant separate symbols. However, the p-n-i-p transistor has special properties, and the presence of an intrinsic layer in the base is shown by drawing the base as a narrow "box."




The p-n-i-p transistor may be regarded as an extreme case of the graded base p-n-p transistor, so a graded base transistor may be represented as above.

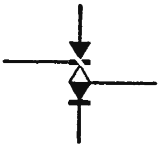
If the transistor is symmetrical it has no defined emitter and is left unshaded.

A transverse field junction tetrode is a junction



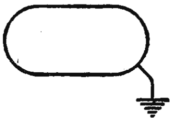
transistor with a second connection (the bias connection) to the base.

When extra junctions are added to the system making such devices as the p-n-p-n transistor, it will have a logical symbol within the system.



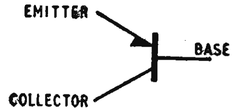
p-n-p-n JUNCTION TRANSISTOR

A shield or earthed case for a device is shown as follows.

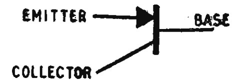


It is drawn to enclose the device or the part of the circuit which is shielded.

For point transistors the emitter is drawn as a point diode, with which it is very similar. It is suggested that the collector, which bears no resemblance to any type of single junction, should not be drawn as one, but should have its own distinctive symbol, as shown here (below left).




POINT TRANSISTOR (n-TYPE)

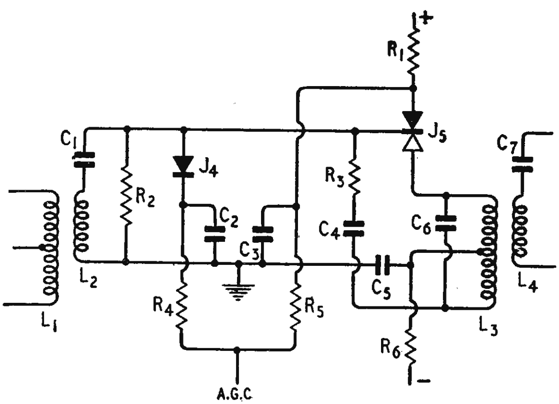


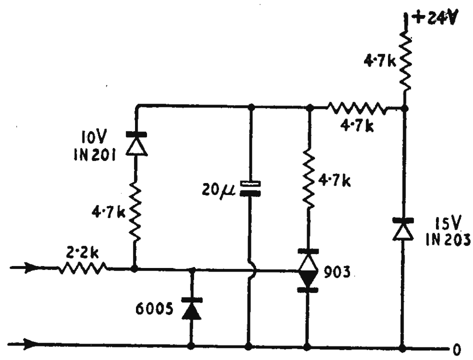

THYRATRON TRANSISTOR (n-TYPE)

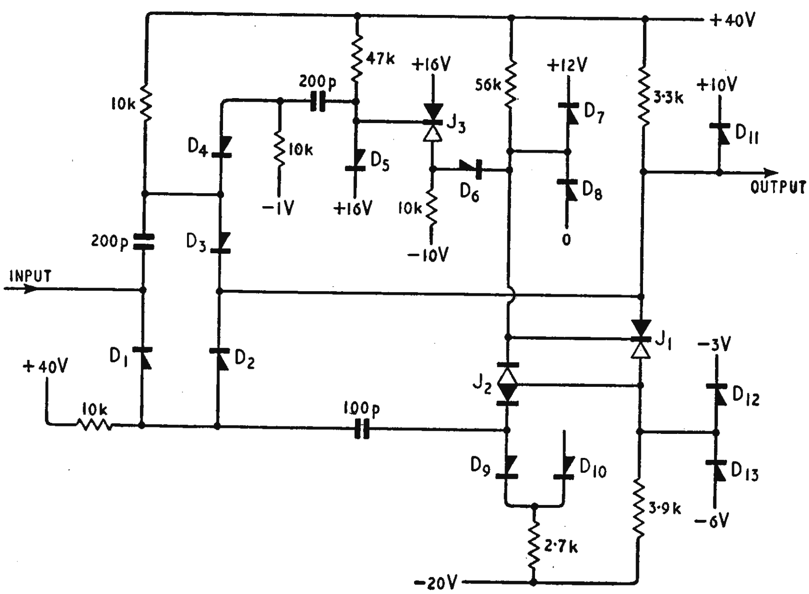
A thyratron transistor (above right), a transistor with a junction emitter and a point collector, is similar in characteristics to a point transistor.

The above examples of semiconductor devices have been in use up to the time of writing. Although all possible variations have not been illustrated, the reader will probably see already how the system can be applied to any new device. As it is inevitable that there will be devices which do not fall clearly into any classification (e.g., gold-bonded diodes), they should be drawn as the device with which they are most similar in their application.

**Complete Circuits.**—Schematic circuit diagrams




*Examples of the use of the proposed symbols in some typical circuit diagrams.*

are line expositions of circuits. These line pictures should be as easy to read as the word pictures or descriptive texts that go with them. If a convention exists for a sub-circuit which is being operated in a conventional manner, it should be used, since the reader is not then compelled to derive the circuit every time from first principles. In general, it should be remembered that the contribution made by the eye when reading a diagram is greater than that made when reading words. The appearance of a diagram, therefore, is not unimportant.

**Rules.**—(1) Connections to positive supplies should be drawn going upwards on diagrams, while connections to negative supplies should go downwards. Connections to intermediate potentials or to earth should be between these two extremes.

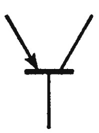
(2) The signal should travel from left to right through the circuit.

(3) Any separate part within the circuit, such as an audio amplifier, should be kept together, and not be mixed in with parts performing other functions, such as an oscillator or pulse shaper.

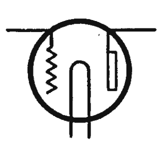
(4) Parts of the circuit which are normally recognizable, such as a bridge or a p-n-p-n trigger cricuit should be drawn in their recognizable form, and not distorted so as to disguise their function.

Components may be labelled as desired, to allow the circuit to be built, or to simplify the understanding of its operation. It is suggested that J is used for a *junction* transistor and P for a *point* transistor as V is for a *valve*. T should be kept for transformers. Diodes could be given D numbers or P and J numbers, depending on whether it is more important to emphasize the difference between transistors and diodes, or different types of diode.

To conclude, it may be instructive to compare the symbols of the Canadian system with some of the other symbols in use to-day, both in relation to self-consistency, and their potentialities for expansion to represent related devices. In this connection it may be possible to draw a parallel between the Bell transistor symbol and an early triode symbol.

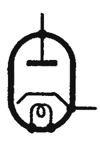


BELL TRANSISTOR

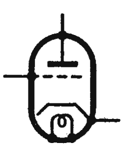


TRIODE VALVE

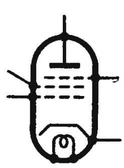
Neither of these can be developed to represent related devices easily, and neither takes a form which suggests the operation of the device. The above triode symbol gave way to a nomenclature based on symbols for anodes, grids, cathodes, etc.



DIODE



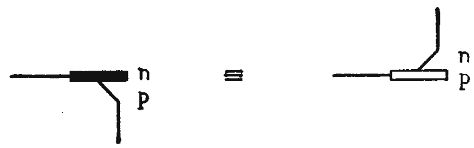
TRIODE



PENTODE etc

These symbols for valves are self-consistent, e.g., the anode is always shown the same way. However, one finds a surprising lack of self-consistency in the symbols that have been suggested for transistors. If, for example, we consider the ways a collector (which is a p-n junction where the essential current flow is from *n* to *p*) is drawn, we find that it differs considerably between the p-n-p, and the n-p-n.

In Chaplin's symbols




while in the Bell, R.C.A. and several other systems there is nothing about the way in which the junction is drawn which indicates which side is *p*, and which is *n*. This depends on whether the transistor is p-n-p or n-p-n.

It is probable that the junction transistor will not be the last widely used device to emerge from the laboratories of the semiconductor researches; and unless a self-consistent nomenclature is adopted one will be faced with a repetition of the present situation each time a new semiconductor device is produced.

## CLUB NEWS

**Birmingham.**—Two R.S.G.B. tape-recorded lectures —"Astronomy and cosmology" by the Astronomer Royal and "Interplanetary travel" by W. A. Scarr—will be given at the November 8th meeting of the Slade Radio Society. The club meets at 7.45 at the Church House, High Street, Erdington. Sec.: C. N. Smart, 110 Woolmore Road, Erdington, Birmingham, 23.

**Bury.**—The November meeting of the Bury Radio Society will be held at 8.0 on the 12th at the George Hotel, Kay Gardens. The speaker will be T. C. Platt (G2GA) and his subject "An old-timer looks back". Sec.: C. L. Robinson, 56 Avondale Avenue, Bury, Lancs.

**Edinburgh.**—The Lothians Radio Society has recommenced holding meetings in the Chamber of Commerce Rooms, 35 Charlotte Square, on alternate Thursdays at 7.30. The next meeting is on October 24th. Sec.: J. S. Nicholson, 10 Hawkhead Crescent, Edinburgh, 9.

**Leeds** Amateur Radio Society meets most Friday evenings at Swarthmore Educational Centre, Woodhouse Square. On November 1st the subject to be discussed will be simple gramophone amplifiers and on the 15th there will be a talk on wartime radar. Sec.: J. R. Hey, 40 Richmond Avenue, Headingley, Leeds, 6, Yorks.

**Sidcup.**—The next meeting of the Cray Valley Radio Club will be on October 22nd and will be devoted to an exhibition of members' home-constructed gear. The club meets on the fourth Tuesday of each month at 8.0 at the Station Hotel, Sidcup. Sec.: S. W. Coursey (G3JJC), 49 Dulverton Road, London, S.E.9.

**Wellingborough.**—At the October 31st meeting of the Wellingborough and District Radio and Television Society, A. C. Homer will give a talk entitled "Reminiscences of a Post Office engineer". On November 28th F. W. Tyler (G3CGQ) will speak on "The International Geophysical Year and the radio amateur". Meetings are held every Thursday at 7.30 at the Silver Street Club Room. Sec.: P. E. B. Butler, 84 Wellingborough Road, Rushden, Northants.

# LOUDNESS

## PHONS OR SONES?

By "CATHODE RAY"

REGULAR readers (if any) of these ramblings may have formed the opinion that in spite of their apparently random titles they all sooner or later lead to critical remarks about terms, symbols, units and so forth. If so, this one will be no exception. For "loudness" is very much a question of definition, and has in no way been spared the muddle-headedness with which the experts (unconsciously, we will charitably assume) make things difficult for the earnest plodder.

The first and most important thing to grasp about loudness is that it is subjective. That is to say it is our human impression of something, and not that something itself. That something is sound, which is a physical disturbance that would exist even if there were no living creatures to hear it. (I am not stopping to argue with the philosophers who hold that everything is subjective.) Before considering subjective loudness, we had better make a quick review of objective sound.

Fig. 1(a) shows, in cross-section, a small part of a gong or other sound-making device; the uniformity of the shading in front of it represents the uniformity in pressure and density of the air around before the gong is struck. The same thing is represented in a different way by the constant height of the line above. An increase in air pressure anywhere can be shown by a darkening of the shading and by a rise in the level of the line, which is really a pressure graph. The graph method is the most used, because it is less tedious to draw; but since it represents the condition of the air less directly, and no expense is spared, I will use both sorts together at this stage.

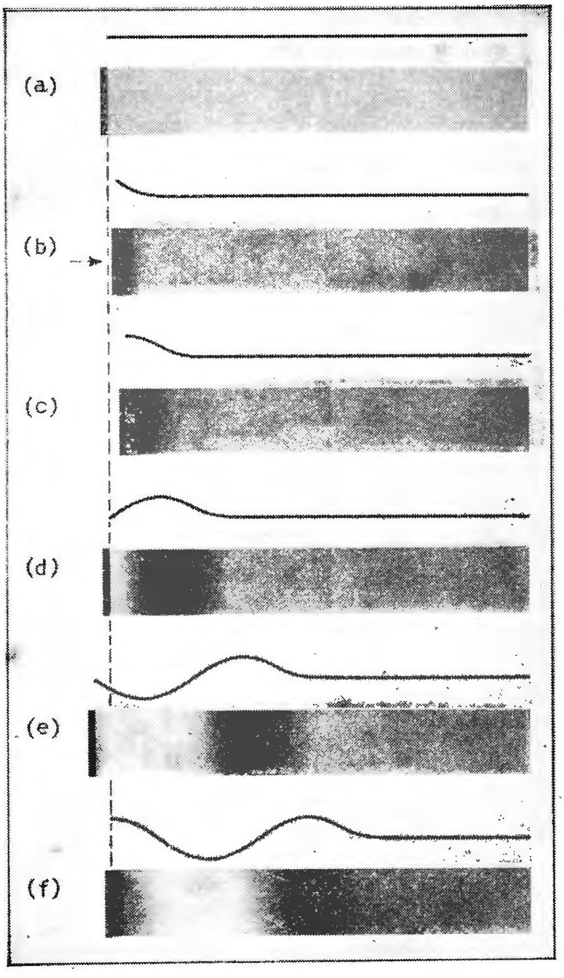
When the gong is struck its metal plate is jerked forward, as indicated by the arrow in Fig. 1(b), and it compresses the layer of air between itself and the whole mass of air beyond. This compressed air compresses the layer next to it (c), and so on, causing a wave of compression (but *not* of compressed air) to travel continuously forwards.

The metal, being elastic, springs back (d); and so the air which had been compressed by it now moves backwards to equalize the pressure. The inertia of the metal carries it behind its static position, so the pressure falls below normal (e). The backward movement of the air is passed forwards in just the same way as the previous forward movement. So a state of rarification spreads along behind the state of compression, completing one whole wave (f). As the gong continues to vibrate, successive waves follow the first one.

The sound of the gong (or of anything else) therefore consists in every particle of air around it vibrating forwards and backwards a short distance around its normal position of rest; imitating, in fact, the motion of the thing that caused it.

There are several ways in which the strength of a sound can be reckoned. It can be reckoned in terms of these alternating variations in pressure, above and below atmospheric pressure. They correspond quite closely to alternating signal voltages, often superimposed on relatively large steady voltages. Like them, they can be reckoned in instantaneous, peak, mean or r.m.s. values. The units could be pounds per square inch, but c.g.s. units—dynes per square centimetre, which are 69,100 times smaller—are preferred. For one thing, the peak pressure of even the strongest sounds is quite

*Fig. 1. Section of a sound-generating diaphragm, with the air in front of it. The pressure of this air is represented by depth of shading and also by the height of the horizontal line above.*



small. One dyne/sq cm is only about one millionth of atmospheric pressure; even so, the standard "reference level" for sound pressures is as little as 0.0002 dyne/sq cm—the reason for which will appear later. Most people who have had the misfortune to hear a pneumatic drill at close quarters would be surprised to learn that it disturbs the normal atmospheric pressure (which they bear all the time without noticing) by only about one ten-thousandth part. Before a sound reached 1% of atmospheric pressure it would be quite literally ear-shattering.

The greater the sound pressure, the faster the air vibrates. By "faster" I don't mean a greater number of vibrations per second, but a greater to-and-fro velocity. To distinguish this velocity of the air from the onward velocity of the air waves, it is called particle velocity. It corresponds to electric current, because it is proportional to the pressure and inversely proportional to something corresponding to impedance. This thing is, in fact, called acoustical unit-area impedance, and depends on the medium in which the sound waves are travelling. Since the only medium we are considering is air, we can regard the ratio of pressure to velocity as fixed.

## Sound Intensity

Seeing that the power delivered to a given electrical impedance is proportional to the square of the voltage or current, acoustical power is presumably proportional to the square of pressure or velocity. While this is true, we must bear in mind that for simplicity we have been comparing sound *waves* with electrical *circuits* instead of with electromagnetic waves. So just as sound pressure is in dynes *per square centimetre*, what is called the intensity of sound is the amount of power the waves carry away through each square centimetre at right angles to the way they are going.

In Fig. 2, S represents a point source radiating sound equally in all directions. (Such things do not exist, but no matter.) At any radius $r$, the total area

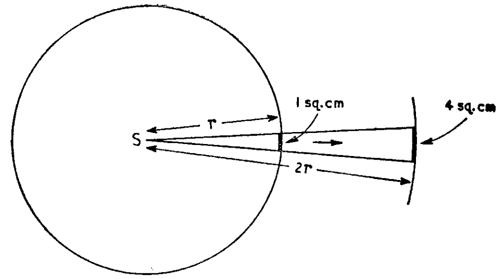



*Fig. 2. S represents a source of sound, radiating equally in all directions. Knowing the total power radiated, one can easily calculate the intensity of sound at any distance from S. (It is assumed that there are no external obstructions.)*

through which the whole power is being radiated is $4\pi r^2$, so if that power is known the intensity at that radius is given by dividing it by $4\pi r^2$. At twice the radius, the same power is spread over four times the area, so the intensity is one quarter as much.

Power is rate of doing work, and the c.g.s. unit of work is the dyne-centimetre or erg. So the c.g.s. unit of sound intensity is the erg per second per square centimetre. Because there is a fixed rate of exchange between mechanical (including acoustical) and electrical power, we can alternatively reckon sound intensity in watts per square centimetre (or per square metre if we are m.k.s. minded). There are ten million ergs per second to a watt, which is too large a unit to be convenient for sound intensity so is usually divided into a million microwatts.

The standard intensity reference level (to which the aforementioned pressure of 0.0002 dyne/sq cm corresponds, if air is the medium) is $10^{-16}$ watt/sq cm, which is $10^{-10}$ microwatt/sq cm or $10^{-9}$ erg/sec/sq cm. I am mentioning all these alternative units because some people use one and some another, and it is useful to have a table connecting them. But before coming to that we must understand why it is that a standard reference level has been fixed. The main idea is to enable sound levels to be given in decibels. As we ought to know, decibels are simply ratios, so cannot be used to specify quantities such as sound intensities or signal strengths except by comparison with some standard level to which zero on the decibel scale can be attached. The statement one often encounters, that "the decibel is a unit of sound," is true only on this understanding. Here then, on the left, is the table.

Everything so far has been plain sailing, because it refers to an objective thing that can be measured with suitable instruments, in the same systems of units that serve for all other physical quantities. There are always some people who will misuse or misunderstand decibels, but that is a very elementary

| dB | Sound Intensity | | | Sound Pressure* | |
|---|---|---|---|---|---|
| | **Watt/sq metre** | **Micro-watt/sq cm** | **Erg/sec/ sq cm** | **Newton/ sq metre** | **Dyne/sq cm** |
| 120 | 1 | 100 | 1000 | 20 | 200 |
| 110 | 0.1 | 10 | 100 | 6.3 | 63 |
| 100 | 0.01 | 1 | 10 | 2 | 20 |
| 90 | $10^{-3}$ | 0.1 | 1 | 0.63 | 6.3 |
| 80 | $10^{-4}$ | 0.01 | 0.1 | 0.2 | 2 |
| 70 | $10^{-5}$ | $10^{-3}$ | 0.01 | 0.063 | 0.63 |
| 60 | $10^{-6}$ | $10^{-4}$ | $10^{-3}$ | 0.02 | 0.2 |
| 50 | $10^{-7}$ | $10^{-5}$ | $10^{-4}$ | 0.0063 | 0.063 |
| 40 | $10^{-8}$ | $10^{-6}$ | $10^{-5}$ | 0.002 | 0.02 |
| 30 | $10^{-9}$ | $10^{-7}$ | $10^{-6}$ | 0.00063 | 0.0063 |
| 20 | $10^{-10}$ | $10^{-8}$ | $10^{-7}$ | 0.0002 | 0.002 |
| 10 | $10^{-11}$ | $10^{-9}$ | $10^{-8}$ | 0.000063 | 0.00063 |
| **0** | $\mathbf{10^{-12}}$ | $\mathbf{10^{10}}$ | $\mathbf{10^{-9}}$ | **0.00002** | **0.0002** |
| —10 | $10^{-13}$ | $10^{-11}$ | $10^{-10}$ | 0.0000063 | 0.000063 |

**In air at normal atmospheric temperature and pressure.*

fault. It is when we come to the human response to sound that things become difficult. One difficulty is that no two human beings are the same, and even an individual's hearing varies with age. It is also enormously affected by a variety of conditions such as the frequency and character of the sound being heard and the presence or absence of other sounds.

## Threshold of Hearing

If a sound is very weak indeed it cannot be heard at all by anyone. So the obvious starting point for a loudness scale is the intensity of sound that marks the dividing line between just audible and not audible. It is called the threshold of hearing, and is defined as the minimum r.m.s. pressure of a pure sound wave that can be heard, under certain specified conditions. To measure this without bringing in individual characteristics, the average is taken of tests on a reasonably large number of people, all aged 18 to 25 and without any hearing defects. The background must be perfectly quiet, and the standard frequency is 1,000 c/s.

The last condition is vital. A 50 c/s sound, for example, is too weak to be heard even if it is 1,000 times the 1,000 c/s threshold intensity. In other words, the intensity corresponding to the threshold of hearing (zero loudness) varies tremendously with frequency. Fig. 3 shows how it varies. In this kind of diagram, sound level (as set forth in our table) is marked as horizontal lines across the whole band of audible frequency. We see how normal hearing becomes steadily less sensitive (i.e., the sound has to be stronger to be heard) as frequency falls below about 800 c/s, but rises slightly about 1,000 and then falls off. If older people are used for the test, it falls off much more steeply at the high-frequency end. The dotted line is the curve obtained in the celebrated tests by Fletcher and Munson* in 1933; the solid line was published last year by Robinson and Dadson† and is claimed to be more accurate.

As a matter of fact, Fletcher and Munson's measured threshold at the standard 1,000 c/s agreed more closely with the newer results than the curve indicates, but it seems that they distorted it a little at this frequency in order to bring it to a convenient round number ($10^{-16}$ watt or $10^{-10}$ $\mu$W per sq cm). It is generally agreed that only exceptionally acute hearing can detect a 1,000 c/s tone at this level.

So right at the start there seems to have been a bit of a fiddle in connection with the loudness scale. The standard reference sound intensity, reckoned as 0 dB, has been fixed at $10^{-16}$ W/sq cm with the idea that that is the threshold of hearing at 1,000 c/s, but actually it is the nearest round number to it. The real threshold of hearing is, after all, only an average of rather tricky measurements made on human beings, who come and go.

But this is not all. Granted that zero loudness is where a sound just begins to be audible (or just ceases to be audible, if you are varying the intensity the other way), where should "1" come on the scale? How loud is unity loudness? Your guess is as good as mine, but hardly likely to be the same. Then, supposing we agree to put "1" on the scale at an arbitrary increase in intensity above "0," where do we put "2"? When is a sound twice as loud? There is a little more to go on than in fixing "1," but still plenty of room for difference of opinion.

Quite a long time ago these difficulties were evaded by deciding to make the loudness scale for 1,000 c/s coincide with the intensity scale. The question then arose: what about sounds of other frequencies? Should the curves for all loudnesses be made the same shape as the zero-loudness curve of Fig. 3, by drawing them exactly parallel to it through the appropriate points on the 1,000 c/s scale?

It was soon found that if they were they certainly could not claim to be equal-loudness curves. For instance, a 50 c/s sound 60 dB above the 50 c/s threshold (i.e., at the 100 dB level) is far louder than a 1,000 c/s sound 60 dB above its threshold. The only reasonable way of drawing equal-loudness curves is so that they show the intensities that are heard equally loudly, even though it means employing the large gang of young hearers for a much longer time in order to arrive at an average of their views on how intense the sounds of different frequencies have to be in order to be as loud as the standard 1,000 c/s sounds. And that is not a thing that can be done quickly or easily, for people are not fitted with pointers that automatically show how loudly they are hearing, and the requisite

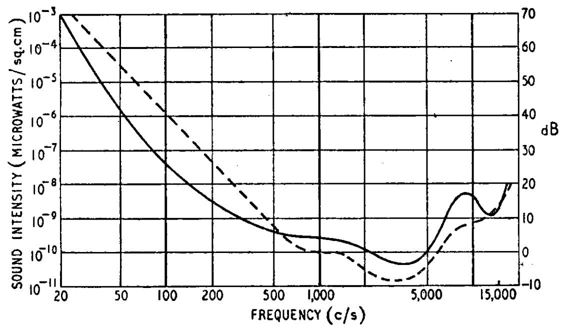
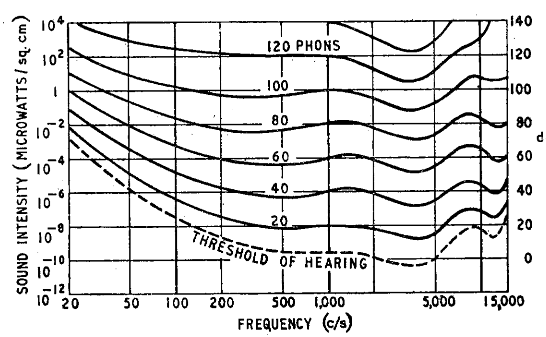



*Fig. 3. "Threshold of hearing" curves. The dotted line is the well-known one by Fletcher and Munson: the full line is a more recent determination of the same thing by Robinson and Dadson.*

*Fig. 4. Robinson-Dadson equal-loudness contours.*




*"Loudness, its Definition, Measurement and Calculation," H. Fletcher and W. A. Munson, *Jour. Acoust. Soc. Amer.*, Oct. 1933.

