Wireless World

RADIO, TELEVISION AND ELECTRONICS

43rd YEAR OF PUBLICATION

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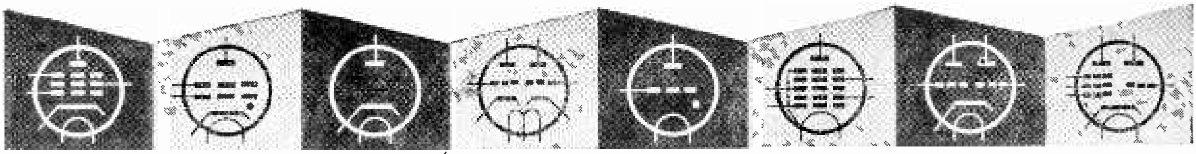

VALVES, TUBES & CIRCUITS

4. "FLYWHEEL" SYNCHRONISATION OF TELEVISION LINE TIMEBASES

The problem of ensuring good line synchronism in the presence of large noise pulses has received more attention in the design of receivers for the negative modulation systems used in the U.S.A. and on the Continent of Europe than in the design of receivers for the British system which employs positive modulation. Nevertheless, a low signal-to-noise ratio in fringe areas in Great Britain also causes poor synchronism when direct synchronising of the line timebase is adopted. This is due, of course, to the timebase being triggered by noise pulses which occur just before the synchronising pulse.

One method of preventing this is to control the frequency of the timebase oscillator by a direct potential which varies with the tendency of the oscillator frequency to drift. The variation of the control potential is obtained by comparing the relative phase of the synchronising pulses with that of the flyback pulse from the timebase oscillator, and this is done by a so-called coincidence detector.

A typical circuit is shown in Fig. 1, and its operation is as follows:

The synchronising pulse input, of approximately 100 volts peak-to-peak, is differentiated and applied to the grid of the triode V1. The grid is so biased that only the negative portions of the differentiated synchronising pulses are amplified by the triode. The pulses appearing at the triode anode then have a leading edge corresponding to the leading edge of the synchronising pulses, but are of shorter duration than the synchronising pulses.

The pentode V2 is employed as the coincidence detector. The pulses appearing at the anode of V1 are applied to the screen grid of V2, and a series of pulses which correspond to the flyback period of the line timebase oscillator are applied to the control grid. The mean anode current of V2 will thus vary with the phase difference between these two sets of pulses, that is to say with the degree of coincidence between them, as illustrated in Fig. 2. The voltage at the anode of V2 will vary accordingly.

V3 and V4 operate as a multivibrator in the conventional manner and constitute the line timebase oscillator, the grid resistor of V3 being returned to the anode of the coincidence detector V2. A positive-going pulse corresponding to the line flyback pulse appears at the anode of V4, and it is this pulse which is applied to the grid of the coincidence detector as previously mentioned. The drive to the line output valve is taken from the anode of V3, being suitably shaped by R1 and C1.

The tuned circuit L1, C2 in the anode circuit of V4 is tuned to the line timebase frequency, and is inserted to improve the long-term stability of the oscillator.

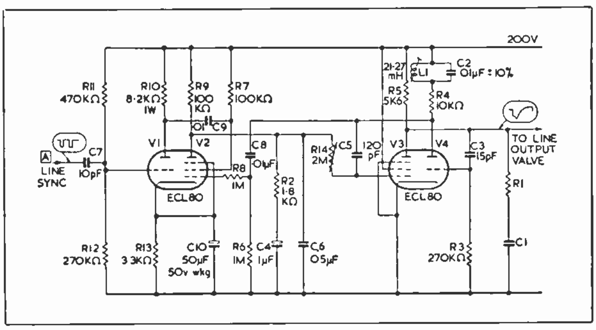

Fig. 1—Typical "Flywheel" Synchronising Circuit.

The cycle of operation of this system is:

(1) Line oscillator frequency falls
(2) Line scanning time increases
(3) Line flyback pulse is delayed
(4) Degree of coincidence between flyback pulse and synchronising pulse at the coincidence detector is reduced
(5) Anode current of coincidence detector falls
(6) Anode voltage of coincidence detector rises
(7) Line scanning time falls
(8) Line oscillator frequency rises

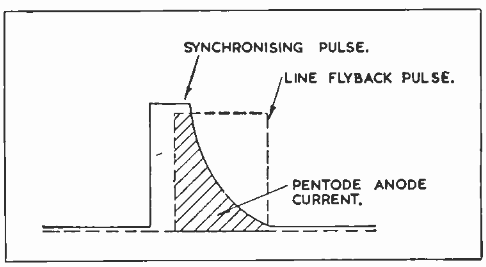

Fig. 2—Positive-going synchronising pulse and line flyback pulse applied simultaneously to the coincidence detector.

For an initial rise in line oscillator frequency, the converse of the above stages occurs.

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Looking Ahead in Television

THE most fervent advocate of our present television system would hardly claim that it should be retained for ever. Sooner or later, there will be a demand for something better—higher definition, colour, three-dimensional or perhaps a combination of these qualities. Depending on the plans we make now, the transition to a new system will be either easy or difficult.

