Wireless World

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As She Is Spoke

EVER since wireless telegraphy became practicable, the tongue that Shakespeare spoke has proved short of words for the clear expression of ideas connected with the new method of communication. True, the long-forgotten journalist who wrote, at the turn of the century, about "the message being flashed" was inspired. That phrase, though never quite to the taste of the professional, conveyed to the layman (at least in the days of spark transmitters) a vivid and not inaccurate impression of what really happened. But, after 50 years or more, messages are still being flashed, and the public seems sadly in need of a new phrase.

Of course, it was not until broadcasting came that radio made a big impact on the public at large. We then had an unrivalled opportunity to start off on the right foot. The word "broadcasting" itself was a first-rate example of figurative English, derived in accordance with the best tradition. It is with shame that we admit ignorance of the true paternity of this heaven-sent word. Was it of American origin? Anyway, "broadcasting" was at once adopted by the professional, but, with a queer lack of good taste, the man in the street showed a strange preference for "the wireless" and later for "the radio."

Each new development brought its own inept phraseology. Television was no sooner established than the expression "radio and television" began to trip off the lay tongue (and sometimes, alas, the professional one as well). A nice puzzle it must make for a foreign visitor with a mainly academic knowledge of English, who may reasonably guess that our television is transmitted pneumatically! We were not surprised to see the other day the headline "British Radio and V.H.F." in a lay journal.

The latest innovation in sound reproduction—ready-recorded magnetic tapes—might easily become the next victim of our genius for choosing the confusing name. They have been referred to as "pre-recorded tapes," which might mean virgin tapes, and "tape recordings," which might mean anything. Fortunately, there is some hope here that a reasonably clear and descriptive name will prevail. E.M.I., the pioneers of these new rivals to disc records, assure us they are to be known as "tape records."

The B.B.C. has not, we fear, proved itself a zealous guardian of the language of its own medium of communication. Some time ago a correspondent drew attention in our columns to the absurdity of that favourite B.B.C. expression "pre-recorded" by enquiring about the meaning of "post-recorded." We believe there is some subtle significance in such variants as "the programme was recorded," "pre-recorded" and "from a recording," but nobody seems to know the code. Then there is the most abominable of all B.B.C. words "tele-recording" which seems utterly unnecessary in any imaginable context. Why "tele-," when, in most cases, distance is not an essential factor? Unless the Corporation mends its ways, abominations like "the telly" will soon become respectable and accepted.

Anarchy in the Ether

RECENT newspaper stories about experimental transmissions from the so-called "Europe No. 1" station on the Felsberg make sad reading, and serve to emphasize the chaotic state of congestion on the medium and long-wave broadcasting bands. The station has been transmitting test signals on various frequencies between 238 and 255 kc/s. Naturally enough, as all the channels in that band are already occupied, severe interference has been caused, and protests have been made by the authorities concerned. The Saar has no allocation in the long-wave band, and so it is difficult to see any excuse for these attempts on the part of the station to find a niche for itself.

The Copenhagen Plan is almost a dead letter. For example, under it the two German Republics and Austria are allowed between them 15 medium-wave stations, but have actually 65, plus 37 stations run by the occupying Powers. Clearly, the only solution lies in drastic reduction of the number of medium-wave stations, with supplementary reinforcing services on v.h.f. To evolve a new plan on this basis must be the first task as soon as the international climate is favourable for a conference.

Television Society's Exhibition

AN annual event of importance to television enthusiasts, the Television Society's Exhibition, was held this year on January 6th-8th. Marconi's had a camera chain in operation, which provided shots of the exhibition itself, and Belling-Lee arranged the distribution of the signal and also of the B.B.C. programme to exhibitors demonstrating apparatus. Belling-Lee also had a demonstration of the effects of interference suppressors in television reception in Bands I and III. Under the conditions of test a Band I suppressor in the leads to a small motor proved very effective in eliminating interference on Band I, but was quite ineffective on Band III. It was shown that to obtain suppression here a special suppressor had to be mounted inside the motor frame close to the brushes. Dubilier showed inductors and capacitors for suppression, the inductors being miniature dust-core types which it is recommended should be connected in series with the motor field windings close to the brushes.

The effect of the form of modulation upon ignition interference was demonstrated by the G.E.C. A signal with positive or negative modulation was fed, with interference, to a receiver which could be appropriately switched to deal with either type of modulation. The superiority of positive modulation was most evident. Although the black spots of interference with negative modulation were in themselves less evident than the white spots with positive modulation, the synchronizing was so greatly affected that the picture was useless, whereas with positive modulation the synchronizing was hardly affected at all.

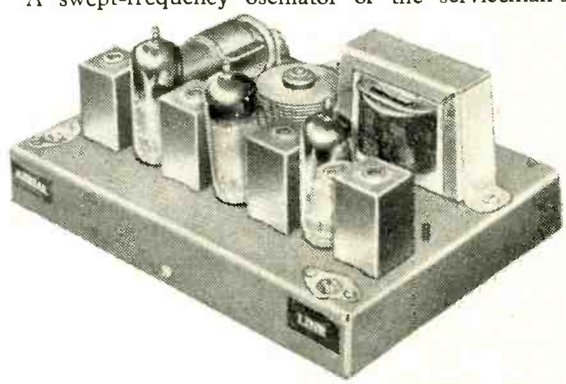
Interference is, of course, a matter of major importance in fringe areas, and a scheme which may well reduce it and also permit a useful signal to be obtained in screened locations was shown by J. S. Fielden. This is a three-valve pre-amplifier designed for mounting on an aerial pole and powered by a 50-c/s supply which can be fed to it through the same coaxial cable that is used for the signal. It is intended for use where it is possible to take advantage of neighbouring high ground to erect an effective aerial, perhaps at some distance from the receiver. The repeater 2000/S5 has a bandwidth of 10 Mc/s and can be used with solid-dielectric coaxial cable at distances up to 500 yards or with semi-air spaced cable up to 1,000 yards. It operates on Band I. For Band III a convertor unit will be available which will be pre-set to change the frequency of the Band III signal to a Band I channel adjacent to the normal Band I signal, so that the repeater will handle both signals.

Another kind of repeater, intended as a line amplifier for a television relay system, was shown by G.E.C. The interesting thing about this was the use of transistors instead of valves. The advantages of transistors for this type of application are, of course, their small size, robustness and need for only one supply of low-voltage power. The amplifier actually uses experimental point types, and it works at a centre frequency of 5 Mc/s with a bandwidth of 3 Mc/s. A gain of 32 db is obtained and the frequency response is flat to within ±0.5 db over the 3-Mc/s band.

Test apparatus naturally formed a large section of the exhibition, and of particular interest was the equipment developed by Bush Radio for the testing and alignment of television sets in production. The heart of the instrument is a swept-frequency oscillator covering about 33–39 Mc/s for i.f. alignment using a cathode-ray display. Spot frequencies are also available for sound-channel rejector adjustment and checking.

The i.f. sweep can be heterodyned to the video range and the resulting video sweep used to modulate r.f. carriers in Bands I and III. Complete television signals, both sound and vision, are provided on three channels in each band, and the vision signal is modulated in alternate "lines" by the video sweep and by a 5-μsec pulse. The receiver output is displayed on a double time-base tube to show the overall video response and the pulse response. Final alignment and adjustment can then be carried out in an overall test. The outputs are "piped" around the factory to the test positions.

A swept-frequency oscillator of the serviceman's



Television pre-amplifier by J. S. Fielden; for a remote aerial.

Band III convertor (below) for the type 1320 Cossor Telecheck swept-frequency oscillator (above).

type was shown by Cossor. This is the 1322 Telecheck which covers Bands I and III and gives a 10-Mc/s sweep on its fundamental and proportionally more on its harmonics. The fundamental range is 10-22 Mc/s. A crystal-controlled marker generator is included. A Band III convertor, model 1321, for the older 1320 Telecheck, which covered Band I only, was shown. It is arranged to screw on to the 1320 instrument.

Amongst an interesting selection of American test gear shown by Livingston Laboratories was an oscilloscope designed for maintenance and adjustment of television transmitter and studio equipment—the Tektronix type 524-D. It can be used for observing the waveforms of complete television frames or single lines or portions of lines. The Y amplifier has a maximum frequency of 10 Mc/s and is flat to 5 Mc/s, while the timebase rate is continuously variable from 0.01 sec per centimetre to 0.1 μsec per centimetre. Special features include variable sweep delay, sweep expansion (for magnifying detail), an amplitude calibrator and time markers at intervals of 1 μsec, 0.1 μsec and 0.05 μsec.

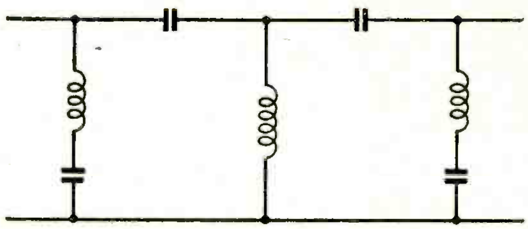
Radio-Aids showed a small three-stage i.f. amplifier feeding a crystal detector and microammeter. It is available pre-tuned to any Band I channel and calibrated to measure signal inputs up to 1 mV. It is intended for use in aerial and feeder testing and, with a known aerial, for determining the field strength so that a dealer may decide beforehand what sort of aerial it will be necessary to erect.

Apparatus for the measurement of oscillator drift on Band III was shown by Ferguson. A crystal-controlled signal is fed into the receiver under test and the i.f. output is mixed with another crystal-controlled oscillator. The initial adjustment is to zero beat. Oscillator drift then causes the beat frequency to rise and this is recorded by a Servograph.

Printed-circuit technique is developing rapidly and T.C.C. showed many examples. One of considerable importance for the future was the basis of a Band III tuner and well showed the advantage of the technique in securing uniformity of lead length in production. Another example was an aerial filter, intended for receivers using a 34.65 Mc/s i.f., to prevent i.f. breakthrough. With the circuit of Fig. 1, the coils and capacitors are all printed. The insertion loss is 2 db and at all frequencies below about 41 Mc/s the insertion loss is never less than 20 db and reaches a maximum of 34 db at 38 Mc/s.

There was very little evidence of work on colour television except in the field of cathode-ray tubes. 20th Century Electronics had modified one of their four-gun oscilloscope tubes so that the screen was divided into four quarters, one having an ordinary white phosphor and the others having red, green and blue phosphors respectively. The four electron guns were arranged in a corresponding pattern, with one directed on each phosphor, so that it was possible to display white, red, green and blue television pictures simultaneously. Each gun had its own electrostatic deflection plates and these were fed from the common scanning generators through blocking capacitors so that individual shift voltages could be applied. It was also possible to control the brightness and contrast of each picture separately.

On the Mullard stand were some 14-inch experimental c.r. tubes with coloured phosphors, intended for use in colour-picture monitors of the type in which the three coloured images are combined optically by dichroic or half-silvered mirrors. The tubes, which



T.C.C. printed "i.f. breakthrough" filter.

are electrically identical and operate with 12 kV on the final anode, are the types 36CDD12-3, -4 and -5, having blue, green and red phosphors respectively. Another new experimental tube shown by Mullard was the 4MK13 flying-spot scanner, intended for use at the transmitting end for scanning coloured slides and films. To obtain the necessary high level of brightness the anode of the triode gun operates at 25 kV, while the 5-inch screen is claimed to give a substantially panchromatic light output.

Various colour phosphors were demonstrated in Ferranti cathode-ray tubes by the chemical manufacturers Derby & Co., and here the difficulty of producing a good red-emitting phosphor was very evident. Most of the colour television demonstrations so far have, in fact, given rather poor colour rendering in this particular component.

TELEVISION STANDARDS CONVERSION

Possibility of Direct Electronic Method

By H. A. FAIRHURST*

STANDARDS conversion in television is by no means new, but it is probably not common knowledge that there is a possible alternative to the "brute force" method (of a camera viewing a c.r.t. monitor) used during the "Eurovision" programme exchanges. Whether this alternative could be developed into a system capable of giving acceptable results is not known, but it has a sound theoretical basis and has been proved to work on the bench.

The fundamental principle of the alternative system is that selected lines of picture information at the higher definition are stretched in time until each occupies the line duration of the lower definition system. This is performed by feeding the selected picture line into a delay line of sufficient delay to accommodate the whole slice of information at once, and then switching the characteristics of the delay line while the information is still all inside the line so that when it does emerge it does so at the new desired rate.

Because the higher definition lines occur at a greater rate than those at the lower definition, some of them must be sacrificed, but from the point of view of the lower definition user he will not miss what he has never had, and as the system is theoretically capable

* Murphy Radio.

of giving full horizontal definition his picture should be fully up to standard.

The system works in its simplest form if certain fixed relationships are preserved between the two standards. For example, it is assumed that the frame frequency is the same in the two cases. It is also assumed that the line frequencies are related in some simple manner—2:1, 3:2, 5:3, etc. This can be argued to be a definite disadvantage of the system, for these particular ratios, assuming 405 lines to be the lower definition standard, call for 405 lines, 50 frames, sequentially scanned, 607½ lines interlaced, and 675 lines interlaced, respectively, in the corresponding higher definition systems.

A 405-line non-interlaced system is a case by itself and will not be further considered here, while 607½- and 675-line systems do not appear anywhere as accepted standards. However, of these three, it can be shown that only the 675-line system is an acceptable higher definition to be linked by electronic standards conversion to 405 lines, and this because of the desirability of preserving the interlaced scan.

For the purposes of illustration, the 675-405 line case is shown in Fig. 1, which indicates the sequence of lines chosen from the higher definition (numbered) to make the consecutive lines at the lower definition (broken lines). Three delay lines are required to handle the information without overlap, and the form and timing of the delay line switching pulses are shown. Owing to the need to use three only out of every five high-definition lines, and to the consecutive nature of the lower definition lines, there will be a regular

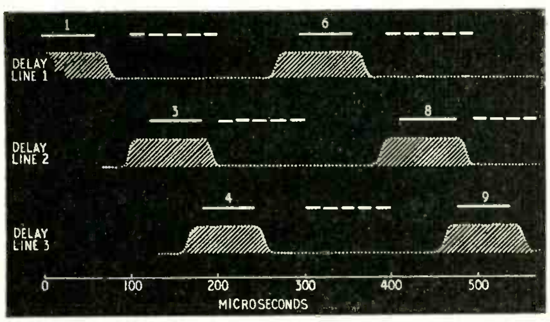


Fig. 1. Showing how the high-definition lines (numbered) are selected and distributed in sequence to the three delay lines, where they are stretched in time to produce the lower-definition lines (broken lines) which follow continuously upon each other. The waveform of the delay-changing current is shown for each delay line.

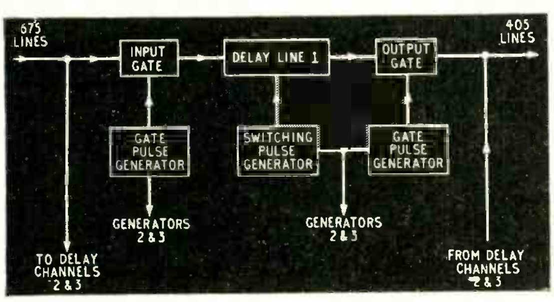


Fig. 2. Simplified block diagram of one of the delay channels. The input gating generators are controlled by the 675-line sync pulses and the output gates from a 5 : 3 count-down circuit operated by these pulses.

slight deformation of the picture in a vertical direction, but this can be shown to be a fixed pattern and normally invisible.

As three delay lines are required to handle the conversion, it is necessary to provide switching and gating circuits to switch the desired picture lines into the correct sections and also to sample the three outputs in turn so as to combine them into the lower definition signal. At the same time means must be provided for switching the constants of the delay lines at the correct times and for the correct durations. Fig. 2 is a simplified block diagram of one of the delay channels.

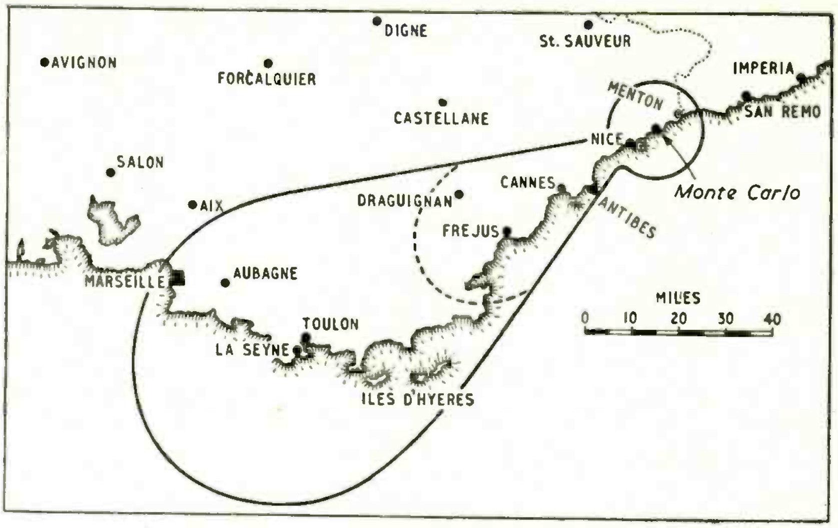
What of the delay lines themselves? The criterion here is that their constants must be capable of being switched to change the velocity of propagation through them. This could be done by winding the elements of the line on closed ferrite cores which can be saturated magnetically by current flowing through an additional winding. One arrangement successfully tried was to wind each element of the delay line as a toroid on a small ferrite ring and then to string them all on to a copper rod through which was passed the saturating current. Such a coil wound on a grade of ferrite suitable for the frequencies involved has its inductance reduced to nearly one-sixth when the core is saturated, so the smaller change required for the conversion process is easily obtained with quite practicable saturating currents.

Further removed, perhaps, from the bounds of possibility is the number of elements required in each line to obtain the requisite delay. It will obviously be a large number, and will depend a lot on the phase characteristic that can be maintained, but if a cut-off frequency of 20 Mc/s be assumed, with the values of $L=25\mu H$ and $C=10\,pF$ the number works out to be over 6,000. This would present a pretty problem for the designer, but it is no doubt not insoluble.

Fig. 2 is very much simplified and gives little hint of the complexity of circuitry which may be involved. It does not indicate, for example, that means must be provided for obtaining an exact timing of the outcoming information and for matching the outputs of the three delay lines. Fortunately the time intervals allow the saturating current pulse to be shifted a few microseconds either way, and this facility could provide a micrometer adjustment on the time the information spends in the line and, therefore, of the instant it begins to emerge. Control of the duration of the outcoming line of information can be achieved by varying the actual amplitude of the saturating current pulse. In this connection it must be noted that the saturating current must have a d.c. component in order to prevent any tendency to saturate the cores in both directions.

Bench experiments with short sections of line have demonstrated the stretching of a pulse and also the various other effects that would be expected on theoretical grounds when the constants of a line carrying a signal are switched. These experiments have shown that to develop such a standards convertor would be a major undertaking, but they have not shown it to be impracticable.

A system of conversion such as this offers one kind of solution to the problem of compatibility in colour television. It would make possible, for example, the transmission on 405 lines of monochrome versions of colour pictures which were being put out on some higher definition system—or, indeed, the transmission of coloured 405-line versions of these higher definition colour pictures.



Estimated polar diagram for the transmitter when it is on full power. The dotted line shows the present estimated coverage.

By

CHARLES B. BOVILL

A.M.I.E.E., M.Brit.I.R.E.

MONTE CARLO TELEVISION STATION

WITH several different standards being used for television in Europe, it was inevitable that eventually the problem of a transmitter located on a "standards frontier" should arise, and it is therefore of interest to examine what has been done in the case of the Monte Carlo television station which was recently put into service.

This station, which is the second commercial television station to be opened in Europe (the other is in the Saar), is situated on Mont Agel, a 3,500-ft mountain overlooking the Principality of Monaco and only some 10 miles from the Franco-Italian frontier.

Since the station is sponsored commercially, and the sponsors are French and handling the publicity for French merchandise, the role of the station is to serve the thickly populated area lying between Menton to the east and Toulon and Marseille to the south west. As Italian television standards differ from the French 819-line system the transmissions would not normally be receivable in Italy. Special receivers will soon be available for this area, however, so that programmes intended for Italian viewers will also be possible.

The design of the station therefore called for the maximum cover towards the south east, and adequate cover for the Principality and French towns extending to the Italian frontier. It will also be appreciated that there is no requirement for any cover over the sea over an arc of about 150 degrees to the south east and south west, nor for cover over the almost uninhabited Alpine region to the north.

The rather special cover requirements have enabled the designers and manufacturers of the station, the Société Radio Industrie, to construct a most economical and effective installation by the use of directional high-gain aerials. The aerials, which are of bat-wing type, provide a main lobe with a horizontal width of about 45 degrees which provides the main Riviera cover towards Nice, Cannes and Toulon. Very small secondary or side lobes—usually a serious problem to eliminate in directional aerial design—provide, with slight modification to the aerial array, the necessary cover for the nearby towns towards Italy. The aerial arrangement incorporates radiators for video and for sound, each having a power gain of about 10, the effective radiation on the video frequency of 199.7 Mc/s being 50 kW and on sound 12.5 kW at a frequency of 188.55 Mc/s. The polarization is horizontal for both video and sound and the French 819-line standard is used, requiring of the aerials a bandwidth in excess of 10 Mc/s. The standard arrangement for France of single sideband transmission is retained.

Next year the power will be increased and the coverage improved as a result.

Preliminary reports of reception indicate very satisfactory results, with clear and steady pictures at St. Tropez, 50 miles from the transmitter. Since the signal travels partly over water to some of the towns to be served by the main lobe, this result is probably to be expected, but it is also reported that good reception is obtained at inland towns such as Draguignan, at which position the signal path is over soil which is notorious for its poor conductivity.

The studios from which the programmes originate are situated in the town of Monte Carlo some 3,000ft below and two miles from the transmitter aerials. In order to avoid the use of buried coaxial cables and their attendant expense for installation and maintenance, and in order to avoid phase distortion in the cables, a duplicated 4-cm radio link conveys the modulations to the transmitters.

The sponsors of the Monte Carlo television station are the "Images and Sound" group, which also operates the Saar television station and which will shortly put into service the extra high-power sound broadcast station for sponsored programmes at Felsberg.

The commercial programme policy of this group is original and differs from that practised in the U.S.A. in several respects. As an example, the group themselves arrange and compose the programmes which are acquired by the publicity organization and the advertising matter is integrated into the programme in a restrained way. Also, the publicity is restricted to one minute every quarter of an hour.

WORLD OF WIRELESS

Colour Prospects ✦ Anglo-French TV Link ✦

B.B.C. Band II Frequencies ✦ Another "Festival of Sound"

Television News

RECENT pronouncements on the possibilities of the introduction of colour television by the B.B.C. within the next two years have been clarified by E. L. E. Pawley (head of Engineering Services). He points out that the decision has yet to be made by the Government (with the advice of the T.A.C.) whether or not we are to have a compatible system. The B.B.C. Research Station is in fact experimenting with the American N.T.S.C. compatible system adapted to our 405 lines with a 5 Mc/s bandwidth, but is also working on a non-compatible system. This would require a greater bandwidth and, therefore, could not be accommodated in the present channels in Bands I and III. Sir George Barnes, B.B.C. director of television, thinks a decision may be reached by the end of the year.

As part of the permanent cross-channel television link to be established by the Post Office a two-way cable link between London and St. Margarets Bay is to be rented permanently by the B.B.C. Presumably the Post Office will be able to provide similar facilities for the I.T.A. should they be required. Until the permanent stations for the cross-channel link are set up in about three years' time the cable will be extended from St. Margarets Bay to Swingate, near Dover (a distance of about two miles), where the B.B.C.'s temporary radio link with Cassel is installed.

Test transmissions from the temporary low-power television transmitter at Tacolneston, 10 miles south west of Norwich, started on January 17th. It is planned to bring the station into regular service on February 1st. Operating in Channel 3 (carriers 56.75 Mc/s vision and 53.25 Mc/s sound, slightly offset) with horizontal polarization, the temporary station will serve an area bounded by Aylsham, East Dereham, Watton, Diss, Beccles and Acle. Vision signals from Alexandra Palace will be picked up near Bury St. Edmunds and relayed by radio to the transmitter site. Sound will be conveyed from Alexandra Palace by line.

For testing Band III aerials and receivers under practical conditions a test-pattern vision signal is to be radiated from a temporary 1-kW transmitter near the site of the I.T.A. South London station. The transmissions, which are due to start on April 1st, are to be conducted by Belling & Lee.

Baird Memorial

AN appeal for funds for a Baird memorial has been launched by the Royal Technical College, Glasgow, where Baird was a student from 1906 to 1910. It is proposed by the governors of the college to establish an annual memorial lecture on developments in television and related fields and to provide a Baird prize in the Department of Electrical Engineering. Donations to the Baird Memorial Fund should be sent to the Secretary/Treasurer, Royal Technical College, George Street, Glasgow, C.1.

V.H.F. Broadcasting

WITH the announcement of the P.M.G.'s approval of an additional v.h.f. station at Wenvoe—making 10 so far approved by the Government—the B.B.C. has made known the frequencies to be used by the 30 transmitters at these stations. The frequencies, together with the e.r.p. for each transmitter, are given in the table below. Incidentally, with the exception of those for Holme Moss and Blaen Plwy, the frequencies conform to the plan for Band II drawn up at Stockholm in 1952. The frequencies given for Wenvoe, however, have yet to be confirmed by the Post Office.

	Home (Mc/s)	Light (Mc/s)	Third (Mc/s)	E.R.P. (kW)
Wrotham (Kent)...	93.5	89.1	91.3	120
Pontop Pike (Co. Durham) ...	92.9	88.5	90.7	60
Divis (N. Ireland)	94.5	90.1	92.3	60
Meldrum (Aberdeenshire) ...	93.1	88.7	90.9	60
N. Hessary Tor (S. Devon)	92.5	88.1	90.3	60
Sutton Coldfield (Warwicks.) ...	92.7	88.3	90.5	120
Norwich	94.1	89.7	91.9	120
Blaen Plwy (Cardigan.)	93.1	88.7	90.9	60
Holme Moss (Yorks.) ...	93.7	89.3	91.5	120
Wenvoe (Glam.)...	94.3	89.9	92.1	120

When announcing the inclusion of Wenvoe in the first batch of v.h.f. stations, scheduled to be completed by the end of 1956, the P.M.G. stated that the Television Advisory Committee had recommended the adoption of the B.B.C.'s long-term plans for v.h.f. development. We understand that these provide for a total of 26 stations, at most of which there will be three transmitters or even a fourth where a station serves two regions.

Repeat Performance

AS announced in December, G. A. Briggs, of Wharfedale Wireless, is giving another lecture-demonstration on sound reproduction at the Royal Festival Hall, London, on May 21st. Tickets are priced 5s 6d and 3s 6d. Within a few days of the announcement of prices, all the tickets for the cheaper seats were sold, but as we go to press there are still some 5s 6d tickets available from "hi-fi" dealers in London.

Mr. Briggs is also giving a similar demonstration in St. George's Hall, Bradford, on April 1st, at 7.30. Tickets at 3s 6d and 2s are available from J. Wood & Sons, Sunbridge Road, Bradford.

Valve "Balance of Trade"

WHILE the exports of valves and c.r. tubes continue to decrease imports of these accessories have increased by over 100 per cent during the past year.

Exports of valves during the first eleven months of 1954 (the latest analysed figures available) totalled £1,743,692, and cathode-ray tubes £122,729, whereas the comparative figures for 1953 were £1,867,079 and £147,590. The actual numbers of valves and cathode-ray tubes exported were 4,447,548 compared with 4,643,005 in 1953.

Figures for the first eleven months of 1954 compared with the same period in 1953 show an increase of 131 per cent in the number of valves imported and 66 per cent in the number of c.r. tubes coming into the country. The total value of these imports was £3,075,419 compared with £1,679,352 the previous year.

"Wireless World" Index

THE index to the material published in *Wireless World* during 1954 is now available from our Publishers, price 1s (postage 2d). It includes both general and classified indexes. Cloth binding cases are also obtainable with index, price 6s 5d by post. The binding of readers' own issues can be undertaken by our Publishers, the cost, including binding case and index, being 17s 6d plus 1s 4d postage on the bound volume.

NEW YEAR HONOURS

Among those receiving decorations in the New Year Honours List are:—

C.M.G.

R. C. McCall, assistant director of television, B.B.C.

O.B.E.

J. Clarricoats, general secretary, Radio Society of Great Britain. (See "Personalities.")

V. M. Roberts, manager, electronic sales department, B.T-H. (See "Personalities.")

M.B.E.

S. W. Brown, chief radio officer (I.M.R.C.) of s.s. *Scythia*.

D. Fairweather, chief of crystal production, Marconi's W.T. Company.

H. L. Peddle, signals officer, telecommunications department, Ministry of Transport and Civil Aviation.

J. J. Sarche, chief inspector, Ultra Electric, Ltd. (See "Personalities.")

B.E.M.

R. Carter, laboratory mechanic, Royal Navy Signal School.

C. W. Jacobs, chargehand (mechanic), Radar Research Establishment, M.o.S.

PERSONALITIES

B. G. H. Rowley, M.A.(Oxon), A.M.I.E.E., Marconi's technical representative in the U.S.A. and Canada since 1950, has been appointed manager of Marconi's Maritime Division in succession to **G. R. Tyler,** who, although having reached retiring age, is continuing with the company as its representative in West Africa. Mr. Rowley was concerned with the development of marine radar at R.N. Signal School at the beginning of the war and was subsequently appointed to the staff of the British Admiralty delegation in Washington. From the end of the war until joining Marconi's he was staff radar officer (Lt. Cdr.) with the Joint Services Mission in America.

Dr. W. J. Thomas, Ph.D., B.Sc., A.M.Brit.I.R.E., has left the Norwood Technical College where he has been since 1947—for the last four years as principal. He has been appointed one of H.M. Inspectors of Schools, the major part of his work being concerned with technical colleges in South Wales. It was largely due to his interest that the Television Society's experimental transmitter was installed in the college, which also houses the society's museum. For a short period at the beginning of the war Dr. Thomas was education officer at the R.A.F. Radio School, Cranfield, and from 1942 until the end of the war was senior instructor at the Army Radio School, Petersham, Surrey.

John Clarricoats, G6CL, the well-known general secretary of the Radio Society of Great Britain, who is appointed an O.B.E. in the New Year Honours, recently completed 25 years' service with the society. In addition to receiving a gift from the members, mentioned last month, he was also awarded the R.S.G.B. Calcutta Key "in recognition of his outstanding service to the cause of international friendship through the medium of amateur radio."

Vernon M. Roberts, B.Sc., A.M.I.E.E., appointed an O.B.E. in the New Year Honours, has been with B.T-H. since 1924, when on graduating at the University of Wales he started a three-year student apprenticeship. During the war he was concerned with the development and production of radar equipment. He is now manager of the company's electronic sales department and a director of Multi-Broadcast (Engineering), Ltd. Mr. Roberts has for some years represented B.T-H. on the Radio Communication and Electronic Engineering Association, of which he was chairman in 1950.

J. J. Sarche, who has been appointed an M.B.E., has been with Ultra Electric, Ltd., for 33 years. He is now chief inspector at the company's Western Avenue factory, having previously been assistant chief engineer.