†"A Re-determination of the Equal-loudness Relations for Pure Tones," D. W. Robinson and R. S. Dadson, *Brit. Jour. Appl. Phys.* May 1956.

listening conditions are difficult to maintain over wide ranges of frequency and intensity.

The results of an extensive set of such observations are shown in Fig. 4, which is Fig. 3 with a superstructure of equal-loudness curves erected upon it. This kind of diagram is very familiar, but the exact shapes of the curves will be less so, for they are the recent ones by Robinson and Dadson instead of those by Fletcher and Munson that have been reproduced so many times during the last 24 years. The reason for their popularity is that a representation of the intensity/loudness relationship is one of the most important in the study of sound reproduction (and especially to Cathode Ray's modest contribution to the subject: the term " scale distortion "!).

In place of the Fletcher and Munson zero loudness curve, which was an observed threshold curve fiddled to pass through the $10^{-16}$ W/sq cm level at 1,000 c/s, Robinson and Dadson show their observed threshold as a dotted line which does not pass through this standard point. It therefore does not form a harmonious foundation for the other curves, which are retained at the Fletcher and Munson levels at 1,000c/s. Presumably this is because it would be inconvenient to alter the levels of the whole lot every time anybody came out with an improved set of observations. Perhaps even the average acuteness of hearing might drift slightly from generation to generation. Personally I would suggest retaining a " zero loudness " curve passing through 0 dB at 1,000 c/s, representing the threshold of an ideal hearer, who at the present time would be about 4 dB more acute than the average.

The curves in Fig. 4 show clearly, though to a less extent than the Fletcher-Munson set, that at low frequencies the divisions on the loudness scale are closer together—in terms of intensity—than at 1,000 c/s and above. So much so that at the 100 dB level sounds of all frequencies are heard almost equally loudly, in contrast to the threshold level. Even the arbitrary tying of the loudness scale to the intensity scale all the way up at 1,000 c/s cannot conceal the fact that these essentially different quantities—intensity and loudness—are in general not even approximately proportional to one another.

## Overworking the Decibel

What can we say then of the authorities who reckon them both in the same units? As if the decibel were not already liable to be misunderstood by the weaker brethren, they chose it to be also a unit of loudness! They label the rather irregular curves, as well as the horizontal straight lines, " dB," so that the same diagram contains two lots of decibels, measuring two basically different quantities not related in any simple way! If a perverted genius had wanted to confuse the issue most completely he could not have hit on a more brilliant way of doing it.

In Europe this scheme of things could not be tolerated for long, and in 1935 (or thereabouts) loudness on this kind of diagram began to be scaled in *phons*. But this civilized custom does not seem even yet to have penetrated to all parts of America.

The next muddle was to draw parallel curves at intervals above the threshold curve—the ones we agreed couldn't possibly be called loudness curves—and call them " sensation levels." In the first place, if this name suggests anything at all it suggests that they are a subjective quantity, which of course they are not. The other thing is that these sensation levels are scaled in—yes, you have guessed it!—decibels! Apollyon himself, the Prince of Darkness, could scarcely have thought of a diagram with three entirely different things all in decibels.

Even if we sensibly mark the Fig. 4 curves in phons and ignore " sensation levels " altogether, these curves are a fraud. There is no justification, except the convenience of dodging a difficulty, for making a loudness scale coincide with an intensity scale anywhere. However widely opinions may differ on relative loudnesses, no one in his senses, asked to double a 40-phon loudness by adjusting the intensity of a sound, would set it anywhere near 80 phons. He would be much more likely to make it 50. So persistent attempts have been made to find a genuine loudness scale.

## Origin of the Sone

Having been so rude about the American fondness for measuring the most diverse things in decibels, I must acknowledge that as long ago as 1936 S. S. Stevens of that land originated the *sone*, which is belatedly being recognized as a loudness unit. More recently he has reviewed the subject fully‡. And I gather that the sone is receiving official approval in this country.

The difficulty, as I have said, is to judge when a sound is twice (or half, or any other ratio) as loud as another. Quite a number of methods have been devised for presenting sounds for such judgment, and results differ somewhat according to the method; and even with any one method the ratios are largely a matter of opinion. However, the averages of large batches of such opinions agree well enough for there now to be general agreement that a loudness scale can be approximately represented on the basis that two-to-one loudness ratios are produced by ten-to-one (10 dB) intensity ratios at 1,000 c/s.

Incidentally, it is interesting to note that what is judged to be a doubling of loudness by increasing the intensity of sound at one ear is equivalent to what is produced by bringing the *same* intensity to bear on the second ear. In other words, equal sounds at two ears give double the loudness of the same sound at one ear only.

Although true loudness and intensity scales cannot be made to coincide like the phon and dB scales at 1,000 c/s, in order to define the loudness unit—the sone—they must be tied together at one point. For convenience the point chosen is 40 phons, which is reckoned as 1 sone. Not only is this a good round number representing a moderate intensity; it is the standard loudness for judging that other subjective quantity—pitch.

So to convert phons to sones it is necessary first to deduct 40. To get the proportionality right, the result is multiplied by 0.03 to make it equal to the logarithm of the number of sones:

$$\log_{10} S = 0.03 (P - 40)$$

where S is the number of sones equal to P phons. Fig. 5 is a curve calculated from this empirical equation.

‡" The Measurement of Loudness," *Jour. Acoust. Soc. Amer.*, Sept. 1955.

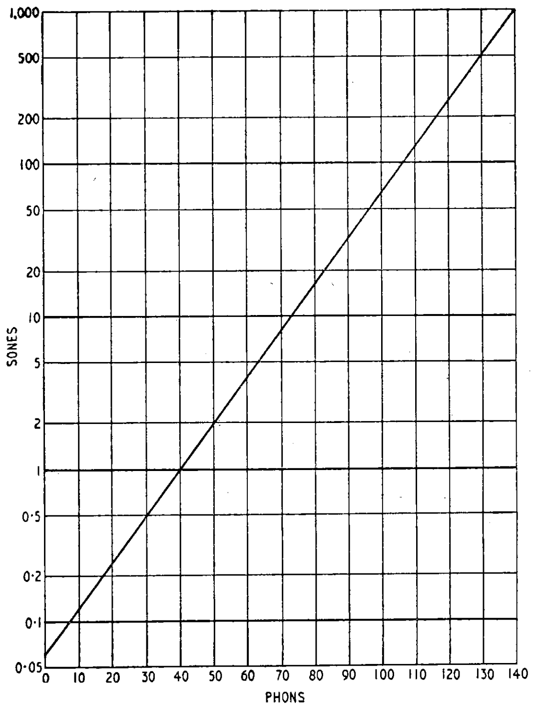



*Fig. 5. Relationship between phons and sones, as calculated by an empirical formula.*

Presumably in an attempt to keep themselves out of the phon fraud, writers on sound often refer to the curves in Fig. 4 as loudness *level* curves. It is, I suppose, something to be thankful for that any distinction at all is drawn between them and the approximation to true loudness curves, but if we were strict we might say that attaching the subjective word " loudness " to the phon curves was a form of the offence committed by using the term " sensation level," though admittedly a milder one seeing that the curves do at least mark equal-loudness intensities.

Acceptance of sones means rejection of what is called the Weber-Fechner law, as regards hearing at least. This " law " is the name given to the theory that our response to a physical stimulus is proportional to the logarithm of that stimulus. If it were true of hearing, then the phon scale at 1,000 c/s would be a true loudness scale, because phons at 1,000 c/s are equal to decibels, which are proportional to the logarithm of sound intensity. But no one would agree that loudness is anything like proportional to the number of phons. And even if it were, the " law " would break down at other frequencies, where the phon scale departs from the dB scale.

Switching from phons to sones does however seem to me to create an anomaly as regards the threshold of hearing. Using the logarithmic phon for loudness meant that there was a zero on the scale, corresponding nicely with the definition of threshold. But this threshold is 0.063 on the sone scale. That is admittedly a small loudness, but it *is* a loudness, which means it can be heard. So, too, is 0.01 sone, which theoretically can be heard. But it is far below the threshold of hearing, so it cannot be heard.

I don't know what the official answer is to this, but two possibilities occur to me.

The actual measured threshold of hearing depends very largely on the amount of background noise; in fact, on what might be called the signal/noise ratio. What is shown in diagrams as the threshold is supposed to be the just-audible intensity when there is *no* other sound than the " signal." But just as it is impossible to have an electrical signal with absolutely no noise, so with sound. Even if the room itself could be perfectly insulated from sound, the threshold of hearing cannot be determined without a hearer. And for the determination to be valid the hearer must be alive. And if he is alive his heart must be beating. I have read somewhere, too, that the aural counterpart of Johnson noise is not very far below the official threshold of hearing. Just as the threshold of hearing a pure tone can be raised to almost any sone level by the intrusion of a sufficiently loud " masking " noise, the official " silent " threshold (0.063 sone) may perhaps be regarded as the loudness that would be registered by a theoretical listener with normal hearing but no noise either outside or inside himself.

Of course this idea is rather unreal, because it is explaining away a difficulty that arises after real subjective observations have been replaced by an empirical formula devised to fit them as well as can be, but not necessarily (or even probably) perfectly at every point.

The other thought is that the infinitely large gap between 0.063 and zero sones belongs only to the logarithmic vertical scales in Figs. 3 and 4. The difference between 0.063 and zero on a linear scale going up to about a thousand is too small to show or to worry about. But does that mean one would use a linear scale for sones? Surely no, for the range of loudness between just audible (0.063 sone) and painfully audible (about 1,000 sones) is so vast that it can't all be shown clearly on a linear scale. So what does one do? One uses a log. scale, which brings one back to Fig. 4 with its phons! Does that mean that sones have been a waste of time? Again no, for the number of them gives a far better idea of the magnitude of loudness than the number of phons. So we should modify Fig. 4 by marking the curves with the numbers of sones instead of (or in addition to) the numbers of phons. Marking the 140-phon curve " 1,000 " shows what a vastly greater loudness it represents than the 80-phon curve, which is only 16 sones—but itself is very loud compared with 20 phons, which is only 0.25 sone.

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## New Induction Heater

COMPACTNESS is an outstanding feature of the new G.E.C. 18kW high-frequency generator, which occupies a floor space of less than 11 sq ft. The single oscillator valve is a BR1102 operating at approximately 500kc/s and power is supplied through six GU21 mercury vapour rectifiers. Forced air cooling is provided with filtering of the air supply, and electrical filters are fitted to prevent h.f. energy being fed back to the supply mains.

Either one or two work stations for surface hardening or brazing can be supplied and the water-cooled work coils are easily interchanged. There is a water-flow safety switch and interlocks on all panels and doors.

An anode current meter indicates power output and an hour meter serves as a check on valve life.

# Bi-Directional F.M. Aerials

## An Unconventional V.H.F. Receiving System

***By H. B. DENT***

WHEN Rowridge, Isle of Wight, commenced regular f.m. transmissions it was decided to make provision for receiving both the new station and Wrotham, which hitherto had been the mainstay of sound broadcasting at the writer's location on the south coast. Rowridge was the more favourably situated of the two and could reasonably be expected to provide a more reliable signal for most of the time. However, anomalous propagation on v.h.f. is not unknown, and it was thought desirable to have a second string available, especially as Wrotham's signals are reasonably strong if a two- or three-element aerial is used. Apart from this there were other reasons which made Wrotham a desirable station to have available at times.

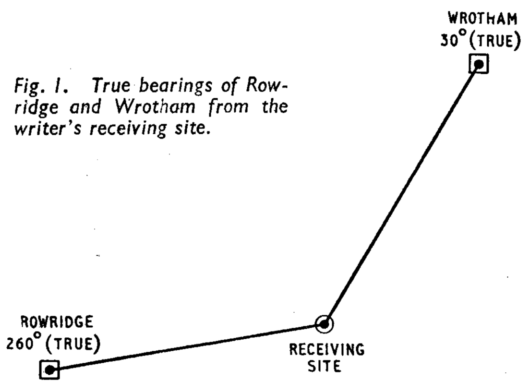



*Fig. 1. True bearings of Rowridge and Wrotham from the writer's receiving site.*

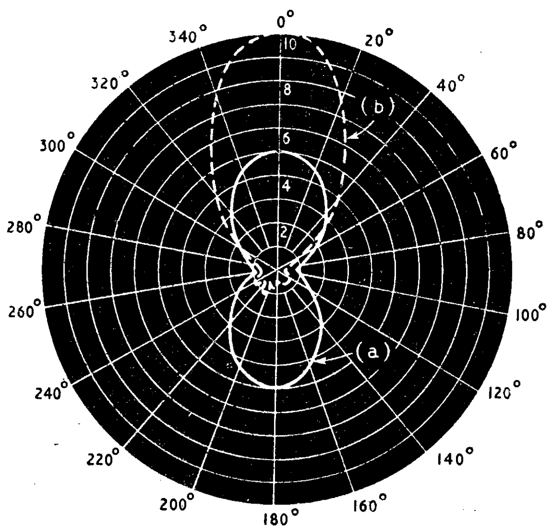



*Fig. 2. Polar diagrams of (a) a halfwave dipole and (b) a 3-element Yagi.*

Reception of both stations with a single aerial is complicated by the locations of the two stations; they lie very nearly in opposite directions from the receiving site and the obvious solution of separate aerials was not very attractive.

Fig. 1 is a plot of the true bearings of Rowridge and Wrotham taken from the receiving site and from these it will be seen that the two stations are not quite 180° apart, also that a bi-directional aerial having a polar diagram comparable to that of a simple horizontal dipole might be expected to serve for both stations. As the aerial cannot be orientated for optimum performance on both stations a compromise orientation must be found and, if possible, the expected efficiency of the aerial on both stations determined, so that the best type of aerial for the purpose can be chosen.

If now a transparency of Fig. 2(a) is prepared large enough to overlay Fig. 1, as shown in Fig. 4, the pattern can be moved around with its centre on the receiving site and a position found giving about equal efficiencies on both stations. Alternatively one or the other can be favoured and the expected performance on both deduced from the transparency. It will be seen that a position has been chosen which brings the bearings of the two stations just over 20° off the optimum line of the aerial, but in opposite directions. If all the data in Fig. 2 for the dipole is included on the transparency, as in Fig. 3, the expected efficiency of the aerial can be read off directly for either station. In this example it is 80% for both stations.

Allowing for equal efficiency in both directions, Fig. 4 shows the optimum orientation of the aerial to achieve this performance. It reveals that if a dipole were used, or an aerial with a similar polar diagram and relative position of the elements, then the plane of the elements in this aerial must be on a line running from 145° to 325°. When laying out this bearing with a compass due allowance must be made for the magnetic deviation. At present this is 9° west at the site of the receiver, so that 9° must

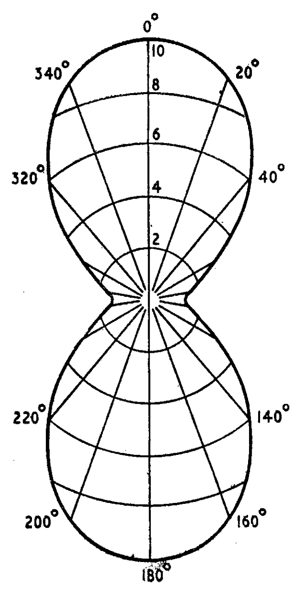



*Fig. 3. Pattern of a dipole's polar diagram to be prepared as a transparency.*

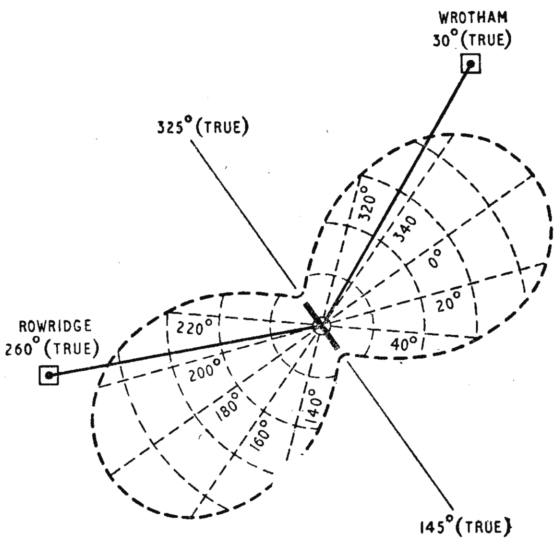



*Fig. 4. The dipole's polar diagram superimposed on the plan, Fig. 1, as explained in the text.*

be added making the bearing read by the compass 154°, or the reciprocal, 334°.

As a two-element aerial with a gain of about 4 dB over a plain dipole gave satisfactory reception of Wrotham, one of about 6 dB gain, but with bi-directional characteristics, should meet the new requirements. Included in Fig. 2 at (b), and plotted to the same scale, is the polar diagram of a three-element Yagi of the type often used in the fringe areas of f.m. stations. It is a uni-directional aerial of course and would not suit the present requirements, but as it can be seen to have a gain of about 6 dB, or twice the voltage gain of a plain dipole, an aerial with this order of gain, but having the polar diagram of the dipole, would serve the purpose. It now only remains to find a design of aerial having these characteristics.

There are several ways of imparting a bi-directional response to an aerial, but the one favoured by the writer for the present case is a vertical stack of half-wave horizontal dipoles. In order to obtain the required figure eight polar diagram in the horizontal plane and at right-angles to the plane in which the dipoles are stacked, all dipoles in the aerial must be connected for in-phase operation. This again can be achieved in several different ways and with a variety of spacings of the dipoles, but one that obviates the need for electrical measurement of any kind, and yet ensures the desired mode of operation, is to stack the dipoles a half wavelength apart, connect the feeder to the lower one and join all dipoles together by open-wire transmission lines, transposed at each level, as shown in Fig. 5.

Whilst Fig. 5 exemplifies the basic idea of a broadside aerial of this kind, it is not a very convenient practical arrangement, as with half-wave dipoles, split in the centre as shown, the terminating impedance, to which the feeder must match, is only about 25 Ω; this is much too low for the 75-Ω type of coaxial feeder in general use. A matching section between the aerial and the feeder can be used, but it is inconvenient.

Folding a dipole steps up its impedance four times if the tube or rod from which it is made is the same diameter throughout. Impedance multiplying factors greater or less than four can be obtained by making the two arms of a folded dipole unequal in diameter, but then the spacing begins to have a greater influence on the resulting impedance than when the diameter is the same throughout.

A stack of four half-wave folded dipoles, each fashioned from a single length of rod or tube, will give a close match to a 75-Ω coaxial cable and yield a gain of about 7 dB in two directions. But for f.m. reception it would need a 15-ft pole to accommodate the elements alone, apart from that required to raise it above surrounding objects. As it is undesirable to fix guy wires to the pole above the lowest dipole, the supporting structure needs to be very sturdy indeed. Guys of non-conducting material, however, could be used and fixed to any part of the aerial system without affecting its performance; except, perhaps, to a small degree in very wet weather. The only material likely to withstand the very variable

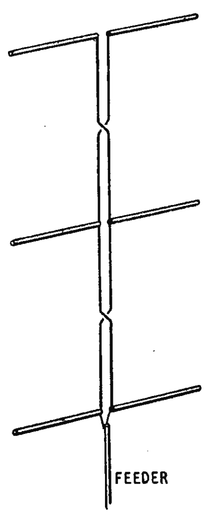



*Fig. 5. Schematic arrangement of a stack of three halfwave dipoles.*

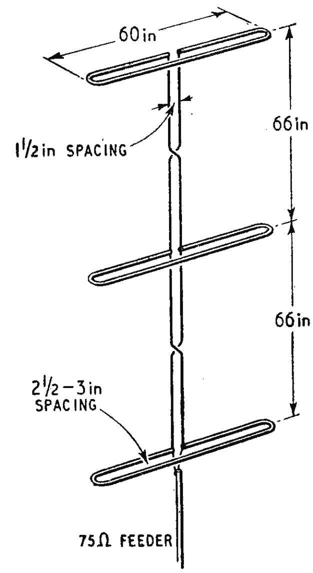



*Fig. 6. Practical broadside aerial using three stacked folded dipoles.*

weather conditions prevailing in this country, without stretching or shrinking to an alarming extent, would be nylon rope, which is expensive.

Pruning the aerial to three folded dipoles, as shown in Fig. 6, brings the length of the aerial down to 11 ft, which is a far more practical size. Its terminating impedance becomes around 90 Ω giving an acceptable impedance match to a 75-Ω feeder. Any standing-wave ratio (or impedance ratio) of less than 2 to 1 is tolerable for most receiving purposes and with this aerial, and a 75-Ω feeder, the impedance ratio is about 1.2 to 1.

Theoretically the feeder should be a twin-wire, or balanced, type and where a coaxial cable is employed there should be a balun (balanced-to-unbalanced connection) between it and the aerial. However, a balun is an additional complication hardly justified for f.m. reception and, moreoever, unless properly designed can impair rather than

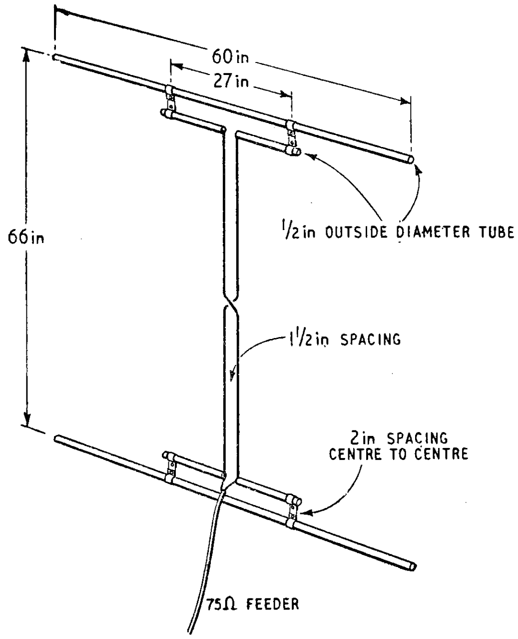



*Fig. 7. Simple two-element stack using T-matched dipoles.*

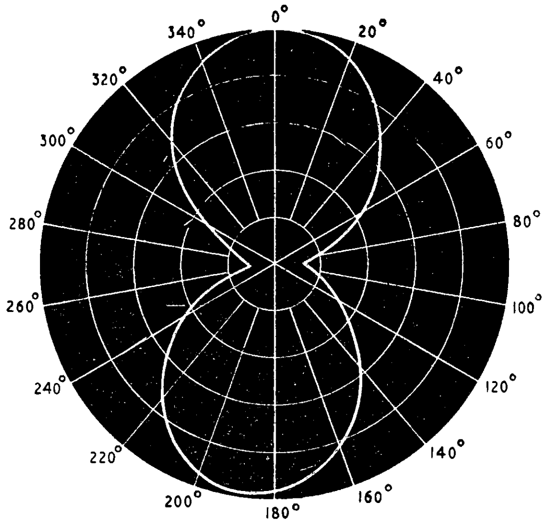



*Fig. 8. Polar diagram of the two-element aerial shown in Fig. 7.*

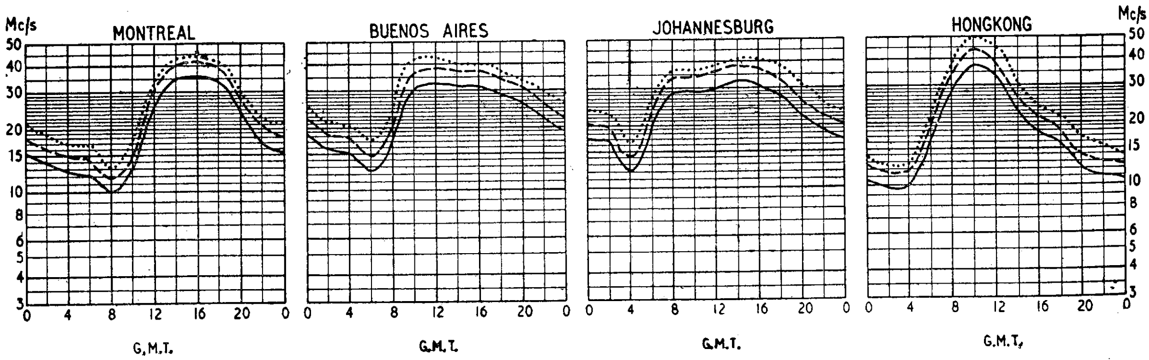
improve the performance of an aerial. By omitting the balun and connecting the coaxial feeder direct to the aerial, the only adverse effect so far noticed has been to introduce a little asymmetry in the front and back lobes of the polar diagram. The measured voltage gain of an aerial of this type is just over 5 dB compared to a single half-wave dipole.