In the midst of the present uncertainties, when the television picture is clouded by party-political acerbity, those responsible for development may be forgiven if their thoughts tend to be deflected from the long-term view to matters of the moment.

Of course, it may be argued that the only practicable way of making a change is to ensure that the new and improved system shall be "compatible" with the old. That is to say, receivers already installed shall be usable with the improved system, though they may derive no benefit from the improvement. If we allow all the available television channels to be filled by transmissions operating on the present standards, there will be no choice; compatibility will be a necessity, and posterity must look after itself.

The other—perhaps less realistic—way of making a change is to introduce new and improved (but incompatible) standards as a parallel *de luxe* service for those who are willing to buy new receivers. In the course of time, when most of the old receivers are worn out, this service would become the national standard, and the original stations would either be converted to it, or, perhaps to system No. 3, something still more refined and highly developed than system No. 2. All this implies, of course, the availability of at least one spare set of channels providing virtually national coverage at the time when the first change of standards is made.

So far as can be foreseen at present, compatibility must imply compromise and the need for tolerating something short of the best. From the technical point of view, everything is against compatibility as a principle of development, but everything is in its favour as a matter of economics.

These thoughts are provoked by the recent appointment of a technical sub-committee to the Television Advisory Committee. The task of that body is not only to advise the Government on the highly controversial issue of competitive television services, but also on the general development of the art. So far as the long-term view is concerned, the technical advisers seem to us to have one fundamental decision to make. Will the problems of the future be solved by compatibility, or should the door be left open for the introduction of some radically new system that may be inherently incompatible with existing practice?

Unjust Tax

AT this time of the year, when the Budget is being prepared, it is customary for those with specialist interests to beg the Chancellor of the Exchequer to lighten their own particular burdens. We will resist the temptation to plead for remission of the very heavy purchase tax carried by broadcast receivers and valves, but feel impelled to draw attention to the recently introduced impost on loudspeakers. This measure, imposed with the idea of bringing the broadcast relay companies into the taxation net in company with makers of receivers for direct radio reception, seems to have worked most unfairly and with harmful results in many directions.

When the tax was introduced last August, we stigmatized it as a drag on progress. There is no link in the chain of sound reproduction that is more susceptible to development than the loudspeaker, and the imposition of tax has lessened the incentive towards improvement. We now understand there has been a sharp fall in the sales of those types liable to tax.

The position of those installing equipment for public address seems to be particularly unfortunate and also anomalous. Some firms escape the tax altogether, while others have to pay. In particular, there is a tendency to penalize low-level sound reinforcement systems of the most up-to-date kind that employ a large number of small cone speakers. Then there is considerable difficulty in deciding precisely what type of reproducer comes within the scheme.

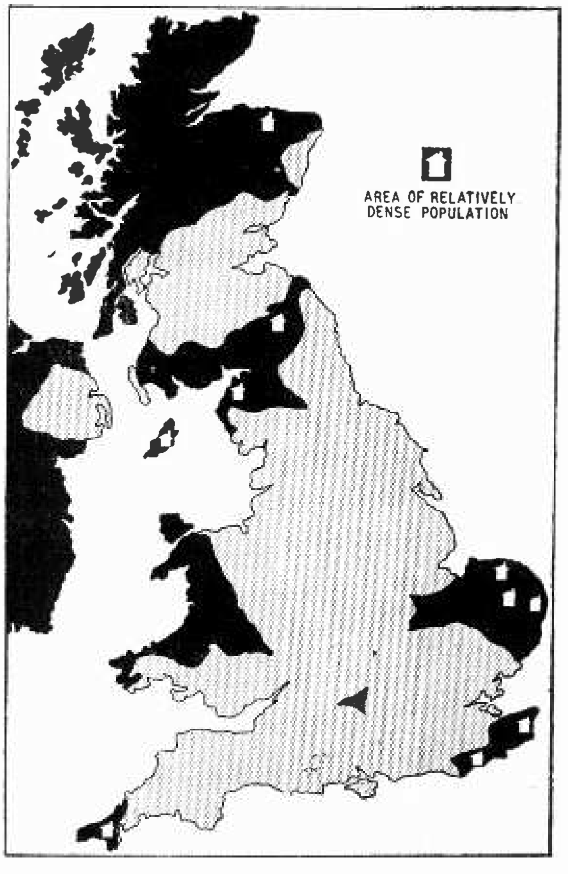
Television "Booster" Stations

Filling the Gaps in the B.B.C. Coverage

By P. J. HARVEY,* B.Sc., A.C.G.I.

IN any scheme of nation-wide television coverage based on a chain of high-power transmitters, there will inevitably be appreciable areas in which the received signal is either unsatisfactory or virtually non-existent. This state of affairs is noticeable in the British Isles, much to the annoyance of long-suffering viewers in the fringe areas, but it will undoubtedly be of much greater concern in countries with more rugged geographical features.