F. E. Debenham, the new manager of the Service Department of Mullard's Valve Division, at Waddon, Surrey, has been with the Mullard group of companies since 1929. For some years during the war he was production manager at the Mullard valve factory at Blackburn. He succeeds **E. B. Rogers,** who has retired after 28 years with the Service Department.

J. CLARRICOATS, O.B.E.

V. M. ROBERTS, O.B.E.

J. J. SARCHE, M.B.E.

F. E. DEBENHAM

David L. Davies, B.Sc., Grad.I.E.E., has been appointed chief electronics engineer of Winston Electronics, Ltd., of Hampton Hill, Middlesex. Graduating at University College, Swansea, in 1948, he joined the staff of the Engineering Department of Edinburgh University, where he was lecturer in electrical engineering for three years. Immediately prior to joining Winston Electronics last January, at the age of 26, he had been working on guided missiles with English Electric.

E. J. Gargini, author of the article "Piped Scanning Waveforms" in this issue, received his technical training at Southall Technical College. After a short period as a trainee at the E.M.I. and Philco organizations he served in the R.A.F. during the war. He rejoined the E.M.I. Group in 1945, where he has been concerned in the design of cinema sound equipment, multi-channel radio-frequency relay systems, and wired television distribution equipment. He has been recently seconded to the research organization to work on domestic colour television.

Arthur W. Wayne, who describes a simple wave-shaper elsewhere in this issue, is both a professional engineer and a professional musician, a combination which he finds invaluable as a designer of sound-reproducing equipment. He has been a consultant dealing chiefly with acoustics for some years and last year formed Shirley Laboratories, Ltd., of Worthing, for the manufacture of amplifiers, tuners and electronic instruments.

IN BRIEF

The annual I.E.E. **Faraday Lecture,** which is "designed to appeal to the layman," is this year being given by T. B. D. Terroni, B.Sc., manager and chief engineer of the Transmission Division of the Automatic Telephone and Electric Company. His subject is "Courier to Carrier in Communications." The lecture will be delivered at the Central Hall, Westminster, on January 27th, at 6.0. Tickets must be obtained from the I.E.E., Savoy Place, London, W.C.2.

The demand for admission to the laboratory course in **Pulse Techniques** to be held at the Borough Polytechnic, Borough Road, London, S.E.1, on twelve Wednesday evenings, beginning on February 23rd, has been so great that it is to be repeated. It will be given on Monday afternoons from April 18th and again on Wednesday evenings from April 20th. The fee is 2 guineas.

A Spanish Edition of Scroggie's "Foundations of Wireless" has been published with the title "Fundamentos de Radioelectricidad." It has been produced by Editorial Alhambra, S.A., of Madrid, and costs 195 pesetas.

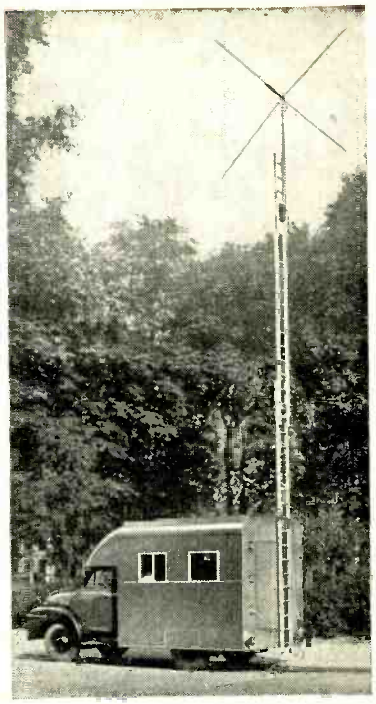
North America's third distant early warning (DEW) radar chain will be within the Arctic Circle. The first, now almost complete, runs across southern Canada, and the second is on the 55th parallel.

Soviet Colour Television.—Experimental transmissions of field-sequential colour television have recently been radiated from the Moscow television centre. An additional mast has been erected at the centre and a specially equipped studio is to be provided.

CLUB NEWS

Birmingham.—At the meeting of the Slade Radio Society on February 18th at 7.45 at the Church House, High Street, Erdington, R. Rew (G3HAZ) will give a lecture demonstration on "Equipment for Seventy Centimetres."

Cleckheaton.—Two *Wireless World* contributors will be giving lectures to the Spen Valley and District Radio and Television Society in February. On the 9th at the Temperance Hall, Cleckheaton, Dr. K. A. Exley will speak on audio reproduction, and on the 22nd at the Bradford Technical College, Dr. G. N. Patchett will deal with transistors. Both meetings begin at 7.30.



MOBILE v.h.f. test unit, with aerial mounted on a 40-ft extensible ladder, has been brought into service by Philips for field-strength measurements. Interchangeable aerials are carried and these are electrically rotated.

Newark.—"Transistor Circuitry" is the subject of the talk to be given by C. L. Wright (G3CCA) to the Newark and District Amateur Radio Society at 7.0 on February 6th at the Northern Hotel, Newark.

Windsor.—In response to requests from past and present students of the East Berkshire College, a radio society has recently been formed and meets on Thursdays at 7.0 at the Royal Albert Institute, Windsor. Details of the facilities provided by the club, which has its own transmitter, G3KAL, are obtainable from F. H. Rickards, East Berks College, Royal Albert Institute, Windsor.

Leicester.—A member of the Leicester Radio Society will speak on power supplies at the meeting on February 14th. A fortnight later the chairman will deal with grid-dip oscillators; their construction and application to amateur radio. Meetings are held at 7.30 at the Club Room, Holly Bush Hotel, Belgrave Gate, Leicester.

BUSINESS NOTES

Baird-Ambassador Merger.—Hartley Baird, Ltd. (formerly Baird Television), of 37, Thurloe Street, South Kensington, London, S.W.7, manufacturers of television receivers and tape recorders, has acquired Ambassador Radio, the well-known manufacturers of domestic radio and television sets. R. N. Fitton, managing director of Ambassador, has joined the board of Hartley Baird as director in charge of radio and television. Ambassador will continue to operate as a separate company.

A contract has been awarded to **Nash and Thompson, Ltd.,** Tolworth, Surrey, for the electrical, physical and mechanical testing of electronic components, excluding valves, to the requirements and under the direction of the Radio Components Standardization Committee. Claimed to be the first of its kind to be granted to a commercial undertaking it supplements the testing and proving of newly designed equipment carried out by the Government research establishments.

The "Martinet" automatic steering device for small craft developed by **Hartley Electromotives, Ltd.,** will be produced at their Shrewsbury factory, but the **Marconi Marine Company** will be the sole concessionaires. The device was shown for the first time on the joint Marconi-Hartley stand at the recent National Boat Show at Olympia.

The name of Blick Engineering, Ltd., of Bedesway, Bede Trading Estate, Jarrow, Co. Durham, has been changed to **Blickvac Engineering, Ltd.** The company, which manufactures high-vacuum impregnators, potting resin impregnating and casting plant and other high-vacuum equipment, has a London technical representative at the offices of the associated company, Blick Time Recorders, Ltd., 96-100, Aldersgate Street, London, E.C.1 (Tel. Monarch 6256).

A new prefabricated factory building is being erected at Shepperton for **Winston Electronics, Ltd.,** who develop and manufacture electronic equipment for the Services, for many diverse branches of industry and for telecommunications.

The London sales office of **Pye Marine, Ltd.** (formerly Rees Mace Marine) at 11, Hinde Street, W.1, is now closed and the London area sales and service headquarters are at Galleons Works, Yabsley Street, E.14 (Tel. East 4216). The office of R. I. T. Falkner, the sales director, is now 157, Regent Street, London, W.1 (Tel. Regent 2712).

Excel Sound Services, manufacturers of the Celsonic tape recorder, were given the task of recording the Bradford Festival Choral Society's recent concert and from the tape produced discs of the programme highlights for members of the society.

Two British aircraft manufacturers—de Havilland and Bristol—are now using miniature **Pye Industrial TV** cameras for research purposes. In one case the equipment is being used to detect the presence of flame in a new engine being tried out in the bomb bay of a test aircraft. The camera is focused on to the engine (which is in complete darkness) through a heat-resistant glass panel. While the monitor on the pilot's dashboard is blank he knows that all is well.

The reconstructed premises of the **G.E.C.** in Wellington Street, Leeds, destroyed by fire two years ago, were reopened in December.

FOREIGN TRADE

Each of the 40 Vickers-Armstrong Viscount aircraft ordered by Capital Airlines (U.S.A.) is to be fitted with **Marconi** automatic direction finders. The standard Marconi radio compass has been modified for operation in North America.

U.S. Import Tariff.—A three-fold increase in the import tariff on radio and electronic equipment is called for by the American Radio-Electronic-Television Manufacturers' Association. The duty was reduced from 35 per cent to 12.5 per cent in 1951. The R.E.T.M.A. states in a report quoted by the *Financial Times* that imports from the U.K. in the first eight months of last year totalled $607,000, compared with $463,000 for the whole of 1953. During the same periods imports from Germany were $295,000 and $109,000, respectively.

S.T.C. and **Marconi's** have jointly been awarded a contract for supplying radio-telephony and telegraphy equipment for a new external telecommunications station being built in Addis Ababa, Ethiopia. S.T.C.'s share of the contract includes two 4-kW transmitters; telephone terminal equipment providing two simultaneous telephone channels and voice-frequency telegraph equipment providing two telegraph channels. Marconi's will be responsible for the receiving equipment and aerial installations.

The Near East Arab Broadcasting Station at Limassol, Cyprus, from which commercial programmes are broadcast to the Arabic speaking countries, is being equipped with a 100-kW medium-wave transmitter and a 20-kW short-wave transmitter by **Marconi's.** Twin 350-foot directional mast radiators have been erected by **B.I. Callenders.** The station operates on 635 kc/s and in the 25, 31 and 49 metre bands.

PUBLICATION DATE

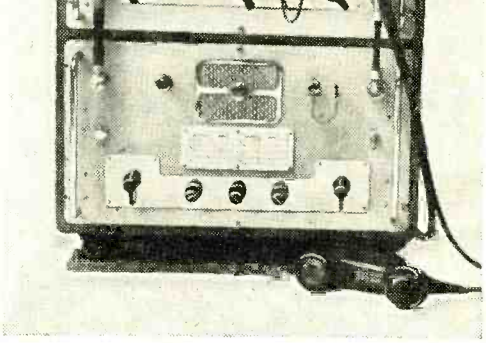
As already announced *Wireless World* now appears on the fourth Tuesday of the month preceding that for which it is dated. The March issue will, therefore, be published on February 22nd

Radel, Ltd., of Strand Road, Ashar, Basrah, are interested in acting as **Iraq Agents** for British radio and electronic equipment and are also seeking tenders for the supply of 500 domestic receivers. They require wired chassis with accessories but with a "prefabricated cabinet to be assembled on site." The universal 5-valve receiver must cover two short- and one medium-wave band, operate on 230 V and have Arabic characters on the tuning scale. Interested manufacturers should communicate in the first place with the company's British representative, L. C. Jenkins, 460, Wilbraham Road, Manchester, 21 (Tel. Chorlton 1801).

Cossor's have supplied four medium-power communications installations (No. 53) to the ruler of Kuwait, Persian Gulf. The equipment, which can be operated as a mobile or fixed station, has facilities for c.w., m.c.w. and R/T, and can be remotely controlled.

MERCHANT SHIPPING R/T

UNDER the Merchant Shipping (Radio) Rules, 1952, it is compulsory for all vessels between 500 and 1,600 tons (which class includes small coasters, tramps, tugs and large fishing craft) to carry radio-telephone equipment. These rules came into force on November 19th last year, and the first transmitter-receiver to be granted the G.P.O./M.o.T. Certificate of Approval as meeting the specification laid down in the rules is the Pye Marine "Swordfish." The 50-watt transmitter is crystal-controlled on eight spot frequencies (between 1,600 and 3,900 kc/s) which are switch selected. The receiver



oscillator is also crystal-controlled, and in addition to covering the same frequency range as the transmitter the set provides for reception on 200 kc/s (Droitwich). The combined set measures 24in high × 20in wide × 10in deep.

INTRODUCTION TO Transistor

I—Physical Basis of Conduction in Semi-Conductors

THE object of this article is to give the reader as clear a working picture of transistor electronics as he has about valve electronics. It is inevitable that such a working picture should be incomplete: in these days theories which deal with all the known facts—where they exist at all—can be expressed only with the aid of mathematics. What is needed, therefore, is a theory which expresses clearly and accurately facts of interest to the engineer rather than those which are needed by the research physicist.

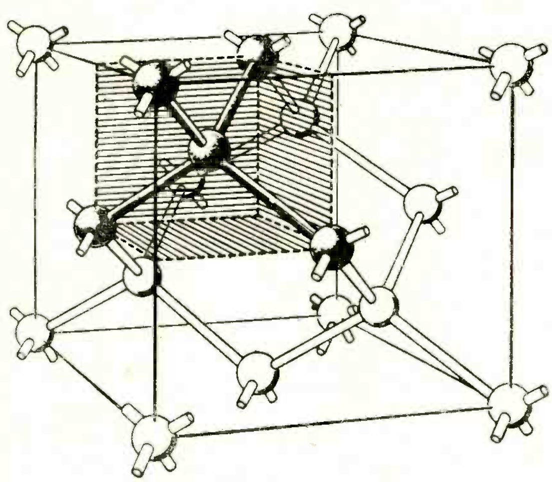
This article is concerned mainly with what happens within the crystal itself and not with transistor circuits. The theory of conduction in semi-conductors (the class in which the germanium crystal falls) is discussed first. This requires an explanation of the structure of these crystals and of the effects due to the presence of certain impurities. These impurities are essential to the production not only of the transistor action but also of the rectifying effects which make the germanium diode possible.

Conduction in Semi-Conductors.—The name semi-conductor applies to a group of elements of crystalline structure, which conduct electricity poorly in general, but which may, in association with discontinuities in the material, have different conductivity for currents flowing in opposite directions. The atoms of the group with which we are concerned have four valency bonds and four electrons in their outer orbits. Carbon and silicon are the commonest of these elements; germanium is rather less abundant. Until recently, in fact, germanium was a rather rare chemical curiosity of little importance, which formed a small proportion of the flue dust which collects in chimneys.

Germanium and silicon form symmetrical crystals, the atomic structure of which is represented in Fig. 1. All the valency bonds are used in forming the structure, each bond being an electron pair. In this perfect crystalline structure there are no free electrons and conduction in the ordinary sense, such as in a metal, by free circulation of electrons, is not possible. A crystal of this nature does, however, conduct some current, and for both germanium and silicon, this current is affected by light falling on the crystal and also by its temperature.

Fig. 2 shows a diagram of the four-valency structure, suitably flattened to two dimensions for simplified illustration. All the valency bonds are satisfied and all nuclear charges neutralized. As it stands there is no form of "carrier" for any electric current. But both thermal energy due to temperature and the radiant energy of light (and higher-frequency radiations) disturb this quiescent state. Either may be imagined to shake the structure; and under certain conditions one of the valency electrons may fly off. This, as seen in Fig. 3, leaves an incomplete bond —a resultant positive charge—which is called a "hole."

It is not difficult to see that a number of electrons so shaken off may become an electrical current if a potential difference exists across the crystal; but it is not so easy to picture holes as being very nearly as effective carriers of electric charges. Surprising as it may seem, a hole has very much the same order of mobility as an electron, though it appears to move in the opposite direction. An explanation of the process is simple enough. When subject to an electric field the stress on a neighbouring valency electron causes it to "jump" into the hole, leaving another hole where it came from; this causes the next one to do likewise, and so on. The hole appears then



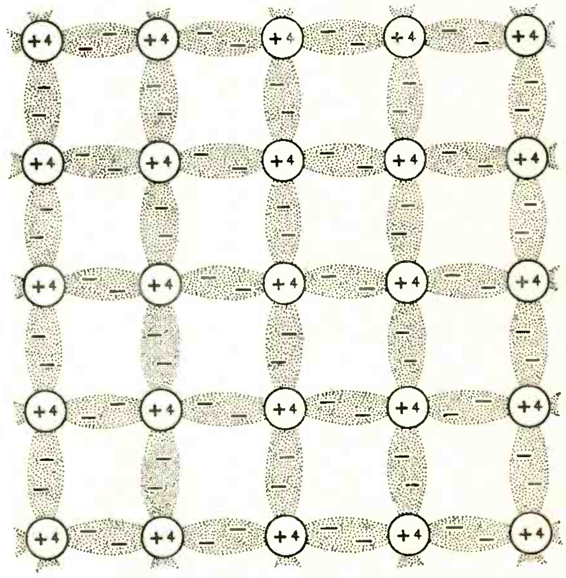


Fig. 1. Atomic structure of a germanium crystal.

Fig. 2. (Right) Representation of valency bonds in silicon or germanium.

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

to move from the positive end to the negative. What is most surprising is not that this happens but that it happens so quickly.

One might imagine that electrons moving this way and holes moving that way would frequently "collide" and neutralize each other. While this happens to some extent it does so in a well-regulated and orderly fashion. Experiments have shown that in general hole-and-electron pairs are generated (and may recombine) only at specific points in the crystalline structure. Irregularities in the crystal structure are an example of such points, though the exact condition necessary for the formation of a generation-and-recombination centre are as yet by no means completely investigated. There would be little point in discussing the present theory here, for it is possible to get a fairly accurate action picture of the transistor from what has been found by experiment. The theory leads straight into quantum mechanics and to realms where simple analogies are quite unusable.

An electron or a hole may be "trapped" in such a centre, where it is held until a hole or an electron comes near enough to be attracted and to combine. Since neither production nor recombination of hole-and-electron pairs is entirely indiscriminate, their lifetime is perhaps rather longer than might be expected.

The conductivity of a semi-conductor depends upon the number of free electrons and holes present, and upon their mobility. The number present depends upon equilibrium between the rate of production and the rate of recombination of such pairs. The rate of production is dependent on incident light or ambient temperature and the rate of recombination, being statistically related to the number which arrive at the recombination centres, depends upon the density of the electrons and holes. Any equilibrium state requires the rate of production and recombination to be the same. Thus the conditions which produce a greater rate of production also cause a higher density of carriers, and, therefore, a higher conductivity. An indication of the dependence of the recombination rate on the density has been given by an experiment which measures conductivity in comparison with incident light; this also shows that the die-away of conductivity, after the light has been shut off, is exponential.

When a hole and free electron are formed by thermal or photo action they move in a random way, similar to the motion of a very small particle in a liquid due to Brownian movement. A number of holes and electrons formed or introduced at a point in the crystal structure diffuse throughout at a rate governed by this random movement, which is itself dependent on temperature. The diffusion rate for an electron in germanium is 93 cm^2/sec and for a hole 43 cm^2/sec. The rate is dependent on temperature and the figures quoted are for 300°K (27°C) and for fairly pure samples of germanium. The most surprising thing is to find that holes and electrons have mobilities which are not very far different.

The conductivity of a semi-conductor is conditioned by temperature and by incident light, but certain impurities in the structure have a much greater effect. For example, "impurity atoms" with five valency electrons fit more or less perfectly in the structure, except that for each impurity atom there is a shortage of one electron. Fig. 4 shows this effect. The atomic nucleus has five units of positive charge and, therefore, is an attracting force for the electron which has been left out of the four-valency structure; but the energy due to temperature is normally enough to cause the electron to diffuse throughout the structure, and not to remain near its parent atom. This is much aided by the reduction of attractive force due to the dielectric constant of the material, which for germanium is 16. Each "spare" electron is, therefore, a potential carrier of electric current. The density of such carriers in a sample is equal to the

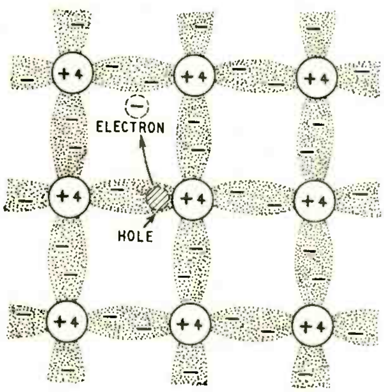


Fig. 3. "Hole" left by electron having "jumped" out of its place, due to thermal or photo effects.

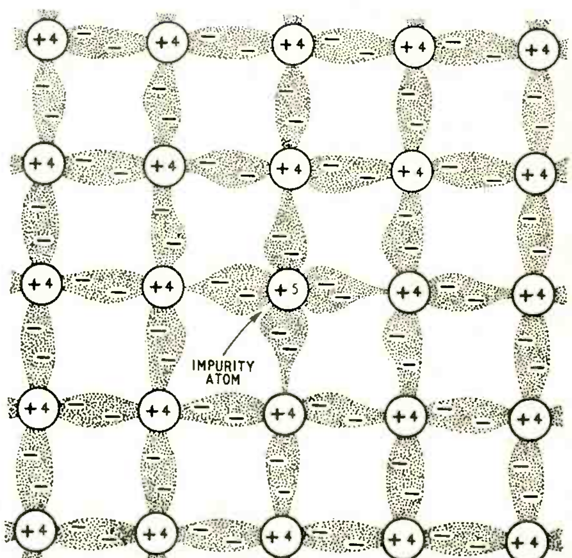


Fig. 4. Illustration of a donor atom in the structure. The effect of the dielectric polarization due to the extra positive charge on the nucleus is shown. The extra electron is assumed to have diffused away from the parent atom and is not shown.

density of impurity atoms, and the overall conductivity is proportional to the total density of such carriers in the sample.

Such an impurity atom is called a donor. Arsenic and antimony are typical donors for germanium and silicon. A concentration of one donor atom to 10^8 of pure germanium is sufficient to increase very greatly the conductivity at ordinary temperature; and although hole-and-electron pairs are still formed as in pure germanium, conduction is due mainly to the donated free electrons.

Germanium which has donor impurity atoms is called negative or *n*-type, because the conduction through it is by means of negative carriers.

There is another sort of impurity which has an equally marked effect on conductivity, and that is the atom with three valency electrons. Examples of this are aluminium, gallium, and boron. These also fit into the crystalline structure without disarranging it,

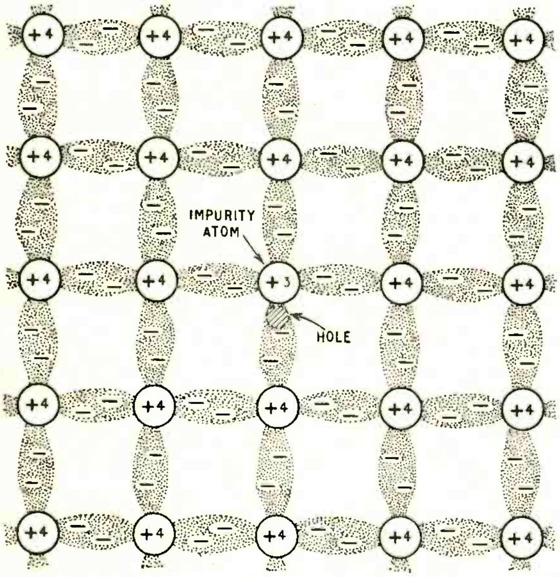


Fig. 5. An acceptor atom shown in the structure. The "hole" diffuses away from the parent atom leaving it with four orbital electrons. In these circumstances, which are normal, the acceptor atoms have a resultant negative charge.

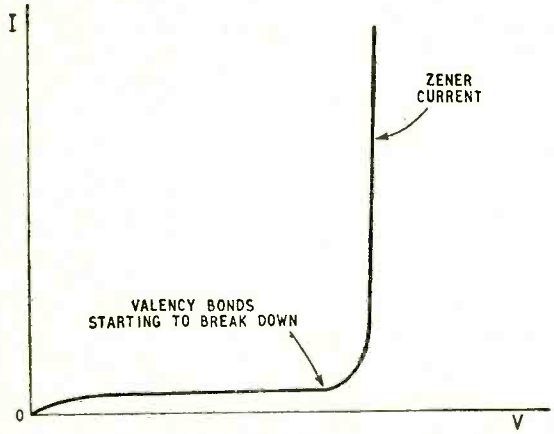


Fig. 6. Zener current in a pure sample of germanium.

but in this case there is an electron missing, instead of one too many. In addition, a nuclear positive charge is missing. The incomplete bond in the structure causes a hole, as seen in Fig. 5. It is perhaps surprising that this sort of hole moves as freely as one caused by light or thermal energy, and diffuses away from the parent atom in a similar way to the donated electron in the previous case. Such an impurity is called an acceptor and the material is then called positive or *p*-type, because the current carriers are holes.

A remarkable effect is shown when the two types of impurity are mixed. The free electrons given by the donor atoms fill the holes from the acceptor atoms, and the balance of holes or electrons remaining carry any current which flows. It is clear, therefore, that if the acceptors and donors are present in equal quantities there are no carriers left, except the hole-and-electron pairs which are generated spontaneously in germanium anyway: the conductivity of the material is then no higher than that of the pure material. Because a small excess of one or other of the impurity atoms causes such a marked change in conductivity the exact proportion to produce this sort of equality is difficult to control in manufacture.

Where both acceptors and donors are present the charge distribution throughout the crystal is uneven when viewed on an "atomic" scale. Each acceptor atom which has had its hole filled represents a resultant negative charge and each donor atom which has lost its fifth electron is a positive charge. There are, therefore, a number of opposite charges fixed in the structure, though the whole is electrically neutral by reason of the mobile charges.

There is one further effect which must be mentioned before the action of the crystal diode and triode can be understood. This is the effect of a large electric field on the production of holes and electrons. When the potential gradient reaches a certain value (the actual value being dependent to some extent on the impurity content of the material) the valency bonds of the structure begin to break up. The effect of such a breaking-up is for a hole to make off towards the negative end and the corresponding electron to the positive end.

All the valency electrons are at more or less the same energy level and in general it would be true to say that a potential gradient sufficient to cause one bond to break up would be sufficient to cause this effect in all other bonds. In practice this is not quite true because of the random thermal energy present, and because the applied potential gradient is modified by the presence of the atoms and electrons. When the potential gradient is not quite high enough to cause spontaneous breaking-up a few bonds will rupture owing to the chance "gift" of some extra thermal energy. The higher the gradient the more likely this is to happen; hence the current due to this effect, known as Zener current, does not start as abruptly as at first it might be imagined. Fig. 6 shows the effect graphically. The bend in the curve is where the first few bonds are torn apart, when the electrical energy plus the thermal energy chance to be sufficient. As the potential gradient is increased more and more valency electrons are able to acquire sufficient energy to break away. The steep part of the curve represents the state in which the electric field supplies nearly all the energy and most of the valency electrons have sufficient energy to break away.

Fig. 7. Presentation of acceptors and donors in the crystalline structure of germanium or silicon.

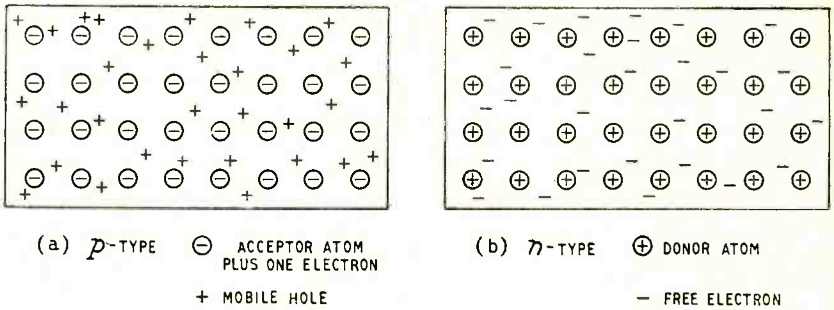
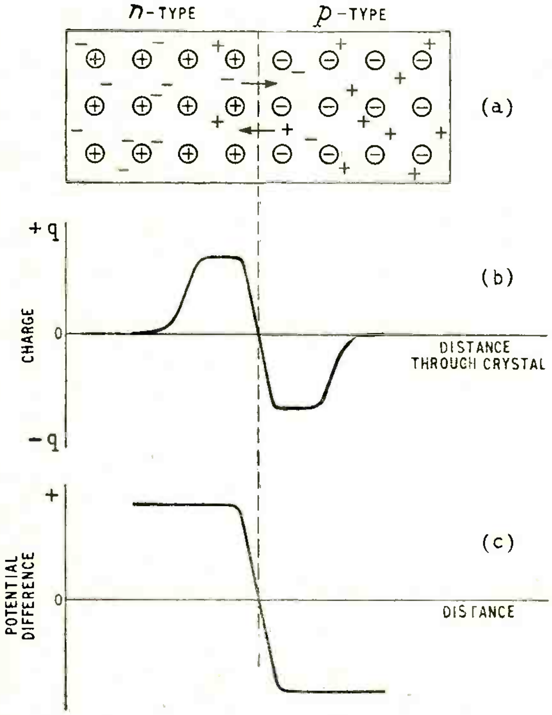


Fig. 8 (Below). Junction under conditions of thermal equilibrium.



It might at first be supposed that this Zener current would disrupt the crystal structure physically, but this is not so. A current produced in this way is quite stable and the point at which the sharp increase occurs is not particularly temperature-sensitive.

p-n Junctions.—Having seen something of what happens in pure and impure material, it is possible to examine the effects at a junction between p-type and n-type material in a single crystal. A possible method of producing such a junction is easy enough to imagine. Arsenic, for example, will diffuse into a germanium crystal which is made hot enough. If one face of a crystal (having already an acceptor impurity such as aluminium) were exposed to arsenic and heated sufficiently, the arsenic could diffuse into the crystal from one end. We have already seen that the material is p- or n-type according to the majority impurity. In this case the p-type material becomes n-type from one end and a dividing layer must, therefore, exist which is "neutral," having an equal concentration of acceptors and donors. On one side of this layer acceptors are in the majority: on the other side donors.

For the purpose of illustration p-type and n-type crystal structure is represented by showing only the acceptor or donor atoms in the structure and the consequent mobile holes or electrons. Fig. 7 (a) shows the p-type material and Fig. 7 (b) the n-type. The acceptor atoms are fixed in the crystalline structure and have the extra valency electrons to which they are not really entitled, hence they have a resultant negative charge. The holes which have wandered away from the parent atoms have an equal positive charge. The material is, therefore, electrically neutral as a whole although throughout the material there are these discrete charges, both fixed and mobile. The donor atoms are similarly fixed but have a positive charge because the fifth electron has wandered away.

When two different materials meet in a junction such as that described above, the holes in the p-type material and the electrons in the n-type material, diffusing in the normal way, cross the boundary into the other sort of material. As we have seen, each side starts electrically neutral, but as holes cross from the p-type to the n-type and electrons go the other way, the n-type material acquires holes and loses electrons, thus becoming positively charged; while the p-type does the opposite and becomes negatively charged. An illustration of the structure is seen in Fig. 8 (a). A standing potential difference is produced between the two materials, and the size of this is regulated by the rate of diffusion across the boundary, the production and recombination rates, and the current of holes or electrons in the reverse direction due to the generation of holes in the n-material and electrons in the p-material. The potential difference is opposed to the diffusion current and equilibrium is eventually reached when the diffusion current is no larger than the reverse current due to the spontaneous generation.