Details are given in Fig. 7 of a simpler form of bi-directional aerial giving a gain of 4 dB. It has two stacked half-wave dipoles each with a T-matching section and it is only 5 ft 6 in high. The sacrifice of 1 to 1.5 dB in gain is more than compensated for by a 50% reduction in size and consequent convenience in mounting.

The T-match rods extend for 14 in each side of the centre insulator and their outer ends are fixed to the dipole by metal clamps. The T-match section of one dipole is joined to the T-match section of the other by an open-wire transposed transmission line and a coaxial cable is connected direct to the lower T-match unit. The polar diagram of this aerial is shown in Fig. 8 and the slight asymmetry in its two lobes, due to the omission of a balun, is only just apparent.

One advantage of using folded dipoles, or T-match dipoles, is that tests for electrical continuity can be made from the receiver end of the feeder, should it be suspected that a spell of poor reception might be due to a defect in the aerial system. Also aerials embodying either of these types of dipole are easily made reasonably safe to lightning by earthing the outer copper braiding of the feeder at, or near, ground level.

## SHORT-WAVE CONDITIONS *Prediction for November*




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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

THE full 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 November.

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

# Recent Audio Developments

## SOME NEW PRODUCTS SHOWN AT THE B.S.R.A. EXHIBITION

ALREADY this year we have reported progress in the field of high-quality sound recording and reproduction as exemplified by commercial products shown at the Audio Fair (April issue, p. 153) and the Radio Exhibition (October issue, p. 470). The rate of development in this field is rapid and at the recent exhibition organized by the British Sound Recording Association many new and interesting pieces of equipment were shown publicly for the first time.

**Microphones.** A ribbon microphone (type CRH) with a frequency response equivalent to that of the type RB has been developed by Reslo to provide a closer approach to uni-directional characteristics at a price much lower than is usually possible with this type of response. This has been achieved by the application of acoustic resistance and phase delay in the loading of the back of the ribbon without resort to organic absorbents such as wool and felt, and with the retention of the ease of ribbon replacement which is a feature of the original RB design. The front-to-back ratio of sensitivities is of the order of 10 dB.

**Tape Recording Equipment.** A professional stereophonic amplifier with the usual facilities of their type 21 single-channel model was shown by Leevers-Rich. Monitoring on both channels is performed simultaneously and the ganged gain control is in balanced steps of $1\frac{1}{4}$ dB. A mixer for two pairs of stereophonic microphones is also available.

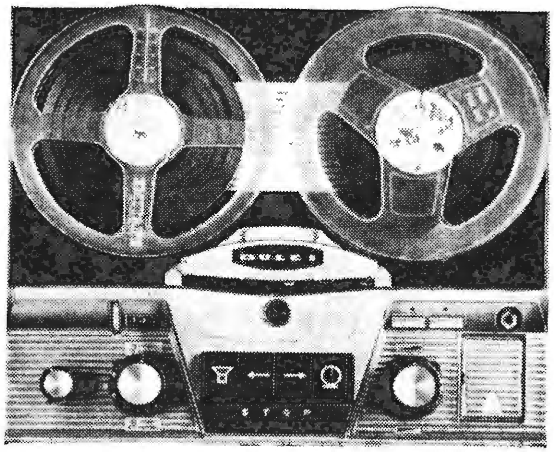
Completely separate record and replay heads and amplifiers are used in the Swiss Revox B36 tape recorder shown by Romagna Reproducers. Two inputs can be mixed with independent variation in their levels. A push-pull circuit is employed for the bias oscillator. It is interesting to note that this recorder dispenses with the use of pressure pads.

A two-speed tape recorder/reproducer with a 500 mV output designed to feed into a high-quality amplifier was shown by Dulci (Dulci-Harting). The bias level can be varied to compensate for different tape characteristics. A microphone input with a sensitivity of 1.5 mV for full output is provided.

Another two-speed tape recorder the German Harting HM6 shown by T.S.L., includes a 4-watt output stage which feeds a 9in × 6in bass speaker and $2\frac{1}{2}$-in tweeter. The wow and flutter is stated to be better than 0.1%.

A new professional sprocket-driven recorder, suitable for use with 16mm film (6 or 17.5mm versions will be available later), was shown by Leevers-Rich. The sprocket assembly, gearbox, spool motors, drive motor and head block are individual sub-units which can be removed and replaced after servicing without disturbing their alignment. The main sprocket which has a circumference of sixteen frames is driven by a worm gearbox, the drive shaft being extended to allow coupling to other machines.

**Tuners.** A number of f.m. (some in kit form) and a.m./f.m. tuners were shown by Jason, models with switched or continuous tuning on f.m. being available. One economical circuit seen in the Prefect switched tuner uses a pentode r.f. valve, a triode pentode as reactance valve (for a.f.c.) and self-oscillating mixer (pentode), followed by two pentodes providing i.f. amplification and limiting, and crystal diodes for the Foster-Seeley discriminator. The sensitivity is about 50 $\mu$V for 20 dB quieting. In the Jason "AM/FM2" the f.m. circuitry includes a low-noise cascode r.f. stage, three i.f. stages, double diode and valve limiters, a Foster-Seeley discriminator and twin-neon tuning indicator. The a.f.c. can be reduced to avoid weak stations being overwhelmed by strong ones on adjacent frequencies. The sensitivity is 2 $\mu$V for 20 dB quieting. R.f. amplification is also provided on medium waves and alternative bandwidths of $\pm$4 kc/s and $\pm$8 kc/s are available, the sensitivity being 10 $\mu$V. The ordinary "magic-eye" tuning indicator also indicates the signal strength on f.m. An adjustable cathode-follower output is provided.



*Dulci-Harting tape unit*

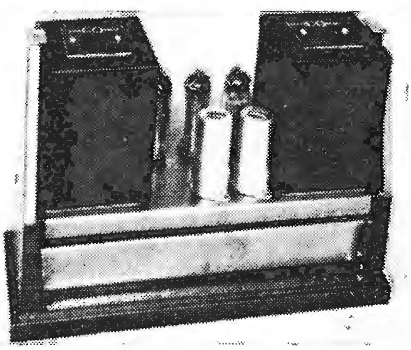
**Pre-amplifiers and Amplifiers.** A maximum sensitivity of 10 mV for 10 watts output with 0.1% total harmonic distortion and a signal-to-noise ratio of 80 dB is obtainable from the CQ combined amplifier and pre-amplifier. The power response varies less than 1 dB between 25 and 60,000 c/s. Mains inputs of 115 or 230 V, 40 to 100 c/s are provided for, and the unit is fully tropicalized.


*Audiomaster pre-amplifier.*

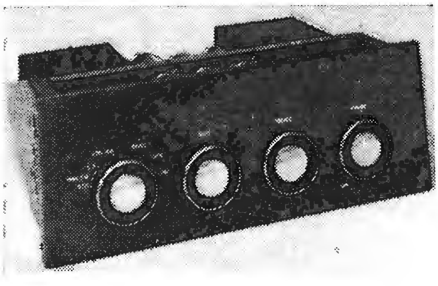
Another 10-watt combined amplifier and pre-amplifier shown by Jason has a maximum sensitivity of 1 mV, and is claimed to introduce less than 0.05% distortion.

Twenty watts output with an intermodulation distortion of 0.7% (40 c/s modulating 10 kc/s with a ratio of 4 to 1) and a signal-to-noise ratio of 89 dB (10 kΩ source resistance) is available from the "Audiomaster" amplifier shown by Musicraft. The power response varies less than 0.5 dB between 30 c/s and 20 kc/s at 20 watts. The damping factor is 50. The associated pre-amplifier includes four alternative record and two tape frequency compensation networks, and controls to give a treble-cut slope variable between 8 and 30 dB/octave from cut-off frequencies of 5, 7, 9 or 12 kc/s. The impedance at the pickup input is variable, the signal-to-noise ratio being 56 dB at the maximum sensitivity of 8 mV. A tape head input with a sensitivity of 1 mV and a signal-to-noise ratio of 45 dB is also available. The total harmonic distortion at 2 V output is less than 0.2% (240 mV gives 25 watts output from the main amplifier).

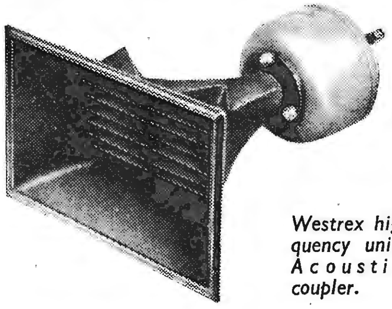
Two low-distortion amplifiers with output powers of 10 and 30 watts for 0.05 and 0.1 V inputs respectively were shown by Westrex. A 100-watt amplifier with a somewhat higher distortion (0.7%) at full output, reduced signal-to-noise ratio (65 dB), and narrower frequency response (3 dB down at 40 c/s) is also available. A transistor pre-amplifier to work between impedances of 600 ohms and with gain alternatives of 40, 55 or 65 dB can also be incorporated in these amplifiers. The frequency response is 30 c/s to 12 kc/s ±2 dB and the distortion 0.7% for 0.1 mW maximum output. The noise contribution from the three OC71 transistors is less than 10 dB up on the basic circuit noise. The pre-amplifier is temperature stabilized, and can operate up to 45°C.



*CQ amplifier showing (above) mains transformer and grain-oriented output transformer and (below) controls on the die-cast pre-amplifier panel.*



**Loudspeakers.** There are some interesting design features in the Westrex "Acoustilens 20/80" loudspeaker system. Two speakers are used with a cross-over frequency of 700 c/s. The 15-in direct radiator bass speaker has a 3-in diameter voice coil of copper tape wound edgewise. This form of construction results in the large total flux linkage of 310,000 Maxwells, with a flux density of 13,200 gauss. The large diameter coil gives a more uniform effective drive



*Westrex high-frequency unit with Acoustilens coupler.*

over the whole cone surface, thus increasing the cone breakup frequency. The reduced distance between the driving point and the outer edge of the diaphragm increases the frequency at which a dip in the response generally occurs due to the sound transmitted through the cone and radiated from its edge being out of phase with that directly radiated from the centre. The proportion of the magnetic gap volume wasted is considerably reduced when the voice coil is wound with tape rather than with the usual cylindrical wire. The speaker is loaded by a 12 cu ft bass reflex enclosure with a low-Q resonance. The distortion for 20 watts input at 120 c/s is 0.8%. The treble unit also uses a 3-in diameter edgewound voice coil to drive a Duralumin dome. The sound from this dome passes through a phasing unit to a fibre-glass horn, incorporating a slotted acoustical lens to give a wide horizontal polar radiation pattern. The slots in this lens are arranged so that the radiation from the horizontal periphery travels a longer path than that from the centre. The central radiation is thus advanced in time over that at the side and a curved front is produced.

A similar acoustical lens will be available for the Mark II version of the Kelly ribbon loudspeaker shown by Romagna Reproducers. A substantially uniform distribution is obtained over an arc of 120° up to 18 kc/s. The matching transformer has a Ferroxcube core and the distortion is less than 0.5% for 10-watts input at frequencies within the operating band (1 to 30 kc/s).

The speakers used in the CQ reproducer are now available for home constructors. These are 9in × 5in and 4-in units whose cones have been specially treated with a non-setting viscous plastic to absorb unwanted reflections at the cone edge. In addition, damping pads are placed on the 9in × 5in unit cones to reduce still further unwanted peaks in the frequency response characteristics. The speakers are individually tested.

A novel speaker mounting was seen in the TSL-Geruphon Omni-D Resonator. This consists of a cylinder only 15¾in long and of 4½in diameter open at both ends, with a moving coil speaker mounted asymmetrically at a suitable point inside.

# Calibrated D.C. Oscilloscope

## A COMPACT, STABILIZED DESIGN

By B. PEARCE

THIS article describes the design and construction of a small portable workshop oscilloscope with a calibrated d.c. amplifier for Y-deflection. The oscilloscope was intended mainly for low frequency work and has a substantially flat response from d.c. to 20 kc/s. The maximum Y-sensitivity is 30 mV/cm. A linear time-base is incorporated, with facilities for free-running or single-sweep operation with internal or external triggering. The unit is mains-driven.

Some time ago the author was contemplating the building of a valve voltmeter to supplement the very inadequate range of test gear in his home workshop. The thought occurred that for the requirements in hand a far more useful instrument would be a calibrated oscilloscope which, with a slight sacrifice in accuracy and convenience, would incorporate the properties of a valve voltmeter and also have all the virtues of oscilloscopes. On perusing the specifications for one or two of the small commercially available instruments it was noticed that all deflection amplifiers were for a.c. signals only. Recollecting how such instruments had proved very exasperating on more than one occasion when a d.c. amplifier would have considerably eased the problem in hand, the author resolved to try to design an economical "scope" having a d.c. amplifier.

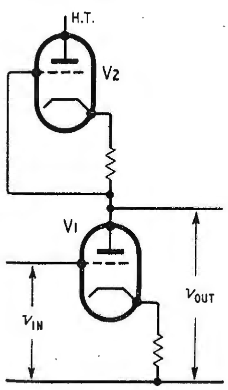
Although a 5-in cathode-ray tube was available, it was decided to use a 3-in ECR30 to keep the design simple and the bulk small. Reference to the manufacturers data showed that a final anode potential of 1,000 V was permissible, and that under these conditions the Y-deflection sensitivity would be 5.9 V/mm. Thus for a full screen deflection of 70 mm a voltage swing of $5.9 \times 70 = 413$ V is required. Using push-pull deflection this would mean a swing of 207 V per anode. To obtain reasonable linearity up to an output of this order, an h.t. supply of at least 350 V would be needed for the deflection amplifier, and as in this case a Schmitt cathode-coupled stage was used, an h.t. supply of 400 V was required. It would, of course, have been possible to use a lower final anode voltage on the c.r.t., but as the author wished to incorporate a single-sweep time-base, a large final anode voltage was used in the interest of trace brightness.

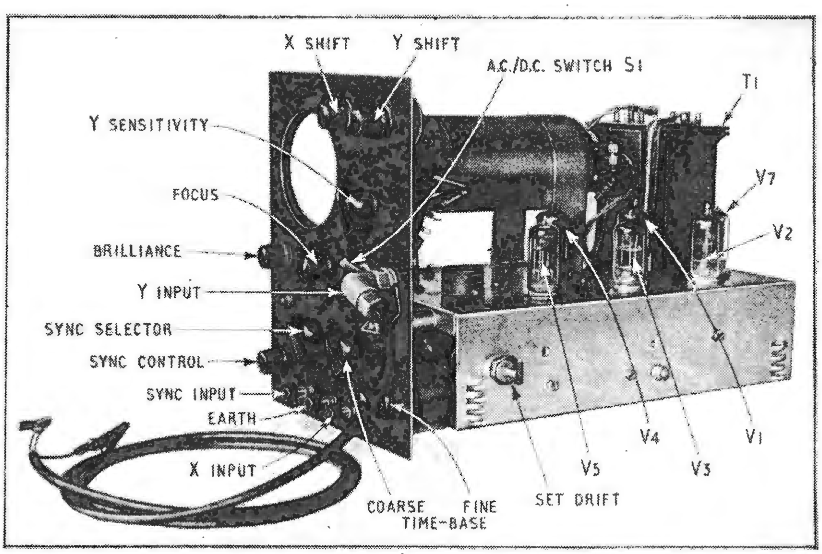
The main problem in the design was the construction of a d.c. amplifier having sufficient long-term stability to warrant calibration. A phase-splitter was required if push-pull deflection were to be used and the Schmitt circuit proved ideal, having a second input for shift control. The output stage, being push-pull, is substantially unaffected by h.t. fluctuations, and thus the 400 V line was not stabilized. The grid potentials, however, being independent of one another, were ultimately derived from a stabilized supply in the interests of stability of the output.

Having decided on the output stage, a rapid calculation for a type ECC91 valve in this role showed that one more double triode stage would be adequate for present requirements so far as gain was concerned. Here, the question of long-term stability reared its head again, though by using a stabilized h.t. supply and high-stability resistors two sources of drift were eliminated. The principal remaining cause was variations in the valve heater voltage, which affect the mutual conductance and anode resistance of the valve. To reduce this effect the circuit of Fig. 1 was used. This consists of a triode voltage amplifier V1 whose normal anode load resistance has been replaced by an identical valve V2 with the same bias. It can be seen from the equivalent circuit (Fig. 2) that the load is now the anode impe-

*Right: General view of oscilloscope showing principal components.*

*Fig. 1. Amplifier circuit to reduce effect of heater voltage variations.*



dance $r'_a$ of valve V2 in series with a generator $\mu v_g$ and the internal impedance $r_a$ of V1. Since the valves are identical and their heaters are fed from the same supply, changes in anode impedance due to heater supply variations will produce identical changes in $r_a$ and $r_a'$, and the voltage output will remain constant.

In practice, even though a double triode with series heaters is used, slight manufacturing variations require that a certain amount of further compensation be included to make the gain of the stage independent of heater fluctuations. This can be done by making one of the cathode bias resistors variable over a small range and adjusting this until the change in the anode voltage of V1 is a minimum when the heater voltage is varied (say) ±10%. Unfortunately, this adjustment varies the anode voltage itself, so that this stage must be set up independently of the following stage, and if a coupling divider is used this must be "tailored" to bring the grid of the Schmitt stage valve to its correct level. This would involve some sacrifice in gain, and because of this the author preferred to dispense with the divider and directly couple the anode to the following grid, although this involved adjustment of the Schmitt cathode resistor and shift grid potential before optimum conditions were obtained in this stage. As a rough guide, the aim is to adjust component values in the Schmitt stage until, when balanced and with equal anode loads, the anode voltages are about half way between cathode and h.t. At the same time it should be remembered that if the heater is "earthy," the heater-cathode voltage should not exceed the recommended maximum value, which for an ECC91 is 100V. In the circuit diagram (Fig. 3) components which may require adjustment are underlined.

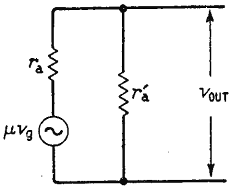



*Fig. 2. Equivalent circuit of Fig. 1.*

With the circuit as shown, a maximum sensitivity of about 30mV per centimetre was obtained using a direct anode to grid connection. With a divider coupling, a sensitivity of 50mV per centimetre can reasonably be expected. Calibration can be effected by adjustment of the divider resistance $R_{13}$. If the maximum sensitivity is required the first position of S2 can be used (connection shown dotted).

The rest of the design is fairly straightforward. The X-amplifier is a single Schmitt circuit with R-C coupling to the time-base and also to a front panel terminal. The dual-input feature of the Schmitt circuit enables an X-input to be applied at the same time as the time-base, and this could conceivably be

## COMPONENTS TABLE

| | |
|---|---|
| $R_1$ | See text (about 750k) |
| $R_2$ | 510k 5% |
| $R_3$ | 180k 5% |
| $R_4$ | 51k 5% |
| $R_5$ | 18k 5% |
| $R_6$ | 5.1k 5% |
| $R_7$ | 1.8k 5% |
| $R_8$ | 510 5% |
| $R_9$ | 220 5% |
| $R_{10}$ | 220k |
| $R_{11}$ | 3.9k 5% H.S. |
| $R_{12}$ | 5.6k 5% H.S. |
| $R_{13}$ | See text (about 1.5m H.S.) |
| $R_{14}$ | 1M 5% H.S. |
| $R_{15}$ | 33k 5% H.S. 1.5W |
| $R_{16}$ | 33k 5% H.S. 1.5W |
| $R_{17}$ | 6.8k 5% H.S. (See text) |
| $R_{18}$ | 470k 5% H.S. |
| $R_{19}$ | 100k |
| $R_{20}$ | 220k |
| $R_{21}$ | 47k 5% H.S. |
| $R_{22}$ | 22k 5% H.S. |
| $R_{23}$ | 47k 5% H.S. |
| $R_{24}$ | 220k |
| $R_{25}$ | 220k |
| $R_{26}$ | 470k |
| $R_{27}$ | 33k 5% 1.5W |
| $R_{28}$ | 33k 5% 1.5W |
| $R_{29}$ | 6.8k 5% (See text) |
| $R_{30}$ | 470k |
| $R_{31}$ | 1M |
| $R_{32}$ | 47k |
| $R_{33}$ | 470k |
| $R_{34}$ | 2.2k |
| $R_{35}$ | 47k |
| $R_{36}$ | 3.3k |
| $R_{37}$ | 1M |
| $R_{38}$ | 100k |
| $R_{39}$ | 68k 0.5W |
| $R_{40}$ | 100k |
| $R_{41}$ | 68k |
| $R_{42}$ | 680 |
| $R_{43}$ | 100k |
| $R_{44}$ | 220k |
| $R_{45}$ | 100k |
| $R_{46}$ | 22k (See text) |
| $R_{47}$ | 100k 0.5W |
| $R_{48}$ | 100k 0.5W |
| $R_{49}$ | 100k 0.5W |
| $R_{50}$ | 100k 0.5W |
| $R_{51}$ | 100k 0.5W |
| $R_{52}$ | 100k 0.5W (See text) |
| $R_{53}$ | 2.2M |
| $R_{54}$ | 2.2M |
| $R_{55}$ | 2.2M |
| $R_{56}$ | 2.2M |
| $R_{57}$ | 22k 3W |
| *Note:* | All resistors ¼W 20% carbon unless otherwise stated. |
| $P_1$ | 2k wire wound linear |
| $P_2$ | 250k carbon linear |
| $P_3$ | 250k carbon linear |
| $P_4$ | 250k carbon linear |
| $P_5$ | 2M carbon linear |
| $P_6$ | 50k carbon linear |
| $P_7$ | 20k carbon linear |
| $C_1$ | 0.25 μ 500V paper |
| $C_2$ | 0.5 μ 150V ,, |
| $C_3$ | 0.5 μ 150V ,, |
| $C_4$ | 0.5 μ 150V ,, |
| $C_5$ | 0.25 μ 350V ,, |
| $C_6$ | 1.0 μ 150V ,, |
| $C_7$ | 0.01 μ 350V ,, |
| $C_8$ | 0.001 μ 350V ,, |
| $C_9$ | 0.01 μ 350V ,, |
| $C_{10}$ | 0.5 μ 350V ,, |
| $C_{11}$ | 0.05 μ 350V ,, |
| $C_{12}$ | 4700 p 350V |
| $C_{13}$ | 470 p 350V |
| $C_{14}$ | 47 p 350V |
| $C_{15}$ | 8 μ 500V electrolytic |
| $C_{16}$ | 0.5 μ 350V paper |
| $C_{17}$ | 0.05 μ 350V ,, |
| $C_{18}$ | 4700 p 350V |
| $C_{19}$ | 470 p 350V |
| $C_{20}$ | 47 p 350V |
| $C_{21}$ | 8 μ 500V electrolytic |
| $C_{22}$ | 16 μ 500V ,, |
| $C_{23}$ | 0.5 μ 1000V paper |
| $C_{24}$ | 1.0 μ 1000V ,, |
| V1 | ECC83, 12AX7, CV492 |
| V2 | ECC91, 6J6 |
| V3 | ECC91, 6J6 |
| V4 | ECC83, 12AX7, CV492 |
| V5 | EF91, 6AM6, 6F12, 8D3, CV138 |
| V6 | ECR30 |
| V7 | QS150/15, CV287 |
| T1 | Mains transformer: Primary 0-210-230-250V, 50c/s. Secondary 350-0-350V, 60mA 6.3V, 2A, 4V, 1A |
| L1 | Smoothing choke: 20 H, 30 mA |
| S1 | Single pole, single throw toggle switch. |
| S2 | Single pole, 9-way wafer switch. |
| S3 | Two pole, 4-way wafer switch. |
| S4 | Two pole, 6-way wafer switch. |
| S5 | Single pole, single throw toggle switch. |
| MR1 | Selenium rectifier stack consisting of two sections each having at least 25 plates 18 mm diameter (S.T.C.). |
| MR2 | "Sentercel" Type K8/15 |
| MR3 | "Sentercel" Type K8/15 |