In Britain the television development programme of the B.B.C. still leaves some 20 per cent or more of the population outside the effective coverage of the transmitters. The areas which are not adequately catered for, and for whom no future plans have yet been disclosed, lie in parts of East Anglia, North Wales, Northumberland and the Lake District, in the remoter parts of Scotland, Northern Ireland and the West Country, and in the Channel Islands and Isle of Man.



Map showing in black the areas of the country not covered by the stations of the complete B.B.C. network (outside the 100μV/m contour). Masses of population in these black areas (over 500 people per square mile) are indicated by the small white houses.

Even if the B.B.C. finally decides to follow up its existing programme with additional facilities for the fringe areas, it will probably find it uneconomic by present methods to effect a complete coverage of the country. Thus, unless a somewhat different approach to the problem is considered, there will always be isolated communities without a satisfactory service.

In the circumstances the only practicable means of achieving a more complete coverage would appear to be the introduction, where necessary, of some form of television relay, to pick up, amplify and re-distribute the signal of the existing network throughout the locality.

The first essential for the successful operation of any relay system of this nature is a satisfactory site at which the network signal can be received at an acceptable level and signal-to-noise ratio. This should be not more than, say, 5 miles from the centre of the community it is to serve. It is seldom that such a site cannot be found, since the geographical obstacles which give rise to most of these black spots can be of assistance in eliminating them, as they will usually provide excellent sites for reception of the network signal. It is economically desirable that all such relay schemes should be fed by the direct reception of the main transmitter's signal, for if extensive cable or radio relays were used to bring the signal into the area the total cost of the installation would probably become prohibitive.

Whilst there must be a basic similarity between all television relay systems, there is some difference of opinion on the best method of distribution. To date the only method that has gained favour is distribution by wire. An alternative to this is distribution by re-radiation. In this form of relay the receiver could be identical with that used in the wired system, but the station would include low-power vision and sound transmitters and function as a local booster to a main station.

Designing the Station

The essential features of an experimental low-power booster station are shown in Fig. 1. The basis of the design is a high-quality sound and vision receiver, from which audio and video signals are obtained and used for the modulation of conventional sound and vision transmitters, using established circuit techniques.

In most applications it is necessary for the operating frequencies of the equipment to be so arranged that

* E. K. Cole, Ltd.