Fig. 8 (b) shows the distribution of charge over the

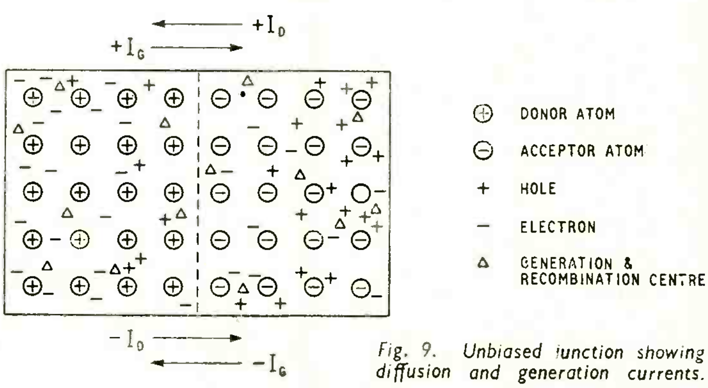


Fig. 9. Unbiased junction showing diffusion and generation currents.

junction when equilibrium has been reached. This is caused by the repulsion of the free electrons in the n-type material by the negative potential of the p-type, and *vice versa.* The mobile current carriers are, therefore, repelled from the vicinity of the junction, leaving only the fixed acceptor atoms on one side and donor atoms on the other. This leads to a high resultant concentration of positive charge on the n-side of the junction and an equally high negative charge on the p-side. Only the fast electrons or holes are able to cross this "barrier."

The reverse current due to spontaneous generation previously referred to arises from the fact that hole-and-electron pairs are generated thermally or photo-electrically on both sides of the junction. On the n-side the electrons merely add to the free electrons produced by the donors, but the holes, if produced close to the junction, "slide down" the potential gradient to the other side. The equilibrium potential is thus automatically adjusted until the diffusion current exactly equals the generation current. This is true of both holes and electrons. Fig. 9 shows this diagrammatically, with a reminder about the presence of production and recombination centres.

When the junction is biased the effects which produce rectification can be seen. If the junction is forward biased, as shown in Fig. 10, the standing potential difference between the n- and p-materials is reduced. The holes in the p-side now find it easier to diffuse to the n-side, so that the diffusion current is increased. The reverse generation current is virtually unaltered, because it is controlled by temperature and incident light only. The two currents are, of course, no longer in equilibrium and the difference flows in the outside circuit. A further increase of bias removes the reverse potential gradient at the junction entirely and the n-side becomes negative in potential while the p-side becomes positive. This means that holes are attracted directly across the junction, as are electrons in the opposite direction. The current is no longer a diffusion current but one in which the carriers are moving under the direct influence of a potential gradient. As the potential gradient increases from zero the rise of current is very rapid, an effect seen in Fig. 11.

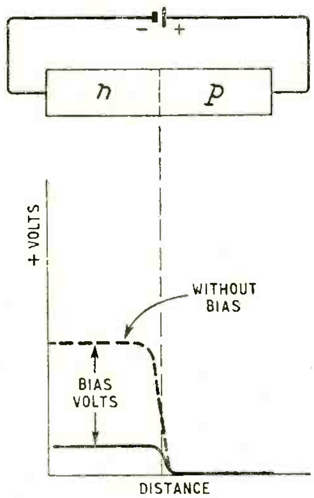


Fig. 10 (Right). Potential gradients with forward bias.

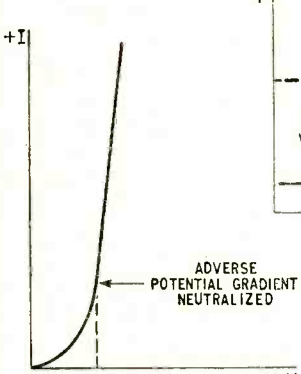


Fig. 11 (Left). Graph of effect of forward bias.

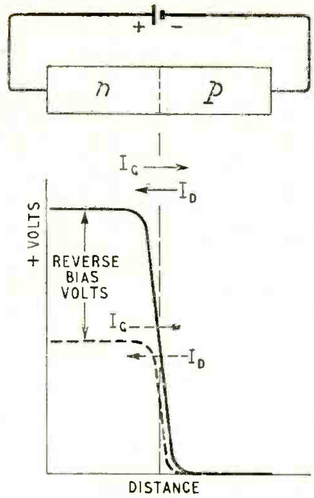


Fig. 12. Reverse bias. Note that the generation current I_G is virtually unchanged by reverse bias while the diffusion current I_D is decreased considerably.

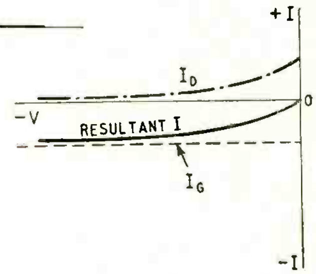


Fig. 13. The alteration of I_G and I_D is shown graphically. The resultant current is that which flows in the outside circuit.

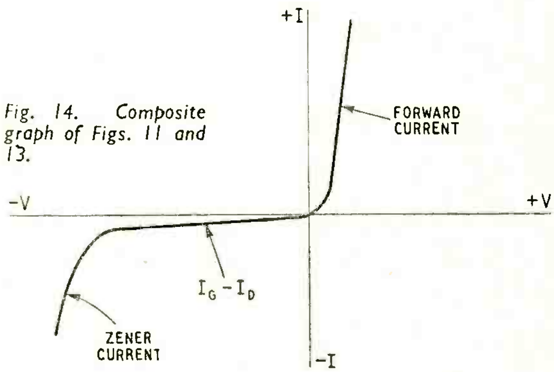


Fig. 14. Composite graph of Figs. 11 and 13.

Biasing in the opposite direction increases the potential difference between the p- and n-sides. This increase, which is shown in Fig. 12, reduces the diffusion current I_D but has little or no effect on the generation current I_G. Again the equilibrium is disturbed and the *difference* between I_D and I_G flows in the outside circuit. Increasing the voltage has the effect of reducing I_D eventually to zero, but has no effect on I_G, as seen in Fig. 13.

If this were all, the characteristic curve would be virtually asymptotic to the graph of I_G, which is nearly constant. But it will be remembered that when the potential gradient reaches a certain critical value the Zener current starts to flow, that is, holes and electrons are generated spontaneously by the breaking up of valency bonds. At a certain point, therefore, the reverse current curve shows a sudden increase, and

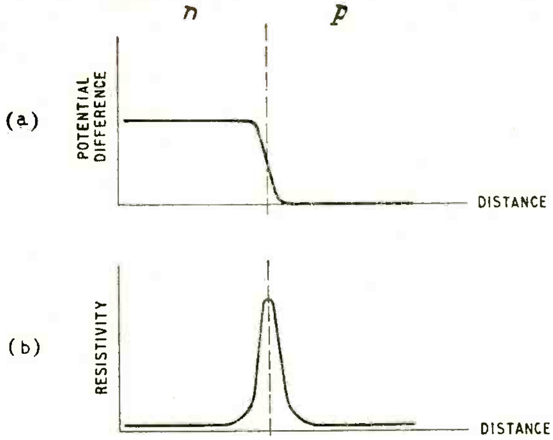


Fig. 15. Graph showing resistivity in different parts of the crystal.

this is shown in the complete characteristic curve at Fig. 14.

It is worth noting that the resistance of the various parts of the crystal may be found very simply by considering the slopes of the curves in Figs. 10 and 12. The graphs show the voltage plotted against distance through the crystal. If we also know the mean current flowing the resistance of any portion of the crystal, or the whole, may be found easily. Again if the cross-sectional area of the crystal is known the resistivity of different portions of the crystal may also be found. Fig. 15 shows clearly that the resistivity is high wherever the potential gradient is steep; in fact, it is proportional to the potential gradient.

The resistance of the junction is, therefore, dependent on the bias and is high when back biased and low when forward biased.

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Acknowledgement.—Figs. 1, 2 and 4 are based on Figs. 1, 3 and 12 respectively of reference 1 above.

(*To be continued*)

Historical Valve Collection

ABOUT the year 1920, Robert McVitie Weston, a solicitor with scientific leanings, took to building his own radio receivers and consequently became interested in the various types of valves then available to the amateur constructor—and subsequently in the history of the valve.

His interest spread from current types and soon he was collecting valves of every age and type. A great deal of his time was spent in searching for specimens and many a lunch-hour was devoted to combing junkshops for material. By 1934 he had assembled a collection of several hundred specimens, including one of Fleming's original diodes and a Lee de Forest triode with a descriptive label in Fleming's own handwriting. Housed on the top floor of Mr. Weston's Reigate home, the collection rapidly expanded, following his decision to investigate every possible source of material, both at home and abroad, and by 1938 the exhibits numbered about 2,000.

The war interrupted active collecting, and a change of address necessitated dismantling the museum. After the war, with insufficient time or space to restore it, Mr. Weston felt that the collection was too large and too important for a single person to handle. He therefore decided to hand it over to Standard Telephones and Cables, thereby ensuring not only the preservation of the existing specimens but also the expansion of this unique museum by the addition of new and interesting valves.

This, quite briefly, is the story behind the actual accumulation of the historically priceless selection of valves now assembled in the entrance hall of the Radio Building at the New Southgate works of Standard Telephones and Cables. The company hopes to enrich the McVitie Weston Collection with further examples of really significant valves from every possible source, and to this end welcomes the co-operation of valve manufacturers and others throughout the world in providing suitable items for inclusion. Students of the subject will doubtless appreciate this permanent record of the history of the valve, and it will be possible for them to visit the collection by making application to Standard Telephones and Cables.

A central display cabinet contains only those valves which, for their rarity or other special reasons, are of major and lasting interest. For the rest, it is intended to keep the display flexible and to stage from time to time special selections illustrating topical aspects of the subject. The main cabinet in the centre of the hall is actually intended to show the general evolution of the valve from the Fleming diode. Outstanding exhibits are two early Fleming diodes; Lee de Forest audions; a Lieben-Reisz gas triode (the only known unused specimen); and diodes used by Marconi at Poldhu.

There are also two corner cabinets, one of which shows the evolution of the water-cooled valve and the other the evolution of forced-air-cooled and radiation-cooled valves. Water-cooled valves include an early example of the Western Electric 220B, the first commercial water-cooled valve and the type with which the 1922 transatlantic radio telephone experiments were carried out. The development is shown continued through the 1929 Standard Telephones 4030A, an early short-wave valve with integral water-jacket, the Marconi CAT14, the first valve of the very high rating, and includes a modern thoriated tungsten filament valve (S.T.C. 30/260E).

The display of forced-air-cooled valves includes the Marconi ACT (an early type) with various more recent types illustrating the development, and also includes early samples of the silica valve developed by the Admiralty and produced by Mullard.

Another cabinet houses a collection of cathode ray tubes including a very early Braun tube dated 1906; a Western Electric ss4A (a genuine Johnson tube); an S.T.C. 4050AG gas-filled c.r. tube; a gas-focused Von Ardenne tube; an Ediswan projection tube (as exhibited at the Physical Society in 1938); and various modern types.

Trends in the development of valves for v.h.f. and higher frequencies are traced from valves with reduced lead lengths: Marconi Mathieu 1930, 500 Mc/s, 3.5 watts; S.T.C. 4304, 400 Mc/s, 50 watts; S.T.C. 4316, 100 Mc/s; the positive-grid oscillator, S.T.C. 4036A, used in the historic cross-Channel microwave radio link in 1931, 1800 Mc/s; the velocity modulated cavity oscillators—klystron and coaxial tube; and the cavity magnetron oscillator and travelling-wave amplifier.

The drive to reduction of size is illustrated by a series of valves of old designs through the octal, loctal, bantam and miniature types, finishing with sub-miniatures of contemporary design.

Ionosphere Review, 1954

End of a Sunspot Cycle

By T. W. BENNINGTON*

IT is very interesting at those relatively infrequent epochs which mark the end of a sunspot cycle to look back over the years during which the cycle has run its course and to examine the changes in radio conditions which the varying sunspot activity has occasioned. Or rather (should we say?) to examine the changes in radio wave propagation which have been brought about by the changing *ionospheric* conditions, the latter having been produced by variations in the ionizing radiations falling upon the atmosphere from the sun, in accordance with the variations in the sun's activity, visible evidence of which has been given by the sunspots which appeared upon it.

We may here consider that the end of a sunspot cycle occurs at the epoch of minimum sunspot activity, although this is not strictly true because the old and new cycles overlap each other to some extent around the minimum. But for radio purposes we are justified in assuming that sunspot minimum represents the end of a cycle. Sunspot minimum apparently occurred during 1954, and it is this fact which occasions the above remarks. But we have to add that it is rather too early to be quite certain about the matter yet, and it is never wise to jump to conclusions when one is dealing with sunspot cycles. However, by the end of 1954 there were several good reasons for thinking that the sunspot minimum might be past.

General Effect of the Sunspot Cycle:—Let us now look at Fig. 1, in which the full-line curve is a graph of the twelve-month running average of the monthly values of sunspot number, the latter being the measure in which the degree of sun-spottedness is usually expressed. The monthly value of sunspot number fluctuates rather erratically, but by taking a twelve-month running average we can smooth out the fluctuations and see the general increase and decrease in sunspot activity throughout the cycle. We see that the activity increased from a minimum at the epoch Feb./March, 1944, to a maximum at that of May/June, 1947, and then decreased so as to reach a minimum at some epoch in 1954 which we shall not attempt to indicate precisely, because the last 12 values are, as yet, only provisional. The curve is of a "saw-tooth" shape, there being a relatively rapid increase from minimum to maximum, and a much slower decrease from maximum to minimum. This is a general feature of all cycles which have a high maximum—and the maximum of 1947 was the highest since that of 1778—whereas the cycles with low maxima are more or less symmetrical about the maximum, i.e., their increasing and decreasing phases are of similar duration. In this cycle the increasing phase occupied 39 months and the decreasing phase about 83 months, the total duration of the cycle thus being about 10.2 years, as compared with the mean duration of 11.1 years for the cycles which have occurred since 1755. But it was in no way remarkable in differing from this mean, for the cycles vary from about 9 years to about 13 years in duration. The decreasing phase of the cycle was marked by very large and erratic fluctuations over periods of a few months, so large indeed that they appear as peaks and troughs and ledges even in the smoothed curve of Fig. 1. Towards the minimum of the cycle the curve "flattened-out"—as is usual—and the month-by-month variation in the activity was

* British Broadcasting Corporation.

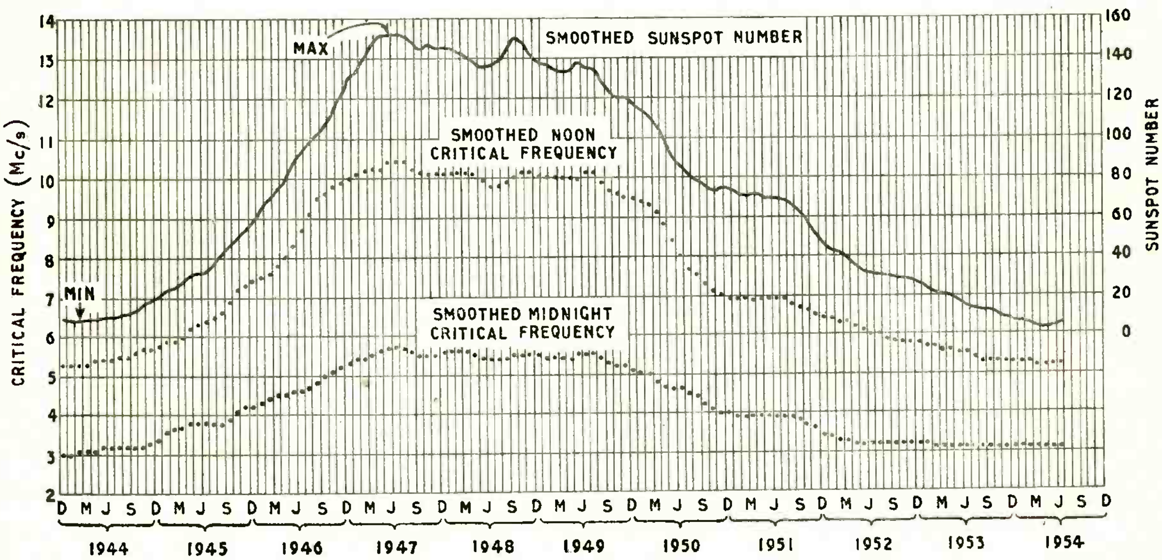


Fig. 1. Twelve-month running average of sunspot numbers and of noon and midnight F_2 critical frequencies over the sunspot cycle.

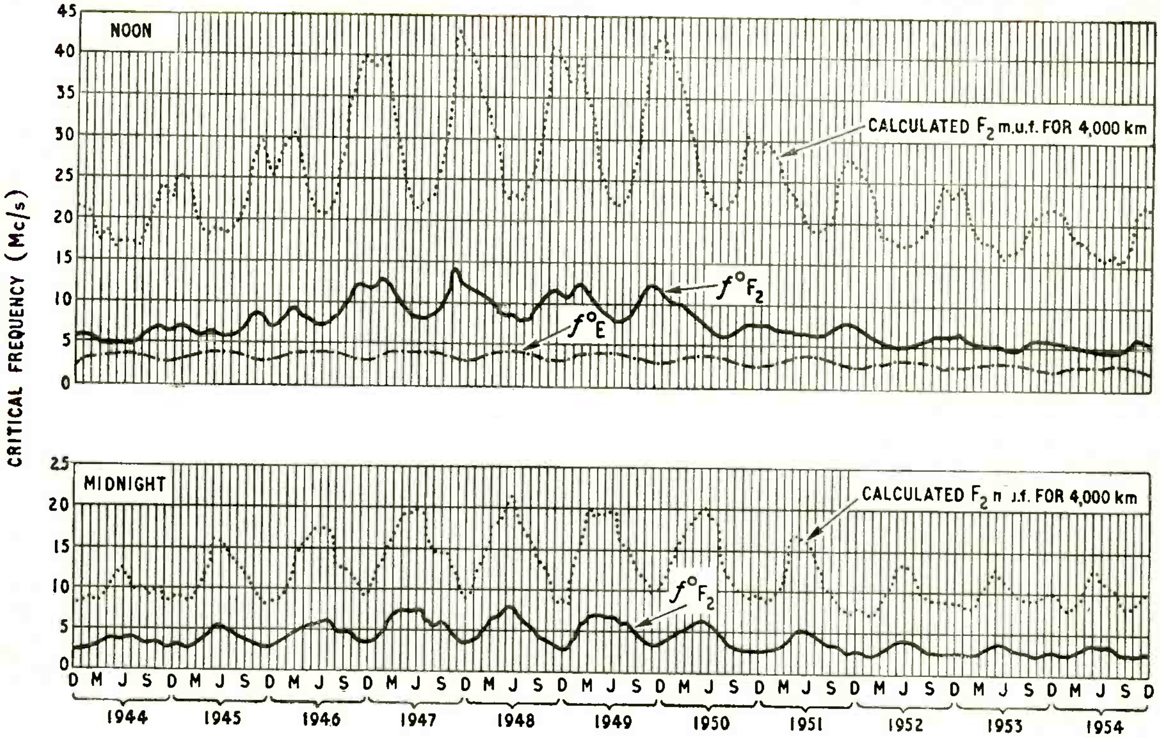


Fig. 2. Monthly mean values of noon E critical frequency, noon and midnight F_2 critical frequencies, and noon and midnight F_2 m.u.f.s over the sunspot cycle.

very small. The value of the 1954 minimum appears to have been lower than that at the 1944 minimum.

The dotted curves of Fig. 1 are from the monthly ionospheric data obtained at the D.S.I.R. ionospheric station at Slough. They are twelve-month running averages of the monthly mean noon and midnight critical frequencies of the F_2 layer, the critical frequency being the highest frequency returned from the layer at vertical incidence. By taking twelve-month running means the large seasonal variations of critical frequency are smoothed out, and the variations due to the changing sunspot activity become more evident.

The object in presenting these curves is to show how the changing sunspot activity affects the frequencies which the ionosphere is capable of reflecting, directly at vertical incidence, and thus by implication, at oblique incidence, as in practical radio communication over a distance. For a variation in the critical frequency at vertical incidence means a corresponding variation in the maximum usable frequency (m.u.f.) for transmission over any given distance.

Both noon and midnight critical frequencies are seen to have followed the variations in the sunspot activity, on this general basis, fairly closely. The noon critical frequency increase with increasing sunspot number was fairly constant until a sunspot number of about 100 was reached, but for higher values of sunspot number the actual frequency increase was less steep, as if a saturation effect in the ionosphere were occurring. It is seen, however, that the general critical frequency variation between sunspot minima and the maximum was of the order of 100% for both noon and midnight, being about 5 Mc/s in the former case and about 3 Mc/s in the latter. The m.u.f.s for short-wave communication would of course undergo corresponding but greater variations than the above, at noon and midnight respectively.

Fig. 1 does show, therefore, how closely the *general* ionospheric conditions at Slough followed the *general* level of solar activity, as indicated by sunspot observations. If we were to look at the ionospheric measurements from other ionospheric stations throughout the world we should see the same trends, though the actual values of critical frequency would be different. We now turn to a more detailed examination of the ionospheric variations, again based on the measurements made at Slough.

Month-by-Month Variations:—In Fig. 2 are plotted, as full lines, the monthly values of the Slough critical frequencies for the F_2 layer (f^o F_2) for noon and midnight for the whole period covered by the sunspot cycle. The dot-dashed curve shows the monthly values of the critical frequency of the E layer (f^oE) for noon.

We may dismiss the latter curve at once by saying that the E layer variations over the sunspot cycle, whilst not without significance, are relatively small. The peaks and troughs in the F_2 layer curves are due to the seasonal variations in critical frequency, which, at noon, are such as to produce low values in midsummer and high values around midwinter, and, at midnight, high values at midsummer and low values at midwinter. This type of variation is now well established, being due, of course, to the variations in the relative position of sun and earth with the seasons.

Superimposed on these seasonal variations, however, there is an evident long-period variation which is that due to the sunspot cycle, the highest values of both noon and midnight critical frequency occurring near sunspot maximum and the lowest near sunspot minimum. It is regretted that, owing to space considerations, these values have had to be plotted on a rather small scale, so that the variations due to the sunspot cycle are less noticeable than would have been desirable. However, if we examine the dotted curves of Fig. 2 we can see the effect of the cycle upon practical short-wave transmission quite clearly. These dotted curves show the monthly values of F_2 layer m.u.f. for 4,000 kms (the maximum possible distance for one hop), as calculated from the Slough monthly critical frequencies, for noon and midnight respectively. That is to say, they give the monthly values of m.u.f. for a one-hop transmission path, with the F_2 layer over Slough as the apex of the trajectory.

The peculiarities of these curves are rather interesting. At noon in summer the m.u.f. increased between the minima and the maximum from about 16 Mc/s to about 23 Mc/s or by approximately 44%, and in winter from about 22 Mc/s to about 43 Mc/s or approximately 95%. The midnight m.u.f., on the other hand, increased from about 12 Mc/s to 21 Mc/s or 71% in summer, but only from about 8 Mc/s to about 9 Mc/s or 12% in winter. Thus the effect of the sunspot cycle was to increase enormously the m.u.f.s during the winter day, to do so to a lesser extent during the summer night, to an even smaller extent during the summer day and to cause hardly a variation at all during the winter night.

A few words about the reasons for these variations may not be out of place. The sun's effect upon the inosphere at night is an indirect one and thus the variations due to its changing activity would not be so great as during the day. During the deep winter night—when the direct effect of the sun has been removed for so long—they seem almost to disappear altogether, whereas during the summer night—with little darkness—they are still quite apparent. During the day the sun's effect upon the F_2 layer is not a simple one, for its behaviour is anomalous, in that during the summer the increase in the ionizing power of the sun's rays is more than counteracted by an expansion effect, so that the ionization per unit volume actually decreases, and the critical frequency falls, as compared with the winter. Thus the greatest effect of the changing solar activity occurs during the winter day, and is not so apparent in summer.

But we are, perhaps, more interested in the practical effects of these variations upon short-wave communication and it is interesting to note, from the dotted curves, the changing utility of various frequencies throughout the cycle. In doing this we should remember that we are studying curves for the ionosphere above Slough only, and that for practical purposes the usable frequencies will be much modified by conditions in other parts of the world.

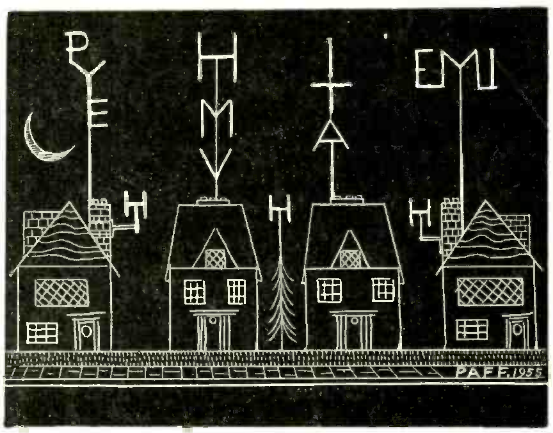
Taking the daytime curves first, the most striking feature is the very high frequencies which would seem to have been usable for long-distance communications during the winter months around the maximum. In fact, the curves indicate that frequencies above 30 Mc/s could have been used during 4 winters, though it is doubtful whether such frequencies were, in fact, put to much use for this purpose. A frequency of 28 Mc/s, it is seen, should have been usable during 6 out of the 11 winter periods, whilst a frequency of 21 Mc/s should have been usable winter and summer alike from 1946 to 1950 inclusive, and to have been too high during the summer periods only of the remaining years. A frequency of 15 Mc/s would have been used throughout the year during the years near the sunspot minimum, but would probably have been too low for years around the maximum. Of course, the daily *periods* of usefulness of different frequencies are not apparent from these curves and would vary from year to year.

The midnight curves indicate that 15 Mc/s would have been usable at night during 6 of the summer periods and 11 Mc/s during the remainder. As to the most suitable frequency for winter night-time use the indications are that 7 Mc/s should have been usable throughout the cycle, and would not need alteration from minimum to maximum. Again it is stressed that some modifications to the above conclusions would be necessary when full account is taken of the actual transmission paths, and of other periods of the night. However, the curves do give us a general indication of the utility of different frequencies, both for daytime and night-time use.

The New Cycle:—So much for the old cycle. We learn what we can from the ionospheric measurements taken during its course. But we now desire to know something about the new one, and particularly about how radio conditions are likely to change in the immediate future. Unfortunately, it is here that we are at a loss. For the laws which govern sunspot cycles are not yet known and we are very much in the dark as to how the sunspot activity will vary in the near future. If we only knew that we could well relate our knowledge of radio conditions to it and say how they would most likely change. But we do not know it and so can only speculate, at least for a year or so to come.

For 1955, therefore, it is impossible to forecast what changes may occur. If the new cycle has well begun the sunspot activity may increase somewhat more rapidly than it has been decreasing during the past year. We say this merely because it has *usually* done so in the year following past minima of which there are records. But it seems unlikely that, by the end of the year, it will have reached a value such as to have produced any large variations in the ionosphere, and to have made any very significant changes to the frequencies at present most useful for short-wave communication.

" I see commercial television is here ! "



SIMPLE WAVE-SHAPER

By ARTHUR W. WAYNE*

Giving Square-wave Output from Sine-wave Inputs from 100 to 5,000 c/s

WHILE spot-frequency square-wave generators are useful for general amplifier testing, a continuously variable source is often of value for detailed investigations; for example, of tone control circuits at various settings.

Many types of shaping circuits are available, each with its own particular limitations. The multivibrator is suitable only for spot frequencies, unless accurately matched tandem gain controls are available; and such components are both expensive and difficult to obtain within the required tolerance. Further, the wave shape is unsatisfactory unless passed through a clipper stage, thus adding cost and complication. The transitron circuit is again capable only of spot frequencies, and is apt to be difficult in regard to its power supply. The cathode-coupled clipper is critical of circuit layout, and is better followed by a further clipping stage, while the tetrode limiter needs heavy driving, and does not always produce a satisfactory waveform unless the output be subjected to further clipping.

In fact, all these circuits are at their best only when followed by clippers, and with this in mind, it was decided to make do with a clipper alone, and so arrange the circuit that deficiencies in the clipper could be easily compensated elsewhere. Fortunately, several sine-wave generators were available, so lack of self-contained excitation was not a serious matter. The arrangement finally adopted was that of Fig. 1, and it proved so satisfactory for its purpose that it is now in production for commercial use.

The circuit is almost self-explanatory, but one or two points are perhaps worthy of comment. In order to keep the clipper independent of external conditions, it was necessary to couple it to the output by a cathode follower; and as a position for this stage had to be provided on the chassis, and only double triodes were immediately available, one half of an ECC33 was used for this purpose, and advantage was taken of the other half to provide an input amplifier.

V2a is an overdriven triode, with component values chosen for very sharp clipping. Operated with zero bias and a very low anode load, excessive grid excitation quickly drives the valve into both the anode bend and saturation regions of the characteristic. V2a is directly coupled to V2b, the grid of V2b being held negative to its cathode by the voltage drop across R_7. C_4 with R_9 form a high-pass filter to help compensate circuit strays and other deficiencies.

Variable Time-Constant

The output from V2b is coupled to VIb via C_5 and VR_1, and in operation the full value of VR_1 is used for the lower frequencies, but is reduced from 3,000 c/s upwards, until at 5,000 c/s only about 25,000 ohms are left in circuit. Unless this reduction in time-constant be made, rounding of the corners occurs at the higher frequencies. When a square-wave is passed through a

* Shirley Laboratories, Ltd.

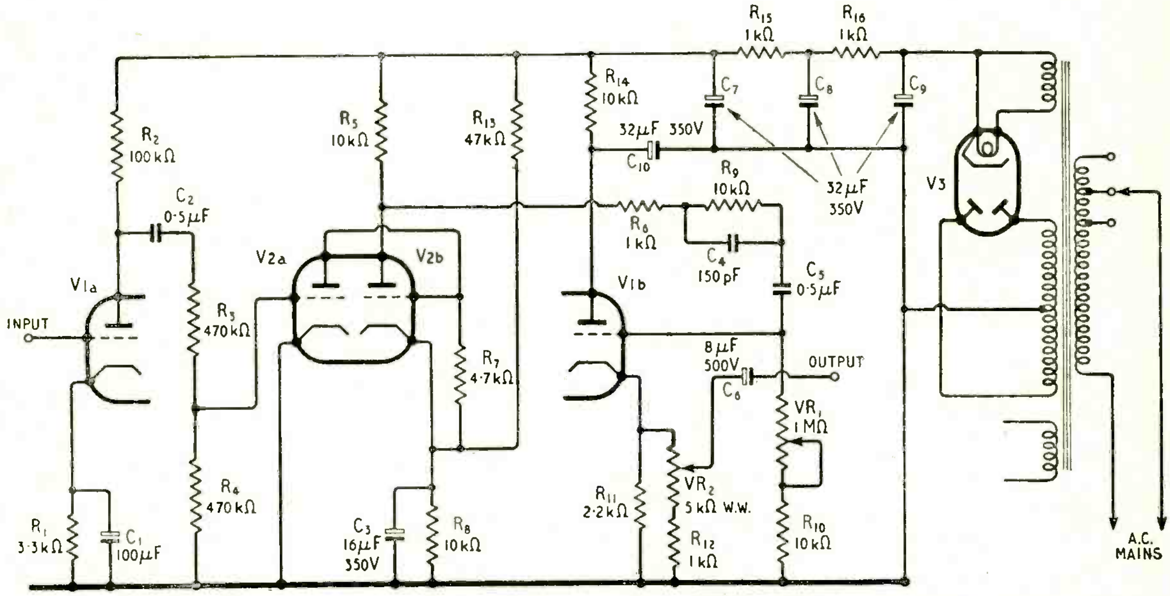


Fig. 1. Circuit diagram of square-wave shaper. All resistors 1-watt except R_{15} and R_{16} which should be 5-watt. V1, V2, ECC33 or ECC82; V3, GZ30 or EZ80.