**Front Panel Controls**

| | |
|---|---|
| P2: | Y—Shift control. |
| P3: | X—Shift control. |
| P4: | Sync. amplitude and sense. |
| P5: | Time-base "Fine" control. |
| P6: | Focus control. |
| P7: | Brilliance control. |
| S1: | Input blocking capacitor switch. |
| S2: | Y—Sensitivity switch. |
| S3: | Sync. selector switch. |
| S4: | Time-base "Coarse" switch. |

(Behind-panel control: P1)

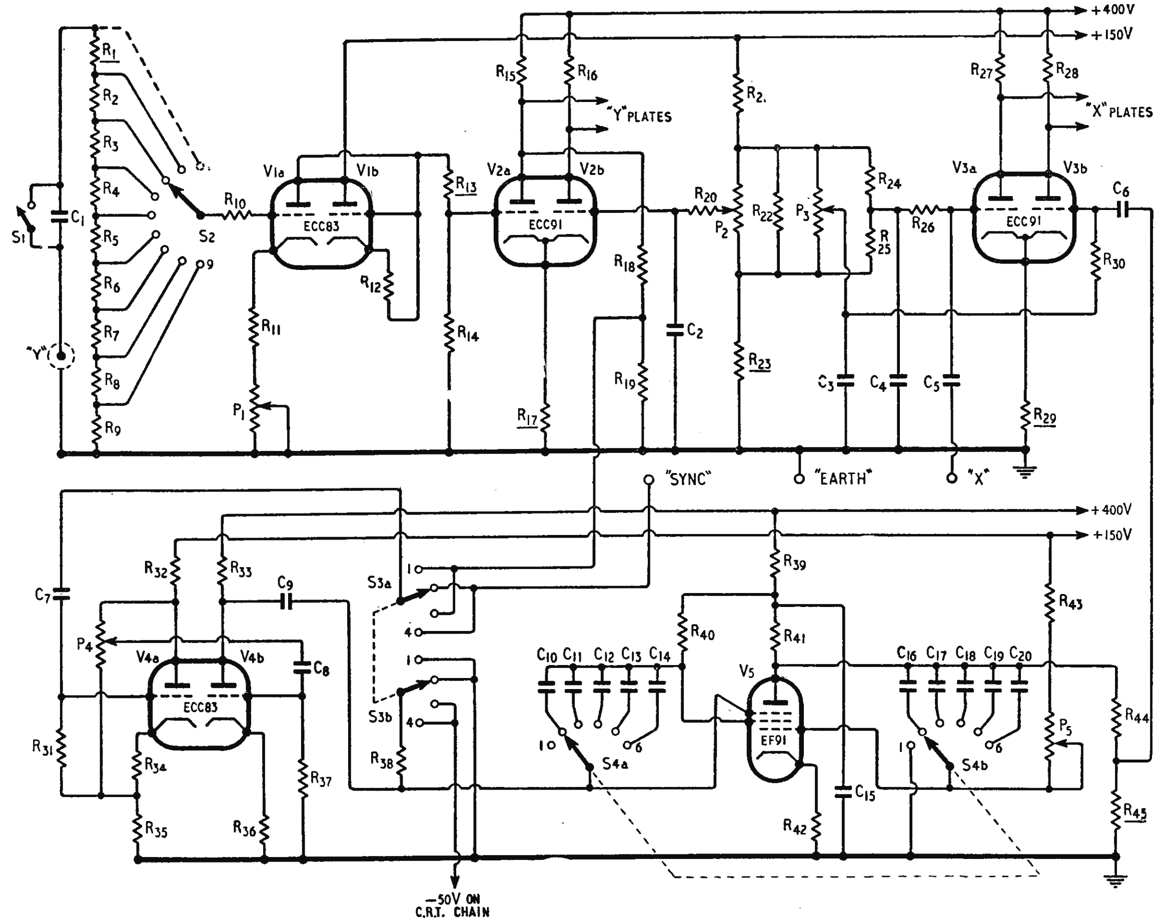



*Fig. 3. Amplifier and time-base circuits.*

used for time measurements. The comparatively poor response of this amplifier causes some non-linearity in the sweep on the higher ranges of the time-base. This was of no consequence in this design, though an improvement (short of using a cathode-follower buffer stage) could be effected by the use of smaller anode loads (say 22k or 15k) with a corresponding adjustment in supplies and cathode resistor to cope with the increased current drain.

The time-base also is conventional and its features need no special mention except that the suppressor can be either earthed via $R_{38}$ or taken to a negative potential on the c.r.t. chain, dependent on whether free-running or single sweep operation is required. In the latter case, triggering is effected by V4 which comprises a phase splitter triode giving positive or negative "sync" from the potentiometer $P_4$, followed by a single triode amplifier feeding the time-base suppressor grid. The "sync" selector switch enables either free-running or single-sweep operation to be used with either internal (i.e. from the Y-amplifier) or external synchronization.

The power supplies were originally built round a particular small mains transformer which the author happened to have handy, but in the design shown this has been altered to use a standard 350-0-350V, 60mA transformer having 4V, 1A and 6.3V, 2A heater windings. The c.r.t. heater should have its own winding, and this should be insulated for at least 1000V. Most production transformers nowadays are tested to this voltage before leaving the factory, so that no trouble should be experienced here. It is important that the c.r.t. heater should be strapped to the cathode at one end. Metal rectifiers were used throughout, though there is no reason why valve rectifiers should not be used instead, if desired. It will be observed from the circuit diagram that the final anode of the c.r.t. derives its voltage from the four deflector plates via four 2.2M resistors. In this way the final anode voltage is kept at the mean value of the plate voltages, thus reducing trapezium distortion.

Mechanical details of the design are to some extent a matter of personal taste. The layout shown in the accompanying photographs was found satisfactory, although it will be seen that conditions under the chassis became a little cramped towards the end! A Mumetal screen round the c.r.t. is desirable, and the mounting of the mains transformer is fairly critical. It is best to build the oscilloscope with this transformer initially on long leads, and as soon as the stage is reached when a spot can be produced on the screen, to adjust the position of the transformer until the stray field produces a minimum deflection of the spot. This is usually when the axis of the transformer coils coincides with the c.r.t. axis.

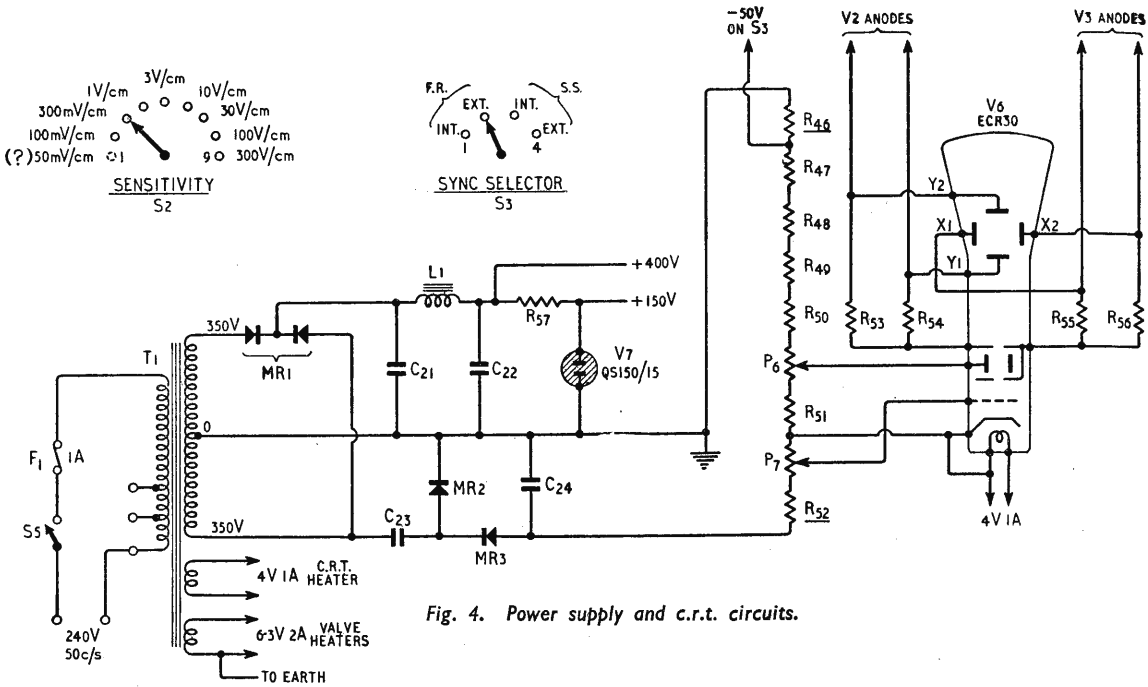



*Fig. 4. Power supply and c.r.t. circuits.*

The inclusion of a spare valve socket in the author's unit as shown in the photograph is of no significance.

A certain amount of initial setting-up is necessary before the instrument is ready for use. It is possible that the anode-cathode voltage of the c.r.t. may exceed the rated maximum of 1000V. A rough check of this should be made by measuring the anode voltages of V2 and V3 (which should all be about the same when balanced) and the current in the c.r.t. divider chain, from which the c.r.t. voltage can be calculated. If necessary $R_{52}$ can then be adjusted as required. Next V1 should be set up by adjustment of $P_1$ as described earlier. If the divider $R_{13}$, $R_{14}$ is used, $R_{13}$ should be adjusted until the c.r.t. spot is central with $P_2$ at mid-position. If the divider is dispensed with, V2's grids should be strapped together and connected via a 220k resistor to V1's output. $R_{17}$ should then be adjusted until V2 anodes are at approximately 240V. Leaving the 220k resistor permanently between V1 and the grid of V2a, connect V2b grid back to the shift control and adjust $R_{23}$ until V2 is balanced with $P_2$ set mid-way. This will now have upset the bias on V3 and $R_{29}$ will probably need adjusting until V3 anodes are at about 240V. Having set up the amplifiers for balance, the input potential divider should be calibrated by injecting a known voltage into the Y-input and adjusting $R_1$ until the correct deflection is obtained. Due to adverse component tolerances it may be necessary to adjust the suppressor bias to V5 when the time-base is in the "single-sweep" condition. V4b grid should be earthed and $R_{46}$ increased until the time-base does not run on any range. The nearest standard value is sufficient for $R_{46}$. Setting-up should now be complete.

# Books Received

**An Introduction to the Cathode Ray Oscilloscope,** by Harley Carter, A.M.I.E.E. Volume in the Philips Technical Library Popular series gives a simple treatment of c.r. tubes and their associated time base, deflection and power supply circuits, and of oscilloscope applications and measurements; and also includes data on standard c.r. tubes with details of four complete oscilloscope circuits. Pp. 100; Figs. 89. Price 12s 6d. Cleaver-Hume Press, Ltd., 31, Wrights Lane, London, W.8.

**F.M. Radio Servicing Handbook** by Gordon J. King, deals theoretically and practically with the stages in turn including the audio section, and with a.m./f.m. receivers. Pp. 188; Figs. 117. Price 25s. Odhams Press, Ltd., 96, Long Acre, London, W.C.2.

**Cathode-Ray Oscillographs,** by J. H. Reyner. Fifth edition covers c.r. tubes and associated deflection and time base circuits, waveform characteristics, including those at r.f. and the possible modifying effects of c.r.t. circuits, frequency comparison and measurement, and circuit characteristic traces. Also includes special applications (e.g. at low frequencies) and techniques such as photography. Pp. 206; Figs. 141. Price 20s. Sir Isaac Pitman and Sons, Ltd., Parker Street, London, W.C.2.

**Elektronenrohren** by M. J. O. Strutt. Third volume in the Lehrbuch der drahtlosen Nachrichtentechnik series initially deals with theory of electrons in electric and magnetic fields, in solids, and in thermionic emission before discussing theories of (including noise in) diodes and other types of valves and also electron optical systems. Applications and data for many types of electron devices including transistors are given. Pp. 391; Figs. 455; Refs. 654. Price 58.50 DM. Springer-Verlag, Reich-bietschufer 20, Berlin.

# 400-watt Audio Amplifier

## USE OF SMALL OUTPUT VALVES IN PARALLEL PUSH-PULL

*By G. R. WOODVILLE**

THERE are basically two alternative methods of generating high powers at audio frequencies using thermionic valves:

1. The use of two large valves in push-pull.
2. The use of several smaller valves in parallel push-pull.

The principal advantages of the second method are:

1. Low cost of valves. In the case of a valve failure the user is not faced with a large financial outlay.
2. High order of reliability. The failure of one or more valves does not result in a suspension of service. Valves may be removed or inserted without switching off (due to the comparatively low anode voltage used).
3. Low cost of the associated power supply, also due to the low voltage used.
4. If an "ultra-linear" circuit is used, the low output (and load) impedances simplify the output transformer design.
5. The high sensitivity permits a low-power driver stage.
6. The maximum available output is determined by the number of valves used.

This article describes an amplifier based on the second method which uses KT88 valves in the output stage. It was designed to give 400 watts output over a frequency range of 75 c/s to 25 kc/s, but the output is in fact well maintained up to 50 kc/s. It has been used for the operation of a vibrator, but is equally suitable for public address work.

The KT88s are used under somewhat conservative conditions; the anode plus screen dissipation for each valve does not exceed 35 watts (and may be as low as 20) during quiescent periods and is approximately 25 watts at full output. The operating conditions are similar to those given on page 4 of the KT88 Circuit Supplement†, but the anode voltage is lower (525 V). This reduces "cross-over" distortion at full output, because for a given dissipation the anode current can be increased and thus a smaller negative grid bias voltage used. The use of a common grid voltage control might otherwise increase the overall "cross-over" distortion because it prevents individual equalization of the cut-off voltages.

**Circuit**—This is shown in Fig. 1, the wiring to only four valves being included. Each KT88 has its electrodes connected to bus-bars, as it were, and the individual cathodes are connected to earth through suitable meter shunts $R_{18}$ of, say, 10 ohms, with series resistors $R_{17}$ leading to the metering switch $S_1$. A 200 $\mu$A f.s.d. meter was used, arranged to read in milliamperes by suitable choice of $R_{17}$ (i.e. about 10,000 ohms).

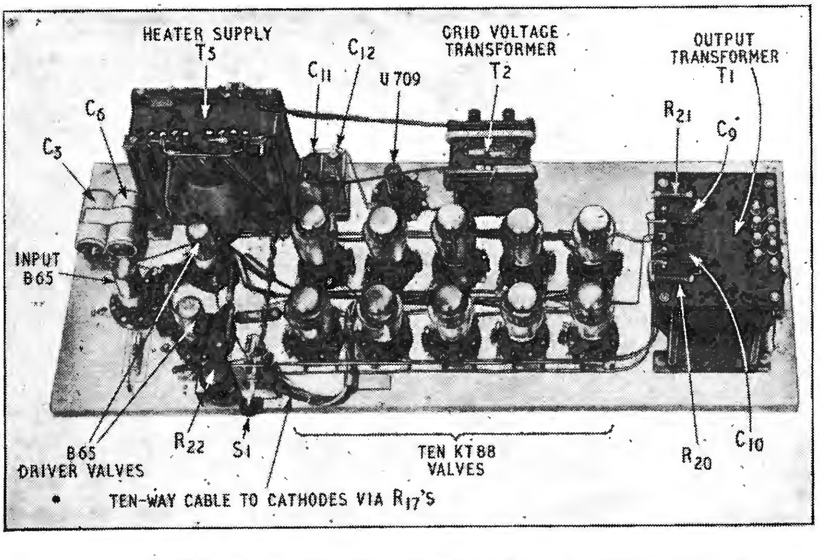
The two grid resistors $R_{14}$, $R_{15}$ are returned to an adjustable (maximum value 90 to 100 V) grid voltage supply $V_g$, from $R_{22}$. It has been found that if the anode supply has a very good regulation a single grid voltage adjustment is satisfactory. This point will be discussed later.

An input of (55 + 55) V r.m.s. is required at the KT88 grids across the resistors $R_{14}$, $R_{15}$ which are necessarily low in value. This voltage is obtained at a distortion of less than 2% from two B65 valves in an amplifier/cathode follower circuit. This stage is, in its turn, driven by a third B65 operating as an amplifier/phase splitter. For full output an input of 0.25 V r.m.s. is needed. The resistance values in the two B65 stages though not critical are somewhat inter-dependent.

**Output transformer**—This would, for the usual industrial service, have a ratio of 5 : 1 or 6 : 1. Screen-grid tappings are provided including 25% to 50% of the total turns on each half-primary to enable the "ultra-linear" (UL) circuit to be used. The 40% tap was used in this amplifier. It is vitally

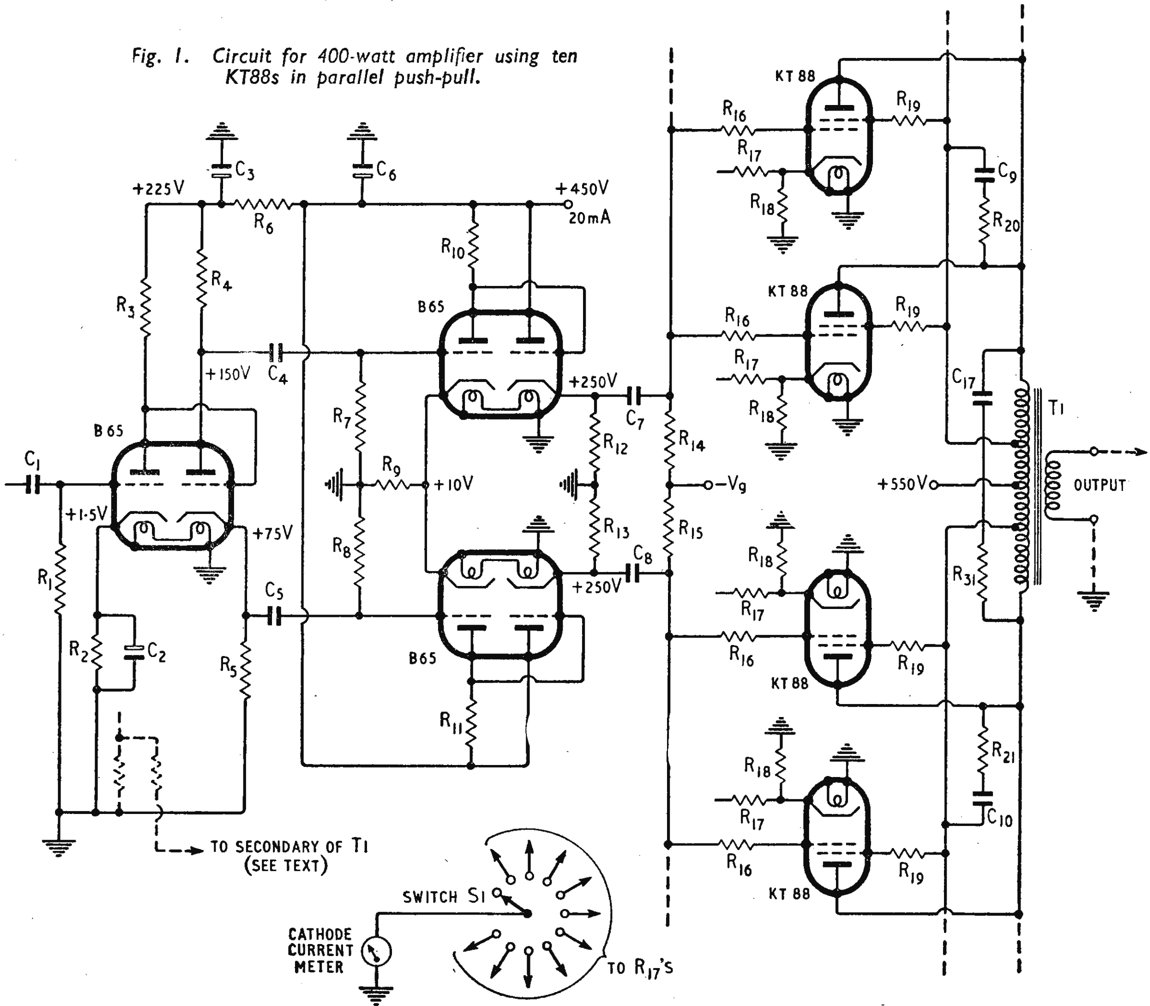
* M-O Valve Co., Ltd.

† Issued by The G.E.C. Ltd. (November 1956).




*Prototype 400-watt amplifier with grid and 6.3 V heater supply components.*

*Fig. 1. Circuit for 400-watt amplifier using ten KT88s in parallel push-pull.*




**Resistors**

| No. | Value Ω | Tolerance % | Rating (watts) |
|---|---|---|---|
| $R_1$ | 1 M | 20 | ¼ |
| $R_2$ | 1 k | 20 | ¼ |
| $R_3$ | 100 k | 20 | ½ |
| $R_4$, $R_5$ | 15 k | Matched pair | ½ |
| $R_6$ | 33 k | 20 | ½ |
| $R_7$, $R_8$ | 1 M | 20 | ¼ |
| $R_9$ | 4.7 k | 10 | ½ |
| $R_{10}$, $R_{11}$ | 220 k | Matched pair | 1 |
| $R_{12}$, $R_{13}$ | 47 k | Matched pair | 1 |
| $R_{14}$, $R_{15}$ | 47 k | 10 | ½ |
| $R_{16}$ | 15 k | 20 | ¼ |
| $R_{17}$ | Meter series resistors | | — |
| $R_{18}$ | Meter shunt resistors | | — |
| $R_{19}$ | 220 | 20 | ¼ |
| $R_{20}$, $R_{21}$ | 1 k (see text) | | 1 |
| $R_{22}$ | 10 k (wirewound) | | — |
| $R_{23}$, $R_{24}$ | 22 k | 20 | 1 |
| $R_{25}$ | 1.5 k | 20 | ¼ |
| $R_{26}$,* $R_{27}$* | 100 k | 10 | ½ |
| $R_{28}$* | 4.7 k | 20 | 1 |
| $R_{29}$, $R_{30}$ | 47 k | 10 | 1 |
| $R_{31}$ | (see text) | | — |

*Optional—see text.

**Capacitors**

| No. | Value (μF) | Rating |
|---|---|---|
| $C_1$ | 0.01 | 350 V (pk.) |
| $C_2$ | 50 (electrolytic) | 12 V |
| $C_3$ | 8 (electrolytic) | 450 V |
| $C_4$, $C_5$ | 0.01 | 450 V (pk.) |
| $C_6$* | 8 (electrolytic) | 450 V |
| $C_7$, $C_8$ | 0.25 | 450 V (pk.) |
| $C_9$, $C_{10}$ | 0.001 (see text) | 350 V a.c. (pk.) |
| $C_{11}$, $C_{12}$ | 2 | 250 V (pk.) |
| $C_{13}$, $C_{14}$ | 300 (100+200, electrolytic) | 350 V |
| $C_{15}$,* $C_{16}$* | 32 (electrolytic) | 350 V |
| $C_{17}$ | (see text) | |
| $C_{18}$, $C_{19}$ | 0.05 | 700 V |

*Alternatives, see text.

**Smoothing Choke**

$L_1$ 2 H 1.2 A. (Haynes Radio Ltd., LUM 24/31 used)

**Transformers**

T1 Output transformer Savage Transformers Ltd., 4T35

T2 Heater and grid supply 300 V C/T; 6.3 V, 20 A.

T3 Anode supply 700 V, 1.2 A, 10 V tappings on primary

T4 Rectifier filament supply 4× 2.5 V, 5 A

**Valves**

| | |
|---|---|
| 3 | B65 or 6SN7GT |
| 10 | KT88 |
| 4 | GXU1 or 3B28 |
| 1 | U709 or U78/6X4 |

important that the transformer has a low leakage inductance between (1) primary (P) and secondary (S); (2) The two half-primaries and (3) each half primary and its UL tapping.

The transformer used in the prototype amplifier was a type 4T35, made by Savage Transformers Ltd., and has the following characteristics:—

Primary inductance, 4 H.

Leakage inductance, P to S, 0.75 mH

Leakage inductance ½ P to ½ P, 0.75 mH.

Leakage inductance ½ P to UL tap, 1.5 mH.

The secondary is composed of four sections, each giving 25 volts at full output.

Components $R_{20}$, $R_{21}$ and $C_9$, $C_{10}$ may be required to stabilize the amplifier and prevent oscillation at an ultrasonic frequency. Typical values would be 1,000 Ω and 0·001 $\mu$F.