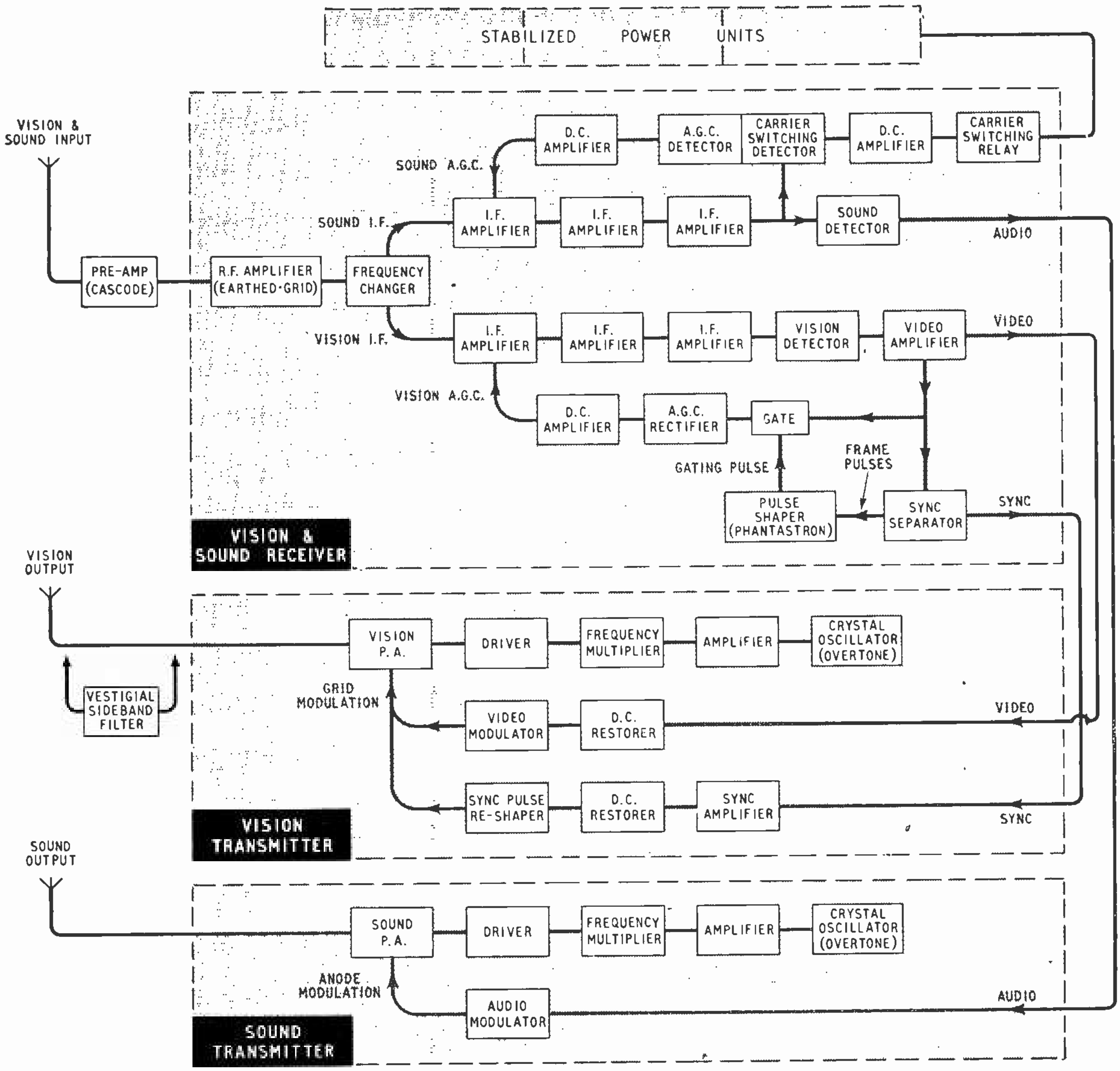


Fig. 1. Block diagram showing the essential features of an experimental low-power booster station.

the separation between the received and re-radiated sound and vision carriers is at least equal to the normal channel spacing. This is to prevent blocking of the receiver by the re-transmitted signals, and to obviate the possibility of loop feedback. If adjacent channel working is to be used, adequate filtering at the receiver input circuit is necessary. The exception to this is the rare instance when the natural features of the locality can be used to supplement the screening between the receiving and re-radiating aerials and to ensure that there is no overlapping of the main and booster station service areas. Re-radiation can then be done on the original sound and vision frequencies.†

It might be thought that the obvious basis for design would be to change the sound and vision frequencies at r.f. and then amplify the converted signals to the required output level. Two main obstacles were encountered in designing the vision stages of a prototype equipment on this basis. The first was the difficulty of maintaining adequate bandwidth and linearity throughout the relatively large number of linear amplifiers necessary to build up to the final level of r.f. output. The second was the multiplicity of spurious frequencies that can be generated by unwanted heterodyning, in the frequency converter stage, of various harmonics of the incoming, outgoing and local-oscillator frequencies. Serious patterning on vision can result if these spurious frequencies are radiated, even at comparatively low power. The effect is produced by the interference of such frequencies with the vision carrier, local oscillator or i.f. of the distant receiver, or with any harmonic of these which produces a difference frequency within the video band. These tendencies become increasingly marked with reduction of the spacing between the incoming

† In the U.S.A. a distinction is made between "boosters," which radiate on the original sound and vision frequencies, and "satellites," which radiate on different frequencies.

and outgoing frequencies. If the frequency relationships are arranged so as to eliminate the effect with one design of receiver, this does not necessarily hold for another using a different i.f.

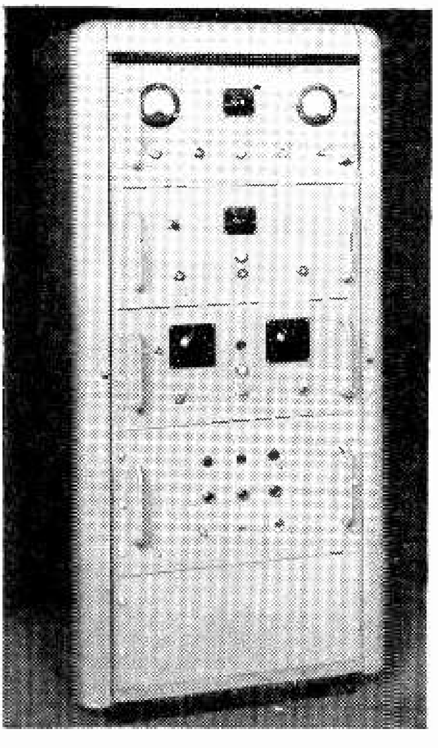
Both these problems are more easily dealt with in a design in which vision and sound are recovered from the incoming signal and remodulated on the transmitted carriers.

Except in favourable conditions, the receiver is preceded by a pre-amplifier accepting both the sound and vision signals, a cascode circuit being used to realize optimum noise factor. If the level of the received signal is at all low, the pre-amplifier unit is located at the top of the aerial mast and connected directly to the receiving aerial. The increase in the overall noise factor due to the feeder losses is thus avoided.

Automatic Gain Control

The design of the vision and sound receiver is largely conventional. The common r.f. amplifier is an earthed-grid circuit, ensuring correct termination of the input feeder. Automatic gain control is effected in the vision receiver by gating and using the frame pulses. The control voltage thus derived, which is proportional to the sync pulse amplitude, is amplified and applied to the suppressor grid of the first i.f. amplifier. The a.g.c. hold thus obtained is adequate, the variation of output being not more than 1db for 30db variation of input. A.G.C. is applied to the sound receiver in a similar manner and a comparable hold is obtained. A switching voltage is derived from the sound carrier for automatic stopping and starting of the transmitters as the station is normally unattended.