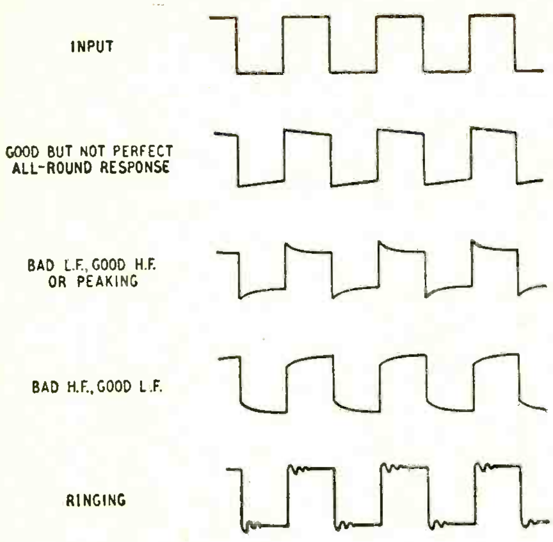


Fig. 2 Typical square-wave distortions and some of the amplifier deficiencies which cause them.

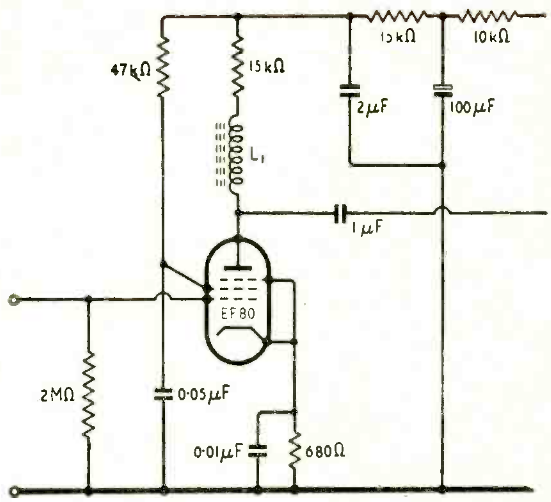


Fig. 3. Wide-band oscilloscope amplifier. A long-wave, dust-cored coil is suitable for L_1.

differentiating circuit, as the time-constant is reduced the waveform distorts, the leading edge rising and the trailing edge falling. Advantage is taken of this to compensate for the integrating action of the strays in conjunction with the circuit resistances. While this, admittedly, is a brute-force-and-ignorance method of obtaining results, it does work quite effectively, so *non olet*.

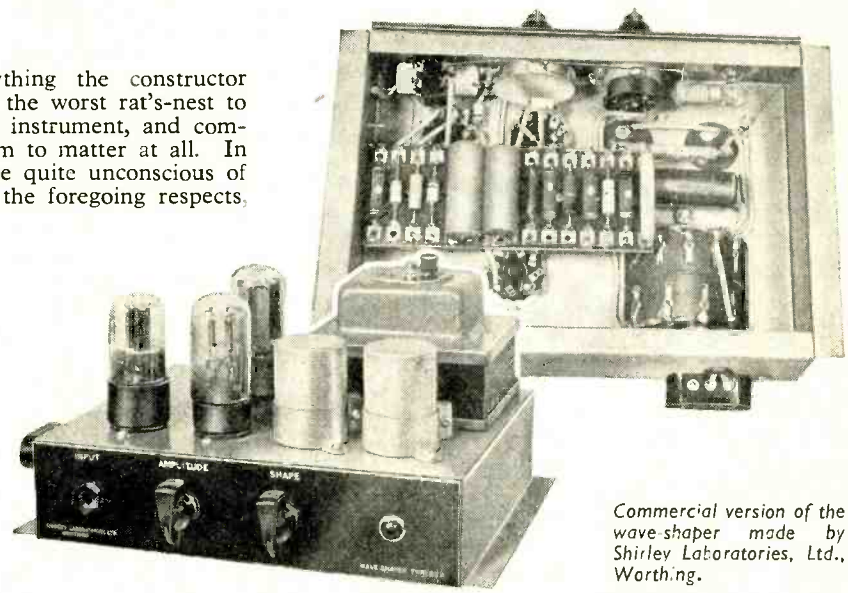
A sine-wave input to the shaper of 4 V r.m.s. is sufficient to ensure satisfactory operation, but some reduction may be necessary from 3,000 c/s upwards. Although a good shape may be obtained from as much as 20 V r.m.s. at 100 c/s, it will be found that between 2 and 6 V r.m.s. is all that can be handled in the higher ranges. In practice, VR_1 is adjusted to give as sharp a leading corner as possible, and the input is then set to give an equal mark-space ratio on the display. It takes less time to set up than to read about.

Constructional Latitude

Circuit layout may be anything the constructor chooses or can achieve, from the worst rat's-nest to a highly finished commercial instrument, and component tolerances do not seem to matter at all. In fact, the shaper appears to be quite unconscious of any deficiencies in either of the foregoing respects, although it was found that the ECC33 and ECC82 functioned more satisfactorily than their American counterparts. The original unit was made in about 3 hours, including post-constructional alterations, from first commencing the drawings to the finished article: it should not take the most meticulous amateur constructor more than 4 hours or so. And while it is in no way a laboratory instrument, being designed only for the limited function and coverage described earlier, it does in fact produce a sufficiently satisfactory approximation to a square-wave, from as low as 20 c/s to well above 10,000 c/s.

For the benefit of those who are not accustomed to square-wave testing of amplifiers, a few characteristic displays are given in Fig. 2. Much information can be gained from observing on the oscilloscope screen the effects of deliberately altering the values of circuit components in the amplifier being tested.

Finally, it must be stressed that, when making square-wave tests, the oscilloscope amplifiers must be above suspicion. Not all commercial instruments meet with this requirement, and for those who are doubtful, a circuit for a wide-band amplifier is given in Fig. 3. Power supplies may be taken from the shaper.



Commercial version of the wave-shaper made by Shirley Laboratories, Ltd., Worthing.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by correspondents

Tape Machines

I SUPPORT Harry Crampin's plea (your December, 1954, issue) for higher tape speeds and larger spools. I also agree that the European standard spool (single-cheeked) is preferable to the U.S. and for the following reasons:—

One should aim at uniform tape tension on both sides of the gate, because failure to vary the torque with the radius gives an additive error. In other words, without radius compensation on either side, at the time when the tape is being least assisted from the gate by the take-up spool it is also being most heavily impeded on its journey towards the gate by the higher speed at which the reservoir spool has to rotate. As is well known, the simplest and most reliable way of minimizing both these discrepancies is to employ gravity clutches whose slip varies directly with friction and therefore with the loading, but it is perhaps not always realized that unless the "weight ratio" equals the "diameter ratio" compensation is not achieved. A European standard spool weighs 29oz loaded and 8¾oz empty, a ratio of 3.3. Similarly, the effective outer diameter is 11in against the core diameter of 3⅜in, again a ratio of 3.3, but on no other design of spool has this been so carefully looked after, certainly not on the U.S. which is also much harder to adapt to the domestic 7in centre and vice versa. The demands for larger spools will not diminish the popularity of smaller ones.

A third advantage concerns track discrepancy. On multi-track machines it is of course possible, with double-cheeked spools, to re-play on a different head simply by turning the spool over, but unless the machine is in perfect alignment this will result in loss of top. Such a procedure is impossible with single-sided spools, each track always having to be replayed from the head through which it was recorded. Also the European standard spool is much easier to thread, join and edit and there is less chance of noise from the tape catching on the cheek of a spool.

Last but not least, the capacity is larger and in view of these many advantages I deplore the present tendency for the U.S. standard to oust the European. Reverting to Mr. Crampin's preference for Continental designs, I would stipulate that in addition to being self-reversing it should be in order to switch off the machine merely by breaking the mains connection. Any form of remote control is out of the question with most British designs as the pressure roller would be left in static contact with the capstan, which the makers strongly deprecate. Could one of the rubber or synthetic rubber manufacturers please state whether too much fuss is not being made over static contacts on pressure rollers, at any rate so far as machines in daily use are concerned?

Cleethorpes, Lincs. R. LEACH.

YOUR correspondent's specification (December, 1954, issue) for an ideal tape recorder reminds me of an R.C.A. wire recorder I had several years ago. This machine was magazine loading like a cine camera, each magazine holding two wires of ¼hr duration each and so arranged that as one was playing the other was rewinding.

The wires were driven at a constant speed by capstans, and a very ingenious spring arrangement between the reels not only kept the wires taut, but also transferred the rotation of the supply reel to the take-up with the necessary compensation for wire build-up. At the end of a reel a notch in a rotating disc (which also served as a footage indicator) tripped over a switch within the machine and reversed the direction of the driving motor and the amplifier connection to the sound heads.

In spite of a bakelite case and 5-in speaker the good design and precision of the mechanism gave a quality and freedom from "wow" seldom obtained with the average popular-priced tape machine.

Doncaster. P. STUART.

Variable High-pass Filters

THE use of variable steep-cutting *low*-pass filters in domestic high-fidelity amplifiers has become almost standard practice. It is therefore surprising that the use of variable steep-cutting *high*-pass filters (not fixed rumble filters) appears to be relatively rare. Such a filter is of considerable value in minimizing listener fatigue due to distracting effects associated with the low-frequency end of the spectrum, and only too apparent in reproducers having speaker systems capable of extended bass response.

The immediately apparent advantages of a high-pass filter are:—

1. Reduction of hum and rumble inherent in many discs, particularly of the l.p. type. This may readily be verified by playing different discs on a high-quality turntable and noting the disc-to-disc variation in reproduced hum and rumble.

2. Reduction of severe non-linearity distortion due to random "cone flutter" in woofers used with amplifiers having useful response down to 2-5 c/s.

3. Reduction of modulation and other hum sometimes presented free of charge in radiated radio programmes.

The preceding advantages are to some extent obtainable from the usual fixed rumble filter. An advantage peculiar to a *variable* high-pass filter is that it will, in conjunction with the commoner low-pass filter, provide ready adjustment of "frequency-range balance." It is well known that when for some reason the h.f. response has been sharply curtailed it is often necessary to curtail the l.f. response as well in order to maintain an aesthetically pleasant tonal balance. A suitable product for the l.f. and h.f. cut-off frequencies is generally given as 500,000. On this basis the respective nominal cut-off frequencies for two 5-step filters could, for example, be: (a) Filters out (say 25-20.000 c/s); (b) 40-13,000 c/s; (c) 50-10,000 c/s; (d) 70-7,000 c/s; (e) 100-5,000 c/s.

The "straight-line" fanatic will probably pale at or beyond step (b). Nevertheless, step (e) will allow enjoyment from a treasured acoustically recorded disc.

The high-pass filter can conveniently be of the R-C parallel-T feedback loop type outlined by Thiessen (*J. Acous. Soc. Amer.*, Vol. 16, No. 4, April, 1945). If an existing pre-amplifier cannot painlessly be modified to this extent, reasonable results can be had by using a multi-pole switch and several cascaded elementary R-C filters. The latter alternative may in fact find favour with those who look with suspicion on sharp knees in filter curves.

Pretoria, S.A. M. R. H. MACNAMARA.

Electronics on the Farm

IT seems to me to be about time that the electronics industry and the farm machinery industry got together on the subject of electric fencer units.

The basic electric fencer, by now a hoary old stager, is a six-volt battery (usually an old car accumulator) feeding a balance wheel interrupter and thence a transformer, to inject spurts of negligible power but about 10 kilovolts into a fence wire which is carried on insulators.

Since the power demand is extremely low, the chief disadvantages of the accumulator become very obvious. Accordingly several manufacturers have produced models designed to run off the ubiquitous radio h.t. battery. As far as I know most of these have also been modified in the interrupter mechanism; but if I am any judge of the contents of a sealed box, and the clicks it produces, the interrupter is still a moving contactor. It is true that the improvements in the interrupter mechanism are probably considerable, for salesmen talk glibly of a five-year guarantee; indeed, I suspect that the timebase is a resistance-capacitor circuit and the contactor a reasonably good magnetic relay. However, I submit that for this purpose a neon tube would be far cheaper and more reliable, and that a wholly electronic unit would be superior to any unit containing mechanism.

I admit that I lack complete technical information. It is possible that I am mistaken in believing that a reasonable neon tube will effectively act as a switch and/or carry the power demand, and I suggest that the matter might well be worth examination.

The advantages which I foresee are cheapness and simplicity in first cost and maintenance, lightness and compactness. The neon tube would certainly plug in, presumably the electrolytic capacitor could also be plugged and, although perhaps unusual, the resistor as well. The transformer hardly ever gives any trouble, and therefore maintenance would consist of nothing more than buying a new relatively inexpensive unit and changing it for the old one. It is true that the older farmer might not know which to change, but that idea is becoming out of date.

Another refinement I have yet to meet, except on my own fencers, is a neon earth detector on the h.t. side. I have de-capped miniature Philips neon lamps and connected them across the output terminals ($\frac{1}{2}$ megohm in series) so that they flash if the fence wire is *not* earthed. Few stockmen will shock themselves to find out if the fence is in fact working, and I suspect that our cattle would be "out" a good deal more often without this aid.

It appears that present fencers usually have a frequency of about two flashes per second. My present balance wheel units suffer far too much from burnt contacts, and therefore when I overhauled them this last spring I reduced the frequency to about one per second, thereby in effect doubling the working life. So far I have found no disadvantage.

My units, being expensive of their kind, carry a simple, but not nasty, battery voltage indicator with a push-button switch. It is perhaps because the h.t. battery type is alleged to run for five months on one battery that this refinement is invariably omitted. It is not easy to justify a moderately expensive unit which will not be used above twice a year, but I submit that a push-button, a resistance, and a torch type bulb might serve; with instructions that the bulb should be held on for a few moments and will fade rapidly on a worn-out battery.

Hempstead, Essex. H. G. P. TAYLOR.

Mathematics

HAVING been cited in the January issue by F. V. Bale as an example of the type of writer who lowers the tone of *Wireless World* by frightening readers off mathematics, may I be allowed to reply?

If indeed I have been guilty of discouraging anybody from the study of mathematics, then I deserve censure. So far from my intention having been that, however, it has been precisely the opposite; namely, to debunk the supposed esoteric nature of mathematics and to break down the mathematicians' "closed shop." In the very article which Mr. Bale quotes I showed how the basic filter equations could be arrived at by schoolboy algebra, and then, having taken the reader to the desired point by presumably familiar ways, revealed the cosh as nothing to be afraid of but rather as a useful tool—"The practical value of the cosh, then, lies in the fact that it enables one to dodge most of the work by looking up tables.... Anybody can do that."

It surely cannot be denied that there are thousands of potential technicians and engineers who do find hyperbolic functions in the abstract a forbidding and largely meaningless subject, and their relationship to filters far from obvious. The above-quoted article being the example chosen by Mr. Bale to deplore, what alternative treatment does he recommend for these readers?

At the other extreme, my own experience as a wartime radar instructor showed me that graduates in mathematics were not automatically able to apply it to practical uses; most of them had never clearly visualized the physical realities represented by their equations. These, too, surely stand to benefit from an alternative approach.

A crime to which I do quite cheerfully plead guilty is that of lack of respect for the type of author who fills his pages with mathematics and considers it beneath his dignity to explain what it means in words. In this attitude I am glad to be in the company of perhaps the most noted authority on the presentation of technical information—Prof. R. O. Kapp, whose concluding paragraphs in his paper "The First Draft"* should be taken to heart by the over-mathematical. "CATHODE RAY."

* Obtainable from the Secretary of the P.T.I. Group, University College, London, W.C.1. price 2s.

Viewers' Strike?

LIVING on a main road within a few yards of the junction with another main road and receiving a weak signal from the Brighton booster and a still weaker one from the new Rowridge station, I am finding out some things about ignition interference.

Of all the cars passing my door, 90 per cent are unsuppressed and even some of the new cars have either unsatisfactory suppressors or the suppressors have been removed.

It is time that the P.M.G. made the fitting of suppressors to cars compulsory, even if it means supplying the suppressors free. The cost of this could be met from the percentage of broadcast licence fees retained by the G.P.O. If all licence holders got together and refused to renew their licences, I am sure a speedy solution would be found.

Worthing, Sussex. W. E. NIALL.

Tape Terms

A LANGUAGE of magnetic tape recording is evolving and, although standardization is yet a toddler as regards technique, some unhappy selections are emerging in the language and seem to have become accepted as standard terms already.

It helps so much to link meaning with function, rather than to blind with slick startlers, that one hopes terms such as "azimuth" will not prevail.

When technicians use that term, the context usually suggests that they mean "head" tilt relative to tape path. "Azimuth" is an ancient astronomical term of different meaning, shortly put as "an arc of the horizon." This is borne out by its origin: Arabic *al* (the) *sumut* (direction). How does it come to be used to suggest a different meaning for which a better word exists, namely, "oblique"; Latin *ob* (before) *liquis* (slanting) defined shortly as "to deviate from the perpendicular?" That, surely, is exactly what is meant.

Bristol Magnetic Recorder Company,
Bristol, 3. W. D. ARNOT.

Overseas Buyers

FREQUENTLY an article advertised in *Wireless World* attracts my attention and I develop an urge to buy it. But I get disturbed about foreign exchange, extra postage for overseas mailing, etc., and I finally decide the product is perhaps not worth all the fuss anyway.

Perhaps this is wrong. Could not your advertisers publish a little bit on how receptive they are to small foreign orders and how to go about it, especially extra payment requirements for overseas mailing?

Yonkers, N.Y., U.S.A. MARTIN L. KENELY.

Vector Addition and the Slide Rule

Rapid Method of Calculation

By A. G. LONDON, B.Sc.(Eng.), Graduate I.E.E.

A GREAT many calculations in electronics involve working out the value of terms of the form

$$\sqrt{(x^2 + y^2)}.$$

Two examples which come readily to mind are:

(i) The magnitude of the resultant of two vectors, V_1 and V_2, at right angles, is given by:

$$\sqrt{(V_1^2 + V_2^2)}$$

(ii) The magnitude of the impedance of a series-tuned circuit is given by:

$$|Z| = \sqrt{[R^2 + (\omega L - 1/\omega C)^2]}$$

The usual method of calculating the value of a term of this form is to find the squares separately, add them, and find the root again. This is a rather tedious business, particularly if it has to be repeated a number of times. A much quicker and easier method exists, however, which eliminates those little addition sums, done on odd scraps of paper. The whole process can be carried out on a slide rule without "taking off" any figure except the answer. The slide rule can be of the simplest type, one with only the four main scales.

A reminder of the properties of these scales may not be out of place. They are usually called scales A, B, C and D, from top to bottom, A and D being on the stock; B and C on the slide. They are so arranged that if the cursor is set to a number on scale D the square of that number appears under the cursor on scale A. Square roots are found by the reverse process. Scales C and B, respectively, have similar properties.

Now suppose we wish to find the value of the root $\sqrt{(x^2 + y^2)}$, y being smaller than x, we proceed as follows.

1. Set the slide rule so that y on scale C is opposite x on scale D. (Arrow 1 on Fig. 1.) Then by the ordinary rule for division, x/y will appear on scale D, opposite the end mark on C. (Arrow 2 on Fig. 1.)

2. Set the cursor to the end mark on scale C. Then, as we have already noted, $(x/y)^2$ will appear under the cursor on scale A. (Arrow 3 on Fig. 1.)

3. To the value of $(x/y)^2$, add 1, and set the cursor to this new figure, still on scale A. (Arrow 4 on Figs. 1 and 2). The cursor now indicates $(x/y)^2 + 1$ on A; and the square root of this on scale D. (Arrow 5 on Fig. 2.)

4. Now move the slide until the end mark on scale C is set against the cursor.

5. Read $\sqrt{(x^2 + y^2)}$ on scale D opposite y on scale C. (Arrow 6 on Fig. 2.) In steps 4 and 5 we have used the ordinary multiplication rule to multiply $\sqrt{[(x/y)^2+1]}$ by y, and,

$$y\sqrt{[(x/y)^2 + 1]} = \sqrt{\{y^2[(x^2/y^2) + 1]\}} = \sqrt{(x^2 + y^2)}$$

In the example shown in the figures, $x = 4$, $y = 3$. Then the successive steps are:

1. $x/y = 1.333$
2. $(x/y)^2 = 1.78$
3. $(x/y)^2 + 1 = 2.78$
4. $\sqrt{[(x/y)^2 + 1]} = 1.667$
5. $\sqrt{(x^2 + y^2)} = 5$

It is important, in step 3, to keep in mind the position of the decimal point in $(x/y)^2$. In the example, the figure 1.78 on scale A actually represents this number, and $(x/y)^2 + 1 = 2.78$. However, according to the relation between x and y, it might represent 1.78 multiplied by any power of 10; e.g., 0.178 or 17.8. Then $(x/y)^2 + 1$ would be 1.178 or 18.8 respectively. Care is therefore necessary at this point in the operation.

The process can very simply be adapted to evaluate a root of the form $\sqrt{(x^2 - y^2)}$. The only change necessary is that, in step 3, 1 is subtracted from $(x/y)^2$, instead of being added, and the cursor is set to this value; i.e., $(x/y)^2 - 1$. The square root is then taken as before, multiplied by y, and the answer read on scale D. The proof is exactly analagous to the case of $\sqrt{(x^2 + y^2)}$. Clearly, this comes in useful, for example, in the series-tuned circuit case mentioned above, if we know the impedance, but the resistance or the reactance is unknown.

$$\text{Then } R = \sqrt{(|Z|^2 - X^2)}$$

While no claim is made that the process described in this article is original, it is a simple and rapid method of solving the particular problem, and deserves to be more widely known. Many readers will, no doubt, be able to find other applications besides those mentioned.

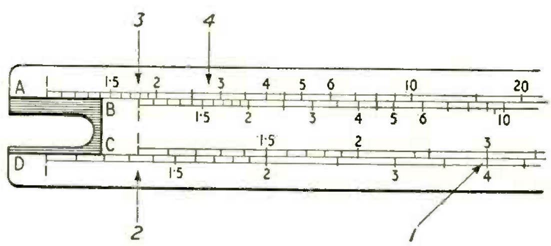


Fig. 1. The first steps in setting the slide rule are shown here, culminating in $1 + (x/y)^2$ at point 4.

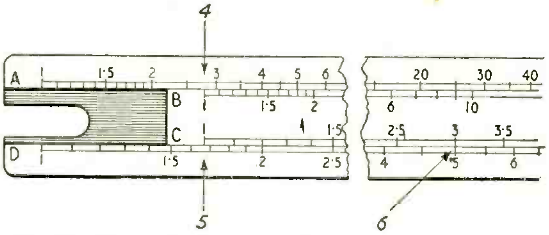


Fig. 2. The final steps are illustrated here, the root appears at point 5 opposite point 4 and multiplying by y gives the answer at point 6.

FLUX-CUTTING or FLUX-LINKING?

A Controversy on Fundamentals—and a Practical Solution

By "CATHODE RAY"

NOT very long ago there took place at the I.E.E. a discussion on fundamental electromagnetic theory*. At the end of it the chairman remarked that although it was the normal policy of the I.E.E. to encourage student members to attend its meetings, he was rather glad they hadn't been much in evidence on that particular occasion. Well, certainly, it did seem somewhat unedifying to hear one learned Professor of Electrical Engineering after another disagreeing flatly on the very basic principles of the subject. Quite enough to shake whatever faith students may have in the authorities, and to make one wonder whether there is anything—even Ohm's Law—that can be relied upon to be true.

One of the most discussed things on such occasions is the question of how to reckon induced e.m.f.—whether on a basis of "cutting magnetic lines of force" or some other way. Nearly all the electricity used in the world is generated by electromagnetic induction. And the process is fundamental in radio too, for radio waves would be impossible without it, and so would transformers, chokes and tuning coils. If then the most eminent authorities invariably disagree on the principles of the thing, how can anybody be expected to understand it and make the necessary calculations for designing radio and other electrical systems? Disagreement about how wages are calculated can be relied upon to give rise to trouble; how is it that disagreement about how to calculate induced voltage does not? Or does it?

Some while ago† I was rash enough to stick my own neck out into this particular controversy, by advocating the flux-linkage (or flux-threading) idea at the expense of the flux-cutting idea. And now I get a letter from a radio engineer in the Belgian Congo who writes in some concern to report that after gladly accepting my view on this matter, as being in line with that of his one-time professor of electricity, he was dumbfounded on being confronted by a junior colleague with a description of an actual electric generator that by its method of functioning absolutely proved the flux-cutting idea. More shaken faith, presumably! He may be interested to know that at the I.E.E. discussion this particular kind of generator was well in the forefront of the battle, and my shocked ears could hardly believe what they heard when one teacher made the highly immoral suggestion that students should be kept in ignorance of it because it did not square with the official curriculum.

Well, far be it from me to pose as a sort of super-authority to put everyone else right, but it does seem to me that at least some of this confusion is capable of being dispelled. First of all, for the sake of any readers who are not yet quite "with us," let me explain what the controversy exactly is. It began with Faraday's famous experiments in 1831. He found that an electric current could be magnetically induced in a circuit in two ways: (1) by moving a magnet near the circuit (or, what comes to the same thing, moving the circuit near a magnet); and (2) by moving neither but varying the strength of the magnetism, say by switching the current on and off in a coil of wire producing it. The first of these processes is applied in every rotary electric generator; the second in every transformer and tuning coil. Faraday visualized the magnetism as lines of force in the space around and within the magnet, and regarded the current in the first class of experiments as being induced by these lines cutting across the circuit (or the circuit cutting the lines). He was inclined to think that the results of the second class of experiments could be regarded in the same way, by supposing the lines of force to spring out of the coil as the current was increased, and so to cut across any coupled circuits.

Before generators and transformers could be designed on a proper engineering basis—and certainly before radio equipment could be designed—it was necessary to be precise about the relationship between movement or variation of magnetic field and the voltage of the e.m.f. generated thereby. The strength of a magnetic field can be reckoned by the force it exerts on a small magnet. It was agreed to suppose that a certain force corresponded to so many lines per square centimetre. The total number of lines over a given cross-section was called the flux. It was found that the e.m.f. generated in a circuit was proportional to the rate at which flux was cut by the circuit, or varied within it. In fact, when the amount of flux corresponding to a "line" had been defined, it turned out that in order to generate an e.m.f. of one volt it

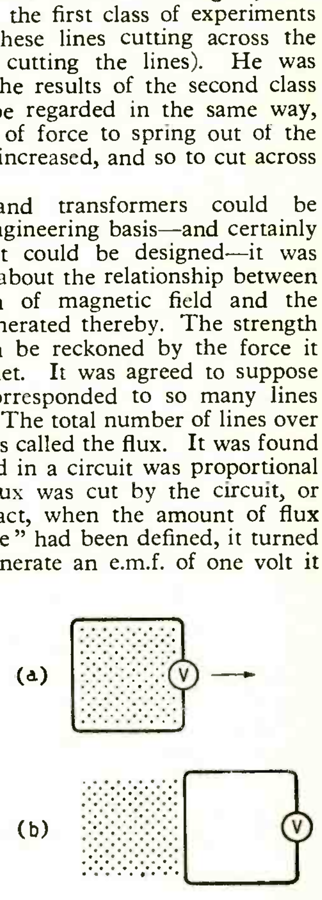


Fig. 1. Here is an idealized example of electromagnetic induction. The dots represent an end-on view of 10^8 magnetic "lines," uniformly distributed. The square circuit is supposed to move steadily from position (a) to position (b) in one second. What will the voltmeter V read during this process? And why?

* "A Short Modern Review of Fundamental Electromagnetic Theory," by P. Hammond, *Proc I.E.E.* Pt. 1, July, 1954.

† *Wireless World*, June, 1953, p. 285 ("Radio Waves").

was necessary to vary the lines at the rate of 100,000,000 ($=10^8$) per second.

Now this is where we get to the controversy. Fig. 1 shows a simple circuit, consisting of a square of wire connected to a voltmeter. So as not to introduce complications caused by the magnetic field due to current in this circuit, let us suppose that the voltmeter has an infinitely high resistance, so that no current flows. The dots are end views of the lines of force produced by a coil not shown, but parallel to the single square turn. To avoid complications again, let us suppose that the return paths of these lines are kept well clear of our picture by means of a high-permeability iron core. Finally let us assume that notwithstanding the fewness of the dots there are actually 10^8 lines of force enclosed by the circuit, and that they are distributed uniformly over its area. If now the circuit were moved steadily to the right from position (a) to position (b) at such a speed as just to clear all the lines of force in one second, we can safely assume that during this process the instrument would read one volt.

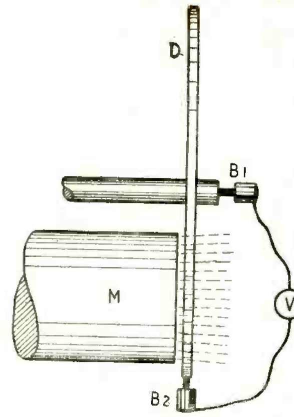
But if you ask a number of engineers to explain this result you will discover two schools of thought. Some will say that three of the four sides of the circuit take no part in the experiment because they cut no lines of force, but that the fourth—the left-hand one—was cutting 10^8 lines per second, and that was why an e.m.f. of 1V was generated. Others will say that at the beginning of the operation 10^8 lines of force were linked with the circuit, and at the end none were; difference, 10^8; so magnetic linkages with the circuit were being varied at the rate of 10^8 per second, and that was why an e.m.f. of 1V was generated.

Divided Counsels

Precisely the same result and explanations are forthcoming if the circuit is kept stationary and the field is moved to the left. And precisely the same result is obtained if both are kept stationary and the current in the unseen magnet coil is reduced at such a rate as to bring the field steadily to zero in one second—but this time the explanations will vary. The line-cutting school of thought splits into two: one group will say that of course this is quite a different effect, so cannot be expected to have the same cause; the others stick faithfully to the cutting idea, and adapt it to cover the changed circumstances by saying that the lines can't just come from nowhere, but that when current in the magnet coil is increased or decreased they spring out or flop back, so cutting the circuit and generating an e.m.f. one way or the other around it. This adaptation of the original line-cutting picture may perhaps be accepted, provided that nothing better can be found and that it is consistent with other known facts. But slightly more elaborate experiments show that an e.m.f. is induced in a circuit by growth or collapse of a magnetic field *even when that field is caused by current in that same circuit*, and I for one find it a little difficult and unconvincing to visualize a wire being "cut" by lines of force emerging from itself.