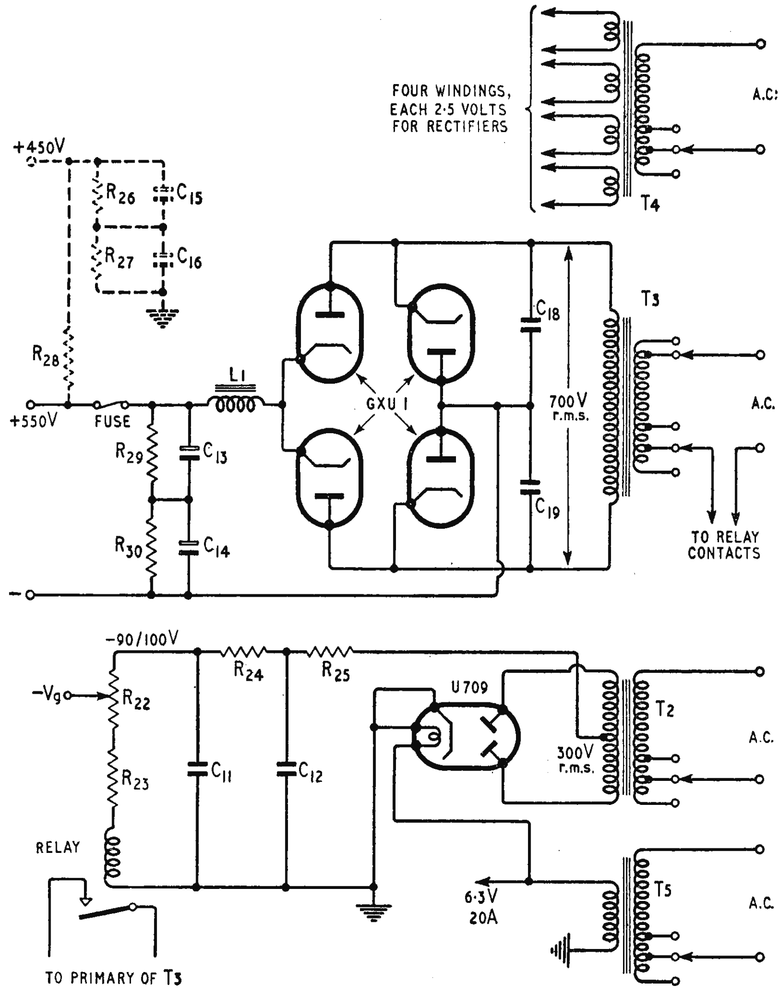



*Fig. 2. Power supplies for 400-watt amplifier.*

**Power supply**—It is essential to design the power supply to give a good regulation, in order to reduce cross-over distortion. An anode supply of bad regulation would call for a low quiescent anode current (i.e. high value of negative grid bias) to keep the dissipation within the rated value at zero output when the anode voltage would be higher than from a well regulated supply.

The power supply used suffered only a 10% change in voltage as the current increased from 400 mA to 1,200 mA, with the result that the output stage would accept a fairly wide variation in valve cut-off voltages without undue cross-over distortion at full output. The four rectifiers are GXU1s, xenon filled valves equivalent to the American 3B28. In this circuit they are very considerably under-run, the peak inverse voltage across each being below 1 kV whereas the rated maximum is 10 kV. They have been chosen due to the excellent regulation obtained. A delay switch is recommended which will not apply the anode voltage until at least ten seconds after the heaters are switched on, in order to allow the filaments time to attain the correct working temperature. This switch can be operated from the grid voltage supply and would then also act as a protective interlock.

The anode supply transformer T3 has primary and secondary resistances of 2 and 12 Ω respectively. The choke $L_1$ has a d.c. resistance of 18 Ω and an inductance of 2H at its rating of 1A, this current being somewhat exceeded at full output. As the heater current from T5 amounts to approximately 20A, an adequate gauge of connecting wire is required.

The resistor $R_{25}$ not only reduces the peak current through the U709 rectifier, but also serves to adjust the grid potential to the recommended value of 90 to 100 V. Capacitors $C_{18}$, $C_{19}$ prevent the radiation to nearby receivers of mains interference generated by the xenon rectifiers.

The B65s require 15 to 20mA at 450 volts. This could be obtained from the KT88 supply, as shown in Fig. 2, by the use of a series resistor $R_{28}$, in which case the capacitor $C_6$ should be replaced by $C_{15}$, $C_{16}$ to give both a higher capacitance and working voltage. A separate 450-volt source may be more convenient if other low level stages are to be used.

## Operating conditions and performance

| | *Quiescent* | *Full Output* | |
|---|---|---|---|
| Line voltage | 570 | 530 | V |
| Anode voltage | 565 | 525 | V |
| Anode current (per valve) | 35–60 | 100–125 | mA |
| „ „ (total) | 450 | 1200 | mA |
| Control grid voltage, approx. | –75 | — | V |
| Anode-to-Anode load impedance | — | 1000 | Ω |
| Output impedance | — | 1200 | Ω |
| Power output | — | 400 | W |
| Distortion | — | 5 to 7 | % |
| Input, grid to grid. r.m.s. | — | 55+55 | V |
| Input to first stage, Fig. 1 | — | 0.25 | V |
| Anode dissipation per valve, approx. | 35 | 25 | W |

Some of the above data will vary with the individual valves used. If any of them give widely differing figures they should be replaced —they will still be quite suitable for use in normal two valve amplifiers. The behaviour with different values of anode load is shown in Fig. 3. The minimum distortion will be obtained when the combined quiescent anode currents for each side (and thus their mean operating points) are equalized by interchanging valves.

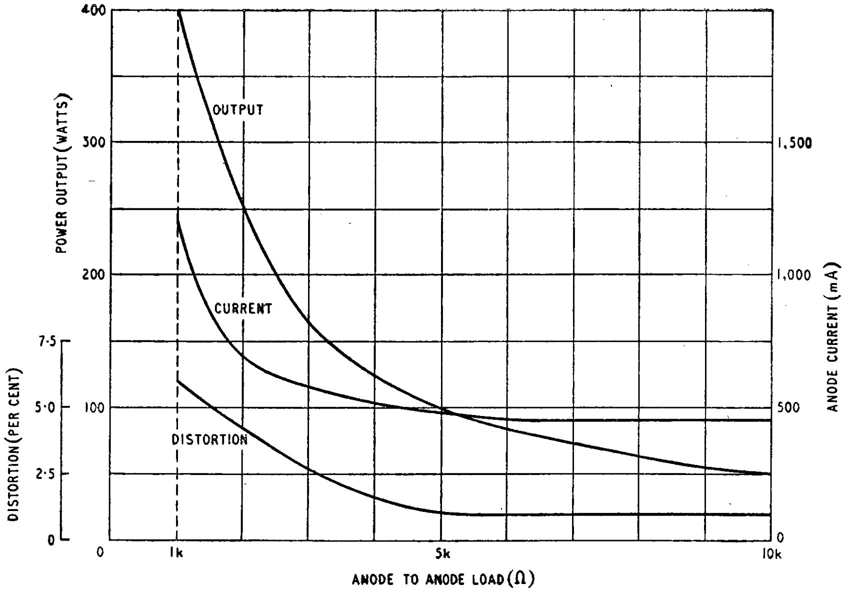



*Fig. 3. Performance of amplifier for various anode loads.*

The prototype amplifier will reproduce, at 80 to 90% of full power, a 5,000 c/s square wave. A resistor and capacitor $R_{31}$ and $C_{17}$ connected across the primary of the output transformer enable the overshoot to be controlled. The values required will be dependent on the transformer characteristics, but were 1000 Ω and 0.0035 $\mu$F with the transformer used in the prototype. In Fig. 4 is shown a reproduction of the excellent waveform which can be obtained, a single overshoot of about 15% appearing.

The performance may be improved if required by the addition of feedback. A 22-ohm resistor should be inserted at the earthy end of $R_2$ and $C_2$ and a second resistor taken to one side of the secondary of the output transformer, the other side being earthed. The correct value for the second resistor will depend on the feedback required and the load impedance in use, but for 10 dB and 25 ohms, the correct value is 5,600 ohms. The connections are shown in Fig. 1 by dotted lines. With 10 dB feedback the distortion falls to 2%, and the residual hum is reduced to a negligible figure.

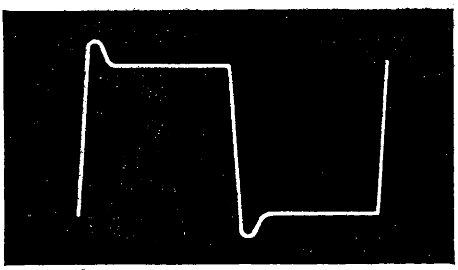


*Fig. 4. Output for 5,000 c/s square wave input.*

**Layout**—To reduce any tendency to instability some care should be taken with the layout. The prototype amplifier had the output valves placed in two parallel lines 3½ inches apart, the valves on each side having a 3-inch spacing. The valveholders on each side were displaced axially to bring pins 6 and 7 opposite each other thus permitting a balanced layout, as in Fig. 5, to be obtained.

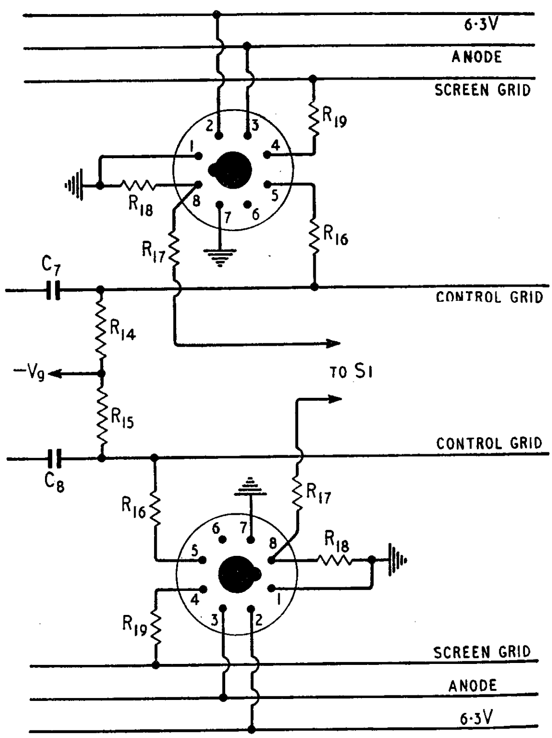


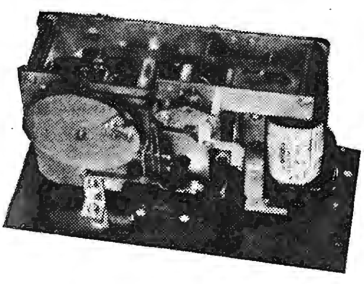

*Fig. 5. Preferred layout for output stages.*

If this layout is used with a rack-mounted amplifier care must be taken to ensure adequate ventilation for the rear row of valves. It is probable that a 2-inch slot, extending horizontally along the panel, would allow sufficient air to be drawn in. In case of doubt tests should be made with "Tempilac" temperature sensitive paint.

# Technical Notebook

**Variable-Velocity Scanning** in television has already been suggested as a means of obtaining bandwidth compression—the idea being that the scanning rate is slowed down over picture areas of fine detail and speeded up over areas of coarse detail, so that a more even (and on the average lower) rate of transmission of information is achieved. With magnetic scanning, the difficulty is that a sudden change of voltage across the deflector coils is needed to obtain a sudden change of velocity, but the stray capacitance across the coils sets a limit to the rate of this voltage change. A variable-velocity scanning circuit in which the speed of response is improved by negative feedback is discussed by M. P. Beddoes in I.E.E. Monograph No. 241R, of June 1957. The negative feedback is obtained from a monitor coil which is coupled to the deflector coils and gives an output proportional to the rate of change of useful flux-producing deflection current. This output is integrated in a Miller integrator to give a signal proportional to the current itself, which is applied as negative feedback to the scanning output amplifier. The circuit will operate at scanning frequencies up to 10kc/s, with a maximum displacement error (during velocity changes) of no more than 0.2%.

**Valve Protection Timer** produced by Venner's is basically a delay relay for ensuring that h.t. is not connected until the heaters or filaments have warmed up—but it has a difference. Normally with these devices, if there is a short interruption in the power



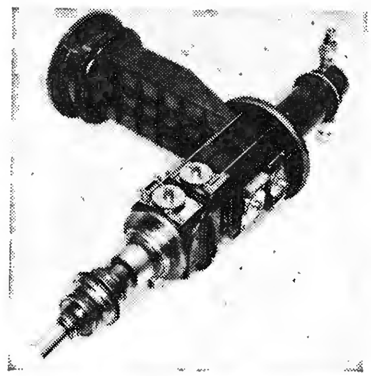
supply the relay resets immediately and then there is a delay before the h.t. is restored. This, however, is not really necessary if the supply interruption is of shorter duration than the normal warming-up time. It is avoided in the Venner device by an arrangement whereby the relay only resets after a certain delay, which is determined by the timer running back to zero at a chosen rate under the control of an escapement mechanism. The reset time can therefore be manually set according to the cooling characteristic of the equipment. An additional feature is that the reset timer can be made inoperative for very brief supply interruptions of less than, say, 10 seconds' duration, coming into action only when the relay is de-energized for longer than this period.

**Circular Waveguide Coupling** for laboratory use, described by P. J. Allen in D.S.I.R. unpublished report PB116623, permits connected waveguides to be oriented relative to each other about their axes, and allows polarization adjustment of components with precise axial alignment.

**Electronic Photo Printer.**—The American LogEtronics equipment mentioned in our July, 1957, issue (p. 332) has now been demonstrated by E.M.I. Electronics, who are handling and further developing it in Britain. As already explained, the system effectively reduces the overall contrast range of the negative to suit the printing paper. This particular machine, however, as distinct from others previously reported, does not use a television type of raster on the cathode-ray tube light source. It has a rectangular form of Lissajous figure generated by applying triangular waves of slightly different frequencies to the X and Y deflection systems. The difference in frequencies causes the rectangles to widen and narrow in a cycle of about once per second along two diagonal axes across the scanning area. This is said to give a more complete and even illumination than the television-type raster, where one has the problem of gaps between the lines to contend with. In addition to the photocell in the feedback system, a second photocell is used in a light integrating arrangement which automatically controls the length of exposure according to the density of the negative being printed. This arrangement, which can be set to view either a part or the whole of the printing area, does not require adjustment, and widely different negatives can be made to give prints of uniform density.

**Superconductive Storage Element,** similar to the "cryotron" described in our May, 1957, issue (p. 232) but much faster in switching time, has been developed by International Business Machines in America. According to *Electronic News* for 2nd September, 1957, the device utilizes a miniature printed circuit of metallic lead on a glass base, and is therefore less expensive to manufacture than previously reported elements using tantalum and niobium. It is said to have a switching time comparable with that of thermionic valves.

**High Power Klystron** amplifier giving some 10kW of c.w. output power is one of the latest valves to be produced by Varian Associates of California, U.S.A. Using internal resonant cavity circuits, it is capable of

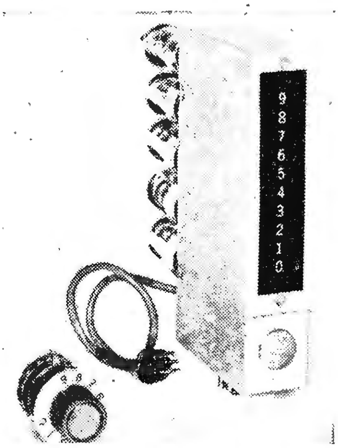


tuning over the wide frequency range of 1,700Mc/s to 2,400Mc/s. Less than 1 watt of r.f. drive power is said to be required for the 10-kW output. The valve is intended for use in forward scatter communication systems, and the makers say it will provide sufficient bandwidth for one or two television channels or hundreds of telephone or teleprinter channels.

**Mechanical Damping Constants** of materials can be measured conveniently by a new electronic equipment in order to test their internal structure for non-homogeneities, flaws and so on. Developed by A. E. Cawkell, it centres around a test bench on which the material under investigation has vibrations applied to it by an oscillator and transducer. A second transducer picks up the vibrations and converts them back into an electrical signal which is fed to a Dekatron counter. When the driving oscillator is cut off, there is a decaying oscillatory voltage at the pick-up transducer resulting from the mechanical damping in the material. The cycles of this voltage are counted between two predetermined levels set by a gate system, and from the count the logarithmic decrement and "Q" of the material can be easily calculated.

**Universal Computer Code** to provide a "common language" for different types of high-speed digital computing machines is being investigated as a possibility by the U.S. Army. In D.S.I.R. unpublished report PB121055, S. Gorn presents the results of an experiment with a simplified semi-automatic coding system run on both the EDVAC and ORDVAC computers.

**Remote Pre-set Counter.**—A new decade counting unit produced by the American firm Computer Measurements Corporation has the useful facility that it can be remotely preset to count up to a selected number and then emit an output pulse. Each decade, of course, only



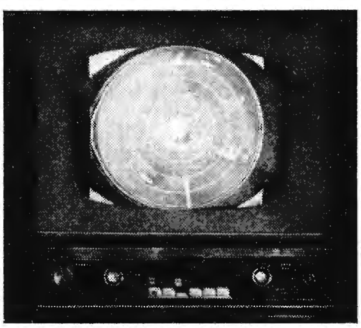
allows the selection of a digit between 0 and 9, but several of the devices can be connected in cascade to count units, tens, hundreds, thousands, etc., and the same method of pre-selection is applied to them all. A rotary switch at the end of a five-wire cable is used for the remote pre-setting of each decade.

**Liquid Valves?** Now that we have successfully utilized the flow of electrons in gases (thermionic valves) and in solids (transistors), the next logical step seems to be to try liquids. According to physicists at the U.S. Naval Ordnance Laboratory, quoted by *Control Engineering* for August 1957, this possibility is not far off, and they think it may lead to smaller, simpler and less expensive equipments than with valves and transistors. The first stage has been the development of a new electrochemical transducer utilizing the flow of ions between electrodes in an iodine solution. A low-voltage dry battery provides the current, and in the transducer this is said to be sustained and varied by outside factors, such as temperature, pressure and light. An application at present under test is a personal "sound exposure meter" for protecting Air Force personnel against the low-frequency sound of aircraft jet engines, which can cause deafness.

**Improved Mercury Switch** recently introduced by Engel and Gibbs has a plastic coating on the glass container for the mercury. This is intended to protect the switch from damage by accidental blows. If a really severe blow shatters the glass, the mercury is held inside the protective coating—an important safeguard in equipment which can be damaged by mercury. The coating is about 0.04in thick and is normally translucent so that the switch can be seen in operation, though an alternative coating available for tropical environments is opaque.

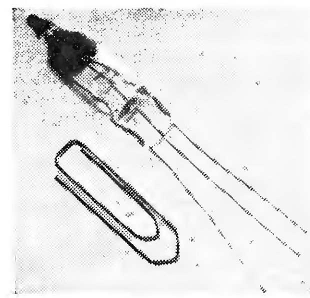
**Transistor E.H.T. Supply** has been developed by the U.S. Atomic Energy Commission to provide 900 volts at 25$\mu$A for Geiger-Müller and scintillation counters. Described by G. E. Driver in D.S.I.R. unpublished report AECHW30602, it is based on an alternate-firing transistor blocking oscillator. It is powered by a 9-V mercury-cell battery, weighs 4.5oz and occupies less than 5 cubic inches.

**Radar on Television**—A special tube for transforming radar images of the usual p.p.i. type into television pictures on 625 lines is used at Brussels Airport to allow controllers to follow directly the course of air-



craft in the vicinity. The television picture (see illustration) is a good deal brighter than the original radar image, so the room lighting does not have to be lowered.

**Subminiature Trigger Tube** of the cold-cathode type recently introduced by Ericsson is designed mainly for computing applications. Known as the GTR120W, it measures only



1.32in long and 0.39in in diameter. The electrical tolerances are slightly wider than those normally met in cold-cathode tubes, but the makers say this is offset by the long life, reliability and low cost of the tube. The anode hold-off voltage is 310V, while the trigger striking voltage is 170V. The operating current limits are 3mA to 9mA, and at 4.5mA the anode-cathode voltage lies between 95V and 140V.

**Torsional-Wave Delay Lines** have advantages over lines propagating longitudinal acoustic waves because they introduce less distortion in the signal and give approximately double the delay for a given length of material. A torsional-wave line using steel wire and giving a 5-millisecond delay at 1.5Mc/s has been constructed by G. Bradfield at the N.P.L. The velocity of the waves can be decreased still further by loading the delay wire or rod with equally spaced discs so that it is composed of alternate large- and small-diameter sections. It then becomes in effect a low-pass filter whose cut-off frequency decreases with increasing diameter, thickness or spacing of the discs. Thus, to obtain high cut-off frequencies small dimensions are necessary. On the other hand, the delay for a given length increases roughly as the square of the ratio between the diameters, so large delays at reasonable frequencies require small-diameter rods and precise machining. Two delay lines of this type machined from solid brass rods have been constructed by P. Andreatch and R. N. Thurston at Bell Telephone Laboratories in the U.S.A.—one having diameters of 0.180in and 0.045in (4 to 1) and the other 0.220in and 0.044in (5 to 1). Transducers made from barium-lead-calcium titanate were soldered on to the ends of the lines. At 32kc/s the 4-to-1 line (with 0.020-in discs and spaces) gave a delay of 43$\mu$sec per centimetre with an insertion loss of 1.7dB. The bandwidth was 4.6kc/s. The delay in the 5-to-1 line (with 0.015-in discs and spaces) was 114$\mu$sec per centimetre, the insertion loss about 1dB, and the bandwidth 6.3kc/s. The cut-off frequency for both lines was about 50kc/s.

# Component Testing Bridge

## Design for an A.C. Comparator Working at 50 c/s

By C. D. LINDSAY*, B.Sc.

QUALITY control and mass production call for rapid means of component testing. The modern trend is to use a comparator, which gives a direct reading of tolerance in per cent. The average sized production line will require a number of comparators, working together, to supply it, and for this reason it is desirable that a comparator should be cheap and compact. First it is desirable to show that little loss of versatility occurs through operating the bridge circuit at 50 c/s rather than the more conventional 1,000 c/s.

Essentially a comparator is a bridge in which the degree of out-of-balance operates a meter calibrated in per cent. In the usual bridge circuit adjustment is made until the detector indicates zero volts into it, so that the impedance of the detector (at balance) is unimportant because no current flows through it. In a comparator this is not so, and the detector impedance must be high enough not to load the circuit feeding a voltage into it.

To obtain a very high input impedance, a cathode follower is called for, and unless one uses a pentode, with a.c. coupling from screen to cathode, one still has an input capacitance of approximately $C_{ga}$. This capacitance appears in parallel with the input resistance, which is approximately $R_g$ $(\mu+1)$. The latter quantity can be in the order of 300 MΩ, and $C_{ga}$ about 1.5 pF. This capacity has a reactance of 2,000 MΩ at 50 c/s and about 100 MΩ at 1,000 c/s. Thus the input impedance of the cathode follower at 50 c/s will be about 300 MΩ, and at 1,000 c/s about 95 MΩ.

It can be shown that the percentage error of the meter reading is given by:—

$$\text{Error} = \frac{100\, Z_1 Z_2}{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1} \text{ per cent}$$

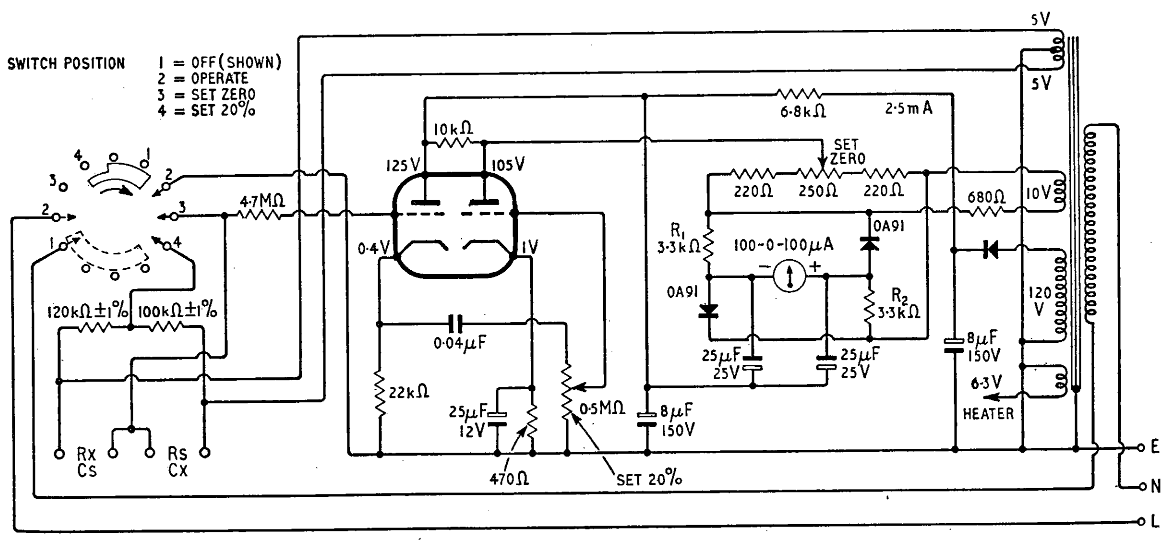
where $Z_1$ and $Z_2$ are the impedances being compared and $Z_3$ is the detector impedance.