The carrier frequencies of both vision and sound transmitters are derived by frequency multiplication from crystal oscillators. It is essential that the multiplication be as small as possible to minimize the number of spurious frequencies to be reduced to an acceptable level, so overtone circuits are used. In fact, if line, or even lumped-constant, circuits operating at the final carrier frequencies can be designed to an adequate stability they are to be preferred from this point of view.



The complete equipment is housed in a single 4-ft rack.

An r.f. power range of 10-250 watts for the vision transmitter is considered suitable to cater for the differing requirements of various applications. Grid modulation of the final amplifier is used, since at these levels of r.f. power little difficulty is experienced in obtaining adequate vision signal power for the purpose. In a power amplifier stage of this type, which is rated for continuous operation at peak power, no increase of efficiency is gained by using anode modulation, and the slight improvement of linearity does not justify the extra video modulating power required. The linearity obtained with grid modulation is quite acceptable, provided that the amplifier is only driven into moderate grid current and the regulation of both the driver and modulator is sufficiently good. The regulation of the h.t. and bias supply is equally important. The driver and modulator stages, therefore, are both designed to present the lowest possible source impedance, and in fact the design principle used in the video circuits is to maintain a low impedance throughout, even at the expense of some efficiency.

The d.c. component is re-inserted at the grid of the modulator, the anode of which is then directly coupled to the grid of the power amplifier. Clamping at the black level would be preferable, but the d.c. restorer gives satisfactory results, provided the a.g.c. hold of the receiver is maintained, and is used by reason of its comparative simplicity.

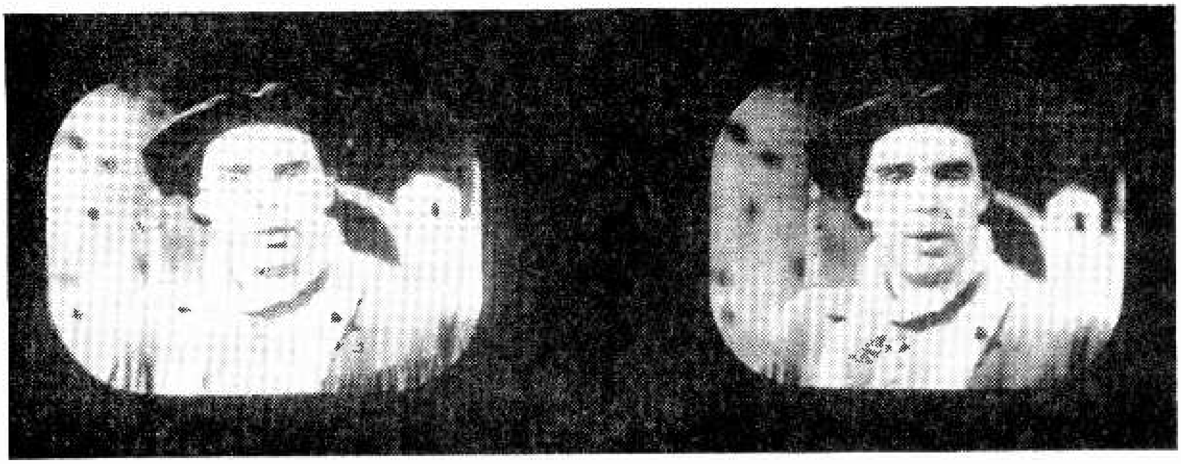
The distortion of the modulation envelope, first by the detection characteristic of the receiver and secondly by the modulation characteristic of the transmitter, largely affects the sync pulses only. To compensate for this distortion a certain amount of reshaping of the pulses is done by means of a separate sync chain, the output of which is applied to the power amplifier grid in parallel with that of the modulator.

A vestigial sideband filter is used to suppress the unwanted sideband of the vision transmitter if the licensing regulations specify such a restriction.

Coverage

The design of the sound transmitter closely follows that of the vision transmitter except that anode modulation is used with advantage since, in this case, the modulation frequency range does not have to extend down to zero. The carrier power is adjusted to be approximately one-quarter of the peak power of the associated vision transmitter. The required range of carrier power for the sound transmitters is therefore 5-50 watts.

An indication of the r.f. power necessary for a typical booster station is provided by tests with the experimental installation referred to above, which radiated 50 watts (peak) vision and 15 watts sound. Satisfactory coverage was obtained over an area of approximately 50 square miles, involving a population of some 100,000, in conditions that were by no means ideal. Where the local topography allows line-of-sight propagation the coverage obtainable with



On the left is shown the picture as received by the booster station, and on the right, for comparison, is the transmitted picture.

radiated powers of this order could be appreciably greater.

The design of the transmitting aerials is largely dependent on the position of the aerial relative to the area to be covered and relative to any distant transmitter operating on the same channel. In the ideal arrangement, which can frequently be achieved, the transmitting aerials are sited at the same vantage point as the receiving aerials and beamed to "look down" on their service area. The coupling between transmitting and receiving aerials is normally minimized by directivity, change of polarization, or in unfavourable circumstances by the use of special reflector screens.

The question of frequencies on which such booster stations might be permitted to radiate is a somewhat vexed one. The lower u.h.f. band (400-600 Mc/s) is not yet overcrowded, and a few channels in the portions of this band allocated for television purposes might be approved by the licensing authority for relay schemes.