When we come to interrogate the linkage school of thought we find them perfectly happy and pleased with themselves, because their account of the previous (Fig. 1) experiment equally well covers the current-varying or transformer experiment, without involving them in having to explain where the lines come from or where they go. Whether the number of lines

Fig. 2. D is an edge view of a metal disk, rotating in the field of a fixed magnet M. B1 and B2 are brushes making electrical contact with axle and edge of disk. Will the voltmeter V give a reading? If so, why?



linked with the circuit is made to change by moving the field or circuit or both, or by varying the strength of field in a stationary set-up, makes no difference to the e.m.f. induced; so why, they say, adopt an explanation that has to be forced to fit some of the facts, or alternatively use two explanations to cover facts that are obviously related and can perfectly well be covered by one?

This is the psychological moment, when these linkage people are swelling with self-satisfaction, to perform the experiment known as the Faraday disk or the homopolar generator. One form of it is shown in Fig. 2. D. is an edgewise view of a copper disk which is rotated steadily. B1 is a brush making contact with its axle, and B2 is another making contact at its rim. M is a fixed magnet arranged so that its lines of force pass through the disk, and the whole circuit is arranged so that no lines link with it. Therefore, according to the linkage school of thought, no e.m.f. can possibly be induced by turning the disk. But unfortunately for them the meter shows that it is. The thing with which my Belgian correspondent was confronted, although different in form, was obviously identical in principle, and was no mere theory or experiment but an actual machine used to generate current for actual electro-plating.

If the line-cutting advocates had been called upon to predict the result of the disk experiment, previously unknown to them, there might have been some hesitation and clearing of throats while they tried to decide whether the part of the circuit formed by the disk was or was not cutting the magnetic field. At first sight it might seem not, since no change in the form of the circuit takes place, and the copper in any one part of the disk is as good as in any other. But if members of this group were electron-minded (as the participants in the I.E.E. discussion apparently were not, for the word "electron" was hardly mentioned) they would realize that turning the disk carried the free electrons in the copper around with it, and so causes them to move in a magnetic field, and by using Fleming's right-hand rule (thumb indicating direction of motion and forefinger direction of field, then second finger shows direction of e.m.f.) they would correctly predict an e.m.f. along the radius of the disk crossed by the field.

Having tactfully allowed the linkage people time to think up a way of talking themselves out of the contradiction between their theory and this experiment, we come back to them and invite their comments on it. The I.E.E. discussion showed what at least one of them would say. He would describe the result as an anomaly, and shamelessly advocate keeping it as dark as possible, lest it confuse his students. I hope we all regard this reply as thoroughly unworthy and unsatisfactory and insist on something less ostrich-like. Pressed thus, some might allow it to be brought to the notice of their students, but only as a "special case" or "exception". But if nothing better can be said than this one would, I should think, be obliged to decide in favour of the line-cutting school, even though that meant accepting their curious pictures of lines cutting wires by springing out of them. Another group, represented in subsequent discussion by at least one very eminent authority‡, refuses to be disconcerted by this attack on the linkage position, but shows that the disk experiment is, after all, not an exception to it. They ask one first of all to substitute for the disk a spoked wheel, and then show that the sector-shaped circuits formed by pairs of adjacent spokes and the segments of rim joining them obviously do link with a varying number of magnetic lines as the wheel is rotated, and that a difference of potential is thereby set up between the two brushes. They point out that this state of affairs does not depend on the number of spokes, and that more can be added until finally they are touching one another all the way, and the wheel has become the solid disk of Faraday.

Having re-established the prestige of the linkage school (and, we hope, expelled those members of it who disgraced it with their treacherous ostrich policy), they go on to conquer other supposedly fatal objections. One of the most interesting of these is Hering's experiment. It is performed with a circuit consisting of a spring clip, normally closed as in Fig. 3(a). The bar magnet M is then forced past the jaws (b) until finally it is inside (c). There is a complete circuit all the time, and clearly a large number of magnetic linkages are introduced into it, yet the most sensitive instrument fails to indicate any e.m.f. This, it is said by some, makes nonsense of the flux linkage idea. It certainly makes nonsense of something, and so it ought, for that something is a misconception of the linkage principle. The fallacy lies in looking at (a) and (c) only, which show an identical circuit with and without a linked field, and forgetting about (b), where the circuit is not identical. As Carrothers and Kapp put it, "the circuit in which one might expect a current to be induced is not there during the time that any inducing could occur."

‡ "Apparent Failures of the Flux-Threading Rule," by C. G. Carrothers and R. O. Kapp, *Bulletin of Electrical Engineering Education*, June, 1954, pp. 7-12.

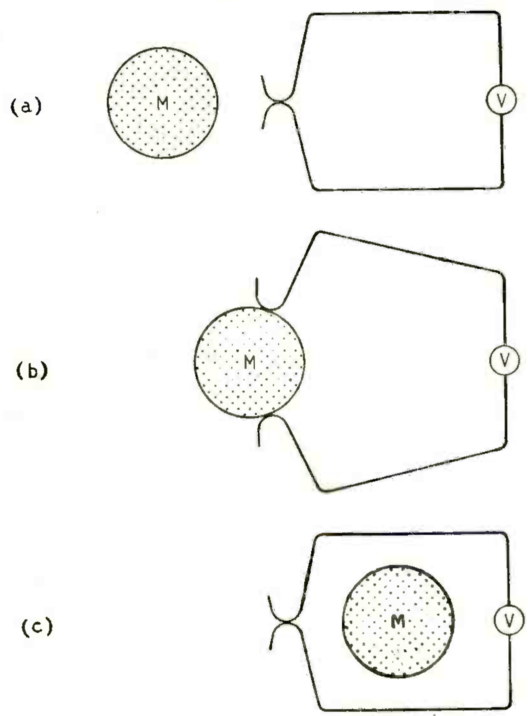


Fig. 3. M is a metal bar magnet which is pushed through the jaws of a spring clip forming a closed circuit. V is a sensitive voltmeter or galvanometer. Does it give any sign while the magnet is being inserted into the circuit? If not, why not? See Fig. 4.

When Is a Circuit . . . ?

This matter of change of circuit needs careful watching, for some changes of circuit during a linking or unlinking process do not necessarily affect the observed e.m.f., and the distinction is sometimes rather a subtle one—as it is in the Hering experiment. For example, altering the shape or extending the length of a flexible lead from a transformer coil to a voltmeter doesn't prevent the ordinary linkage rule from being used to predict the voltage correctly. But the change in circuit during the (b) period in Fig. 3 does upset what might seem to be a valid application of the rule. This can perhaps be more easily seen in Fig. 4. The right-hand part of the double wire square at (a) is not linked with the flux passing through the magnet M. If now the switch is opened (b) the magnet can be moved through into the right-hand square (c) but doing so does not alter the number of lines linked with the circuit that then exists. If now the switch is closed (d) there is a closed circuit the same as in (a), but linking with flux that was not there before. Yet there was no stage at which one would expect V to give a reading.

The fact that in the Hering experiment the switch-over is gradual makes no real difference. The process can be more exactly imitated by the arrangement in Fig. 5, in which the slider is moved from the position shown, where the magnet is not embraced by the circuit (the path through the resistance is dead-shorted by the direct path), to the other end, where it is. No one, surely, would expect moving the slider to set up a potential difference between *a* and *b*, such as certainly would be set up if a wire between *a* and *b* were moved across the pole face of the magnet.

Another demonstration in which the number of circuit linkages is increased by a sort of trick, without generating any e.m.f., is Blondel's experiment, shown in Fig. 6. Wire is wound from a metal cylinder, which acts as a short-circuit, to an insulating cylinder fitted with a metal slip-ring, with which contact is made by a brush B1. This cylinder is placed in an axial magnetic field. By rotating the cylinder, the number of turns linking with the field is made to increase gradually from none at all up to the maximum provided. Yet no e.m.f. is indicated. Nor should one be expected, for it is a sort of continuous Hering experiment.

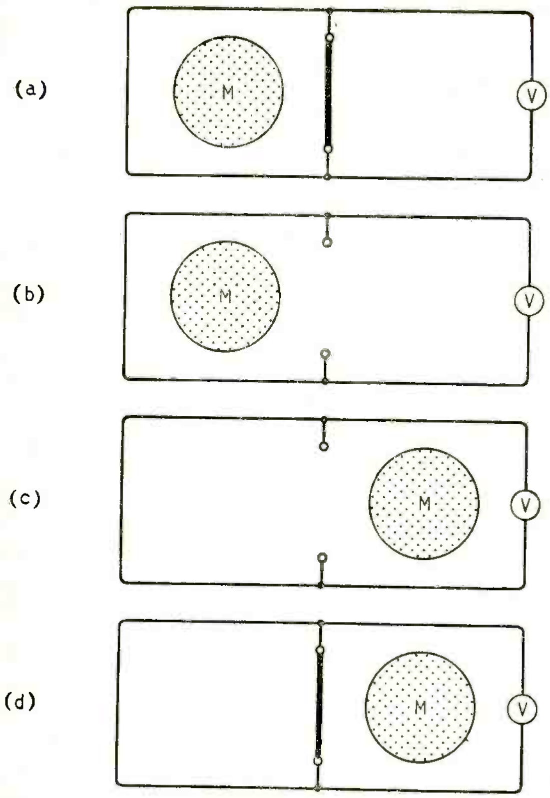
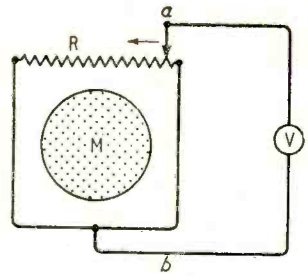


Fig. 4. This variation of the Fig. 3 experiment may make it easier to answer the questions about Fig. 3. If it doesn't, see Fig. 5.

Fig. 5 (right). R is a resistor with a sliding contact which is moved from one end to the other. Do you still feel sure about Fig. 3?



What is the moral of all this? Of the people we questioned, who are right and who are wrong? And what about the people who don't seem to have been represented in our Gallup poll, who refuses to acknowledge the very existence of magnetic fields? Are they like those who hold on to the belief that the earth is flat, regardless of the clear evidence to the contrary? Or are they the only ones who are right?

Before we can answer we shall have to decide what, in this connection, "right" and "wrong" mean. If we think that any rule or theory or idea is—or could be—*the* right one, we had better think again. In such a question as deciding which of several men in an identification parade stole our wallet last night, it would be possible (whether by luck or good observation) to be right. But in such matters as stating precisely how electromagnetic induction works, nobody can be right, because there are no still more fundamental terms with which to describe the fundamental processes of nature. We can describe the construction and working of a machine, because it is made up of simpler parts that are familiar. But if we press the analysis back to such things as electrons we cannot say what they are made of. If we begin to describe an electron as "a very tiny particle . . ." we are not really describing it, because one should immediately ask "What is a particle?" and the enquiry would never end satisfactorily, because we would be committing the logical sin of defining the obscure in terms of the more obscure. A particle, as commonly understood, is a more complex structure than an electron. If we could start with a knowledge about electrons and such things, then perhaps we could go on to describe a particle of matter accurately. But even if one day we find that an electron is made of still simpler units, that will only transfer our ignorance from the electron to them.

A Cloak for Ignorance

It is the same with induction. When we talk about lines of force, flux, and even fields, we are using these terms to hide our complete ignorance of what is really happening. All we know is that when certain conditions are provided certain results invariably follow. And what we do in the science of the subject is to state as precisely as possible the relationship between cause and effect. To assist in this it is necessary for most people to use mental pictures or concepts. The test of such a concept is not whether it corresponds accurately with ultimate reality—we wouldn't know—but whether it is (a) consistent with all observed behaviour, and (b) convenient for its purpose. Of these requirements, (a) might at first sight seem to be essential, but in practice, for the sake of (b), one often uses concepts that only approximately fit the facts, or fit only some of the facts; this apparently unscientific practice is allowable so long as the limitations are clearly understood by all concerned. The position is complicated, however, by (b) being so largely a matter of opinion.

Let's face it—we just don't know how or why it is that pushing a magnet into a coil of wire causes a voltmeter across its terminals to indicate. Probably no one will ever know. But all electrical engineers have to be able to make use of this fact to obtain desired results, such as providing light, heat, and television in our homes. Since it would be difficult to discuss such matters if blanks had to be inserted in place of words wherever our absolute knowledge was lacking, it is necessary to use concepts. To most

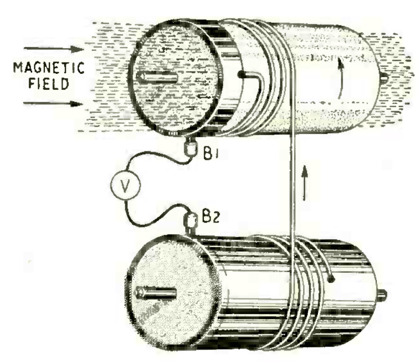


Fig. 6. This is a machine for causing an increasing number of turns to be linked with a magnetic field. Does this process cause V to read? If so, why?

people, the concept of a "field"—a sort of sphere of influence—around a magnet renders it easier to discuss induction and to make the necessary calculations. Calling it a field does not in the very least increase our knowledge of it, or prove that it exists. But even if it could be proved that it does not exist, it might still be a good thing to keep it as a concept.

Spectacles for All

The concept of just a field is still too vague and shadowy for most people. So lines of force were invented. Now in so far as anything about a magnetic field *can* be known, it is known that lines of force do *not* exist. They are simply a means of showing on diagrams—or visualizing in the mind—the directions in which fields act. They also help to suggest, by their closeness together, the relative strength of the field. As great a mind as Faraday's was not ashamed to use them as a mental aid. In just the same way contour lines on a map help one to visualize the direction and steepness of a slope, but supposing that a magnetic field actually consists of lines is as sensible as supposing that a hillside consists of lines. Yet so firmly does the line idea get one that it is quite difficult not to imagine that if a cylindrical bar magnet were rotated about its axis its lines of force would rotate with it and generate an e.m.f. in a stationary circuit through which they passed. But if we think of the field as we should, as having at any point only magnitude and direction, we realize that turning the magnet does not alter either of these properties anywhere, so is incapable of inducing an e.m.f. in an external circuit (though the stationary field does generate an e.m.f. in the rotating metal of the magnet itself).

Calling the unit of flux a "line," as some people still do, so that magnets are bought and sold on a specification of the number of lines they provide, makes the line idea even more difficult to keep in its proper place. Calling it a maxwell was better, but one couldn't help remembering that 1 maxwell is equal to 1 line. Now that the maxwell has been superseded by the weber, which is equal to 10^8 maxwells, there may be a better chance of thinking of flux as a continuous magnitude, like length or inductance.

To Clerk Maxwell, Faraday's lines seemed rather quaint; as a mathematician he found a mathematical symbol more appropriate and precise. Mathematical symbols themselves are only concepts, of course, but it must be admitted that they are the most precise and flexible way of stating generalized results of observations. For example, observations on electrons have shown them to have properties that defy any "mechanical model" to imitate, but can be expressed mathematically. Unfortunately only people with exceptionally mathematical minds can get any enlightenment from these expressions. To generalize the observed facts about induction by magnetism, even such a lucid writer as Faraday required a sentence of no fewer than 126 words. Mathematically the same thing can be stated much more precisely thus:

$$\oint \epsilon.dl = -\frac{d}{dt}\iint B.da$$

But there are plenty even of qualified electrical engineers, not to mention elementary students, who fail to appreciate this way of putting it. However, according to the author of the paper discussed at the I.E.E., those who can should escape falling into the silly misunderstandings of those of us who through mental incapacity are obliged to make do with visual concepts like the cutting or linking of flux lines. He showed that the foregoing equation produces two terms, one corresponding to the transformer or linkage-changing effect, and the other to the motional or cutting effect, and in any particular case one of these effects is often absent. No doubt he always gets the right answers.

But some other mathematician might come along and express what we know about induction in some other way, perhaps without reference at all to magnetic fields, and also get the right answers. We poor morons who haven't a clue to these refined methods, but use either or both of the two flux rules, provided we use them with discretion and beware of trick cases like Hering's, can also get the right answers. Perhaps one day we may meet a Viet Namese refugee who gets the right answers by manipulation of an abacus and a prayer wheel. The point is that as long as each of us understands what we are doing, and can get the right answers by a process that to us makes sense, it is mistaken zeal to insist that everybody must do it in one particular way, which is the only right way. Agreed that it would be convenient if everybody used the same method. Evidently Carrothers and Kapp think so, for they have expressed the view that it would have been better if the flux-cutting rule had never been thought of! Nevertheless, while like them I find flux-linking the most convenient and reliable way to look at induction problems in general, I am not sure that it is invariably simpler and more natural than flux-cutting. All such concepts are spectacles to aid our limited mental vision. I would hesitate to insist that everyone must use a replica of mine.

ONE way of solving the battery problem—but perhaps more suitable for nomadic Arabs than for stay-at-home Britons—is exemplified by this new transistor transmitter, which is powered entirely by sunlight through the medium of selenium cells. Built by Edward Keonjian (General Electric Company of America), it has a range of about 100ft.

Measurement of Rise-Time

Simple Circuits for Displaying Pulse Characteristics

By E. G. DANN

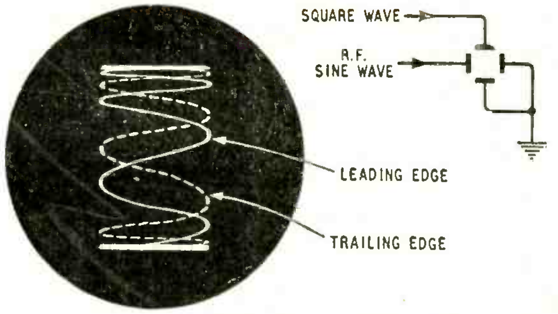


Fig. 2. (Above) Display obtained when a sinusoidal r.f. voltage is applied to the horizontal deflecting plates.

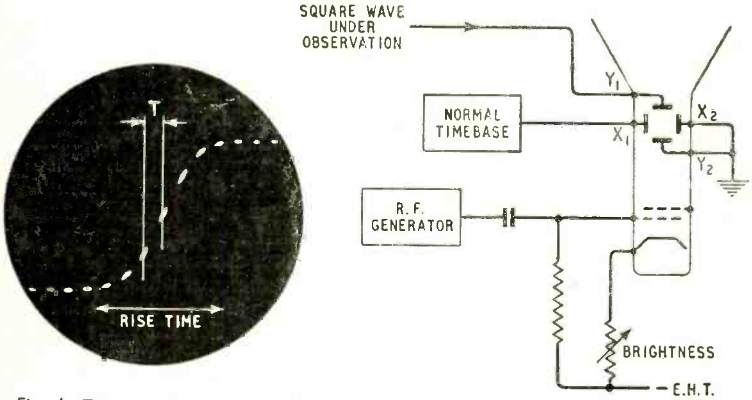


Fig. 1. Time markers derived from the positive half-cycles of a radio-frequency input to the c.r.t. grid.

THE experimenter may on occasions wish to make some observation which is beyond the normal capabilities of his test gear, either as regards the range of measurement or the degree of accuracy available. In these circumstances it is necessary to find some method by which existing equipment may be used to obtain the desired result.

The writer recently needed to make a measurement of the rise-time of the output of a multivibrator, and, while the repetition frequency could be ascertained with a reasonable degree of accuracy, the time-base of the oscilloscope used was insufficiently well calibrated to measure the time of rise of the positive excursion of the square wave.

One well-known method of providing an accurate time scale is to feed a radio frequency to the grid of the cathode-ray tube on which the waveform is displayed. This results in a brightening of the trace over the positive half-cycles of the r.f. wave as shown in Fig. 1. Since the distance between dots corresponds to the periodic time T of the r.f. wave, a fairly good assessment of the rise-time can be made.

Sinusoidal R.F. Time-base

A more accurate method of measuring rise-time devised by the writer is one in which the normal time-base of the oscilloscope is replaced by the output of an r.f. generator. Since the leading edge of the waveform under investigation has some pretensions to linearity the resulting pattern is a series of waves with a vertical time axis. Thus, by observation of the number of cycles displayed and from knowledge of the applied radio frequency, the rise-time may be accurately determined. (See Fig. 2.) For example, if a stationary trace with a convenient number of vertical waves results when the applied frequency is 1.8 Mc/s, the rise time is 1/1.8N microseconds, where N is the number of whole waves displayed.

Bunching of the cycles at the top of the pattern is an indication of slower rate of rise of the upper portion of the leading edge of the square wave.

A simple pattern of the kind shown in Fig. 2 will result only when there is an integral ratio between the square-wave frequency and the applied radio frequency, as follows from the normal behaviour of Lissajous figures.

The insertion of a filter in the lead to the oscilloscope X plates will improve the purity of the r.f. cycles displayed by elimination of harmonics in the output of the r.f. generator.

Due to the fact that the square wave must necessarily have a negative-going excursion the pattern will ordinarily show a return trace and this will afford observation of the fall-time. If, however, the oscilloscope has provision for blackout of its normal fly-back and remains synchronized with the square wave, the return trace will not normally be displayed.

A PARABOLOID four feet in diameter is mounted on top of this 60-ft mobile extensible mast which the B.B.C. has recently introduced for television outside broadcasts. The aerial, which can be remotely rotated through 360°, can be adjusted to within ±1°. When extended the mast is self supporting but provision is made for stay wires if needed.

Workshop R-C Bridge

Incorporating a 1,000-c/s Source and a Protected Sensitive Indicator

By B. T. GILLING

THE instrument to be described was designed by the writer for quick but searching tests of capacitors and resistors in the workshop. It is actually two test instruments in one, namely a resistance-capacitance bridge and a direct-reading leakage indicator for testing electrolytic capacitors at voltages up to 500. As will become apparent, one of its features is its robustness. Although extremely sensitive the instrument is so designed that there is no possibility of damage by overload, even if it is carelessly used.

The full circuit diagram is shown in Fig. 1 and can be divided into five parts as follows: signal source, bridge, bridge indicator, leakage indicator and power supply. These will be dealt with in turn. It will be seen that only one pair of test terminals is used, the required facility being selected by the three-pole switch, S4.

Signal Source.—An alternating-current source is needed, and it is possible to obtain this from a special winding on the mains transformer, but the reactance of capacitors in the picofarad range to 50 c/s is inconveniently large. An R-C oscillator of a very simple design is used in the instrument and the circuit values shown give a frequency of about 1,000 c/s when the voltage at the h.t. decoupling point is 150. The value of the 68-kΩ decoupling resistor may need modification to obtain this voltage.

The output waveform and amplitude are controlled by the cathode resistor, and some slight adjustment of this may be needed. The output transformer T1 is a small 6:1 intervalve type using the high-inductance winding as primary. Any small transformer of about this ratio is suitable provided that the high-resistance winding will carry 5 mA. A Wearite transformer Type 262 is actually used and gives an output of 18 volts peak across the 1,000-ohm ratio arms. A transformer T2 of the same type is used at the output of the indicator.

The Bridge.—The ratio arms consist of a Colvern 1,000-ohm potentiometer Type CLR 7001/15. The standards are selected by switch S3, their tolerance and the number used is limited only by expense, but the six shown give an adequate coverage. Should a standard other than one of those included be needed at any time it is connected to the "Match" terminals. Cracked-carbon close-tolerance resistors are quite cheap, but really accurate capacitors are, unfortunately, costly. A point to remember when buying them is that a capacitor supplied to a definite value is always expensive, but one close to the desired value and very accurately calibrated is less so. For example, it will be less expensive to accept a capacitor from stock calibrated at, say, 0.0988 μF than to insist on one of 0.1 μF ±½ per cent. Provided the value is low it can always be made up to the desired value with added capacitance.

The 100-ohm variable resistor in series with the 1-μF standard is to enable a sharp balance to be obtained with capacitors having appreciable losses. If desired this control can be calibrated by the experimenter to give an indication of the relative magnitude of the losses.

A decade resistance box must be considered essential for calibrating the ratio arms and the use of one can usually be obtained at a local technical school, or a suitable approach will often get the co-operation of

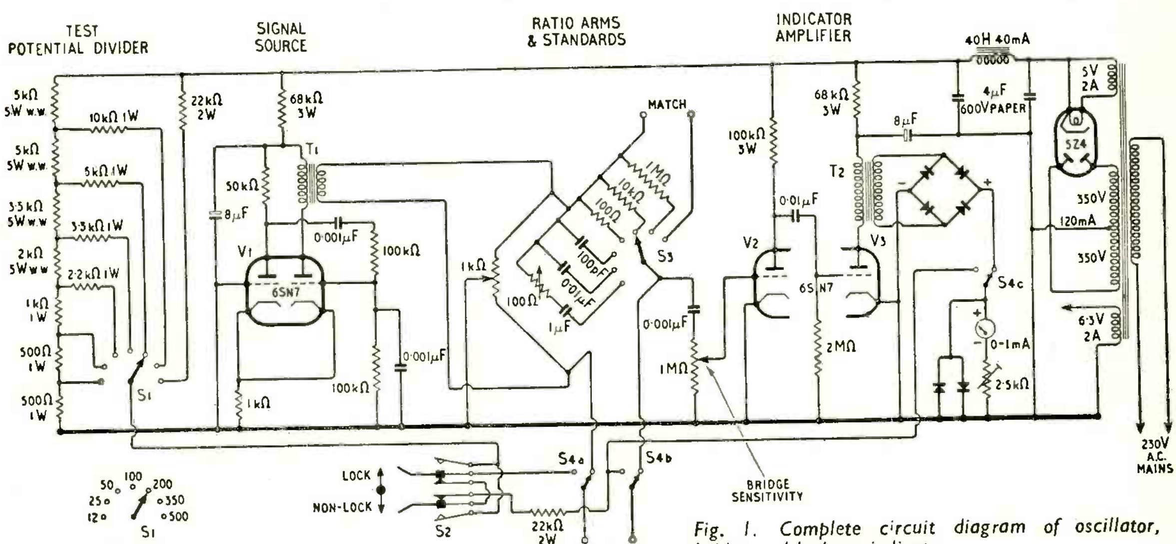


Fig. 1. Complete circuit diagram of oscillator, bridge and leakage indicator.

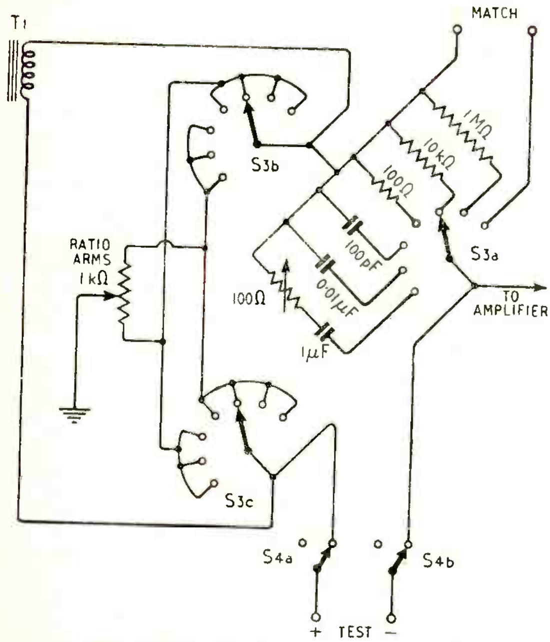


Fig. 2. The addition of two wafers to switch S3 in Fig. 1 permits the use of a single calibration for the ratio-arm scale.

R.E.M.E. or even of a Post Office engineer. At any rate, it is not the insuperable difficulty that it is often made out to be.

The circuit, as set out in Fig. 1, will need two scales on the ratio arms, one the reciprocal of the other, since low resistance and high capacity will be at the same end. Since the resistance element is linear and very evenly wound, the ratio arms can be reversed for capacity measurement and only a single scale will be needed. This is carried into effect as shown in Fig. 2 by using two additional wafers on the standards switch. It is an embellishment well worth incorporating as it simplifies the use of the instrument considerably.

Indicator.—The indicator consists of two parts, the amplifier and the meter. The first comprises two valves operated at zero bias. As the ratio arms move away from the null point the signal to V2 increases and when it exceeds a certain amplitude V2 and V3 act as limiters. The output waveform from the limiters is very distorted but this is of no consequence since the important part of the signal is around the point of balance and then its amplitude is too small to overload the valves.

The output from the amplifier is passed through a step-down transformer, of the same type as that used in the oscillator, to a bridge rectifier and thence by switch S4c. to the meter. This meter movement has a full-scale deflection of 1 mA and has two half-wave metal rectifiers connected back-to-back across it. These act as a variable shunt. When a low voltage is applied to it a metal rectifier has a fairly high resistance, but as the voltage is increased so the resistance decreases shunting a greater proportion of the current away from the meter. The second rectifier section is to protect the meter from any reverse current which may appear in certain conditions when it is being used as a leakage indicator. The 2,500-ohm variable resistor in series with the meter is to enable its maximum deflection to be adjusted to full scale when setting up the leakage indicator with 25 mA in the shunted circuit.

The rectifiers are both by Westinghouse, Type 4/1A is used as meter rectifier and Type 2/6A, with its outside ends connected together, as the shunt. Alternatively, rectifiers can be made up from an old copper-oxide unit; the bridge consists of one disc per section and the shunt of six per section with one set reversed. No cooling fins are needed.

Fig. 3 illustrates the action of the limiters and rectifier shunt combined. Balance is assumed at the centre of the ratio arms scale and curve A shows the output with no limiting action when care is taken not to overload the meter. The curve is very open and the null point not at all clearly defined. If the balance is to be made sharper a curve such as B is needed which assumes amplification but no limiting. This gives an excellent indication of balance; but when the arms are away from the null point the meter will be hopelessly overloaded and damage will inevitably result. With the limiters in use curve C is obtained, which has the sharpness of B, but which at no time exceeds the full scale deflection of the meter.

In practice the instrument gives a very sharp balance indeed. With the sensitivity control at maximum, as the ratio arm pointer is swung round the dial the meter remains at nearly its full scale deflection until the point of balance is reached. Then the meter moves from full scale to zero and back to full scale again in a matter of five to ten degrees. The sharpness of balance is maintained on all scales, and at the lower end of the 100-pF one it is easily possible to measure to within 0.5 pF. A point to remember when measuring these low capacities is that the residual capacity of the test leads must first be measured and this figure subtracted from the measured value of the component. On all the scales for ease of searching the sensitivity control needs to be set well back and only increased when a really close balance is required.