Hence, for an error of, say, 10% of the meter reading (i.e. meter reads 9% when it should read 10%), the top limit of a 50 c/s comparator would be 67 MΩ or 47 pF, while for a 1,000-c/s comparator it would be 21 MΩ or 7.5 pF. The possibilities of a 50-c/s comparator are, therefore, quite considerable.

In the comparator on which measurements were made the 50 c/s were supplied by the mains transformer, and in the interests of accuracy this should be run from a stabilized mains supply. The circuit of the comparator (Fig. 1) is self explanatory, and it could hardly be simpler. The first half of the double triode is the high-input impedance cathode follower; the other half acts as an amplifier to feed the meter bridge. This bridge is phase sensitive (thus reducing the effect of phase angle in capacitor measurements, and that of capacitance when measuring resistors). The phasing voltage which "opens" the meter bridge must be supplied from the same transformer as that which feeds the component bridge. It would be possible to measure small phase angles by applying the phasing voltage through an RC network, so that

* Mc Murdo Instrument Co., Ltd.

*Fig. 1. Circuit diagram of the 50-c/s comparator described in the text.*



it was shifted 90° when measuring phase angles. This was omitted on the model in the interests of simplicity. A further refinement is to replace $R_1$ and $R_2$ by two further diodes (connected in a series ring); this increases the sensitivity of the instrument. Meter overload is cared for by limiting the possible output from $V_2$, and no damage will occur when a component under test is removed from the test terminals.

The usable range with the model tested was from about 100 Ω to over 100 MΩ, and from 100 pF to over 12 μF. for an error of well under 10% of the meter reading. The limit of the low-impedance end is determined by the output current it is possible to take from the transformer without lowering its voltage. A standard is built into the instrument for setting up the gain control. It is most important that the voltage to the component bridge is very accurately centre tapped.

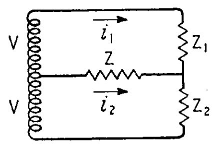


*Fig. 2. Basic circuit of the comparator.*

Apart from checking the tolerance on components, it is possible to use the instrument for any impedance measurement, such as measuring the output impedance of a stabilized power supply, or the mutual conductance of a valve by measuring the output impedance of it as a cathode follower, and many similar applications.

## APPENDIX

Applying Kirchhoff's Law to Fig. 2:—

$$V = Z_1 i_1 + Z_3 (i_1 - i_2) = Z_2 i_2 + Z_3 (i_2 - i_1)$$

From which we get $i_1 = \dfrac{Z_2 + 2Z_3}{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}\,V$

and $i_2 = \dfrac{Z_1 + 2Z_3}{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}\,V$

Hence detector voltage is

$$V_0 = \frac{(Z_2 - Z_1)\,Z_3}{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}\,V$$

if $Z_3$ were $\infty$ $V_0$ would be $\dfrac{Z_2 - Z_1}{Z_1 + Z_2}\,V$

∴ The voltage error is

$$\frac{Z_1 Z_2 (Z_2 - Z_1)}{(Z_1 + Z_2)(Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1)}\,V$$

and the percentage error $\dfrac{100\,Z_1 Z_2}{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}\,V$

and if E is the permissible percentage error,

$Z_3$ must be greater than $\dfrac{Z_1 Z_2 (100\text{-}E)}{E\,(Z_1 + Z_2)}$

In practice $Z_1$ and $Z_2$ are very nearly equal

which gives $Z_3 = \dfrac{Z_1 (100\text{-}E)}{2E}$

∴ For 1% accuracy $Z_3 = 50Z_1$
5% „ $Z_3 = 9.5Z_1$
10% „ $Z_3 = 4.5Z_1$

# Servicing Printed Circuits

## AN AMERICAN SERVICEMAN RECORDS SOME (PRINTABLE) COMMENTS

### By JACK DARR*

ONE of the latest of the many inventions to come boiling out of the brains of the design engineers is the Printed Circuit. Nowadays, when the TV technician removes the back from a receiver, he is confronted with something that looks rather like a nest of intoxicated snakes which had unwisely decided to take a nap in front of a road-roller! Attached here and there to this maze are a few parts which look vaguely familiar: valves, transformers, resistors, condensers, etc. This is intended to replace the old homely jumble of wiring inside the chassis, in which he felt quite at home, to tell the truth. At least, colours here and there guided his probing instruments to a small degree.

Gone forever, apparently, is even that slight aid and comfort; instead of the old faithful "blue for anode, red for h.t., green for grids, etc.," to guide him, he is expected to trace circuits and wiring on a brownish "board," looking something like a metallic jigsaw puzzle. To trace a given wire, he locates one of the aforementioned serpents, by a bewildering process of turning the board rapidly back and forth, finding the given tube or part on one side, then attempting to turn the board over quickly enough to remember where the part in question was! Some setmakers give him the cold comfort of telling him that he can shine a flashlight through the board, thus silhouetting the parts on the other side, enabling him to orientate himself "with ease." The quotes are from them, not me!

Having thus found either head or tail of said reptile, he proceeds to follow its meanderings over the surface, often covering the entire board, more or less, only to find himself back within an inch or two of where he began. This wandering is made necessary by the obvious impossibility of crossing two of these "wires." By this time he has usually forgotten just which circuit he was tracing, and the whole process must be repeated.

Now, having located the offending component, or what he suspects is one, he proceeds to apply some of the old reliable methods of testing. Chief among these, of course, is that of disconnecting one end of a part to make accurate measurements on it. Complications immediately set in. Resistors and capacitors, of course, are mounted by poking the ends of the leads through holes in the board, and soldering them there, to either head or tail of

* Ouachita Radio-TV Service, Mena, Arkansas.

a snake. Now arises the problem of getting one end of the thing loose without disrupting the whole assembly. He cautiously applies his regular soldering iron to the joint, only to discover that the bit is so big that half of the board is melting away before his horrified eyes. So, he renders the tool unfit for normal service by filing it down to an extremely sharp point. Now, it doesn't apply too much heat to the joint, causing damage to the wiring: in fact, it doesn't apply enough!

This brings on some very picturesque remarks in Urdu, Swahili, or preferably German (the last language lends itself admirably to the invention of long and complicated swear-words). Further experiment finally develops a sort of compromise point, and the suspected component is loosened and tested. Of course, by the perverse nature of things electronic, this is not the part he wanted. After a repetition of the process, the correct part is located and replaced.

This can also be quite a novel process. According to the "authorities," the accepted method of performing this act is to cut the part in two with a pair of diagonal cutters, then crush it between the jaws, leaving the wire leads firmly attached to the board. The ends of these leads are then formed into a small loop, and attached to the shortened leads of the new part. This joint is identical with those used to mend barbed-wire fences. There are only a few small difficulties inherent with this process, though. Have you ever tried to cut a 0.1 $\mu$F condenser in two with a pair of 4-inch diagonals? Experimentation will prove that this is hardly a practicable way to make a living.

It does work, however, with such components as resistors (small) and condensers (mica or ceramic). They may be crushed, according to the book, and the loop formed. The worst headache attached to this is the revolting tendency of such joints to loosen in the board, due to the heat conducted down the wire itself as the loop is being soldered. Thus, the end comes out of the board just as you complete the joint, and the whole effort is brought to naught; one may as well remove the whole board in the first place. Incidentally, the object of this operation is to enable the harassed technician to remove and replace parts without removing the printed circuit board from its place on the chassis, or in the cabinet. (This is often a much bigger job than removing chassis, locating part, removing and replacing part, on the old familiar type of set!)

## Thermal Rat-race

Having thus satisfactorily(?) dispensed with the replacement of small parts, we now arrive at the next category, the replacement of larger parts, such as valve-holders (tube-sockets, to us), transformers, filter condensers, and the like. These *objets d'art* have, as a rule, rather more connections than the small parts, with their two terminals, and hence may prove more difficult. (The preceding understatement is merely the opinion of the writer, and his colleagues.)

Referring once again to the maker's instructions, this jovial soul recommends that leads, lugs, etc., used to mount the part in place, be heated and loosened one at a time, until the part is free. This again is much easier said than done. Upon attempting the removal of such an item as, say, a filter condenser block or can, a multiple unit, from its home on the board, the technician finds that he is expected to unsolder, more or less simultaneously, the three condenser terminals, and three more for the can itself, or a total of six. These protrude through eyelets in the board, rather resembling the eyelets in shoes or boots, and are firmly and immovably held in place by large gloops of solder. Said technician optimistically melts one of these, then goes to the next. While this is melting, No. 1 has firmly set again. Likewise, as No. 3 is heated, No. 2 and No. 1 set still firmer, and so on, *ad infinitum*. In only a short while, this has degenerated into a sort of thermal rat-race, as he dashes madly around and around the base, trying to get each one hot enough to stay more or less liquescent until the remainder are heated. This proving to be an utter impossibility, he is faced with one of two alternatives: either toss the whole assembly into a large furnace, thus bringing it to a temperature suitable for the method outlined, or finding a method whereby each of the joints can be loosened and kept loose until the rest can be loosened in turn.†

After some cogitation, he finally secures a small pick, or perhaps his wife's eyebrow-brush, and manages to pick and heat one of the joints until he has knocked off at least part of the surplus solder. This, of course, is only the surface solder; the part that does the actual holding, deep down inside the joint, is still setting its plumbic teeth and holding on with bulldog tenacity. In desperation, he attempts a drastic alternative: heating the joint well, and brushing like mad, the while flexing the board to an alarming degree, one of the joints is persuaded to let go. Keeping up the flexing until this joint has set, he finds that he has at last accumulated a wee bit of play, which aids in loosening the rest by the same drastic process. At this point, it is tea time, and he takes a well-deserved rest. After tea, with the base joints loose, the rest of the job is a breeze.

This breeze continues until he finds that in his entire stock he does not have a suitable replacement for the highly specialized filter condenser used in the original circuit! Electrical values, yes; these are common enough. But the special can-type mounting, with small pointed projections on the bottom instead of the standard husky lugs? No, never. Use instead, separate units to make up the required capacitance? One would be required to construct another chassis of equivalent size to hold the same capacity, if used in single units. The only hope is to secure the compact multiple block or can equivalent.

Well, how about using one of the standard "twist-lock" can types? These useful units have comparatively large lugs on the bottom of the can, which are inserted into slots in the chassis, and twisted. Can we file these down to fit into the tiny holes in the board, which are round?

After some filing and bending, it is found that the lugs might conceivably be made to fit the holes, but another disturbing factor enters here: while the can lugs now fit, after a fashion, the condenser connections won't! This unit having been rendered almost totally unfit for further service of any kind, unless it is secured to the chassis with a bit of

† Plessey in this country have solved the problem with spring tension connecting tags.—Ed.

string, it is now laid aside, and other action contemplated. (At times, the first alternative considered is dropping the whole thing off the nearest cliff, and going back to raising turnips, re-entering the military, etc.) But now a ray of hope begins to show itself. On the shelf is a paper tubular condenser, almost the proper capacity, or near enough so that it won't matter, filters having a generous tolerance, thank goodness. This useful bit of apparatus is equipped with long flex leads, fastened to terminals. By clipping the leads off about an inch long, removing the insulation, and stiffening them with solder, they may be inserted through the holes in the board and soldered in place. The negative lead, which is usually on the other end, can be brought down the side of the can, and slipped into one of the holes which previously held the can in place. The stiffness of the leads will be ample to hold the light unit in place. If necessary the negative three holes may be joined with bits of scrap wire, to restore circuit continuity, and the job is done. As an average, it has consumed only enough time to make from three to five similar replacements on the older type sets, including two stops for tea: now the only thing remaining is to get the thing back into the cabinet and collect for it!

### "Intermittents"

Now, albeit somewhat reluctantly, for we have never really relished the utterly gruesome type of tale, we arrive at the Ultimate Horror: the Intermittent Printed Circuit! This is the unit which, when jarred lightly, such a vibration as might be caused by a large housefly sneezing in the next room, gives off a deafening howl or stops playing altogether. The trouble is caused, of course, by one (or more) of the very delicate foil strips developing a fine crack. This cleavage may be caused by almost anything, apparently; defective solder joints, thermal expansion or contraction of the board, or, in most cases, sheer dislike of the electronics maintenance profession as a whole.

This defect, of course, is seldom of an obvious nature. The ends of the ribbon do not curl up and invite the eye, saying "Look, here I am!". No, indeed. They will hide themselves whenever possible, beneath the false façade of an apparently perfect, smooth solder surface, smiling happily up at the technician, saying, "Who, me? Bad joint? Never! Look at me, I'm as sound as a dollar! (Pound, lira, rouble, yen, mark, zloty, etc.; take one). Me make an intermittent connection? Never! Perish the thought!". In the weary course of investigating this phenomenon, the technician will discover that there are just certain ways in which the board may be flexed that will either aggravate or stop the trouble. The average noisy intermittent in printed wiring will be so sensitive that jarring the set anywhere will produce the same ear-splitting crack; this may also be brought forth by any form of disturbance. The horse chewing on a tough stem of grass in the back yard, or the barmaid at the local setting a glass down a bit hard, either will induce the symptom. This renders the job of locating the source quite simple: it is definitely within just this *one* set! But which section of the set? This may be found by applying some of the techniques previously used with older types: tapping parts, cursing, tapping more parts, cursing, disabling some circuits in order to eliminate them from consideration (this becomes quite a problem in some sets, with their series filament circuits). Of course, a duplicate tube, with the anode pin clipped off, may be inserted to disable a given stage. This means that one must disable a full set of perfectly good tubes in order to make this test!

After finishing his peregrinations through the *terra incognita* of the remainder of the set, we will assume that our technician has been fortunate enough to locate the one single printed wiring board which holds the defect. Now arises the problem of locating, among this flattened nest of silvery serpents, the one lone defective joint. This one bit of helpful information can be passed along right at the beginning: it is utterly impossible to locate the thing by applied inductive reasoning, logic, tests or measurements of any kind! This is the correlated result of tests made by millions of servicemen. One American technical lecturer said quite recently, "Stop trying the physical method, and instead try the mental!", meaning that troubles could be found much more easily if technicians would stop and think out the problem, instead of aimlessly reading voltage, resistance, etc. We regret to state that this is an entirely impractical approach in these cases. Herewith a bit of advice from men who have spent a lifetime (in only a few short days) in hunting for troubles in these boards. Abandon the mental approach entirely, and concentrate on the physical! In other words, there is really only one practical way to solve the problem of in intermittent joint on a printed circuit board. Immediately upon beginning the job, fall to and resolder every blooming joint on the whole board! Some men have even resorted to a grease-pencil, or a black crayon filched from their youngest's colouring set, to mark off the board into sections, to make the job of counting joints easier. Usually, every single joint must be resoldered, to effect a cure!

So, for the inevitable reason, economy of manufacture, it seems as if we're stuck with the things for a long time to come. However, we will, as in the past, develop methods of coping with them, on both sides of the Atlantic, just as we have for all of the countless other difficult-to-service innovations which have come bursting forth in the past few years. One item which will definitely be added to our stock of gadgets will be a pair of very sharp needle-pointed test leads, for piercing the plastic coatings. Others will be worked out as needed, and we may even become resigned to them, after a while! For your information, the American technicians, although as a whole quite bitter about the things, have learned to cope quite well; I'm sure the rest of us will, too!

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Do you know the limits of the v.h.f. band?

What is the formula for finding the Q of a coil?

How many turns of 26 s.w.g. (single silk covered) can be accommodated in an inch?

Where does one apply for a mobile radio licence?

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If you cannot readily answer all these questions then you should obtain a copy of the *Wireless World* Diary for 1958. In addition to the 80-page information section there are the usual diary pages of a week to an opening. It costs 6s 3d (leather) or 4s 6d (Rexine), including purchase tax. Overseas prices are, respectively, 5s 3d and 3s 9d, plus 4d postage.

# Severe Ionospheric Storm

SOME NOTES ON THE DISTURBANCES OF AUGUST 29th TO SEPTEMBER 6th

ONE of the most intense ionospheric and magnetic disturbances of recent years occurred during the period August 29th to September 6th, 1957, when for certain prolonged intervals during this 9-day period, radio communications via the ionosphere, and especially those over high-latitude transmission paths, were widely disrupted. Though there were, on some of these days, periods between the disturbed intervals when conditions were more or less normal, it would, perhaps, be correct to regard the time between about 2030 GMT on August 29th and about 1200 GMT on September 6th as that of the lifetime of a single ionospheric storm.

It is interesting to note that, at the time of the occurrences leading up to the disturbance, there were two large sunspots near the sun's central meridian, both being due to cross it on August 31st.

The event which would appear to have initiated the disturbance occurred on September 28th, when, between 0913 and 1215 GMT an intense solar flare was observed on the sun, reaching maximum intensity at 0955 GMT. Simultaneously with this—at least between 0920 and 1200 GMT—a severe "sudden ionospheric disturbance" of the kind which causes a temporary fadeout of short-wave signals occurred. These two events are, most often, intimately connected, the fadeout being due to ionization in the D layer set up by ultra-violet radiation from the flare. But the corpuscular emission from the flare, which is assumed to cause the major ionospheric disturbance, does not arrive in the earth's orbit until many hours later, and, as has been pointed out in these pages, it sometimes does not appear to arrive at all, for the expected ionospheric storm sometimes fails to materialize. However, in this instance it certainly did.

At about 2030 GMT on August 29th propagation conditions over transatlantic paths began to deteriorate, and an hour later an ionospheric storm was evidently in progress, whilst, at the same time, the earth's magnetic field became disturbed. Assuming 2030 GMT to be the time of the storm's start the travel time of the corpuscles would thus have been about 35 hours. During the night the ionospheric disturbance intensified, but towards the evening of the 30th both ionosphere and magnetic conditions became undisturbed. The 31st was more or less normal so far as short-wave propagation was concerned, though towards evening the magnetic field was again disturbed. Soon after midnight propagation conditions again deteriorated and by 0200 GMT on September 1st a renewal of the ionospheric storm was apparent. On the afternoon of this day conditions, both magnetic and ionospheric, again became undisturbed, but the worst phase of the storm was yet to come. It started with a deterioration in propagation conditions at about 0600 GMT on 2nd. By 1200 GMT the ionospheric storm was again intense, and soon deepened in intensity, with the magnetic field becoming more disturbed as the day went on. Thereafter propagation conditions remained continuously disturbed until the end of the storm, at about 1200 GMT on 6th. Magnetic conditions were also continuously disturbed except for the early part of the 4th.

There were further "sudden ionospheric disturbances" at 1306 GMT on August 31st and at 1024 and 1422 GMT on September 3rd, which may have indicated further eruptions on the sun from which corpuscular streams would be emitted, tending, perhaps, to prolong the major ionospheric storm.

So far as propagation conditions were concerned the most intense phases of the storm were 0900-1300 GMT on 3rd, 1800-2100 GMT on 4th and 0100-1130 GMT on 5th, when reception over high-latitude transatlantic paths was practically impossible. The ionospheric measurements made at the D.S.I.R. station at Slough also indicate the severity of the disturbance during the two latter of these phases, the $F_2$ layer critical frequencies being generally over 40% below normal. The magnetic disturbance on both 3rd and 4th reached the proportions of a Great Magnetic Storm, and was very severe on 2nd and 5th, the most intense phases being 1500-1800 GMT on 3rd and 1500-1800 GMT on 4th.

It is interesting to note that the aurora borealis, which is produced by the solar corpuscles when they enter the earth's atmosphere, was seen at numbers of places in Great Britain: on the nights 29th/30th, 31st/1st, 2nd/3rd, and 4th/5th, that on the first of these nights being seen as far south as Devon.

The solar and terrestrial events connected with this disturbance were, no doubt, comprehensively observed throughout the world, as part of the I.G.Y. programme, and interesting data as to the correlation between the solar and terrestrial happenings may thus become available. T. W. B.

## Spring-loaded Terminal

DESIGNED for mounting on metal panels up to $\frac{1}{8}$ in thick this new, small, spring-loaded, insulated terminal enables wires or pins up to $\frac{1}{8}$ in diameter to be easily and quickly inserted or removed. When seated the overall height of the terminal is $\frac{7}{8}$ in.

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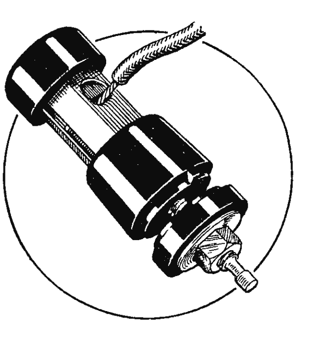
The price is 1s 4d and the makers are Howard S. Cooke and Co., Ltd., Arrow Road, Redditch, Worcestershire.



*Howard S. Cooke spring-loaded insulated terminal.*

# Television Frame Pulse Separator

## SINGLE-PULSE CIRCUIT FOR ACCURATE INTERLACING

By H. D. KITCHIN*

THE problem of achieving a good interlace in television receivers has formed the subject of much work in recent years. Although an accurate interlace has always been the ideal to aim at, many commercial receivers have fallen short of the ideal owing to the cost of the circuitry necessary to ensure a consistently accurate interlace in production. However, the trend towards larger tubes now makes the requirement of good interlace essential if the line structure of the existing 405-line picture is not to be too obvious.

The synchronizing pulse waveform in the British television system presents a difficulty to frame pulse separation because of the differences between odd and even frames. The waveforms associated with the train of frame pulses for even and odd frames are shown in Figs. 1(a) and (b) respectively. It will be seen that on odd frames the frame pulses start only half a line after the preceding line pulse, this being necessary to achieve an interlaced scan. Also, the interval between the end of the last 40-μsec frame pulse and the following line sync pulse is only 10μsec for an even frame against 60μsec for an odd frame. The effect of these differences in differentiating and integrating circuits is to give rise to differing pulse shapes on odd and even frames. An examination of these defects formed the subject of an investigation by Patchett[1], where it was shown that the ideal pulse for frame timebase synchronizing is a single short pulse with a sharp leading edge. The last requirement precludes the use of integrating circuits, leaving only some form of differentiating circuit for frame pulse separation.

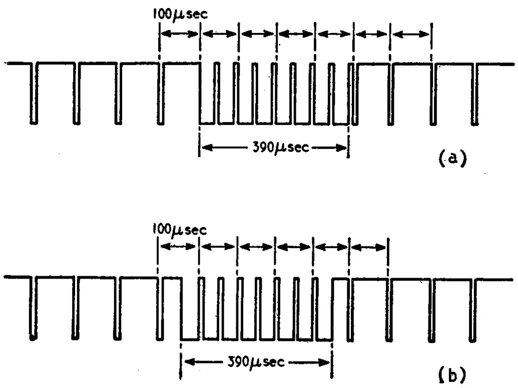



*Fig. 1. The standard television synchronizing waveform, showing frame pulses at the end of (a) an even frame, and (b) an odd frame.*

Previous methods of using differentiating circuits have fallen into two categories, which are illustrated in Figs. 2 and 3.

In Fig. 2 the composite synchronizing pulses, after removal of the video signal, are applied to a circuit having a much slower response to input excursions of one polarity than for excursions of the opposite polarity. Such a circuit has been termed a "smearer."[2] For an input waveform having negative-going line sync pulses, as in Fig. 2, suitable smearer circuits are shown in Figs. 4(a), (b) and (c). In these circuits a capacitor is charged through the low resistance of a valve and discharged through a high resistance leak, the valve being cut off. In the circuit of Fig. 4(d) the discharge of the capacitor takes the form of the well-known Miller run-down, the valve being conductive. Charging of the capacitor takes place through grid-cathode conduction and the anode load, anode current being cut off by the suppressor grid being negative. As the conduction and non-conduction periods of the valve are the reverse of those for the other circuits of Fig. 4, the input required must have positive-going line sync pulses.

Because a frame pulse is four times the duration of a line pulse, the potential of the capacitor during a frame pulse will be four times that during a line pulse, assuming a linear fall in potential. The output, shown as waveform (b) in Fig. 2, may then be clipped to remove the line pulses, giving a train of frame sync pulses identical on both frames. This clipped waveform, shown at (c), will give triggering on the sloping front of the first triangular pulse and can give variable interlace if the triggering level or pulse amplitude varies. This effect will obviously be inversely proportional to the slope of the leading edge, and could be much reduced by having a triggering pulse with a sharp leading edge. Simple short-time-constant differentiation of the clipped waveform will give such a sharp edge, of the opposite polarity to that of the sloping front, at the instant of each half line pulse, as shown at (d). This can be used to trigger the frame timebase, giving, theoretically, perfect interlace. Although the use of a differentiating circuit for final shaping may appear somewhat of a refinement, it should be noted that it is essential if the requirement of a sharp leading edge is to be satisfied.