Consideration would have to be given to the design of commercial receivers for these frequencies. Unless the relaying of television programmes at u.h.f. gained general acceptance it would not be economic for manufacturers to market a special set for these bands, and to begin with converters would have to be used with existing v.h.f. receivers. However, it is reasonable to assume that the cost of such converters would not be greatly in excess of that of the pre-amplifier at present common in fringe areas. When set off against the additional cost of the multi-element aerial arrays which are also widely used in these areas, the u.h.f. converter should not involve any alarming increase in the total cost of a receiving installation and might even reduce it.

Tests carried out at v.h.f. indicated that the signal which could be laid down by a booster station of this type would permit the use of an inexpensive indoor aerial in some 75 per cent of the service area. There is no reason to assume that results would be greatly inferior at u.h.f.

It might be pertinent to consider also whether the existing channels in the v.h.f. band (41-67 Mc/s) could be put to further use. The primary consideration for operating booster transmitters on any of these channels would be the complete elimination of any possible interference with existing services on the same channel. The magnitude of this problem should not be over-estimated, since with radiated powers of this low order and suitably directive transmitting aerials it should not be difficult to confine the effective service area of the transmitters within quite narrow limits. A change of polarization from that of the original service on the channel might lessen the possibility of mutual interference, although such interference would probably occur in conditions of tropospheric propagation and the possible rotation of the plane of polarization in these conditions would tend to lessen the advantage.

Economics of the System

In comparison with distribution by wire the booster transmitter scheme has the advantage of relative simplicity, resulting in an appreciably lower capital outlay for the relay installation and lower maintenance costs. The circuitry of the complete booster station is comparable with that of the central receiving and amplifying equipment of the wired system. The receiving equipment used by the viewer with either system is also similar, although in the case of the booster station scheme there is the added advantage of using standard television receivers supplied through normal retail channels. The additional complexity of the wired system thus lies in the extensive network of feeders, amplifiers, matching pads and equalizers required for distributing the relayed signals, and this additional complexity is a measure of the difference in cost of the two systems.

The problem of providing a satisfactory service in the fringe areas must eventually resolve itself into one of economics. At present, distribution of television programmes in this country is organized almost solely on a national basis, with the exception of one or two relay systems installed by large commercial organizations. However, in the fringe areas, owing to the uneven distribution of communities it may well be that the problems of distribution can only be solved by independent small-scale relay schemes of the type envisaged in this article.

There is considerable doubt that the B.B.C. or any commercial concern would find it economic to operate such relay schemes. The type of organization which suggests itself for the purpose is a syndicate representing local television interests, functioning on a part-time non-profit-making basis. The booster station equipment described above is particularly suited for such a venture by reason of the low capital outlay involved, the fact that it is designed to operate unattended, and that maintenance would be well within the scope of the local television dealers' service organizations. A company could be formed to implement these proposals, representing receiver owners, local television dealers and the Town Council, or other local authority, but care would be necessary to ensure that such a body would show no less a sense of responsibility than the national authority in guaranteeing the permanence, continuity and quality of the service.

Any such departure from established practice would of course necessitate the approval first of the B.B.C. in the matter of copyright and secondly of the G.P.O. for the grant of an operating licence. Local television relay schemes would not involve the B.B.C. in any additional expenditure, but the increased licence revenue resulting from the extension of coverage should benefit them financially.

It seems likely that the cost of such relay schemes would have to be borne solely by the local viewers, since it is doubtful if any portion of the licensing fee could be diverted for this purpose. However, an intelligent guess at the balance sheet of a typical relay service of the booster transmitter type indicates that the additional annual cost to individual viewers need not be alarming. It is estimated that the initial outlay on equipment for a booster station would not exceed £4,000, and the annual cost of operation and maintenance £500. Assuming the average size of a community involved to be 50,000, a rough estimate of the number of television receiving licences might be 3,000. An extra charge of 10s per annum per licence would realize an income of £1,500, which should be adequate to finance the scheme.

The material for much of this article was obtained from experimental investigations of the possibilities of booster television stations. The work was done under G.P.O. licence on behalf of the author's firm.

RADIO IN INDIA

WITH but one broadcast receiver per thousand of the population, India is virgin soil for the radio manufacturer. It must not be thought, however, that it is open to prospectors, for restrictions bar the import of complete receivers. There is, therefore, a growing indigenous radio industry, which, according to figures recently given, now produces over a quarter of a million broadcast receivers a year.

Surveying the general situation both industrially and culturally, an article in *Industrial Review** criticizes the Indian government's general broadcasting policy and calls for a commission to investigate the working of All India Radio with a view to improving the service. Despite the fact that the licence fee has been increased by 50 per cent—to Rs. 15 p.a.—it is evident that the government cannot afford to undertake any major expansion programme. The writer considers that the only alternative is to introduce commercial broadcasting by private enterprise. The interest in, and regular reception of, the transmissions from the commercial stations in Goa and Ceylon are cited as proof of the failure of A.I.R. to meet the needs of the average listener.