The total deflection of the meter in out-of-balance conditions is controlled by the anode voltage of V3,

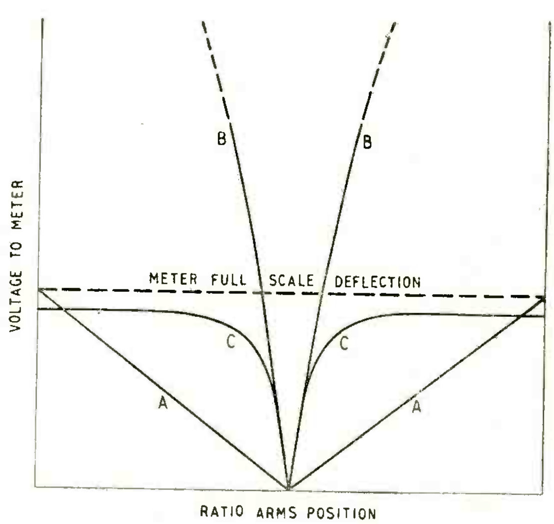
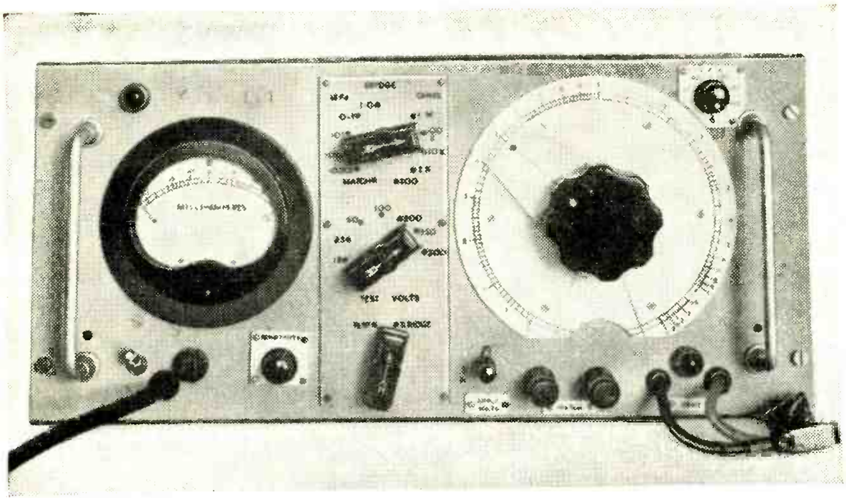


Fig. 3. Indicator response, with meter only (A), with amplification (B), and with amplification and limiting (C).



Layout of controls on the front panel. Black and red leads are used to indicate the polarity of the test clips.

and some slight adjustment of the value of the decoupling resistor to this valve may be needed. This should be done after the leakage indicator has been set up.

Leakage Indicator.—Provision is made to test the leakage of capacitors, especially electrolytics at voltages from 12 to 500 and these are selected by switch S1. Potential points are taken from the voltage divider chain across the h.t. supply and series resistors are introduced between these points and the selector switch contacts to limit the current flowing to 25 mA in each range when the test terminals are short circuited. This makes a limiting safeguard without impairing the value of the test, since, although at high current leakages the voltage at the test terminals is reduced greatly, as the leakage current decreases the voltage will rise until at 1 mA and under it reaches the full indicated potential.

The selected test voltage is applied to the capacitor by switch S2. This is a three-position key switch with one non-locking position, allowing the voltage to be applied either momentarily or for "soak" tests and the forming of electrolytics. In the central off position of the switch a 22-Ω resistor is connected across the test terminals to make sure that the capacitor under test is discharged.

Leakage is measured directly on the bridge indicating meter. The shunt rectifier is left in circuit and the meter scale calibrated by hand in milliamps. The scale is roughly logarithmic, 0-1 mA occupying approximately the first third of the scale, 1-10 mA the second third and full scale being set at 25 mA by the 2,500-Ω series resistor. As an alternative to hand calibration, a graph can be made of the new scale against the original linear one.

It will be seen that the instrument when used as a leakage indicator is immune from overload damage irrespective of the test voltage applied.

Power Supply.—A standard 350-0-350 volt, 120 mA transformer is used. At the light total h.t. current of 40 mA a 4-μF reservoir capacitor gives a smoothed h.t. voltage of 500. At this voltage it is advisable to use paper capacitors in both the reservoir and smoothing positions.

General.—The photograph of the author's instrument shows that it has more standards than are actually necessary, and a 3½in meter which happened to be available was incorporated although a smaller one would have given perfectly satisfactory results. The "Test" connections are brought through the panel and consist of about four inches of flex ending in crocodile clips. This is a much more convenient method than the conventional terminals. The method of figuring the dial calibrations can be seen in the photograph. The figure 1 at the middle top of the scale corresponds with the standard in use. No powers of 10 are indicated, each decade starting with 1. Over a period of years this method of calibration has been found to be far less confusing than the normal method in which a dial of this type would be calibrated 0.01-100. The added ciphers only lead to difficulties of interpretation.

BOOKS RECEIVED

Mathematics of Engineering Systems (Linear and Non-linear) by Derek F. Lawden, M.A. Treatise on differential equations and their solution by classical and modern methods, with examples of their application to problems arising in the design of electrical networks, amplifiers, oscillators and servo-mechanisms. Pp. 380+viii, Figs. 97, price 30s. Methuen and Company, Ltd., 36, Essex Street, London, W.C.1.

Active Networks by Vincent C. Rideout. Textbook of basic principles and formulae for students of communication engineering, including chapters on negative feedback, transient response of amplifiers, demodulation wave-shaping circuits, noise and information theory. Pp. 485+xvi; Figs. 364, price 42s. Constable and Company, Ltd., 10-12, Orange Street, London, W.C.2.

Valves for A.F. Amplifiers by E. Rodenhuis. Description of relevant Philips valve types, general hints on amplifier construction and eight complete circuits for amplifiers with outputs from 3 to 100 watts. Pp. 144+viii; Figs. 97. Price 10s 6d. Cleaver Hume Press, Ltd., 31, Wrights Lane, London, W.8.

The Inventor of the Valve, by J. T. MacGregor-Morris, D.Sc. (Eng.), M.I.E.E. A biography of Sir Ambrose Fleming, published to celebrate the 50th anniversary of his first valve patent. Pp. 124+xviii; Figs. 22. Price 10s. The Television Society, 164, Shaftesbury Avenue, London, W.C.2.

Audio Frequency Power Measurements, No. 8 in the series "Notes on Applied Science" published by the National Physical Laboratory. Discusses the basic principles and describes wattmeters of the electrostatic, thermal and electro-dynamic type, their advantages and disadvantages. Pp. 16+iv; Figs. 8. Price 1s. Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2.

Transistors and Crystal Diodes, by B. R. Bettridge. Simple explanation of how they work, and how they can be applied by the experimenter in sound receivers, television sets and amplifiers. Pp. 72; Figs. 47. Price 5s. Norman Price (Publishers), Ltd., 283, City Road, London, E.C.1.

Wireless, by Frederick Roberts. History of the development of communication without wires, written for use in schools. Pp. 98; over 60 illustrations. Price 5s. The Educational Supply Association Ltd., 181, High Holborn, London, W.C.1.

"Piped" Scanning Waveforms

Unusual Wired Television System Giving Simpler Receivers

By E. J. GARGINI*

THE commercial success of sound broadcast relay companies can be attributed to the simplicity, and hence low initial and maintenance costs, of the terminal equipment. The design of television distribution equipment to the same order of simplicity is clearly desirable so long as the sending equipment and network costs do not become limiting factors. The system described here is based on the principle that terminal equipment should not include circuitry which may be transferred to the sending end, although at the same time this transference should be halted when it comes to power distribution.

Fig. 1 is a circuit of a vision terminal unit which embodies this principle. Two r.f. signals are transmitted over the input cable together with sound signals at service level. A choke assembly separates the sound signals (in a separate control unit) which are then applied to the loudspeakers. The higher frequency r.f. signal is a 5.42-Mc/s carrier wave modulated with picture information only. A vestigial sideband transmission is used, the upper sidebands being suppressed at the sending end. The lower frequency signal is a 1-Mc/s modulated carrier wave, and this effects the double-sideband transmission of a modulated waveform which includes line and frame scanning signals.[1,2]

By passing the demodulated scanning waveform through a low-pass filter a frame scanning waveform is developed, and by passing the demodulated waveform through a high-pass filter a line scanning waveform is obtained. Input filters at the terminal unit separate the two vision signals. The video carrier modulated signal is amplified in the N309 and then applied via a low-impedance coupling circuit (L_1 and L_2) to the grid of the c.r. tube. Adjustment of the tube bias to the condition that anode current only flows during positive-going carrier pulses results in the display of monochrome pictures at a dot spacing,

* Electric and Musical Industries. This article is based on a lecture which the author gave recently to the Tevision Society.

[1] British Patent 704141.

[2] British Patent Application No. 1658/53.

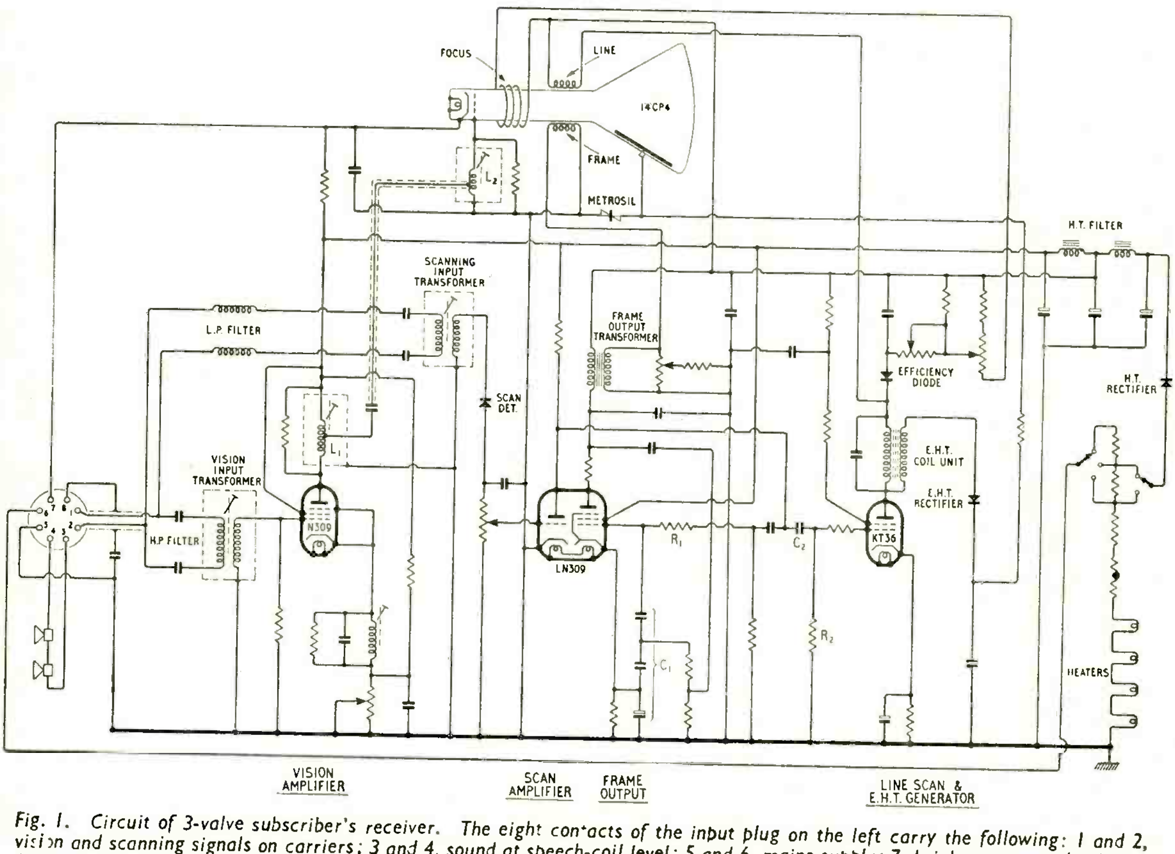


Fig. 1. Circuit of 3-valve subscriber's receiver. The eight contacts of the input plug on the left carry the following: 1 and 2, vision and scanning signals on carriers; 3 and 4, sound at speech-coil level; 5 and 6, mains supply; 7, brightness control voltage; 8, earth connection.

that is, the line is broken up into dots which correspond to the 5.42-Mc/s carrier waves. This tends to render the line structure less prominent.

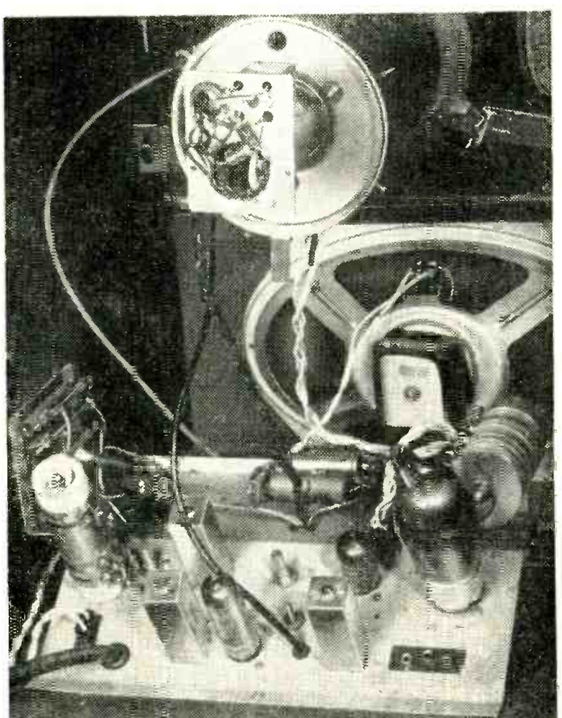
The scanning signals, after rectification at a XT1 crystal diode and amplification by the triode section of the LN309, are applied to the network R_1 and C_1. The composite signal is integrated by this RC filter and the resulting frame sawtooth is applied to the pentode frame output stage. The composite scanning signal is differentiated by the high-pass filter C_2 R_2 which results in the production of a line-scanning sawtooth waveform. This is applied to the KT36 line output valve.

This output valve has in its anode circuit directly coupled scanning coils which are shunted by an efficiency diode circuit comprising a diode in series with a resistor shunted by a capacitor. The operation of this circuit is conventional. The diode circuit rectifies the negative overshoot which appears at the valve anode at the termination of the long flank of the sawtooth grid potential. The resulting current produces the first part of the line scanning signal through the coils. The initial positive rise of potential is applied to a section of a low-pass filter which, after rectification, provides e.h.t. for the c.r. tube.

Simple Adjustment

It will be noted that if the unit is constructed for a.c./d.c. mains operation and capacitance-coupled high-impedance frame coils are used, no iron-cored transformers are necessary. Moreover, no synchronizing controls are necessary and the subscriber only has to adjust the focus, contrast and brightness. As the d.c. level is fully maintained and zero carrier can represent black level, the separate brightness control may in certain circumstances be dispensed with.

Rear view of 14-in cabinet-model subscriber's receiver, showing the 3-valve chassis of which the circuit is given in Fig. 1.



This simplification has not been obtained without some complication of the sending and network equipment. Fig. 3 is a block diagram of the main waveform generator at the sending end. Fig. 2 (a) illustrates the envelope shape of the carrier wave when the carrier has been modulated by the frame scanning signals of the composite waveform. They are generally of a pulse-like character with interruptions between the pulses, which reduces the envelope amplitude to about 15% of the peak amplitude of the frame scanning signal. These interruptions correspond to the frame return intervals.

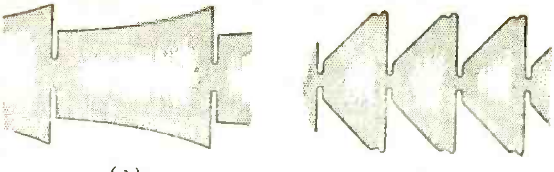
The line scanning signals are shown in Fig. 2 (b). These are of constant amplitude and of a sawtooth character. They comprise a linearly rising portion giving way to a ripple of between 50 and 60 kc/s. Interruptions in the waveform correspond to the line return intervals. When the line and frame signals are combined the line frequency components occurring during the frame flyback period are considerably reduced in amplitude. During the curved portion of the frame waveform the line scanning signals modulate the carrier wave to 90% at the beginning of the portion and to 60% at the end.

In Fig. 3 the input signal is the complete video signal obtained from a receiver at the sending installation. A circuit suppresses the video signals, leaving the sync pulses, which are fed in parallel and with negative polarity to two groups of circuits, one for line waveforms (above) and the other for frame waveforms (below). In the line waveform channel pulses are fed to a valve through a differentiating circuit which produces alternative negative and positive spikes at the beginning and end of the sync pulses. The positive spikes are removed by grid current in the valve, leaving only the negative spikes. The positive spikes produced at the anode of this valve are applied to a delay line with a delay of 90 μsec.

Each positive spike at the anode of the valve is followed 90 μsec later by a spike of negative polarity. The resultant output waveform at the anode of the valve is applied to the grid of another valve, which removes the positive spikes by grid current limitation and amplifies the negative spikes to produce a positive spike output, 90 μsec delayed with respect to the sync pulses received from the vision suppressor. The effect is that the spikes produced are 10 μsec in advance of the received pulses. This advance is provided because the video signals are relayed as modulation of a carrier wave of higher frequency than the scanning waveform signal carrier. Consequently the scanning signals are liable to be delayed in the transmission system to a greater extent than the video signals. There may also be relative delays in filter circuits at the terminal unit.

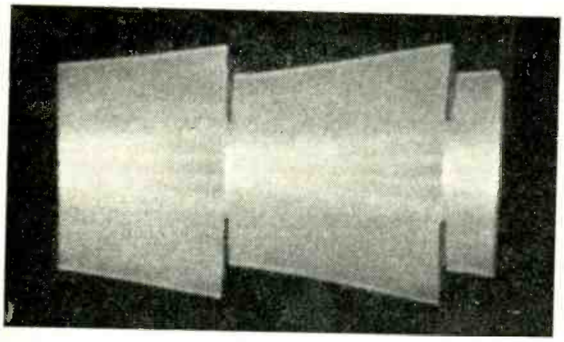
The 10-μsec advance represents the greatest relative delay likely to be encountered. The advanced pulses are next fed to a phase discriminating circuit included in a flywheel sync circuit which also includes a cathode-coupled sine-wave oscillator. The voltage output of the discriminator circuit controls a reactance valve and thereby the frequency of the oscillator in such a manner as to obtain accurate frequency tracking between the oscillator and the line frequency of the television programme.

Negative pulses set up at the anode of the oscillator valve are applied to a differentiating circuit. The differentiated output of negative and positive spikes



(a) (b)

Fig. 2. (a) Envelope shape of the frame scanning signal modulated on its carrier wave, (b) envelope of the line scanning signal on its carrier.



Composite scanning waveform from the sending generator, produced by combining the line and frame waveforms in Fig. 2.

are applied to the grid of a valve forming part of a sawtooth waveform generator. This valve is normally biased off except on the occurrence of positive spikes at its grid. These positive spikes discharge a capacitor in the circuit and generate the short flank of a sawtooth waveform. During conduction of the valve an anode-cathode potential drop produces one of the interruptions in the line scanning signals (Fig. 2 (b)).

The waveform at the anode of the sawtooth oscillator is applied to a shaping circuit which has the effect of providing a relatively sharp transition from the interruption to the linear part. The waveform is then fed through two cathode follower amplifier stages. The output from the first of these is adjustable so that the amplitude of the line scanning signal may be adjusted without introducing waveform distortion. The second cathode follower stage acts as a line and frame combining stage.

Frame Waveform Generator

Returning now to the vision suppressor, the complete sync pulse train from this circuit is also applied to the first valve in the frame waveform section. This has a delay line in its anode circuit which causes the valve to function as a frame pulse separator. The broad pulses which constitute the frame pulse in the broadcast waveform have superimposed on them reflected pulses from the delay line, but the narrow line sync pulses have not. The output from the first stage is fed to a limiter valve which conducts only in response to the superimposed pulses. Anode current, therefore, only flows when the frame sync pulse occurs.

The output signal from the limiter is applied to a differentiating circuit and the differentiated pulse is used to fire a blocking oscillator valve. This discharges a capacitor which is charged through a resistor during the interval when the valve is blocked. The capacitor is connected in series with a variable resistor which produces the interruption in the frame scanning signals of Fig. 2 (a). The waveform set up at the anode of the blocking oscillator valve is linearized in a shaping circuit and is finally applied to two cathode follower stages. A common cathode resistor functions as a combining resistor for the cathode follower output stages of the line and frame sections.

A low pass filter connected between the line output stage and the modulator input cuts off in the region of 300 kc/s, and its function is to prevent high harmonics of the line scanning signals from beating with the scanning carrier. A low pass filter following the frame output stage cuts off in the region of 3 kc/s and prevents line signals from passing into the frame circuits.

The combined line and frame scanning signals are now fed to the cathode of an amplifier valve. The output from this stage is connected to the suppressor of a modulator valve which has a carrier oscillation at 984.7 kc/s applied to its grid. This is derived from a conventional crystal oscillator. The scanning signals fed to the suppressor of the modulator valve are of such an amplitude that the anode current is cut off during the interruption in the frame scanning signal. In this way the line scanning signals are suppressed during the flyback time.

The output of modulated carrier frequency signals from the modulator valve is fed by a transformer to an r.f. amplifier stage. The output signal is developed across a tuned circuit which forms part of a wide band filter network. A fraction of this output is taken from a tapping point of the circuit and is applied by a capacitor and inductance to the input of a cathode follower and to a diode. These circuits constitute a π-type filter whose output is rectified by the diode. The load circuit of this diode comprises a low pass filter, the output of which is fed to the control grid of the modulator input valve. The signals fed to this valve are modulation frequency components which provide negative feedback, thereby linearizing the modulation process.

A low pass filter prevents feedback of carrier frequency signals and its pass band is approximately that of the modulation frequency band. The filter begins to attenuate at about 50 kc/s, and the reduction of negative feedback at these frequencies gives pre-

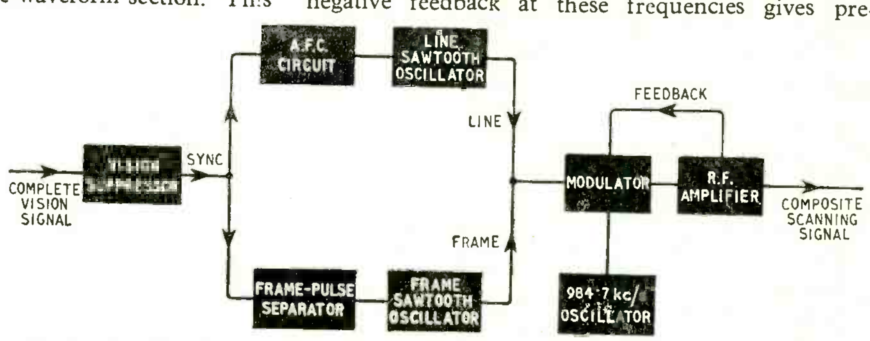
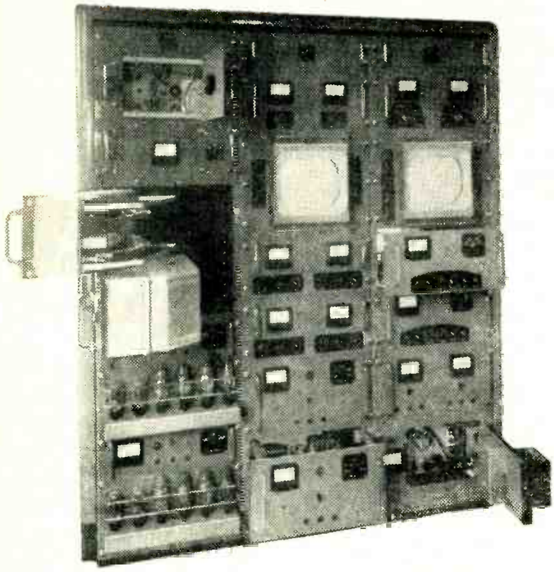


Fig. 3. Simplified block schematic of the waveform generator at the sending installation.



Racks of equipment at the sending installation.

emphasis of the higher frequency components of the line scanning signals. This produces the ripple shown in Fig. 2 (b). A series capacitor reduces the feedback at low frequencies and produces the upward curvature of part of the frame scanning signal in Fig. 2 (a).

The pre-emphasis in the wave shape Fig. 2 (a) of the frame waveform serves to correct for the finite inductance of the practical transformer in the receiver circuit, Fig. 1. The ripple in the line scanning waveform Fig. 2 (b) serves two purposes. It enables more effective use to be made of the scanning carrier and sharpens the cut-off of the KT36 in Fig. 1 produced by the waveform interruption. A sharp cut-off is required to permit the production of high e.h.t.

The ripple in the waveform does not produce "banding" in the picture since it exists only at a time when the KT36 is taking grid current. By virtue of the filters R_1C_1 and R_2C_2 in Fig. 1 the whole of the scanning signal waveform is integrated in the capacitor C_1 (the effective capacitance of all the capacitors in the grid circuit to earth), the line signals having negligible effect on the voltage across it.

The scanning signals from the waveform generator are amplified to a 9-watt level and applied to a low pass filter. Vision signals after demodulation are remodulated on to a 5.42-Mc/s carrier wave; these signals need contain no sync pulses. They are also amplified to a 9-watt level and are fed through a combining filter network which includes a section to which the scanning signals are applied. The composite signal is then combined with sound signals at service level and applied to the line.

Safety Devices

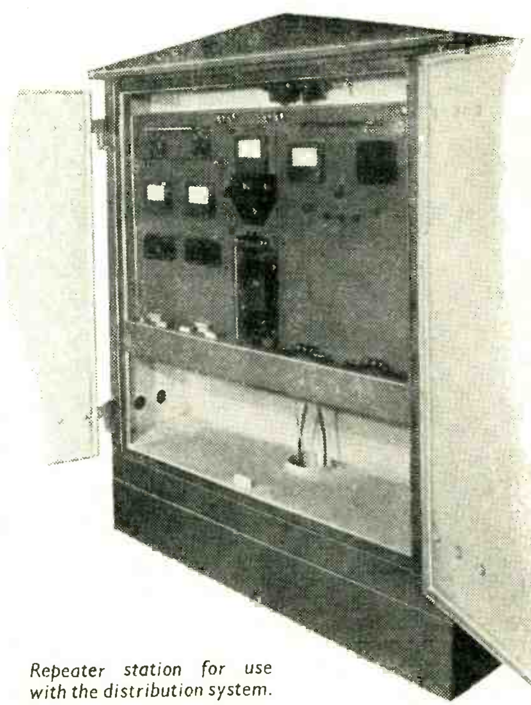
Under fault conditions or at the end of a broadcast a d.c. potential is transmitted from the sending equipment to take out of circuit all repeaters and any subscribers' equipments which may have been left switched on. At the subscriber's premises it operates a small relay in the control box. Another safety device is a resistor connected between the grid of the receiver c.r. tube and true earth which serves to inject a considerable hum into the picture if the subscriber has inserted his mains plug so that the chassis is connected to the live conductor instead of to neutral.

The receiver in Fig. 1 requires at least a 100-mV vision signal and a 200-mV scanning signal. As the sending equipment produces a 30-volt vision signal the total insertion loss must not exceed 50 db. The total effective attenuation of an equalized network using 22 s.w.g. cable is approximately 4 db per 100 yards, which may be taken to include the insertion loss of other subscribers. In the spur cable to the subscriber's down lead transformer, 14 db is the minimum attenuation that can be tolerated without producing a noticeable mismatch. The balance of 36 db may be shared between the transfer loss of the main feeder to spur transformer and the effective cable attenuation. Assuming a transformer loss of 16 db, the remaining 20 db may be accepted as the cable attenuation of a 500-yard cable run and at least six repeaters would be necessary to cover a square mile area.

If the terminal unit sensitivity was 10 mV (on vision) the planning loss would be 70 db and the cable run could be extended to 1,000 yards. At least two repeaters would be required to cover a square mile area. The purpose of this calculation is to show that there must be a cost compromise between terminal unit simplification and the number of repeaters required in a given area.

Higher Sensitivity Receivers

The position is further complicated by the fact that if the number of subscribers is low the cost of the repeaters becomes the limiting factor. One solution is to adopt the 70 db planning figure, which entails the use of receivers with 10-mV sensitivity over part of the area, and then use low-sensitivity receivers in



Repeater station for use with the distribution system.

the area close to the repeating equipment. A 5-valve receiver was used in North London in a field test of the system and this had a maximum sensitivity of 5 mV at vision frequencies. A receiver of this sensitivity was chosen because it was most likely to indicate the degree of interference from all sources.

The equipment field tested was primarily designed for single-channel operation. A number of proposals have been made for multi-channel operation. The latest high-grade cables have a cross-talk factor of the order of 50 db at 5.42 Mc/s at the end of a 1,000-yard run and are very similar to existing cables, although manufacturing tolerances have been reduced. A modification of the present system for multi-channel operation uses cables of this type. It employs quadrature transmission of vision and scanning signals in such a way that the resulting cross modulation takes the form of an interfering phase modulation of the desired signal. The effect of this phase modulation is negligible.[3]

All network transformers and equalizers in the system described cover a band between 0.7 Mc/s and 6.5 Mc/s. It is possible that the vacant band between 1.2 Mc/s, the top end of the scanning signal spectrum, and 2.7 Mc/s, the lower end of the vision signal spectrum, could be used later for colour television.

Finally, I wish to thank the engineers of E.M.I. and B.R.S. whose co-operation has made possible the practical investigation of this type of wired television distribution system.

[3] British Patent Application No. 14511/54.

Lacquer Film Capacitors

Development of Sub-Miniature Units for Use with Transistors

EXTREME miniaturization of capacitors for low-voltage operation for use in equipment employing transistors depends to a large extent on the ability to produce very thin dielectric films which are strong enough to withstand the various processes involved in the manufacture of capacitors.

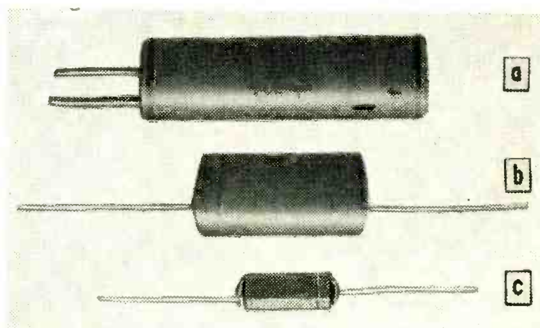
Ceramics of very high dielectric constants, say of several thousand, offer only a partial solution since there are practical limitations to the extent to which such materials can be reduced in thickness and still be usable in capacitors. Generally speaking the upper capacitance limit is about 0.01 μF for this type of capacitor, so where larger capacitances are required the wound type, typified by the rolled-paper and metal-foil pattern, offers many advantages.

Recently some work has been done in the Bell Telephone Laboratories in America on the production of extremely thin lacquer films suitable for use in the manufacture of the wound type of capacitor. A paper published in the December, 1954, *Proc.I.R.E.* under the title "Miniature Lacquer Film Capacitors" gives some interesting details of the method employed and of the characteristics of the sub-miniature low-voltage capacitors developed by this means.

The lacquer films are normally too fragile to be self-supporting and to withstand the metallizing, trimming and other processes entailed in the manufacture of the capacitors. The film is therefore formed on a supporting base, or carrier, and remains so supported right up to the final winding process.

The carrier, for which ordinary capacitor paper tissue may be used, is first coated with a "parting layer," the purpose of which is to enable the processed lacquer film to be separated easily from the carrier when the time arrives. If a carrier were used from which the film would naturally strip easily then there would be no need for a "parting layer." When employed, the "parting layer" must consist of a material which is not attacked appreciably by the solvent of the lacquer, or by the lacquer itself.