Of the four types of smearer circuit in Fig. 4, only the diode type (a) has been used commercially—the interlace filter. The Miller circuit suggested by Patchett[3] possesses certain advantages but, unfortunately, requires a pentode with a short suppressor-grid base, a type which is not in the current preferred ranges of valves for television. The clipper associated with this type of separator is invariably the diode type for economy.

We will now examine the method of frame pulse separation illustrated in Fig. 3. In this case differ-

* Formerly with Ambassador Radio & Television, Ltd.

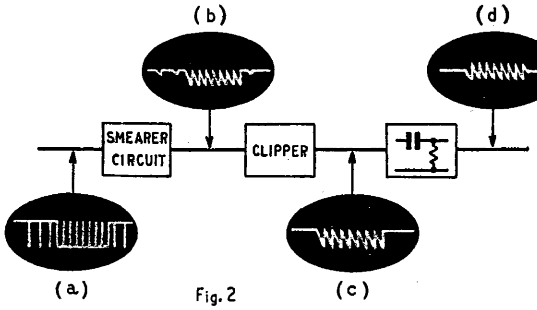



Fig. 2

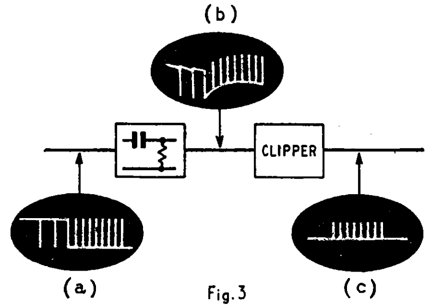



Fig. 3

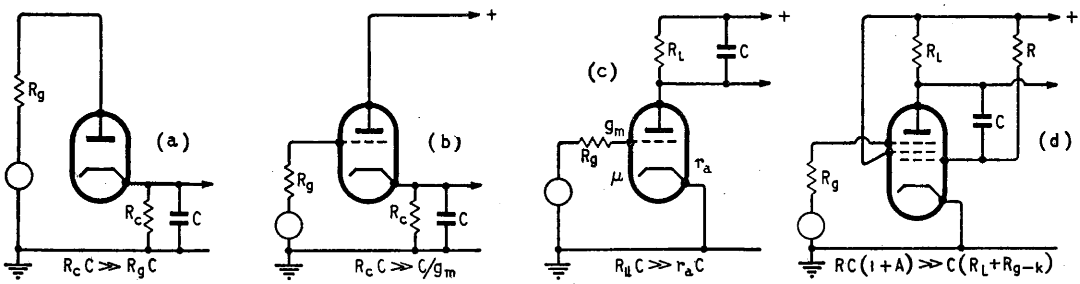



Fig. 4

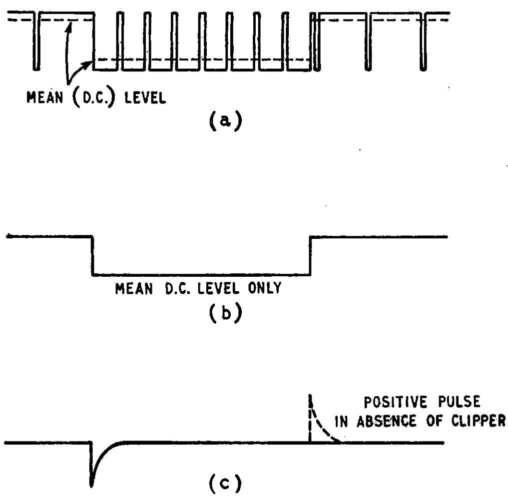



Fig. 5

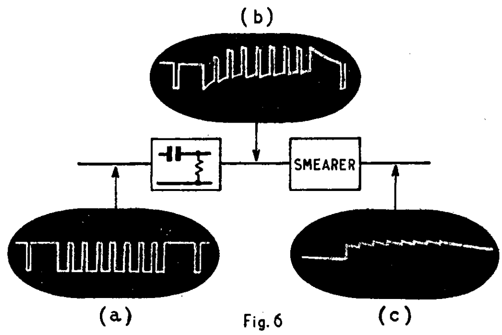



Fig. 6

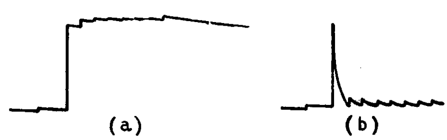



Fig. 7

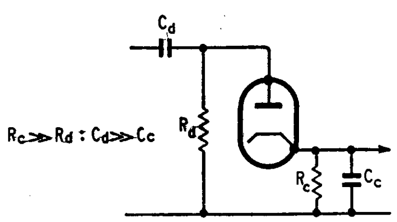



Fig. 8

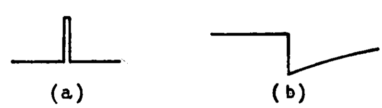



Fig. 9

entiation is the first operation, using a critical time-constant RC network. The use of such a network is well known and forms the basis of a large group of sync separators. For the British system the maximum difference obtainable between line and frame pulses is 47% of the line pulse amplitude, and is produced with a time constant of 21.6$\mu$sec.

The waveform obtained by such differentiation is shown in Fig. 3 waveform (b). By means of a suitable clipper the line pulses may be eliminated, leaving a train of short pulses, waveform (c), consisting of the half line pulses which occur between consecutive frame pulses. The first pulse of this train may be used to synchronize the frame timebase.

A difficulty with this method of separation is the presence of the large amplitude line pulses which make the clipper design critical with regard to operating potentials and the input signal. A considerable improvement is obtained by the use of grid leak bias in conjunction with a short grid-base valve, but if the input signal is reduced below a certain level then the line pulses start to appear in the output and may produce poor interlace.

If we return now to consideration of the original composite synchronizing waveform and the mechanism of timebase synchronizing it is apparent that:—

(a) Only the first frame sync pulse from the frame pulse separator is of any value in synchronizing the timebase. The remaining pulses serve no useful purpose and may upset the timebase during flyback, causing faulty interlace during scanning.

(b) During the frame pulses the mean d.c. level changes. This is illustrated in Fig. 5(a). It is this change which the popular integrator type of frame pulse separator responds to, and is also the reason for the displacement of the half line pulses with the critical time-constant RC differentiator.

Thus we see that if we could separate out the change in d.c. level whilst still maintaining a sharp transition, then by short time-constant differentiation we should obtain a single short pulse with sharp leading edge ideally suited for synchronizing the frame timebase. This process is shown in Figs. 5(b) and (c).

It is now proposed to describe a frame sync separator which gives, virtually, such a short pulse with sharp leading edge and is not critical in regard to operating potentials and component tolerances.

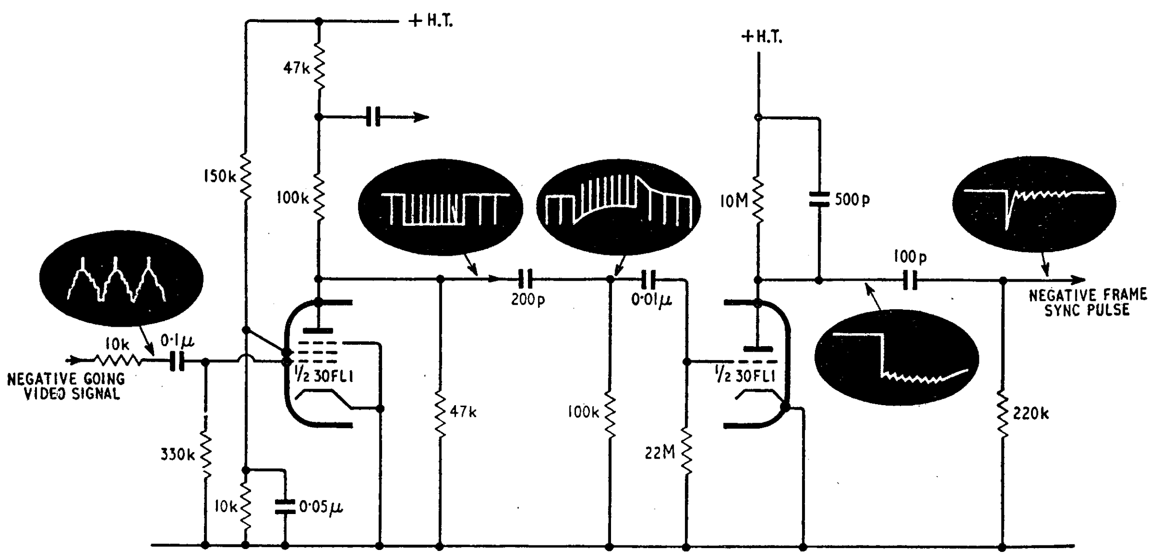
This is done by combining certain features from each of the previous methods of Figs. 2 and 3. The composite pulses are first differentiated using a critical time-constant network, and the resulting waveform passed to a smearer circuit with a long decay time-constant. This results in the waveforms illustrated in Fig. 6, where it is seen that the line pulses have been eliminated and the frame pulses are "smoothed," by the storage action of the capacitor, into a single frame pulse with a sharp leading edge. This eliminates the differences at the end of the train of frame pulses present in the input. By short time-constant differentiation of this "smeared" pulse a short pulse with a sharp leading edge is obtained, followed by much smaller short pulses as shown in Fig. 7(b). This pulse is very close to the ideal for synchronizing the frame timebase.

Any of the four smearer circuits shown in Fig. 4 are suitable, the choice depending on the polarity of the input available. The simplest and most obvious choice is the peak rectifier diode at (a). For satisfactory operation of this circuit it must either be fed from a low impedance source, for example, a cathode follower, or from a differentiator which has constants chosen in accordance with the conditions specified in Fig. 8, otherwise the circuit functions as a counter.[4]

The diode has the merit of simplicity, requires the normal negative-going line and frame sync pulse input, and gives a positive output pulse, which is suitable for triggering a blocking-oscillator or thyratron timebase. It suffers from the disadvantages of the output pulse being less than half of the peak-to-peak input voltage and of transfer of line pulses through the diode capacitance.

If the input signal is sufficiently large, the cathode-follower smearer of Fig. 4(b) may be used with a long

*Fig. 10. Complete circuit diagram of the improved frame pulse separator, based on a double valve.*



time-constant in the cathode, when the well-known inability of a cathode follower to follow large negative changes is exploited to advantage. In this case there is no limitation on the relative values of input and output circuit impedances, for provided no grid current flows, the charging current for the cathode circuit comes from the h.t. supply. The anode supply voltage should be just sufficient to prevent grid current flow in order to provide the shortest possible grid base. This type of circuit, in common with the diode, gives a positive output pulse, and requires negative-going line and frame sync pulses. However, the modern tendency towards a multi-vibrator as a sawtooth generator makes a negative pulse desirable, as it may be fed on to the "free" grid of the cathode-coupled type and also gives easier triggering with the cross-coupled type. The Miller integrator smearer of Fig. 4(d) is unsuitable as it, also, gives a positive-going output pulse and requires an input with positive-going line and frame pulses. This requirement necessitates an additional valve after the usual sync separator valve.

The earthed-cathode smearer of Fig. 4(c) will provide the required negative output pulse from the normal negative-going line and frame pulse input, as shown in Fig. 9(a) and (b). When the triode conducts the anode capacitor charges through the low impedance of the valve, giving a sharp drop in anode potential. When the valve is cut off discharge can only occur through the high resistance anode load, with a consequent slow rise in anode potential. A complete circuit using a triode as described above is shown in Fig. 10, the correct operating point is maintained by the use of grid leak bias. The fall of the leading edge is determined by the anode impedance at zero grid volts and anode capacitance, the rise of the trailing edge by the anode circuit time-constant. Suitable time-constants are between 0.5 and 5.0$\mu$sec for charge and 100 to 1,000$\mu$sec for discharge. A valve with low anode impedance and short grid base is desirable. The attainment of a short grid base is assisted by choosing an anode supply voltage only about 50% greater than the output pulse required for satisfactory synchronizing of the timebase.

The circuit has the advantage of not being critical in the component values required, owing to the break-through of line pulses being almost eliminated by the large discharge time-constant in the anode circuit. Care should be taken that the charging time-constant ($r_aC$) is not too long, otherwise a counting action takes place on the half line pulses and gives a step waveform. Also, it is essential to preserve the sharpness of the half line pulses during the eight frame sync pulses in any circuit using critical time-constant differentiation. This will usually necessitate feeding the differentiator directly from the usual sync separator limiter anode, with particular attention to minimizing stray anode-to-earth capacitance.

By the use of a triode-pentode, with the pentode acting as the normal video limiter as shown on the left of Fig. 10, a single valve sync separator is obtained having excellent interlace—provided, of course, that the normal precautions are observed to prevent stray line pick-up in the frame circuit and also to prevent transfer of line pulses back through the video limiter. This circuit has been employed in production receivers for over a year and found to be trouble-free and to give a consistently good interlace. The noise susceptibility of this particular differentiator type of frame pulse separator has not proved to be any worse than the usual simple integrator type.

Finally, the author wishes to thank T. C. Isaac for much helpful discussion during the preparation of this article.

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[2] G. E. Valley and H. Wallman. "Vacuum Tube Amplifiers," Section 3.3, p. 128.

[3] G. N. Patchett. "Faulty Interlacing," *Wireless World*, July and August, 1952.

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## APPENDIX I

For an exact analysis of the response of an RC differentiating network to a composite train of line and frame sync pulses it is necessary to know the effective capacitor charging voltage during a line pulse and during a frame pulse. This effective charging voltage will be equal to the amplitude of a line or frame pulse less the charge remaining on the capacitor from the previous pulse. As the first frame pulse follows a line period (at the end of an even frame in the British system*), the effective charging

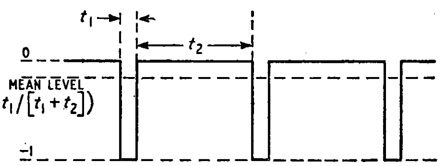


Fig.1

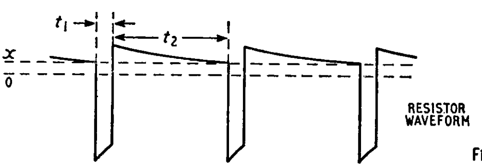


Fig.2

voltage for the first frame pulse will be the same as that for a line pulse.

The response of an RC differentiating network will be examined for the steady state condition, and an expression derived for the charge remaining on the capacitor at the end of a line period.

Due to the series capacitor of such a network there can be no transmission of any d.c. component of the input wave. Thus the average charge on the capacitor will be that of the d.c. component. This requires the output waveform to have equal positive and negative areas about the zero level, which implies that the charge gained by the capacitor during any part of one complete line period must be equal to the charge lost during the rest of the period.

If it is assumed that the input pulses have unity amplitude as shown in Fig. 1, then the waveforms across the resistor and capacitor will be as shown in

* The first frame pulse will follow after only half a line period at the end of odd frames in the British system, and after a half line period on both frames in systems employing equalizing pulses.

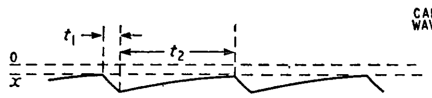

Fig. 3

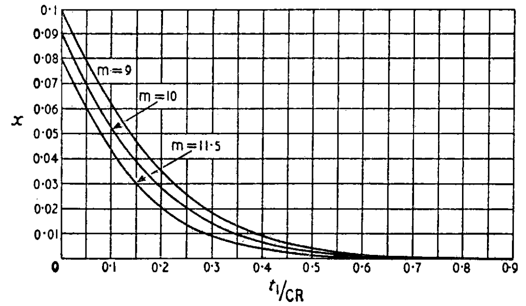

Fig. 4

Figs. 2 and 3 respectively. Referring to these figures, we will let the voltage on the capacitor at the end of the period $t_2$ be $x$, then the amplitude of the effective charging voltage during the line pulse $t_1$ will be $1 - x$, the capacitor charging up according to the relation

$$(1 - x)(1 - e^{-t/\mathrm{CR}}).$$

The voltage on the capacitor at the end of a line pulse will be

$$(1 - x)(1 - e^{-t1/\mathrm{CR}}) + x$$

This is the initial voltage on the capacitor available for discharge during the period $t_2$, the expression for this discharge being

$$[(1 - x)(1 - e^{-t1/\mathrm{CR}}) + x]\, e^{-t/\mathrm{CR}}.$$

The voltage remaining on the capacitor at the end of the period $t_2$ will be

$$[(1 - x)(1 - e^{-t1/\mathrm{CR}}) + x]\, e^{-t2/\mathrm{CR}}$$

and is equal to $x$ when equilibrium has been attained; hence we have as the equilibrium condition

$$[(1 - x)(1 - e^{-t1/\mathrm{CR}}) + x]e^{-t2/\mathrm{CR}} = x$$

simplifying and rearranging this gives

$$x = \frac{1 - e^{-t1/\mathrm{CR}}}{e^{-t2/\mathrm{CR}} - e^{-t1/\mathrm{CR}}}$$

If we put $t_2 = mt_1$ this becomes

$$x = \frac{1 - e^{-t1/\mathrm{CR}}}{e^{mt1/\mathrm{CR}} - e^{-t1/\mathrm{CR}}}$$

We may plot curves, according to the above equation, showing the variation of $x$ with $t_1$/CR for various values of "$m$." This has been done for $m = 9$, 11.5 and 10, representing the British, American and continental systems respectively, the curves being shown in Fig. 4. It will be seen from these curves that the voltage on the capacitor at the end of the period $t_2$ is not more than 1% of the peak-to-peak input voltage if the ratio of $t_1$/CR is greater than 0.4.

## APPENDIX II

When a train of composite line and frame sync pulses are passed through an RC differentiating network, there is an exponential change of the average charge on the capacitor during frame pulses due to the different average level during these pulses to that prevailing during line pulses. The extent of this change will depend on the time-constant of the network in relation to the duration of the pulses. The general effect of the network on the frame pulses has been shown in Figs. 3(b) and 6(b) of the main text. By varying the time-constant of the network we will vary the degree of the response of the circuit to such changes. If we make the time-constant sufficiently long then the level will not have time to change during the frame pulses and they will be transmitted with negligible shift in level. If we now shorten the time-constant the shift in level during the frame pulses will become apparent and the half line pulses between the frame pulses start to rise up above the level of the line pulses, as in the above-mentioned diagrams. This suggests its use as a frame-pulse separator, only a simple clipper being required to eliminate the line pulses and leave a train of half line pulses during the frame pulse period. (This simple method has disadvantages which have been dealt with elsewhere[1].) As can be seen in Fig. 1, another effect appears as the time-constant is shortened—that of differentiation of the line pulses, giving rise to an overshoot as they return to black level. This overshoot will subtract from the displacement of the half line pulses which occurs during the frame pulses, as any clipper will have to take the peak of this overshoot as a limit, in order to completely eliminate the line pulses.

As we further shorten the time constant the amplitude of this overshoot starts to increase faster than the displacement of the half line pulses until, with a very short time-constant, both tend to the peak-to-peak input amplitude. This condition is shown in Fig. 2, for an RC network of 1-2$\mu$sec time-constant. Between the two limiting cases of very long and very short time-constants, neither of which gives any difference in amplitude between the line and the half line pulses, we would expect some particular time-constant to give the maximum difference. This time-constant is termed the "critical" time-constant and its relationship to the pulse lengths of the input wave will now be examined.

In order to simplify the analysis it will be assumed that the charge remaining on the capacitor at the end of a line period is negligible, otherwise it would be necessary to take variation of this voltage with variation of the time-constant RC into account when differentiating with respect to RC. From the considerations in Appendix I this assumption is permissible if the ratio $t_1$/CR is not less than 0.4.

The output from the differentiating network at the end of a frame (in the British system, an even frame) will be of the form shown in Fig. 1. We

*(Continued on page 559)*

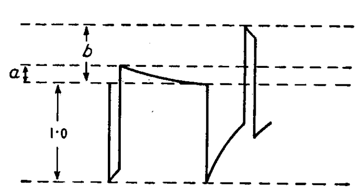

Fig. 1

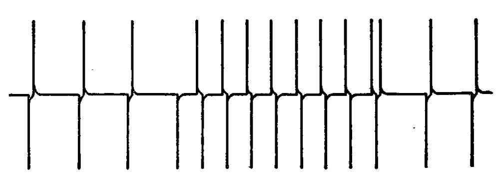
Fig. 2

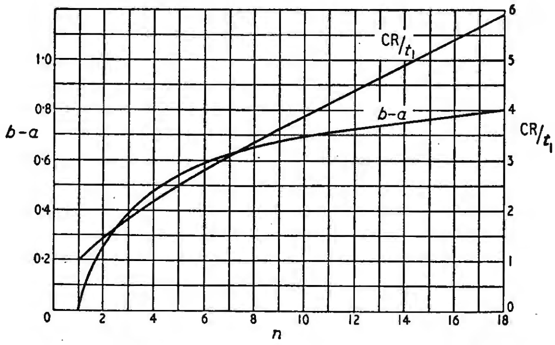


Fig. 3

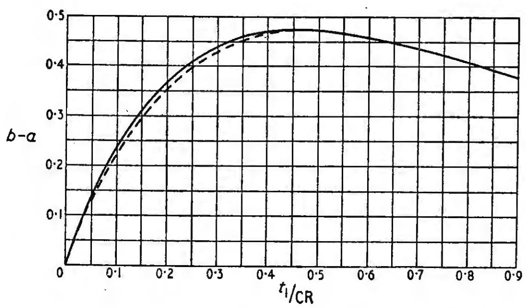


Fig. 4

require the maximum difference between the amplitude of the first half line pulse, $b$, and the amplitude of the overshoot of the line pulses, $a$, in order to give the greatest latitude in clipping level. The amplitudes $a$ and $b$ are given by the voltage rise on the capacitor during the intervals $t_1$ and $t_3$, i.e.

$$a = 1 - e^{-t1/\mathrm{CR}}$$

and $$b = 1 - e^{-t3/\mathrm{CR}}$$

From these the difference $b - a$ becomes

$$b - a = e^{-t1/\mathrm{CR}} - e^{-t3/\mathrm{CR}} \quad \ldots \quad 1$$

Differentiating this expression with respect to CR, we have

$$\frac{d(b-a)}{d\mathrm{CR}} = \frac{1}{(\mathrm{CR})^2}\left(t_1 e^{-t1/\mathrm{CR}} - t_3 e^{-t3/\mathrm{CR}}\right).$$

Equating this to zero, the condition for the maximum value of $b - a$ is

$$\frac{t_3}{t_1} = \frac{e^{-t1/\mathrm{CR}}}{e^{-t3/\mathrm{CR}}}$$

putting $t_3 = nt_1$ this becomes

$$n = e^{t1/\mathrm{CR}\,(n-1)}$$

and giving, after rearrangement

$$\frac{\mathrm{CR}}{t_1} = \frac{n-1}{\log_e n} \quad \ldots \quad 2$$

Substitution of equation 2 in equation 1 gives the maximum value of $b-a$ as

$$b - a = (1 - 1/n)\, e^{-\frac{\log_e n}{n-1}} \quad \ldots \quad 3$$

Curves are plotted, in Fig. 3, of the above equations 2 and 3, showing the maximum value of $b-a$ for any value of $n$ up to 20, and also giving the time-constant, expressed as the ratio CR/$t_1$, necessary to realize this maximum value.

When circuits using a critical time-constant differentiating network are to be used in production equipment, it is desirable to know the manner in which the output $(b-a)$ varies with the time-constant CR for a given value of $n$, in order to determine component tolerances. In Fig. 4 is shown a curve of $b-a$ against $t_1$/CR for the British television system, where $n$=4, calculated from equation 1. It will be seen that a broad maximum occurs at $t_1$/CR = 0.463. If a 5% drop in the amplitude of $b-a$ can be tolerated, without affecting synchronizing, then, from Fig. 4, the limits of $t_1$/CR are 0.315 and 0.645, giving CR from 31.7$\mu$sec to 15.5$\mu$sec when $t_1$ = 10$\mu$sec. Thus a nominal time-constant for CR of 22$\mu$sec with a 10% tolerance on both C and R should be satisfactory. It should be remembered that the curve of Fig. 4 will be subject to an increasing inaccuracy as $t_1$/CR decreases below 0.4, due to the effect of the residual charge on C at the end of a line being neglected in the analysis. The result of taking this residual charge into account, according to the analysis in Appendix I, is shown by the dotted curve of Fig. 4. The divergency from the simplified treatment is negligible for practical purposes.