Many other aspects of the Indian radio industry are discussed in the *Industrial Review* survey including component manufacture, receiver exports and, too, the need for breaking down the Indian's prejudice against articles marked "Made in India."

Another of the more convincing arguments for the introduction of sponsored broadcasting in India is adduced by the editor of the *Radio Times of India* in the issue of December 16th. With the total press circulation in the country reaching barely 1 per cent of the population, the need for a medium which will reach the millions who do not, or cannot, read the newspapers and magazines is obvious and can, it is claimed, be met by commercial broadcasting. It will, of course, be argued that the present radio density of 1/1,000 is even lower than the press circulation, but few advertisers take space in all publications. Moreover, it is claimed that better programmes from more stations will create a greater demand for sets.

Illiteracy is, of course, a tremendous drawback to the advancement of any country, and, in an endeavour to overcome the present confused multi-lingual situation in India the government has decreed that Hindi will be the national language and will, during the next 15 years, gradually replace English.

Considerable concern is felt in academic circles over this change. The question of translating textbooks into Hindi will inevitably take many years and a letter from a number of distinguished Indian educationists is published in the December 16th issue of the *Radio Times of India* criticizing the method of transition. "We see," they write, "no possibility of our being able to do without some good knowledge of English, for any number of translations will never completely meet the needs of all the subjects taught in our universities. . . . It follows that in the interests of higher education in India it is eminently necessary to keep up an adequate standard of English even after it ceases to be the medium of instruction. . . . It is a regrettable feature of our present-day education that the standard of English has been steadily going down, which has very seriously affected the study of all subjects."

* Published monthly in Bombay

Oscillator/Filter Unit

—a Correction

IN the circuit, Fig. 3, p. 130 of the last issue the ganged switch S_1, S_2 is in the position giving rejection filter characteristics and not the connections for oscillation. The lettering of the switch should, therefore, be reversed.

Electronic Film-Making

Application of Television Principles to Motion-picture Production

By T. C. MACNAMARA,* A.M.I.E.E.

ALTHOUGH WORK which has been carried out on the process to be described was primarily intended for the production of cinematograph films for theatrical release, it is becoming increasingly obvious that another and equally important application exists in the need for an economic method of "canning" television programmes.

It would be difficult to run a sound broadcasting service without constant recourse to recorded programmes. The need is even greater in a television service where a much greater rehearsal-to-transmission ratio has to be faced and where studio sets, lighting and all the paraphernalia of vision have to be erected and dismantled. In consequence, the amount of studio space to maintain a wholly "live" television programme becomes prohibitive and "pre-filming" is considered to provide the only means of satisfying the otherwise insatiable demand.

Other arguments for pre-filming television programmes are based on the difficulty of securing the services of leading artists at the studio during the most important viewing hours, when they may be working in the theatre or cabaret. Also, in a large country like America, time differences are of extreme importance. Last, but not least, due to the high costs of television programmes, some permanent record, which can be used for a repeat performance without further encroachment on studio or artists' time, and which can be sold to other broadcasting organizations, becomes an economic necessity.

The use of an intermediate electronic process in the production of motion-picture film is an idea which has intrigued technicians for some years. The major attraction is that it would confer upon the film maker the ability to produce a motion picture in precisely the same way as a television broadcast programme is produced, by substituting a motion-picture camera (photographing a cathode-ray screen) for the radio transmitter. The camera would faithfully record on film an entire production, complete with all cuts, fades, wipes, titles, etc., in full continuity in the actual time taken to enact the performance. The resultant film would, in theory, be capable, after printing and development, of projection as a finished product without cutting or further editing.

Doubtless in practice this ideal would be difficult, though not impossible, to achieve in its entirety, but the sponsors of this system of production are confident that by its use films can be produced in a much shorter time than by orthodox methods using optical cameras. The general arrangement of the apparatus used in the proposed process, where electronic cameras are substituted for optical cameras on the studio floor and the pictures emanating from them displayed at a control point simultaneously on a number of viewing units, is shown in the diagram. Any number of cameras may be used, each with its separate viewing unit, but, in practice, the number is likely to be limited to three or four.

At the control point, the director can, by means of instantaneously acting controls, select, cut, mix or superimpose any of the available shots, and judge the finished result on a master viewing screen. In parallel with this master viewing tube, but elsewhere in the building, is a monitor c.r.t. from which the photographic image is recorded. Continuous recording can be achieved by the provision of two motion-picture cameras operated in relays with a small overlap.

The use of multiple optical cameras, in orthodox film-making, has been regarded by most film technicians as impracticable because of the difficulty of reconciling the different viewpoints; not to mention the difficulty of lighting satisfactorily for more than one camera.

It must be conceded that the use of more than one optical camera is artistically too hazardous. The value and composition of a picture and the effectiveness or otherwise of the lighting can only be judged by the operator who sees the scene through his camera's eye by looking into the viewfinder. Even so, he can only look through the viewfinder of his own camera and cannot simultaneously assess the complementary viewpoints of other cameras focused on the scene from different angles.