After depositing the lacquer film on the prepared carrier, it is metallized and the strip is trimmed and cut to the width required. During the final winding process the processed film is separated from the carrier by winding the film on to the capacitor mandrel and the carrier on to another mandrel of the same winding machine.



Steps in the miniaturization of capacitors. All units are 2 μF and (a) is paper and metal foil construction, (b) is metallized paper and (c) is the new metallized lacquer film type. The largest capacitor is $2\frac{1}{2}$ in long.

Assuming a lacquer film 0.1 mil (one ten-thousandth of an inch) thick is used, it is said to be possible to produce a metallized lacquer film capacitor for low-voltage operation which is only 1/6 to 1/7 the size of the smallest metallized-paper type of the same capacitance.

The illustration, taken from *Proc.I.R.E.*, shows some recent advances in miniaturization of capacitors. All units are of 2 μF capacitance and (a) is an early style made from two layers of 0.3-mil paper and aluminium foil, (b) is a 0.3-mil metallized paper capacitor and (c) is the 0.1-mil metallized lacquer-film type described here.

Tests over a period of some 2,000 hours are said to show satisfactory stability for this style of construction, while during the tests a counter circuit detected only a small number of punctures, which, incidentally, are self-sealing as with the metallized-paper type of capacitors. This was with a test voltage of 120 V d.c.; with 80 V d.c. all dielectric break-downs were eliminated so that 50 V d.c. would be a conservative rating for this type of capacitor. It will satisfy all or most present requirements of transistor circuitry.

RECORDING TOPICS

Some Factors Influencing the Quality of L.P. Discs

By O. J. RUSSELL, B.Sc., A.Inst.P.

FROM correspondence arising out of my recent comments on recording matters[1], several interesting points have arisen. Accordingly something of a rider to the previous article appears in order, particularly as interesting information has been supplied by a professional recording engineer, who wishes to remain anonymous.

The first happening of interest is that many firms are adopting a standard playback characteristic. This characteristic, which is not very different from the old A.E.S. playback curve previously given, will be variously known as the "new" A.E.S. curve, the NARTB curve and the R.C.A. "Orthophonic" curve. The playback characteristic is shown in Fig. 1(a), and it is very similar to the "old" A.E.S. curve. Suitable compensating circuits are given in Figs. 1(b) and (c).

This is a valuable measure of standardization, although not as complete as some might wish. Briefly the curve will apply for all American l.p. and "s.p." (78 r.p.m.) recordings, but the EMI group and the Decca group it is understood will continue to use their present characteristics for 78-r.p.m. recordings while using the new playback curve as a basis for l.p. recordings. No agreed "zero hour" exists for this changeover, and in fact some firms made the change in December, 1954; during 1955 most of the others will have followed suit. As the new playback characteristic (like the earlier A.E.S. curve) is virtually a "universal" curve, it does in fact compensate satisfactorily for almost all l.p. characteristics previously employed, and also for 78-r.p.m. records employing "top boost," with the possible exception of the Decca "ffrr" 78-r.p.m. characteristic. Thus a single fixed equalizer can be employed in the U.S.A., and with an adjustable tone control would suffice for British records with the exception of some pre-war recordings. However, many virtuoso pre-war recordings have been re-issued in l.p. form, and the recent drastic removal of many noteworthy pre-war recordings from the 78-r.p.m. lists may be an indication that these may be dubbed on to l.p. discs.

Considerable numbers of pre-war recordings have already been dubbed on to l.p. records. The frequent observation that the l.p. dubbing supplies superior quality to the original pressings has been explained by my professional informant. The l.p. discs are frequently made by playing back the actual 78-r.p.m. metallic positives ("mothers") when resurrecting pre-war and pre-tape recordings. Some imperfections of early types of cutting heads may be electrically compensated in the process, and the final l.p. pressing, due to improvements in techniques, may frequently be of superior quality to the original 78-r.p.m. pressings. The very low compliance of the metallic "mothers" increases the frequency of the upper pickup resonance, so that there is presumably less difficulty in extracting high frequencies from the "mother" during the dubbing process. Incidentally, experiments in dubbing from early acoustic "mothers" has shown that frequencies thought to be above the top frequency limit of the acoustic recorders can be recovered. Dubbing has clearly advanced from the days when

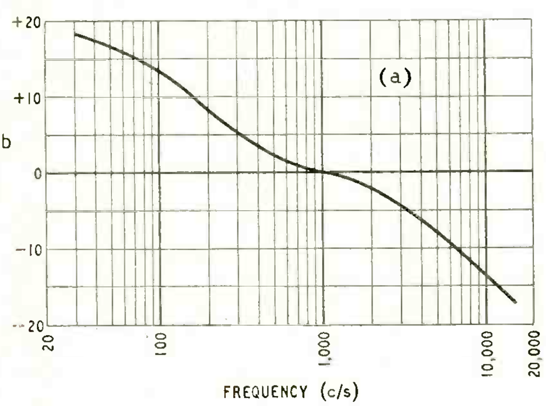
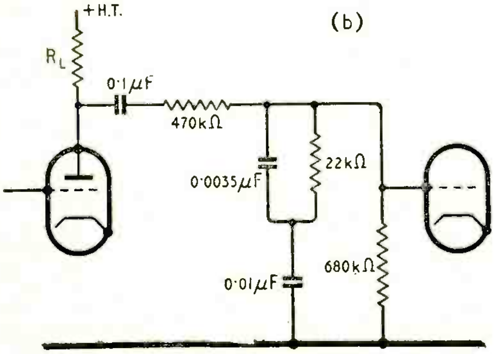
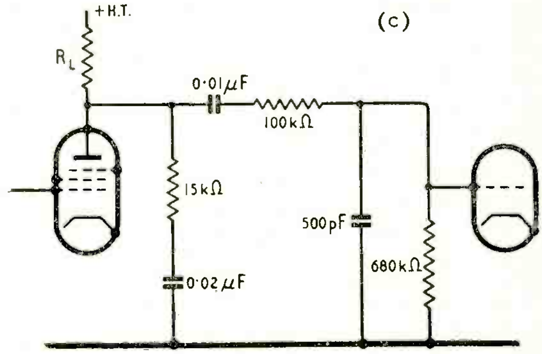


Fig. 1(a) New playback characteristic for long-playing records, with appropriate filter couplings to follow (b) a triode and (c) a pentode.





wax cylinders were duplicated by a pantograph process, although the process described above is basically a mechanical pantograph process electronically refined!

Incidentally, in the past "masters" were burnished, and it has been stated that this burnishing or "polishing" process, while only slightly increasing harmonic distortion, may greatly increase intermodulation distortion.[2] Considerable success in the restoration of early recordings has been obtained when unpolished masters are available.

In view of the many complex processes intervening between the original tape recording and the finished pressing, it is something of a miracle that modern recordings are generally of such superlative quality. Music in particular is a singularly difficult commodity to "can" to the satisfaction of musicians, technicians and critics simultaneously. The added difficulties of l.p. microgroove techniques have in fact resulted in considerable numbers of recordings suffering from technical blemishes. As might be expected the closer groove spacing renders l.p. discs particularly vulnerable to "pre-echo" due to heavy groove modulation distorting the adjoining outer groove, and thus producing the effect of a "pre-echo" as a faint impression of the sound is heard when the stylus traverses the distorted groove preceding the heavily modulated groove. The longer time delay between grooves due to the slower rotation of l.p. records gives the "pre-echo" a better chance of being heard, as it may coincide with a quiet passage prior to a violent crescendo.

Tape Joins

The impact of technical factors at every point in the overall recording process upon musical quality does not appear to be appreciated in some quarters. However, many technical blemishes in records appear to be directly attributable to the master tape. Tape joins are a particular *bête noire* of the reviewers. Briefly, they account for abrupt changes in quality, noise level, volume and pitch. While tape is a very suitable medium for long continuous recording, it should be noted that for the master tapes a speed of 30 inches per second is used. Thus a 3,600-ft spool lasts just over twenty minutes, and consequently tape joins are frequently inevitable in practice. Abrupt changes are frequently noticeable at tape joins in the finished l.p. discs. An even more horrifying possibility is the allegation that repeats in classical works are sometimes faked by merely playing the tape through again.[3]

Even harsher accusations against recording practices have been made[4], and it is certainly true that the control engineers play a very important role in the recording process. A simplified diagram of the overall process from studio to the lacquer "cut" is shown in Fig. 2. The acoustic properties of the studio may be adjusted by the use of screens and absorbers, a process in which the recording artists may be expected to have very definite ideas. Pick-up of sound and balancing of orchestral sections may be by the use of several microphones, three to twelve being quite usual. One American recording concern, however, uses only a single microphone for many of its classical recordings. The microphone inputs are individually equalized, mixed and passed through a variable equalizer into a tape recording and playback unit. The microphone outputs are mixed and the variable equalizer adjusted by the engineer until the replay

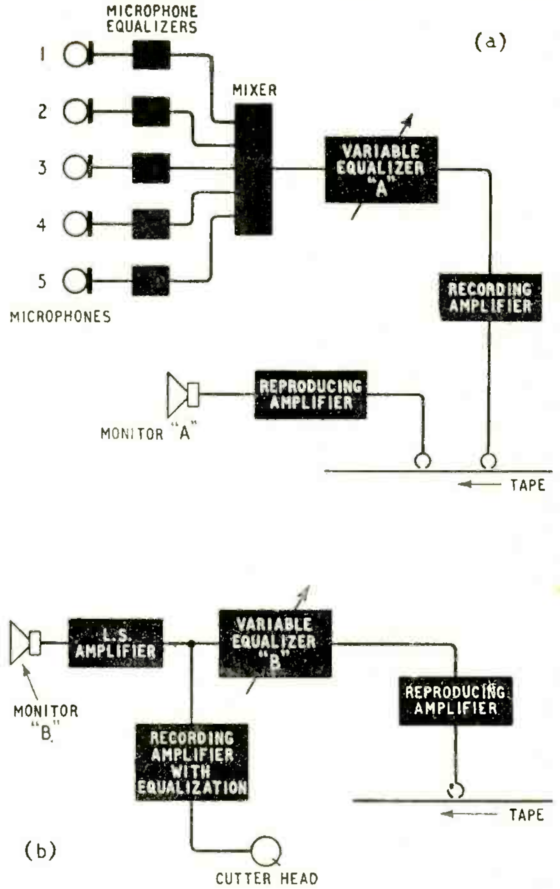


Fig. 2 Stages in the production of a lacquer "cut"; (a) recording the tape master, (b) transcribing from tape to disc.

speaker "A" gives the desired balance in its own particular acoustic environment. While the environment will usually be a familiar one, it may well be a totally unfamiliar one such as the ante-room of a foreign concert hall or theatre.

The lacquer "cut" is made by playing back the edited tape recording, and generally a different machine and a different monitor speaker "B" in a different acoustic environment will be used. A playback equalizer is used, and generally a disc is cut without need for adjustment of the playback equalizer, although tapes from machines of different characteristics may require equalizing adjustments. When a satisfactory playback is achieved, the lacquer disc is cut via a recording amplifier also incorporating an equalizer. Unfortunately, this equalizer cannot be designated as a "black box" imposing the "recording characteristic," tempting as such a description would be.

Indeterminate Variables

It is clear that so many variables are present, including those variables of the "personal equation" type, that it is pointless to argue over a decibel or two at the extremes of the audio spectrum. This is quite apart from such technical variables as high-frequency playback loss which also enter the picture. Moreover, with the additional technical processes involved in producing the finished pressings, it is clear that perfection in recordings is not easily achieved. Contemplating the overall system from recording studio to the home listener's loudspeaker it is frustrating that overall negative feedback cannot be applied. At present negative feedback is only applied in the broadest cybernetic sense through the activities of critics and the purchasing preferences of the public and the depth of their pockets.

REFERENCES

[1] RUSSELL, O. J., "Stylus in Wonderland." *Wireless World*, October, 1954.
[2] ROYS, H. E., "Intermodulation Distortion Analysis as Applied to Disc Recording and Reproducing Equipment." *Proc. I.R.E.*, Vol. 35, page 1149 (October, 1947).
[3] WARRACK, J., "Chamber Music for All." *Daily Telegraph*, November 8, 1954.
[4] Editorial, *The Gramophone*, October, 1954.

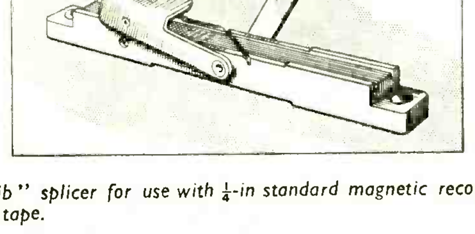
Recording Tape Splicer

IN theory it is a simple matter to join broken magnetic recording tape, using a pair of scissors or a razor blade and a bit of sticky tape. Those who have tried it will know that in practice it can be very fraying to the temper, and that it is by no means easy to align the ends properly or to produce a joint that will not subsequently hold up in the guides.

The "Bib" tape splicer produced by Multicore Solders, Ltd., Hemel Hempstead, Herts, and used in conjunction with Scotch Boy No. 41 "non-oozing" adhesive tape, produces a perfect joint with the minimum of effort.

The body of the splicer is a brass block grooved to a clearance fit for standard ¼-inch tape, with cork pressure pads on hinged arms located to hold the ends firmly in line. A transverse slot at an angle of about 60° is provided to guide the cutter when making the scarfed joint, and parallel slots at the edges of the tape guide ensure that the joint is reduced slightly in width when trimmed—actually by the thickness of the razor blade if it is held vertical. Although not mentioned in the instructions, we found that it was important to make the direction of each trimming cut towards the tapering point on each side, otherwise there was a tendency to pull the extreme point out of the joint slightly. With this precaution a perfect splice was obtained every time.

The retail price of the "Bib" splicer is 18s 6d. It is supplied on a flock-sprayed wooden base, but can be removed from this and attached directly to the recorder deck by two screws, if desired. The instruction leaflet contains useful general hints on tape editing.

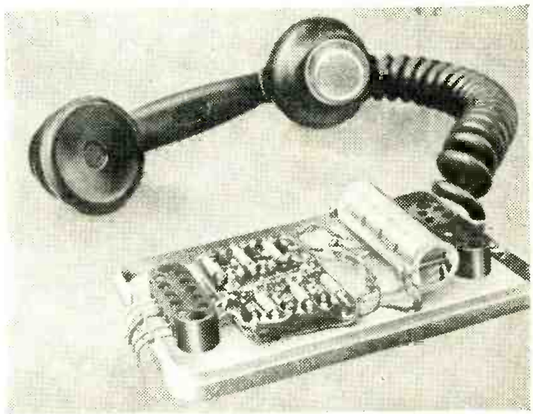


"Bib" splicer for use with ¼-in standard magnetic recording tape.

Transistorized Telephone

SHOWN in the illustration is a telephone handset fitted with a microphone designed for use in very noisy locations. It responds only to sounds originating close to the mouthpiece; in consequence, the output is much too low for its use in ordinary telephone systems without pre-amplification.

An amplifier designed around Mullard junction transistors is shown. It comprises two stages for bringing the output of the microphone up to the normal level and a third to give further amplification where a high noise level prevails at both ends of the line. The amplifiers are operated from hearing-aid type batteries in the plastic tube on the right of the unit.



Noise-cancelling telephone and transistor amplifier.

As transistor equipment can, where necessary, be made very small the amplifier could be incorporated in the handset itself and powered by the low-voltage supply of the normal telephone system.

Commercial Literature

Band III Television Converter with station selector switch, on/off mains switch (which also controls the main receiver) and Band-III station tuning control. May be operated with either a.c. or a.c./d.c. receiver and power consumption is 10 watts. Also a **Television Pre-amplifier**, a **Distribution Unit**, and a **Multi-outlet Box.** Leaflets from Aerialite, Castle Works, Stalybridge, Cheshire.

Oxidation Insulation for closely spaced wire-wound resistors. A new process giving a coating of good insulating properties to the nickel-chromium-iron alloy "Brightray B," described in a leaflet from Henry Wiggin & Company, Wiggin Street, Birmingham, 16.

Capacitance Meter with range of 0-250pF and facilities for measuring stray capacitances *in situ*. Frequency modulation of a transitron oscillator is changed by capacitance to be measured and the change is detected by a linear discriminator. Also an **A.C. Voltage Regulator,** an **Oscilloscope Camera,** a **Cathode Follower Unit** and various **Pressure Transducers.** Leaflets from J. Langham Thompson, Bushey Heath, Herts.

Arc Soldering Iron with one electrode formed by hollow carbon bit and the other by resin-cored solder fed through the centre of it. Contact with work completes the circuit, forms an arc and melts the solder. Current supplied from 4-V or 6-V battery or transformer. Description on a leaflet from C. J. Casey (London), 49, St. James's Street, London, S.W.1.

Test Gear and Electronic Instruments. Services offered by Livingston Laboratories as agents for a large number of different makes are explained in a booklet "What We Can Do For You." From Livingston Laboratories, Retcar Street, London, N.19.

Gramophone and Microphone Pre-Amplifier

(Concluded from page 14 of January, 1955, issue)

Constructional Recommendations: Test Procedure

By P. J. BAXANDALL, B.Sc.(Eng.)

IN building the pre-amplifier, there are several practical matters which must receive attention if first-class results are to be obtained.

To keep the hum level in the input stages as low as possible, the following recommendations should be adopted:—

(a) The wiring, particularly that associated with the grid and cathode circuits, should be arranged so as to avoid forming loops of large area, since hum voltages of appreciable magnitude can be induced in such loops by stray 50-c/s magnetic fields from nearby mains transformers, etc. A good layout for the microphone and mixer stages is shown in Fig. 8.

(b) The valveholders for the EF86's should be made of high-grade dielectric material, ordinary Bakelite being liable to introduce appreciable coupling between heater and grid pins; the holders made by Ediswan-Clix in p.t.f.e. are suitable. (The advent of all-glass valves such as the EF86, with the grid pin diametrically opposite the heater pins and with internal shielding between them, together with special valveholders, has made it possible to obtain extremely low hum levels even when the grid-circuit impedance is high, so that the advice given by the author in an earlier article,[11] always to use top-grid valves for such applications, may now be regarded as out of date.)

(c) Heater wiring should be twisted and the chassis should not be used as a return lead for heater current. Stray capacitance between the heater leads and grid circuit wiring should be kept as small as possible, a good arrangement being to run the heater supply along the top of the chassis, taking each heater feed down through a hole in the chassis near the valveholder but diametrically opposite the grid pin.

(d) A common heater supply may be used for all

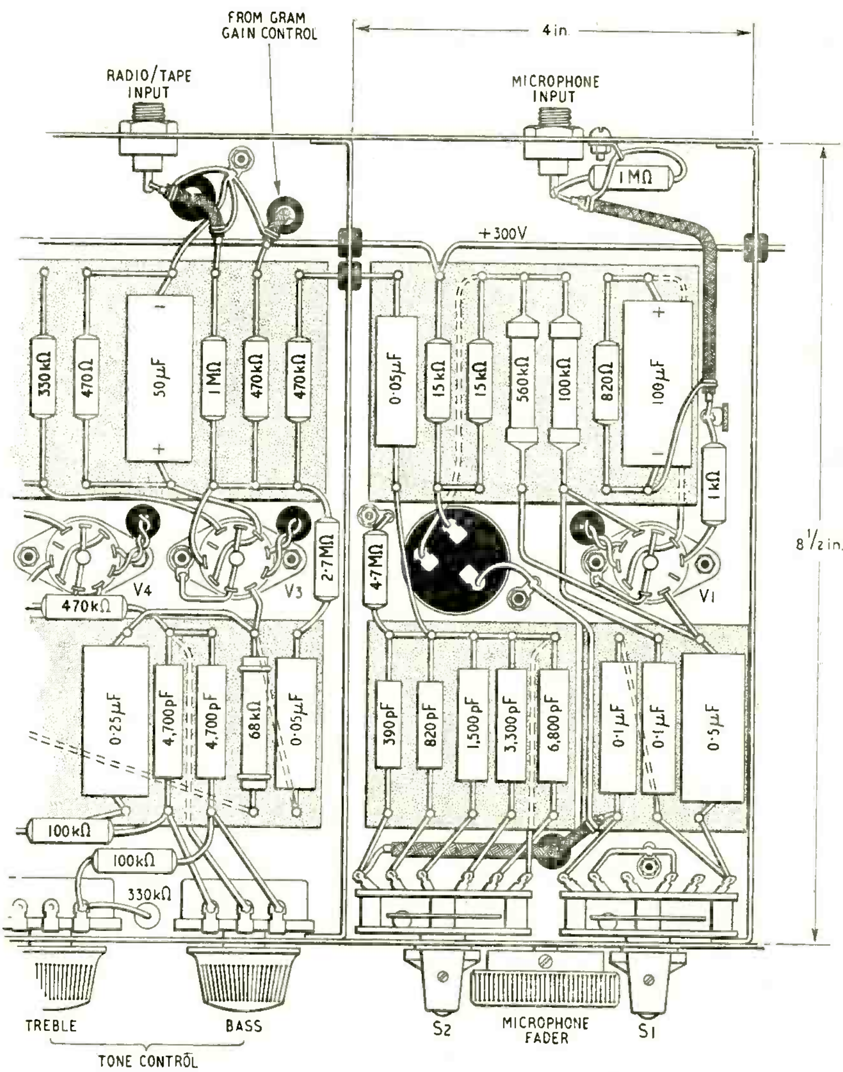


Fig. 8. Underside view of part of the chassis, showing a suitable layout for the microphone and mixer stages.

valves, and should have either a fixed centre-tap, connected to chassis, or, alternatively, a "hum-dinger" potentiometer, of value about 100Ω, whose slider is connected to chassis. A fixed centre-tap should be quite satisfactory if all other precautions have been taken, but a potentiometer has the advantage of enabling the hum on one particular input stage to be reduced to a specially low value if and when required. (The application of a d.c. bias voltage to the heater supply, as recommended in an earlier article,[14] is unnecessary with moderrn valves such as the EF86, which have been specially designed for input stages.)

(e) The whole pre-amplifier circuit should be electrostatically screened, by mounting in a metal cabinet or by fitting a base-plate to the chassis.

(f) If a microphone input transformer is used, it should be enclosed in a Mumetal screening box. (The "Bi-limboid" series of astatic input transformers, made by Wright and Weaire Ltd., may be recommended; their hum-cancelling properties enable a screening box to be dispensed with under some circumstances, but when used in conjunction with ribbon microphones, it is usually desirable to employ a screening box.)

Some further practical points, relating to matters other than hum, are as follows:—

(g) It is very desirable that when one input stage is faded right down, but is receiving a large input signal, no audible signals from this channel shall get through to the output *via* unintentional stray couplings. For example, a fraction of a picofarad of stray capacitance between the anode circuit of the input stage in question and the grid circuit of the mixer stage, is sufficient to give very appreciable break-through with the gain control set to zero. Stray capacitance coupling between one input stage and another gives a similar result, except that the volume of the break-through sound is then dependent on the setting of the gain control of the "receiving" stage. In both cases the sound is thin and screechy, due to the greater effectiveness of the stray capacitance coupling at high audio frequencies.

To avoid the above trouble, the components associated with one input stage should be grouped together and a screening partition placed between them and the group of components associated with the next stage. The signal-output lead from each input stage should be screened and taken through to the mixer-stage compartment, where the 470-kΩ mixer-input resistors should be mounted.

(h) A further desirable feature is that no appreciable clicks should be heard on operating the switches associated with the low-pass filter or the microphone bass-cut circuit. In the latter case, it has been found that the main precaution necessary is to mount the bass-cut capacitors on a separate group board, as shown in Fig. 8; if they are mounted on a group board which also contains components having applied d.c. voltages, the slight leakage currents flowing in the group board are sufficient to cause the unused capacitors to become charged, resulting in large clicks when they are switched into circuit.

In the low-pass filter, resistors of 10 MΩ are connected across the switch contacts to ensure that the capacitors are charged to the appropriate voltage before being switched into circuit.

With regard to the general form of construction, the simple scheme depicted in Figs. 8 and 9 is considered to have much in its favour, though the size of the unit could certainly be reduced by adopting a more advanced layout. Due to the use of miniature valves and double electrolytic capacitors, the overall size is, however, small enough for most applications.

For applications where all the facilities given by the circuit of Fig. 1 are not needed, some of the following simplifications may be made, with consequent reduction in cost:—

(a) Adopt triode connections permanently in the microphone input stage; the gain will then be fully sufficient for all normal purposes when a good moving-coil microphone is used, and enough for many purposes using a ribbon microphone. (Connect anode to G_2, G_3 to cathode, and make the anode load and cathode bias resistors 100 kΩ and 1 kΩ respectively.)

(b) Omit the bass-cut circuit in the microphone stage, or provide a smaller number of positions.

(c) Omit the gramophone input stage. and employ a crystal pickup feeding directly to the mixer stage.

(d) Use the two halves of an ECC81 (12AT7 or CV455 are equivalent) for the mixer and tone-control stages. The anode loads should be 68 kΩ and the cathode-bias resistors 680Ω. Occasional samples of this valve may possibly be too microphonic[6], but, in view of the reasonably high signal level, little trouble is likely to be experienced.

(e) Omit the master gain control at the output of the pre-amplifier; the facility it provides for fading out two programme sources simultaneously may not be needed.

(f) If the pre-amplifier is to be operated exclusively off a power pack separate from that in the main amplifier, only one stage of decoupling is necessary in the h.t. feed to each input stage. (It is possible, provided suitable precautions are taken with regard to layout and wiring, to obtain a satisfactorily low hum level even if the power pack is built on the same chassis as the pre-amplifier; in particular, the mains transformer should be mounted as far from the input stages as possible and non-magnetic chassis material is desirable. Trouble from hum is, however, much less likely if a power pack well separated from the pre-amplifier is employed.)

Tests.—The circuits employed in this pre-amplifier are such that no critical adjustments are normally required in order to obtain the desired performance; but, as with any electronic equipment, it is quite possible that—due to faulty components, wiring errors or unsuitable layout—the correct result may not be obtained straightaway.

It is strongly recommended that, no matter what other tests the reader may wish to make, the first test should be to measure various d.c. voltages with a high-resistance meter such as an "Avometer" Model 8. If a meter of lower resistance be used, allowance should be made for the reduction in voltage caused by connecting the meter.

The h.t. supply voltage should be within the limits 270 V to 330 V. and anode and cathode voltages should then be within the following limits:—

(a) Cathode to earth, on all valves: 1.2 to 1.8 V.

(b) Anode to earth, on all valves except output valve: 60 to 150 V.

(c) Anode to earth, on output valve: 80 to 170 V.

If any of the above voltages are found to be dependent on the settings of one or more of the controls, then wrong connections, faulty components or self-oscillation should be suspected, in that order.

If the pre-amplifier has passed the above d.c. tests, it is reasonably safe to assume that the non-linearity

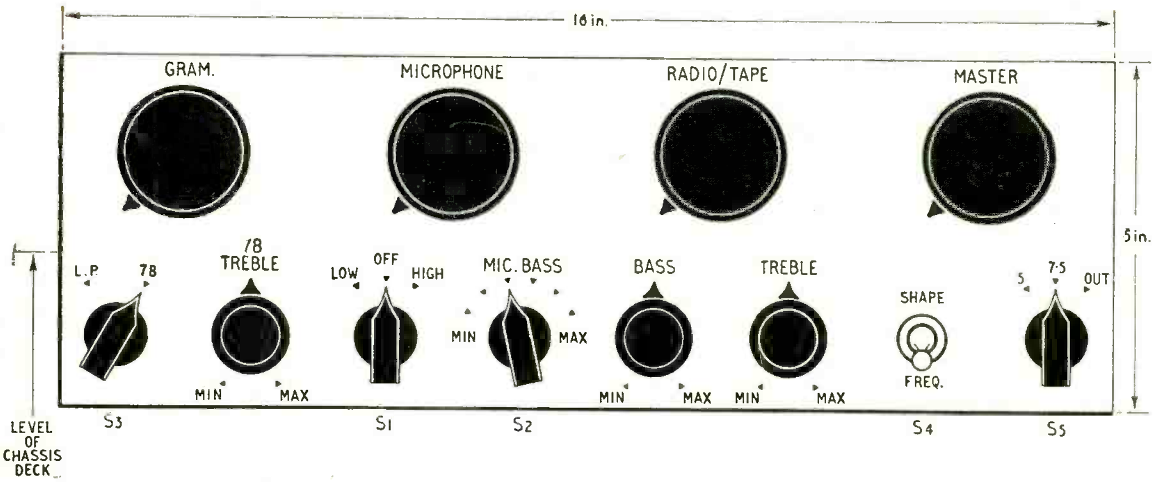


Fig. 9. Suggested front-panel layout corresponding to the under-chassis construction shown in Fig. 8.

distortion will be satisfactorily low and that it will remain low despite normal variations in mains voltage, valve ageing, etc.

Readers possessing, or able to borrow, suitable test gear, will, no doubt, wish to check the frequency response with various control settings. However, the absence of such measuring facilities need not be regarded as an overwhelming handicap, since careful listening tests should be able to indicate whether or not the controls are functioning in approximately the correct ways.

A suitable frequency-response test to start with is to measure the overall response from the microphone-stage input to the final output. The bass and treble tone controls should be set half way between full-lift and full-cut positions, giving a nominally flat response, and the microphone bass-cut and low-pass filter switches should also be set for level response. The effective load on the pre-amplifier output should be 250 kΩ. The overall response curve should then agree with Fig. 7 within ±1 db over the frequency range 40 c/s to 15 kc/s. If satisfactory agreement is not obtained, the responses of the various stages should be measured separately, and the origin of the discrepancy discovered. The following points may be helpful:—

(a) If the two 4700-pF capacitors and the two 100-kΩ resistors in the main tone-control network are perfectly matched pairs, the gain from the mixer stage input to the tone-control stage output will normally fall by a fraction of a decibel as the frequency is raised from about 400 c/s to about 4000 c/s. Such a small change in gain is really quite unimportant, but it may be eliminated if the 100-kΩ resistor between the mixer valve anode circuit and the 1 MΩ bass-control potentiometer is reduced in value by an amount equal to the effective output impedance of the mixer stage, this impedance being just under 10 kΩ when two input stages are employed. In practice, due to the effects of component tolerances, the fall in gain between 400 c/s and 4000 c/s may appreciably exceed 1 db, or it might conceivably be a rise rather than a fall; in either case the remedy is to shunt an extra resistor across the appropriate 100-kΩ resistor in the tone-control network.

(b) The frequency response of the mixer stage, when not connected to the tone-control stage, should be flat within a fraction of a decibel up to 15 kc/s. If the response falls off appreciably at the top end, the cause is almost certainly the existence of too much stray capacitance across the 2.7-MΩ feedback resistor; 4 pF would be sufficient to give a loss of 3 db at 15 kc/s. It is not difficult to arrange the wiring so that the stray capacitance across this resistor is kept down to 1 pF, in which case the top loss will be quite negligible. If, due to unsuitable layout, it is found to be impracticable to obtain a low enough stray capacitance, the resultant top loss may be approximately compensated by connecting a small capacitor across each of the mixer input resistors.

(c) Effects of a similar nature to the above can occur in the output stage, and the wiring should be arranged so as to keep the stray capacitance between anode and grid circuits to a minimum.