An additional consideration with the British television system is the difference between the start of the first frame pulse on odd and even frames, the odd frame pulses starting only half a line after the preceding line pulse. The effect of this is to start the first frame pulse on odd frames from a different level to that on the even frames, due to there being more residual charge on the capacitor. With a time-constant of 22$\mu$sec this difference in level, which gives rise to a difference in amplitude of the first frame pulse between odd and even frames, amounts to about 1.4% of the peak-to-peak input. This represents 3% difference in the amplitude of $b-a$ between odd and even frames and will be unimportant if the triggering pulse for the timebase is sufficiently large, so that triggering does not occur during the top 10% of the frame pulse.

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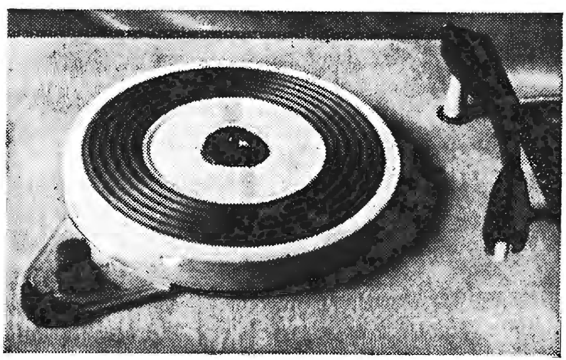
## Four-speed Gramophone Turntable



*The Birmingham Sound Reproducers Ltd. new TU9 four-speed turntable and pickup is fitted with a B.S.R. 'Ful-Fi' turnover crystal cartridge type TC8H. The 45 r.p.m. centre hole record adapter is permanently fitted to the turntable and can be raised or lowered as required. The separate pickup arm has a special mounting which virtually eliminates acoustic feedback. The address of the manufacturers is Monarch Works, Old Hill, Staffs.*

# News from the Industry

**Mullard Research Expansion.**—To meet the growing demands on the resources of the Mullard Research Laboratories at Salfords, Surrey, a new building with a total floor space of 28,000 square feet has recently been opened. As a matter of policy three main activities—fundamental research, development and advisory service on Mullard products, and Government contracts—are carried on simultaneously and with mutual benefit at Salfords, which can now claim to be among the largest laboratories in this country devoted to radio, electronics and allied subjects.

**W. S. Electronics (Production), Ltd.,** Brunel Road, East Acton, London, W.3, which since its formation in 1945 has been largely concerned with producing under contract army h.f. communications equipment and mine detectors, has recently been manufacturing its own proprietary lines. Its D103 u.h.f. transmitter-receiver has now been ordered for the Navy and the R.A.F. It is a wholly-owned subsidiary of K. G. Holdings, Ltd., who also own Bonocord, Ltd., and Tellux, Ltd. G. C. Wheeler and J. Wolff have resigned their directorships of the company and Col. A. E. Tyler has been appointed general manager. He also becomes general manager of the associated W. S. Electronics (Extruder), Ltd.

**B.C.C.**—Mobile radio-telephone equipment is to be installed by British Communications Corporation at the railway marshalling yard at Newport, near Middlesbrough. Six locomotives and two signal boxes ("up" and "down") are being equipped A double-frequency simplex system is employed.

**Telefunken** tape recorders are now available from the Welmec Corp., Ltd., of 147, Strand, London, W.C.2, who have been appointed sole distributors in the U.K.

**"By Any Other Name . . ."**—Because Collaro's trade name "Challenger" is inadmissible in America, to which they export a large quantity of record changers, they have renamed their changer "Conquest."

**Rhoden Partners, Ltd.,** who provide a service for the design and development of specialized manufacturing equipment, have moved to 29, Park Crescent, London, W.1 (Tel.: Langham 7488). They are not manufacturers, but will undertake the design of manufacturing equipment or modifications to existing assembly lines.

**Semiconductors, Ltd.,** recently formed jointly by the Plessey Co. and the Philco Corp., of Pennsylvania, to manufacture in this country transistors and other semiconductors under Philco patents, are to build a factory on the Cheney Manor Estate, Swindon, Wilts. Production is expected to start during next year with the manufacture of h.f. surface barrier and Micro-Alloy transistors, now made by the Lansdale Tube Co., a division of Philco. Germanium Micro-Alloy diffused transistors for operation at 250 Mc/s will be available later in 1958. To assist manufacturers in the development of transistor equipment samples are being obtained from the U.S.A.

**Adhesive copper foil** known as "Plymaster," made by the Rubber & Asbestos Corp., of Bloomfield, New Jersey, U.S.A., to which we referred on page 296 of our June issue, can now be imported under open general licence, so that individual import licences are not required. The sole U.K. distributors of the foil, used for making "copper clad" for printed circuits, are Omni (London), Ltd., 35, Dover Street, London, W.1.

**Marconi's** are to supply the equipment for the f.m. radio-telephone service for Southampton Harbour. The equipment includes five 25-watt v.h.f. transmitters and five receivers for the fixed stations, and three mobile transmitter-receivers. The fixed stations will be remotely controlled from a central site.

**Decca Navigator** is to be fitted in a further 44 tankers of the Shell Petroleum Co., making 66 in all.

**CQ Audio, Ltd.,** is the new name adopted by RGA Sound Services, Ltd., who market CQ amplifiers. They have moved from Plymouth and are now at 2, Sarnesfield Road, Enfield, Middlesex. A. R. Neve, a director of the company, and Stanley Kelly have also floated a new company, Audio Amplifiers, Ltd., of the same address, to manufacture audio equipment.

## OVERSEAS TRADE

**Surveillance radar** is to be supplied and installed by Marconi's at two air bases in Wellington, New Zealand—the civil airport at Rongotai and the N.Z. Air Force base at Ohakea. Both installations will include duplicate 500-kW sets (Type S264A). At Rongotai the scanner will be erected at the top of a 1,650-ft hill, from which the radar information will be fed by a microwave link to both the airport and the airways control centre in Wellington city, approximately four miles away.

**Solartron's** commercial director, Eric E. Jones, is visiting the United States. Whilst there he will make arrangements for the manufacture under licence in the U.S.A. of the Solartron electronic reading automaton (E.R.A.). The group has an American subsidiary, Solartron Incorporated, of Los Angeles, set up a year ago, and has agreements with Rheem Manufacturing Co., of New York, and the Consolidated Electrodynamic Corp., of Pasadena.

**Tape Recorders.**—Two production models of the recently introduced "Thoroughbred" tape recorder were flown by Winston Electronics, Ltd., to their North American distributors Mechron Products, Ltd., for exhibition at the Canadian Institute of Radio Engineers show in Toronto (October 16th to 18th).

**A £1M contract,** calling for the complete reorganization of the long-wave broadcasting station at Ankara, Turkey, including the addition of a second 120-kW transmitter for parallel operation with the existing one, has been awarded to Marconi's.

**S. W. Transmitter.**—British Sarozal, Ltd., whose new address is 1-3, Marylebone Passage, Margaret Street, London, W.1, have supplied to the Radio Club of Cape Verde a 5-kW transmitter for broadcasting in the 19-, 41- and 75-metre bands. The transmitter gives an overall frequency response of $\pm 2$ dB between 30 c/s and 15 kc/s with distortion below 4%.

**Thorn Electrical Industries** plan to invest more than £A2,000,000 on a development project in Victoria to provide facilities for the production of the complete range of the company's products in Australia.

**Television Receivers.**—There is at present no television service in Chile, but three stations using American 525-line standards are being operated experimentally by institutions. British manufacturers will have the opportunity of showing their television equipment at the technical exhibition at the Universidad Tecnica del Estado in Santiago in December. Details are obtainable from the Exhibitions and Fairs Branch of the Board of Trade.

**Automation Exhibition.**—The 4th International Automation Exposition and Congress will be held in New York Coliseum from June 9th and 13th next year. British firms interested in exhibiting or in visiting the Show should communicate with the organizers, Richard Rimbach Associates, 845, Ridge Avenue, Pittsburgh 12, Pa.

# NOVEMBER MEETINGS

**LONDON**

1st. R.S.G.B.—"Microwave link equipment" by S. Korytko (S.T.C.) at 6.30 at the I.E.E., Savoy Place, W.C.2.

5th. I.E.E.—"The design of the control unit of an electronic digital computer" by Dr. M. V. Wilkes, W. Renwick and Dr. D. J. Wheeler; "A decimal adder using a stored addition table" by M. A. Maclean and D. Aspinall; and "An accurate electroluminescent graphical output unit for a digital computer" by Dr. T. Kilburn, Dr. G. R. Hoffman and R. E. Hayes at 5.30 at Savoy Place, W.C.2.

8th. Junior Institution of Engineers.—"Television" by T. M. C. Lance (Cinema-Television) at 7.0 at Pepys House, 14 Rochester Row, S.W.1.

12th. Institute of Physics (Electronics Group)—"Crossed field interaction in microwave valves" by W. E. Willshaw (G.E.C. Research Laboratory) at 5.30 at 47 Belgrave Square, S.W.1.

13th. I.E.E.—"Broad-band slot-coupled microstrip directional couplers"; "The application of printed circuit techniques to the design of microwave components"; and "Re-entrant transmission line filter using printed conductors" by J. M. C. Dukes at 5.30 at Savoy Place, W.C.2.

15th. Television Society.—"Industrial television" by I. M. Waters (Pye) at 7.0 at 164 Shaftesbury Avenue, W.C.2.

15th. B.S.R.A.—"Some recent developments in loudspeaker enclosure design" by A. R. Neve, at 7.0 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

25th. I.E.E.—"Problems of sound and television broadcasting coverage" by G. Millington at 5.30 at Savoy Place, W.C.2.

27th. Brit.I.R.E. — "Transmission standards and signal distortion in television and other communication systems" by Dr. A. van Weel at 7.15 at the London School of Hygiene & Tropical Medicine, Keppel Street, W.C.1.

29th. Television Society.—"Some aspects of waveguide technique" by J. C. Parr (Kelvin Hughes) at 7.0 at 164 Shaftesbury Avenue, W.C.2.

29th. R.S.G.B.—"Some aspects of atmospheric radio noise" by F. Horner (D.S.I.R. Radio Research Station) at 6.30 at the I.E.E., Savoy Place, W.C.2.

**BIRKENHEAD**

22nd. Brit.I.R.E.—"Scatter propagation" by M. Telford at 7.0 at the Birkenhead Technical College.

**BIRMINGHAM**

25th. I.E.E.—"Magnetic materials" by Professor F. Brailsford at 6.0 at the James Watt Memorial Institute, Great Charles Street.

**BRADFORD**

12th. I.E.E.—Discussion on "The teaching of radio and TV servicing" opened by Dr. G. N. Patchett at 6.30 at the Technical College.

**CAMBRIDGE**

12th. I.E.E.—"Some radio aids for high-speed aircraft" by Dr. J. S. McPetrie at 8.0 at the Cavendish Laboratory, Free School Lane.

**GLASGOW**

21st. Brit.I.R.E. — "V.H.F./F.M. transmission" by H. V. Sims at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

**IPSWICH**

4th. I.E.E.—"Colour television" by L. C. Jesty at 6.30 at the Crown and Anchor Hotel.

**LIVERPOOL**

18th. I.E.E.—"Some aspects of half-wave magnetic amplifiers" by G. M. Ettinger at 6.30 at the Royal Institute, Colquitt Street.

**MANCHESTER**

6th. I.E.E.—"The importance of research in hearing and seeing to the future of telecommunication engineering" by Dr. E. C. Cherry at 6.45 at the Engineers' Club, 17 Albert Square.

14th. Brit.I.R.E.—"Some electronic techniques used in textile research" by K. B. Todd at 6.30 at Reynolds Hall, College of Technology, Sackville Street.

**NEWCASTLE**

4th. I.E.E.—"The importance of research in hearing and seeing to the future of telecommunication engineering" by Dr. E. C. Cherry at 6.15 at King's College.

11th. I.E.E.—"Cathodic protection" by L. B. Hobgen, K. A. Spencer and P. W. Heselgrave at 6.15 at the Neville Hall, Westgate Road.

13th. Brit.I.R.E.—"Electronic control of machine tools" by H. Ogden at 6.0 at Neville Hall, Westgate Road.

**NORWICH**

25th. I.E.E.—"Germanium and silicon power rectifiers" by T. H. Kinman, G. A. Garrick, R. G. Hibberd and A. J. Blundell at 7.30 at the Assembly House.

**READING**

25th. I.E.E.—"Cathodic protection" by J. H. Gosden at 7.15 at the George Hotel, King Street.

**RUGBY**

26th. I.E.E.—"Transistor circuits and applications" by L. P. Morgan at 6.30 at the College of Technology.

**SHEFFIELD**

20th. Institute of Physics.—"The velocity of light" by Dr. L. Essen (N.P.L.) at 5.0 in the Physics Department, University of Sheffield.

**SOUTHAMPTON**

6th. I.E.E.—"Frequency-modulated v.h.f. transmitter technique" by A. C. Beck, F. T. Norbury and J. L. Storr-Best at 7.0 at Southampton University.

**WEYMOUTH**

29th. I.E.E.—"Equivalent circuits of transistors and their application" by L. E. Jannson at 6.30 at the South Dorset Technical College.

**WOLVERHAMPTON**

13th. Brit.I.R.E.—"Cold cathode switching techniques" by J. Beesley at 7.15 at the Technical College, Wulfruna Street.

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**LATE-OCTOBER MEETINGS**

21st. British Computer Society.—"The machine's-eye view" by Professor D. R. Hartree at 6.15 in the William Beveridge Hall, Senate House, Malet Street, London, W.C.1. (Applications for admission to the secretary, 29 Bury Street, London, S.W.1.)

30th. Brit.I.R.E. — "Tropospheric scatter system evaluation" by M. Telford at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

# RANDOM RADIATIONS

**By "DIALLIST"**

## *Hi-Fi and V.H.F.*

WRITING from St. Peter Port in Guernsey a reader, who is a hi-fi enthusiast tells me that, though he can receive in the right conditions North Hessary Tor, Rowridge, Norwich and Wrotham, he always makes use of the last of these when possible owing to the much superior quality of reproduction obtainable from any of its transmissions which originate in or near London. He makes the suggestion that I should let this be known for the benefit of other followers of the hi-fi cult—and this I willingly do. Wrotham, as you may recall, was started as an experimental v.h.f. station some years before work was begun on the f.m. network. It is served by a very special cable from London and its modulation band of a.f.'s seems to be considerably wider than that of most, if not all, of the B.B.C.'s other Band II stations. What exactly is its upper limit is rather a mystery. When, in 1956, filters restricting the upper limit to 10 kc/s were installed readers wrote to *Wireless World* complaining about the fall in quality. The filters were subsequently removed. In two I.E.E. papers 15 kc/s has been given as the upper limit but this is by no means certain. I can, however, testify to the quality of the reproduction obtainable from Wrotham.

## *Comparisons Are Instructive*

For some little time during the experimental transmissions from Wrotham—I was then living in Hertfordshire—I had on loan one of the f.m. receivers, which were made for the B.B.C. by Ambassador and cost, I believe, not far short of £100 apiece. At the same time I had a good medium- and long-wave broadcast receiver and a television set which did full justice to the sound part of the TV transmissions. The v.h.f. set had a muting switch and I fixed up similar contrivances for the others. It was thus possible to turn instantly from one set to another. It seldom happened, of course, that the TV and sound programmes were the same; but quite often concerts (though not always the same ones) were being broadcast on the medium waves and Bands I and II. Comparison was easy to make and it showed how infinitely superior was Wrotham's transmission of music. The TV sound was a good long way behind as second and there was no doubt that the medium-wave transmissions from London—or, rather, Brookmans Park—were badly beaten into third place by the necessarily high selectivity of the i.f. circuits in the receiver. I notice that several people in the part of East Anglia where I now live have their Band II aerials directed on Wrotham instead of Norwich. Some even have aerials for both stations and musical folk tell me that they use Wrotham when it's receivable.

## *Who's Responsible?*

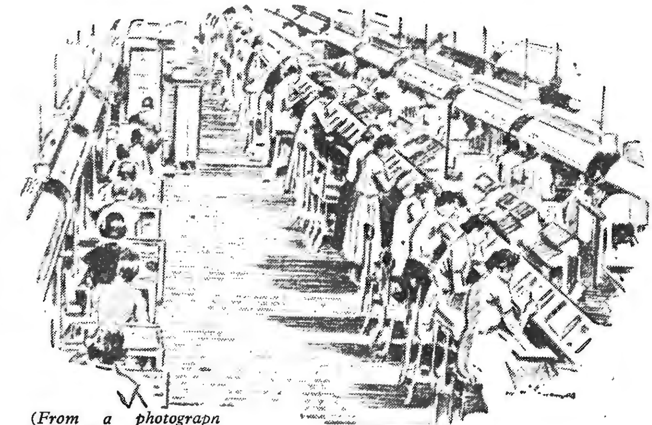
UNDER the heading "Mechanical Engineering is Key to Reliability," the American weekly *Electronic News* published a report on the second symposium on reliability held in June by what was then known as the Radio-Electronic-Television Manufacturers' Association. The title has since been tidied up and is now simply Electronic Industries Association. Representatives of several countries took part in the symposium. One of them, R. E. Clark, of the Royal Naval Scientific Service, is reported to have said that reliability in electronic equipment is not so much a matter of electronics as of mechanical engineering. I agree heartedly up to a point. But hasn't this always been so? It's hard to think of a fault in sound radio or television equipment, for example, which is purely electronic in origin and nature. And there are a tidy few of electro-chemical origin. If the emission of a valve or a cathode-ray tube becomes low, the common causes are a cathode faultily made in the first instance, or poisoned by the electro-chemical action of residual gases which are present because the pumping was not good enough, or blocked by the formation of an interface (electro-chemical action again) between the metal part and the emissive coating. Common purely mechanical faults are disconnections, poor contacts and short circuits. Resistors or capacitors may break down if such a fault subjects them to loads a good deal beyond what they are designed and rated to carry. Composite resistors not infrequently "go high," or "go low," owing, I suppose, to electro-chemical effects. It seems, then, that the electronic engineer, the chemist and the mechanical engineer concerned with the design and production of receivers and components have all their parts to play in improving reliability and that their responsibilities are very closely inter-related. You can't blame the mechanical engineer if his products are misused or grossly overloaded by accident, it is the job of the electronic engineer to devise means of ensuring that such things don't happen. The chemist (and the metallurgist too) have big parts to play in the selection of suitable materials.

### *Dust*

ONE feature I'm glad to notice in some of this year's television receivers is the protective mask easily detachable from the front. The seal between the mask and the big end of the cathode-ray tube isn't always as dust-tight as it should be. However clean the room in which a TV set is used there's always sure to be a good deal of fire dust in the air. This is sucked in through the louvres and moves, when the set is warmed up, at a fairly high speed about the "works" inside the cabinet. If the aforesaid seal is poor, dust gradually collects on the glass over the screen, forming unsightly patches. It's annoying for the knowledgeable viewer to have to remove the chassis from the cabinet in order to clean it off. And it's still more annoying for the unskilled viewer who has to summon his dealer every so often and to pay for his services. May we, please, beg manufacturers to give us really dust-tight seals, or masks which can be quickly removed from the front?

### "*Tweediness*"

IN the Norwich area, where the TV transmitter is still working on low power, though the v.h.f. sound service is going full out, what people call "tweedy" patterning is very much in evidence, particularly in or near the television fringe areas. Both transmissions are horizontally polarized, so it's perhaps not altogether surprising. Fortunately, the patterning can be virtually eliminated by the use of a filter designed for the purpose—though it's a bit surprising to find how many people to whom the cost of a filter would be neither here nor there regard the interference as just one of those things and do nothing about it. A more serious nuisance, because no filter can cope with it, is interference from the Belgian television transmitter at Liége. Luckily, it's not always in evidence; though when it is it pretty well ruins the picture. Things should be better before the end of the year, for I hear that the B.B.C., the G.P.O. and the Belgian authorities have worked out between them a means of minimizing the trouble.



*(From a photograph taken in one of the E. K. Cole factories.)*

# UNBIASED

By FREE GRID

## *The Torso Two*

I WONDER if you happened to read with as much interest as I did, the account given by "Diallist" (Sept. issue) of how a stone-deaf man was made to hear by sticking one end of the secondary of an audio transformer into his auditory nerve and the other end into a muscle. The secondary was placed under the skin by plastic surgery and the primary was outside the body over the area of the subcutaneous secondary.

The reason for my special interest is this. I have long had the idea of developing a portable receiver which was self-contained within the human body or, in other words, a personal receiver in the literal sense of the word. The great snag has always been to turn the a.f. electrical impulses into sound without the use of loudspeaker or headphones external to the body; now this problem has been solved.

Briefly my idea is to get a plastic surgeon to embed under my skin, at strategic points, a number of transistors and other components of Lilliputian dimensions; probably I shall start on a modest scale and call my initial effort the Torso Two.

These components will be connected in circuit not by having wiring put under my skin. I intend to use the modern technique of a "printed" circuit formed by tattooing. The "ink" used by a tattoo artist is not a good conductor, as I found when I made tests on a seaman's chest in a waterfront pub with a Megger, but by a simple addition it can be made so.

Thus it would be possible to tattoo many turns of "wire" around each of a man's legs. The turns would be tattooed on each leg in the opposite sense so that by varying the distance between the legs the same tuning effect would occur as we used in our old variometers years ago. No variable capacitor would be required.

There are one or two problems to be solved before my idea is ready for commercial exploitation. One question is that of self-contained battery power, for even transistors need a few volts. However, it must not be forgotten that the blood and other bodily secretions, such as serum and sweat, are salty solutions having some of the characteristics of the electrolyte of a Leclanché cell. It should surely not be impossible to embed a carbon and a zinc rod somewhere. If any of you have any ideas on the matter please let me know.

Chest test.

## *Worthless Wireless Facts*

RECENTLY I had a letter from a reader asking me if the oscillating crystal technique about which *W.W.* published a good deal of information in the early 'twenties was the forerunner of transistors. The question surprised me for *W.W.* has several times stated that this was so.

I don't think many readers realize how old oscillating crystal technique really is. I find from my scrapbook of worthless wireless facts, which I have been painfully putting together for many years past, that oscillating crystals date back to Edwardian days. They were demonstrated in action before the Physical Society of London by Dr. W. H. Eccles in May 1910; and when that month began King Edward VII was still on the throne.

This really means that the oscillating crystal preceded the oscillating valve, for although the triode was with us long before 1910 the principle of regeneration was not introduced until 1912. As for the transistor, it is my belief that by the time *W.W.* celebrates its jubilee in 1961, it will have almost completely displaced the valve in our receivers, and I thought the cartoon of the imperious transistor showing the door to the lachrymose valve, displayed on Pye's stand at the Radio Show, to be highly prophetic.

As I have already told you I have a mania for collecting in my scrapbook wireless facts which are not usually to be found elsewhere. Most of these facts are quite worthless but I am always glad to receive any of them. Maybe if you send me enough of them I will try to get a book published under the title of "Free Grid's Book of Worthless Wireless Facts."

## *Lament for the Past*

AS I mentioned some months ago there was a time when every reader of *W.W.* was familiar with the succinct abbreviation 1-V-2 as an adequate description of a certain type of receiver. The magic figures 1 and 2 together with the V formed the vital statistics of the set which conveyed as much information to the wireless fan of 1925 as the vital statistics of Marilyn Monroe do to the film fan of to-day.

Another long-forgotten thing known only to us "old contemptibles" of radio is the expression "tuning indicator." We used to put a simple milliammeter in the anode circuit of the detector to serve as an indicator of what was going on. In later days manufacturers gave us a thermionic tuning indicator and we used to refer to it as such, or as a cathode-ray indicator. Nowadays we use this device also as a recording-level indicator in our tape machines.

Unfortunately, however, the thermionic indicator had not long appeared when some manufacturer's publicity pundit evolved the comic-strip expression "magic eye" which instantly caught on and is now used by the most learned technologists. Such men would baulk at referring to the c.r.t. of their TV sets as a "magic mirror" or to a valve as an "Aladdin's lamp" although there is every bit as much justification for doing so.

However, by far the most astonishing instance of once-familiar things being lost in oblivion is the push-button set of the type with which we were all familiar a few years ago. At the show this year there were push-button sets in plenty but I found only one of them used the buttons for tuning-in stations; this particular one went the whole hog and housed the buttons in a remote-control unit. Maybe there were other sets using push-buttons for tuning which I missed and if so I should be glad to hear from their manufacturers. On the other sets I saw the buttons performed only the function of a wave-change switch.

What impressed me most, however, was that push-button tuning not only seemed to have disappeared but to have been forgotten. At the stand of a famous manufacturer where I enquired for a push-button tuned set I not only drew a blank but a look of blank surprise as well. The young man of whom I enquired had never heard of them but he did think the whole thing an excellent idea to pass to his firm's designers as a novelty for next year's show.