(d) The frequency response of the output stage in the 30-c/s to 60-c/s region (see Fig. 7) may be adjusted slightly, if necessary, by altering the value of the 8.2-MΩ feedback resistor.

(e) The frequency response of the gramophone input stage, on the "78" setting of S3, may be adjusted, over a region similar to that mentioned in (d), by changing the value of the 6.8-MΩ feedback resistor. In the "LP" (long playing) condition, the response at such low frequencies is determined mainly by the value of the 3.3-MΩ resistor in the network connected to the "LP" contact of S3.

With the pre-amplifier connected to a power amplifier and loudspeaker, and set for a flat frequency response, the Johnson noise at full gain on a microphone channel, with no signal source connected to the input, should be clearly audible all over the room, and should sound louder than the accompanying hum. If the hum level is undesirably high, and if it cannot be satisfactorily minimized with the "hum-dinger" potentiometer, the first thing to do is to find out whether the hum is due to the a.c. heater supply or not; this is easily done by momentarily disconnecting the heater supply—the valves will continue working for a few seconds on their stored heat. No matter what the cause of the hum, a careful consideration of the principles outlined previously should enable it to be cured.

Acknowledgment.—The manuscript of this article has been carefully scrutinized by E. F. Good, who has also done independent calculations to check the mathematical results. This valuable service is hereby gratefully acknowledged.

Apology.—Since the appearance of the negative-feedback tone control article,[2] in October, 1952, so much correspondence has been received that it has, unfortunately, not been possible to reply to all letters. The writer would like to apologize to the readers concerned and to any others who have been inconvenienced by the fact that, due to unexpected curtailment of spare time, the present article has appeared much later than was originally expected and implied.

REFERENCES

[1] "High-Quality Amplifier Design" by P. J. Baxandall, *Wireless World*, Jan. 1948. (Also appears in a booklet "High-Quality Audio Amplifiers" available from *Wireless World*.)

[2] "Negative-Feedback Tone Control" by P. J. Baxandall, *Wireless World*, Oct. 1952.

[3] "Equipment for Acoustic Measurements—Part 1" by D. E. L. Shorter and D. G. Beadle, *Electronic Engineering*, Sept. 1951.

[4] "New Equipment for Outside Broadcasts" by A. E. Barrett, C. G. Mayo and H. D. Ellis, *World Radio*, July 21 and 28, 1939.

[5] "New Equipment for Outside Broadcasts" by S. D. Berry, *B.B.C. Quarterly*, Summer 1952.

[6] "Newly Developed Amplifiers for the Sound Programme Chain" by S. D. Berry, *B.B.C. Quarterly*, Summer 1954.

[7] "Microphones," B.B.C. Engineering Training Manual, page 29, published by *Wireless World*.

[8] "Radio Designer's Handbook," page 730, fourth edition, published by *Wireless World*.

[9] "High-Quality Amplifier: New Version" by D. T. N. Williamson, *Wireless World*, Nov. 1949.

[10] "Pickup Input Circuits" by R. L. West and S. Kelly, *Wireless World*, Nov. 1950.

[11] "Filters" by "Cathode Ray," *Wireless World*, Jan. and Feb. 1950.

[12] "The Miller Integrator" by B. H. Briggs, *Electronic Engineering*, Aug., Sept. and Oct. 1948.

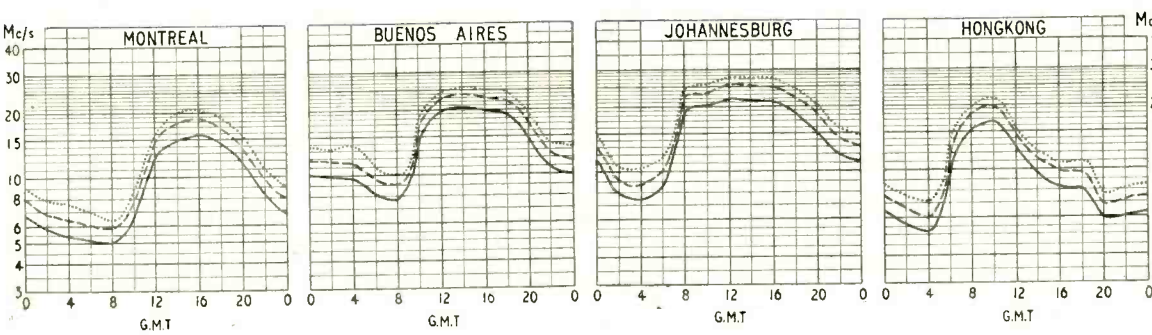
[13] "Design of High-Pass, Low-Pass and Band-Pass Filters Using R-C Networks and D.C. Amplifiers with Feedback" by C. C. Schumard, *R.C.A. Review*, Dec. 1950.

[14] "Hum in High-Gain Amplifiers" by P. J. Baxandall, *Wireless World*, Feb., 1947.

AUTOMATIC SWITCHING. Sound broadcast programmes for the B.B.C.'s West Region transmitters are switched to their destinations by a system something like an automatic telephone exchange. It is operated by a single engineer at this control desk, which is the "nerve centre" of a new control room recently installed at the West Region headquarters in Bristol.

SHORT-WAVE CONDITIONS

Predictions for February



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

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

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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

Simple Inductance, Capacitance and Resonance Meter

By L. F. SINFIELD

A Useful Adjunct to a Service Signal Generator

THE measurement of small inductors and capacitors for use at radio frequencies is quite a problem, as normally a fairly high degree of accuracy is desired and this entails the use of expensive equipment such as a laboratory universal bridge. Such equipment is certainly not economic if measurements are required only occasionally, as is usually the case.

Although the resonance method does not normally give a direct reading of the inductance it is a simple matter to lay a ruler across a resonance "abac" at capacitance and frequency and read off the inductance. A dynatron, transitron or cathode-coupled two terminal oscillator can of course be used, but even if this will oscillate satisfactorily it is rather cumbersome as it requires valves and power supply, and in any case also requires additional apparatus to measure the frequency.

An adaptor was therefore built to work in conjunction with a signal generator so that the generator would resonate coils with a calibrated capacitor and give meter indication of resonance. It was not expected that any very high degree of accuracy would be obtained, but on test inductors of known values have given readings within limits normally required for this range.

Basically the unit consists of a detector and meter to indicate the signal generator output. The tuned circuit is in series with the meter and its high impedance at resonance gives a dip in the meter current.

The generator used was a cheaper grade "servicing" type, and was modified so that the output was obtained via a cathode follower to give a low-impedance output (about 100 ohms) at maximum output through the entire fundamental range of 100 kc/s to 80 Mc/s. Signal generators using a buffer stage, link-coupled output, or both, will be quite suitable and need no modification.

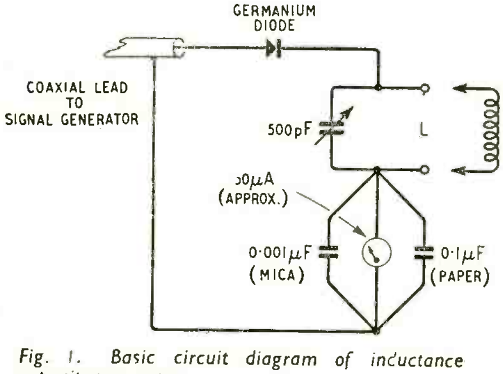


Fig. 1. Basic circuit diagram of inductance capacitance meter.

A germanium diode (GD5-OA61 or other equivalent) provides rectification for the meter which is of approximately 50μA full-scale deflection. The exact sensitivity and calibration of the meter are unimportant as it merely indicates dip. An ex-Government oil temperature meter was adapted by the author, but a centre-zero movement from a visual indicator unit (see *Wireless World*, Sept., 1951) could be used. The meter is by-passed by a 0.1μF capacitor and a further 0.001μF mica type, so that as far as r.f. is concerned the meter and the frame of the 0.0005μF tuning capacitor, as well as one side of the inductor, are all earthy.

Actually the meter can be dispensed with entirely and a pair of phones substituted. The signal generator should then be audio-modulated and the tone will be audible in the phones. The unit is then tuned for minimum audio signal. 100-ohm moving-coil and 4,000-ohm moving-iron phones have been tried and both work satisfactorily, but the high-resistance type gives a louder signal. An ideal arrangement would be to fit a closed circuit jack in series with the meter so that high-resistance phones could be inserted in series with the meter to give indications by either method.

Layout and Calibration

Layout is as shown in Fig. 2 and the overall size about 5in×4in×2¼in. A bakelite panel is used and the whole can be put in a wooden or bakelite box. This is a precaution against increasing the minimum capacity of the tuning capacitor. No trouble has been experienced with hand capacity at any frequency.

Using a known inductance (Wearite PA2-170μH, PA6-37.5μH, PA5-5.5μH) the capacity scale is calibrated. Set the signal input with the generator output control to nearly full scale with the PA2 in place. Set up the following frequencies and calibrate capacitor at each resonant point: 550 kc/s–0.0005μF;

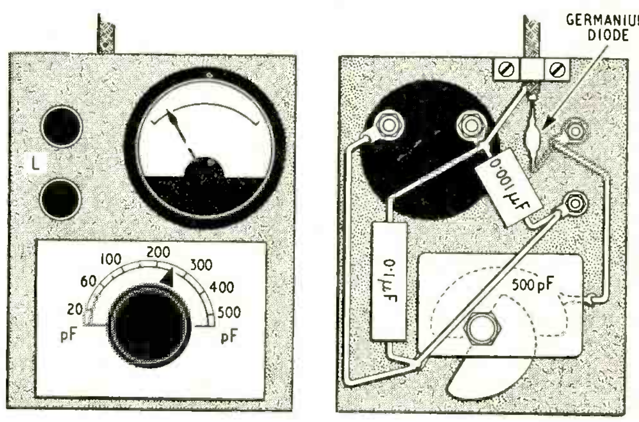


Fig. 2 (right). The layout and wiring are simple. A non metallic box should be used to keep stray capacitance at a minimum.

610 kc/s - 0.0004μF; 705 k/s - 0.0003μF; 865 kc/s 0.0002μF.

Below 200pF it is advisable to use a coil having a single layer of spaced turns so that the coil capacity will not appreciably add to the main tuning capacity and cause calibration error. Use now the PA5 type coil and set up as before: 4.8 Mc/s-200pF; 5.5 Mc/s-150pF; 6.75 Mc/s-100pF; 7.5 Mc/s-80pF; 8.7 Mc/s-60pF; 10.7 Mc/s-40pF; 15 Mc/s-20pF.

These are the calibration points used on the original and are satisfactory for most purposes. The lower limit may or may not be obtainable as it will vary within capacitor types.

Order of Accuracy

As a test of inductance measurement accuracy a number of known inductance coils were measured with following results.

Coil	Capacitance (pF)	Frequency	Calculated L	Actual L
PA3	200	10 Mc/s	1.23 μH	1.2 μH
PO5	200	5.15 Mc/s	4.7 μH	4.8 μH
PA5	200	4.9 Mc/s	5.2 μH	5.5 μH
PO6	200	2.1 Mc/s	28.0 μH	27.45 μH
PA6	200	1.8 Mc/s	38.5 μH	37.5 μH
PA7	200	630 kc/s	320 μH	310 μH
R.F. Choke	200	225 kc/s	2.5 mH	2.5 mH

The capacitor should preferably be kept at a fairly high value in order to swamp coil self-capacity, provided that adequate dip can be obtained. High values of inductance such as i.f. or long-wave coils, unless pie-wound and of high "Q" may not give a sharp-enough dip for good indication. Also, if such inductors are wound in a single pie the high self-capacity may give a false inductance reading.

It is possible to indicate resonance by either setting a given capacity and varying the frequency or vice versa. If the frequency is varied it is necessary to ensure that the dip is actually a resonance and not a comparatively dead spot in the signal generator output. This can be checked by leaving the generator at that frequency and varying the capacitor, when the dip should again be indicated as the capacity goes through the resonant point.

If the signal generator waveform is not pure and is rich in harmonics there is a probability that the tuned circuit will also resonate at harmonics of the input frequency. The correct actual tuning point is therefore the highest frequency setting of the signal generator at which the dip occurs.

Measurement of small capacitors of up to 480pF is carried out by resonating an inductance with the main tuning capacitor, then connecting the unknown capacity in parallel with the coil and retuning back to the dip. The unknown will then be equal to the difference in the main capacitor settings.

It is not considered that the present layout would permit an exact measurement of inductors of less than 1μH, due to inductance of the internal connections. However, ample dip has been obtained up to the limit of the present set-up (80 Mc/s-20pF-0.2μH). This would indicate an inductance of 0.2μH, but the actual external inductance will in fact be slightly less than this.

MAGNETIC INDUCTION HEADPHONES

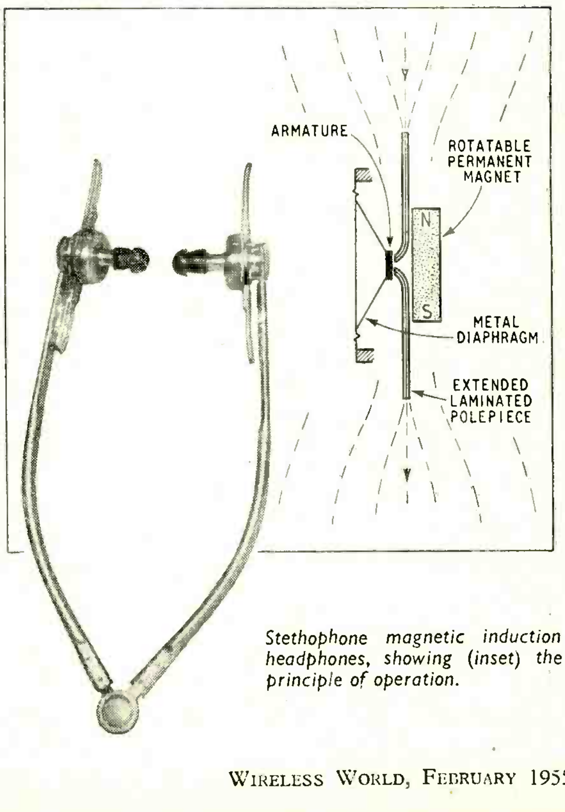
THE method of using a wire loop surrounding a cinema or hospital ward to supply energy to headphones without the inconvenience of connecting leads is by no means new. In general, standard type headphones have been used in conjunction with a small loop to supply them with current by electromagnetic induction.

No electric current is induced in a new type of headphones designed by V. A. Foot, and the forces actuating the diaphragms are purely magnetic. The sketch accompanying the photograph illustrates the principle. Laminated pole pieces of high-permeability material are extended to collect a concentration of flux from the surrounding field, which passes across short air gaps and through a circular armature disc attached to a small conical phosphor bronze diaphragm. As in conventional headphones a polarizing field is necessary, and is supplied by a short permanent magnet which can be rotated to reduce the flux in the air gaps and so to control volume.

The sensitivity is unexpectedly high, and the power required to give good volume in the primary loop surrounding the room is of the order of 10 watts per 1,000 sq ft of floor area.

With no fine wire or wax-impregnated windings to worry about, the phones can be boiled in water or otherwise disinfected, a point which has commended the system to hospital authorities. For hospital use the earpieces are rotatable so that the pole extensions can be kept in line with the vertical magnetic field when the patient is lying down. No volume control is provided in this type.

The price of both standard and hospital types is £2 2s per pair and of lorgnette type phones £3 3s each. A matching transformer suitable for supplying a loop from domestic radio receivers costs 12s 6d. The makers are the Magnetic Broadcasting Co., Ltd., 1, Upper Richmond Road, London, S.W.15.



Stethophone magnetic induction headphones, showing (inset) the principle of operation.

FEBRUARY MEETINGS

Institution of Electrical Engineers

London.—February 7th. Discussion on "The Problem of Radio Interference" opened by C. W. Sowton at 5.30.

February 9th. "A Study of Commercial Time Lost on Transatlantic Radio Circuits Due to Disturbed Ionospheric Conditions" by J. K. S. Jowett and G. O. Evans; and "Performance Characteristics of High-Frequency Radio Telegraph Circuits" by A. M. Humby, C. M. Minnis and R. J. Hitchcock at 5.30.

February 14th. Discussion on "Teaching Faraday's Law of Electro-Magnetic Induction" opened by P. Hammond at 6.0.

February 21st. "The Recent Search for and Salvage of the Comet Aircraft near Elba" by Cdr. C. G. Forsberg, R.N., and G. G. MacNeice at 5.30.

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

Cambridge Radio Group.—February 15th. "Colour Television" by L. C. Jesty at 8.15 at the Cavendish Laboratory, Cambridge.

North-Eastern Radio & Measurements Group.—February 7th. "Radio Aids to Marine Navigation" by Capt. F. J. Wylie, R.N. (Ret.), at 6.15 at King's College, Newcastle-upon-Tyne.

North-Western Radio Group.—February 16th. "An 8MeV Linear Accelerator for X-ray Therapy" by C. W. Miller at 6.45 at the Engineers' Club, Albert Square, Manchester.

South Midland Radio Group.—February 28th. "Thermionic Valves of Improved Quality for Government and Industrial Purposes" by E. G. Rowe, P. Welch and W. W. Wright at 6.0 at the James Watt Memorial Institute, Great Charles Street, Birmingham.

North Midland Centre.—February 21st. Faraday lecture "Courier to Carrier in Communications" by T. B. D. Terroni at 7.0 at the Town Hall, Leeds.

North Staffordshire Sub-Centre.—February 14th. "A Transatlantic Telephone Cable" by M. J. Kelly, Sir Gordon Radley, G. W. Gilman and R. J. Halsey at 7.0 at Duncan Hall, Stone.

South-West Scotland Sub-Centre.—February 2nd. "A Study of Some of the Properties and Materials Affecting Valve Reliability" by E. A. O'Donnell Roberts at 7.0 at the Institution of Engineers & Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

Western Centre.—February 8th. Faraday lecture "Courier to Carrier in Communications" by T. B. D. Terroni, at 6.30 at Brangwyn Hall, Swansea, and on February 10th at 6.45 at Colston Hall, Bristol.

British Sound Recording Association

London.—February 18th. "Electro-Acoustics of Microphones" by H. A. M. Clark at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

Manchester Centre.—February 14th. "Reproducing Needles" by L. Rollin at 7.30 at the Engineers' Club, Albert Square, Manchester.

Radar Association

London.—February 23rd. "Airborne Electronic Equipment" by Air Vice-Marshal R. G. Hart at 7.30 in the Anatomy Theatre, University College, Gower Street, W.C.1.

British Institution of Radio Engineers

London Section.—February 23rd. "A Versatile Electronic Engine Indicator" by R. K. Vinycomb (Southern Instruments) at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

West Midlands Section.—February 9th. "Electronic Motor Control Systems" by J. C. Rankin (B.T-H.) at 7.15 at the Wolverhampton and Staffs. Technical College, Wulfruna Street, Wolverhampton.

North-Eastern Section.—February 9th. Papers by students at 6.0 at Neville Hall, Westgate Road, Newcastle-upon-Tyne.

Merseyside Section.—February 3rd. "Colour Television—Prospects and Problems in the U.K." by D. W. Heightman (English Electric) at 7.15 at the College of Technology, Byrom Street, Liverpool, 3.

North-Western Section. — February 3rd. "Recent Developments in Test Gear in the Radio, Television and Radar Fields" by A. G. Wray (Marconi Instruments) at 7.0 at the Reynolds Hall, College of Technology, Sackville Street, Manchester.

South Wales Section.—February 23rd. "The Training of Radio Engineers" by H. W. French (H.M. Inspector of Technical Colleges) at 6.30 at the Glamorgan Technical College, Treforest.

Scottish Section.—February 10th. "Radio Telephone Systems to the Islands" by T. Moxon (G.P.O.) at 7.0 at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

Television Society

London.—February 11th. "Television Coverage of Gt. Britain" by R. A. Rowden (B.B.C.) at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

February 24th. "Modern Microwave Techniques" by R. L. Corke (P.O. Research) at 7.0 at the C.E.A., 164, Shaftesbury Avenue, W.C.2.

Radio Society of Great Britain

London.—February 25th. "Radio Astronomy and the Radio Amateur" by R. C. Jennison (Jodrell Bank Experimental Station) at 6.30 at the I.E.E., Savoy Place, W.C.2.

Society of Instrument Technology

Chester Section. — February 23rd. "Some Useful Electronic Circuits for Measuring Purposes" by E. Higham (Lever Bros.) at 7.0 in the Board Room of the Chester & Dist. Hospital Committee, 5, Kings Buildings, King Street, Chester.

Fawley Section.—February 4th. "Electronic Computers" by a member of the staff of Elliott Bros. at 7.0 in Copthorne House, Fawley, Hants.

Incorporated Practical Radio Engineers

East Midlands Section.—February 25th. "Transistors and Their Possible Future Uses" by a member of the staff of the G.E.C. at 7.15 at the Electricity Board Demonstration Theatre, Smithy Row, Nottingham.

Midlands Section.—February 22nd. "Cathode Ray Tubes" by a member of Mullard's staff, at 7.30 at the Connaught Room, Imperial Hotel, Temple Street, Birmingham.

RANDOM RADIATIONS

By "DIALLIST"

Exploring Band III

HIGHLY interesting results should emerge from the Band III reception tests which those enterprising people Belling and Lee are soon to begin. As you probably know, Sutton Coldfield is radiating experimental square-wave transmissions on the 189.75 Mc/s vision carrier frequency which has been allotted to the I.T.A. for its Midland service. The Belling-Lee test unit will first of all balance up the Band I and Band III vision signals from Sutton Coldfield at some convenient spot where both are well received. It will then drive over a large part of the service area and a careful record of the comparative strengths of the two signals will be made. Myself, I believe that in districts which are not of the hill-and-valley kind the range of the Band III transmission will turn out to be a good deal greater than many people think. When Wrotham started its sound transmissions in Band II with an output of around 20kW most of us thought that it wouldn't reach out very far; but at 40 odd miles I get a tremendous signal from it with a simple dipole, provided with neither reflector nor director. I'm told, too, that it is received as far away as Shrivenham, Berks (90 miles). If Band II exceeded expectations in the matter of range, I don't see why Band III shouldn't provide surprises as well.

Shadows and "Ghosts"

But Band III is likely to present some pretty problems in hilly country, where wireless shadows may abound. The travelling test unit will have plenty of opportunities of finding out, for there are hills galore around Birmingham. I can testify to that, for I'm writing these notes right up in the Lickey Hills, where I've been staying since Christmas. They're only about 10 miles from the middle of the City. Looking out of the window, I can see the Warwickshire Hills to the south-east; and there'd be another lot in view to the south-west if it wasn't for a belt of trees. My bet, then, is that reception of the Midland Band III transmitter will be rather patchy. "Ghosts" may also be a considerable nuisance, for the shorter the wavelength, the more liable is it to reflection. On the whole, I think that the I.T.A. engineers will have some difficult siting problems; and I doubt whether they'll find the B.B.C.'s aerial masts of much use to them in some places. There'll be some hard thinking, too, for the designers of Band III receiving aerials intended for use in places where "ghosts" abound or the field strength is on the poor side.

North Hessary Tor and Others

THE B.B.C. didn't expect the low-power temporary transmitter at North Hessary Tor to be of much use to Torquay and parts adjacent. But I've already heard from two friends who live there that it is giving them an excellent signal. In the case of one of them this is a great surprise. His house is towards the Babbacombe end of the town and the ground to north and north-west of it, which lies between it and the transmitter, slopes steeply upward. So steeply, in fact, that you don't have to go far from the back of the house to be on a level with the aerial, which must be a very long way below the line of sight from North Hessary Tor. Rowridge, I.o.W., seems also to be giving a service at a greater distance than was predicted; in some directions, at any rate. There was a storm of indignation, by the way, on the Island when one of the B.B.C. announcers, when giving details of the impending opening of Rowridge, pronounced the first syllable to rhyme with "blow" instead of with "plough." Five new medium-power TV transmitters should be in full operation with their permanent aerial masts before the end of the year. These are Meldrum, Rowridge, Pontop Pike, Divis and North Hessary Tor. The whole of the B.B.C.'s No. 1 programme system should be completed within the following twelve months by the addition of the medium-power Norwich station and the five low-power transmitters planned.*

"Europe No. 1"

THOSE monstrous radio and television stations projected for the Saar and for Monaco are likely to be pretty bad nuisances. So far as this country is concerned, the Saar's 500-kW sound transmissions aren't likely to do much harm, for they are on the

* These will be at, or near, Dover, Inverness, Londonderry, Towyn, and Carlisle.

long waves and probably won't interfere with Droitwich. But the TV transmissions may cause havoc, particularly when sporadic E is much in evidence. Interference with television reception here was widespread last year at intervals from early June until December. It's a thousand pities that European countries can't get together over the very important question of sound and vision broadcasting channel allocation.* If only we could agree to arm an international body with the powers of the United States Federal Communications Commission!

" Potmeters "

IT'S a queer thing that after all these years we still seem to find it so difficult to make reliable and long-lived controls of the potentiometer type. I'm thinking particularly of those used as volume controls and for the contrast control in TV receivers. Far, far too soon do many volume controls become scratchy and scrapy; far, far too soon do those used for the contrast develop such jumps and jerks that it becomes difficult to adjust the gain exactly to your liking. There are, I know, types which don't behave in this exasperating way; and that makes it all the more puzzling that set manufacturers should be content to use any other sort.

Overheating

SUFFICIENT attention isn't always paid by designers to the cooling arrangements in broadcast receivers. Yes, I know that when a set starts dripping blobs of waxy stuff on to the table beneath it the cause may often be that its owner has so placed it that its back is jammed tight against the wall. But it isn't always so. I've seen nasty messes made by sets which were standing well away from the wall. And once that sort of thing starts trouble is on the way. Sometimes the ventilating louvres are in the wrong place; sometimes there aren't enough of them; sometimes they're not long enough. They can't be made wider because they must not allow a " standard finger " to be poked in far enough to touch any live part. Adequate cooling is probably made more difficult by the use of miniature valves; for these run very hot and owing to the smallness of their bulbs there is only a restricted area from which heat can be dissipated.

* Monaco *was* a signatory to the Stockholm v.h.f. plan under which she is allocated a 50-kW (e.r.p.) television station in each of Bands I and III. The Saar was allocated a 100-kW (e.r.p.) station in Band I.—Ed.

UNBIASED

By FREE GRID

Cuckoo in the Nest

I WAS deeply interested in the Editor's plea in the December and January issues that the control of wireless should be taken out of the hands of the P.M.G. and his all-powerful department. But while desiring to strike the G.P.O. gyves from the wrists of radio he is obviously unable to shake the shackles of editorial caution from himself. In this matter he shows something of a Menshevik mentality rather than the ruthless spirit of the "Old Bolsheviks" which has always characterized his utterances on other matters.

This is clearly shown by the pious hope expressed in the January issue that the Minister who replaces the P.M.G. in assuming parliamentary responsibility for radio will *not* be one who is the head of any of those ministries which are large and greedy users of radio channels. This, surely, is the original argument put forward years ago by the Editor emeritus of *W.W.* against the P.M.G.'s stewardship. Although that argument still stands, it forms only one count in the case against G.P.O. control.

Radio has grown up since the P.M.G. took it over as a puling infant in 1904, and is more than big enough to justify having a ministry of its own to control its multifarious interests. It is, in fact, fast becoming a cuckoo in the nest, as its rate of growth is so prodigious that in a few years it has already crowded out the G.P.O.'s more legitimate interests, and if handed over to another ministry it would eventually do this cuckoo act in its new nest. Distasteful as the idea may sound to many, what we seem to need is a Ministry of Radio.

Racing by Radio

THERE does not at first sight appear to be much connection between racing and radio, but if certain suspicions of mine are confirmed there will prove to be a very strong connection indeed. As we all know, there are sometimes unexpected results in racing, horses which were considered "dead certs" by the experts being outstripped easily by rank outsiders.

It has been suggested that some of these unexpected results could be accounted for by jockeys receiving pre-race instructions from unscrupulous owners and trainers not to try too hard. The racing correspondent of one national daily writing about this matter at the end of the last "flat" season rather pooh-poohed the idea. He considered that pre-race instructions were greatly over-rated, but added that if it were possible for an unscrupulous interested party to communicate with a jockey during the progress of the race it would then be a matter for serious concern. When reading this my worst suspicions were aroused, for during the past season there seems—judging by the money I have lost—to have been an exceptionally large number of these "unexpected results."

It would be a perfectly easy matter to design an ultra-compact lightweight receiver which could be carried about a jockey's person; in fact the thing needn't be concealed, for it could be disguised as a hearing aid. I find there is nothing in the rules of racing against a jockey wearing an aid to hearing any more than there is against his wearing an aid to clear speech in the form of a well-fitting denture.

The bowed shape of his legs gave him away.

At this time of the year jockeys are in normal civilized garb but there is no mistaking one as his small stature and the bowed shape of his legs give him away. Whenever I pass such a figure, as I did the other evening outside a famous club in the Pall Mall, I cannot help regarding him with suspicion although I must confess that so far I have yet to find one wearing a hearing aid.

Euroscopes

EIGHTEEN YEARS ago when the B.B.C. was giving us M & B transmissions from Alexandra Palace on alternate days, television receivers were provided with a switch to change over from the M to the B system and *vice-versa*. As in the case of the famous tablets each of the letters M and B is the initial of a well-known man, and they are used instead of their names, to prevent identification which would result in a free advertisement to their respective firms.

Now, this change-over switch meant quite a lot of complication in the receiver for, not only was the lineage different in the two systems but one used interlacing and the other didn't. But all these problems were solved. I feel, therefore, that it should not be too difficult for some enterprising manufacturer to solve similar problems and produce a set having a change-over switch labelled "British" and "French." This would enable those living in the Cinque Ports section of the south coast to receive French programmes when desired.

I put forward this suggestion as I have a friend living on the White Cliffs of Dover who has a French television set and gets better reception from Lille than he does from A.P. on his British set. He has also been getting a goodly number of viewers to see the French programmes at his house with the result that several French sets have been imported, some by people who do not speak French. Surely this shows that some of the French programmes have a greater eye appeal than anything the B.B.C. radiates. It would seem, therefore, that there might be a market for change-over sets in suitable high-ground localities on the south coast and even a bit inland. The Channel Islands might be another suitable locality for these Anglo-Euroscope receivers.

Tape Recorders

I WAS very interested in a letter published in the December issue in which various shortcomings of tape recorders were pointed out and suggestions made whereby manufacturers could improve them. There was one particular complaint with which I heartily agree and that is the irritating business of loading and threading up. No mention was made, however, of what is, in my opinion, the ideal way of getting rid of this bugbear and that is to follow the technique that has found so much favour with the users of amateur cine cameras.

At one time it was quite a work of art to load an amateur cine camera *quickly* without getting the film all snarled up. Minor improvements were made but the real thing which put joy into the business was the development of cassette loading. It is the work of a moment to slip into the camera specially designed for it a cassette consisting of a tin box containing both spools, with the film all threaded up ready for use.

It would be necessary to redesign the deck of the tape recorder. But eventually the old separate spool recorders would die a natural death.