The director, for his part, is working blind the whole time and must rely on his skill and judgment and the advice of his cameraman to form a mental picture of the scene as it will be recorded by the camera. He, moreover, knows that he will not be able to see the result of his work until the next day when the "rushes" are developed and printed, by which time it will be difficult and expensive to retake scenes which, when viewed subsequently in the projection theatre, fall short of the effect he strove to secure.

It is natural, therefore, that both director and cameraman should feel impelled to embark on a lengthy series of retakes until each is satisfied that there is sufficient satisfactory material in the "can" to render it virtually certain that a good sequence can be extracted from it.

This and the elaborate cutting process that naturally follows are two of the main reasons why the production of motion pictures is such a protracted and costly business, often yielding only one or two minutes of finished film per day from each studio stage, because only a very small proportion of the large footage shot is actually used. If electronic cameras are used, however, an entirely different state of affairs supervenes.

First, the electronic camera can be made smaller

* High-Definition Films, Ltd.

and lighter than its optical counterpart. It is more sensitive and hence needs less lighting intensity, it is noiseless in operation and requires no reloading.

These, however, are incidental gains and the real advantage reposes in the fact that the director can see on individual screens before him the simultaneous picture output of one, two, three or more cameras and can mix, fade or cut them at will. By directing his camera operators through headphones he can secure exactly the effect he desires on the master screen, with the full knowledge that what he is seeing is being photographed by a motion-picture camera from the screen of another c.r.t.

His judgment can be confirmed and strengthened by his advisers looking at duplicate screens, either on the spot or elsewhere in the studio. The precise effectiveness of the lighting for all cameras can be assessed by the lighting expert and, due to the flexibility of the electronic apparatus, minor defects in lighting can be corrected while actually observing the result of the adjustment on the screen.

Because of this, the number of retakes can be reduced to an absolute minimum and the amount of finished film produced per day should be capable of being raised to 10 or even 20 minutes, which represents a large saving in time and hence cost.

In addition, the facilities provided by the electronic process may be fully exploited during rehearsal when cameras can be used and a large part of the work normally carried out in the cutting room or laboratory subsequent to taking can be worked out and scripted during rehearsal thus ensuring that the actual shooting will proceed smoothly and rapidly. Exterior shots taken with normal optical cameras can be inserted in their proper context during studio shooting by means of film scanning apparatus, and long sequences of the production can be assembled in proper continuity and presented as a "rough cut" of the finished picture—all without recourse to cutting-room work or the introduction of opticals in the laboratory.

Multiple Filming

Because the actual cinematography is from the screen of a cathode-ray tube several negatives may be simultaneously produced by operating a number of tubes in parallel. For example, both a 35-mm and a 16-mm negative can be produced simultaneously and to these can be added a 16-mm direct positive, made by reversing the picture electrically and photographing the negative image on the c.r.t. screen. This direct positive can be "hot-processed" and, in less than a minute after production, can be televised back on to the director's master screen for his scrutiny or, alternatively, projected for the enlightment of the artists.

Apart from the savings in time and cost outlined above, there are additional, less obvious but not unimportant advantages. To mention only a few:—

First, the director himself remains in personal control and can supervise and modify camera height, angle, speed of tracking, panning, etc., all with complete assurance that comes from being able to see what he is doing.

Secondly, the use of the electronic multi-camera technique enables successive sequences to be shot with a high degree of continuity and this, with the ability to see the resulting picture throughout and not to have to wait a day to see disconnected rushes, enables the director to preserve an equally high degree of continuity of thought and grasp of the theme of the story in all its subtle nuances of presentation. Without the electronic method and faced with the limitations of a single optical camera technique, the director is in the position of a painter who is denied the ability to sketch in his outline first and must bring one by one all the small details to perfection first, like a worker in mosaic.

Thirdly, the ability to work rapidly and in logical sequence of continuity tends to be of great assistance to the artists and enables them to give a better, more consistent and personally satisfying performance.

Finally, an advanced stage has been reached in the development of artificial scenic devices including various inlay and overlay processes. By these methods all types of glass shots, back projection and travelling matte shots may be effected electronically during the actual shooting and without subsequent optical work in the laboratory. By immensely fast electronic switching from a master foreground camera depicting the artists to a slave background camera focused on a small photograph of the required scenery, a perfect illusion can be achieved. The potential saving in cost offered by this process requires no further comment.

Alternative Electronic Aids

A number of attempts have been made from time to time to fit optical motion-picture cameras with "electronic viewfinders." These consist of a television camera coupled by a split optical system to a common taking lens. The director can thus assess the picture being received by each camera and, by remote switching, each film camera can be operated at will.

There is no doubt that this scheme offers advantages over the use of purely optical cameras and makes multi-camera working a much more practical proposition. In the view of the author and his associates, however, it represents only a half-solution of the problem because it does not eliminate the necessity for subsequent work in the cutting room or production of optical fades, etc., in the laboratory. Moreover, artificial scenic devices of the electronic type cannot be used, nor is immediate "playback" available.

Added to this, the combined optical and television camera becomes extremely bulky and heavy and it is not any more silent than a normal motion-picture camera.

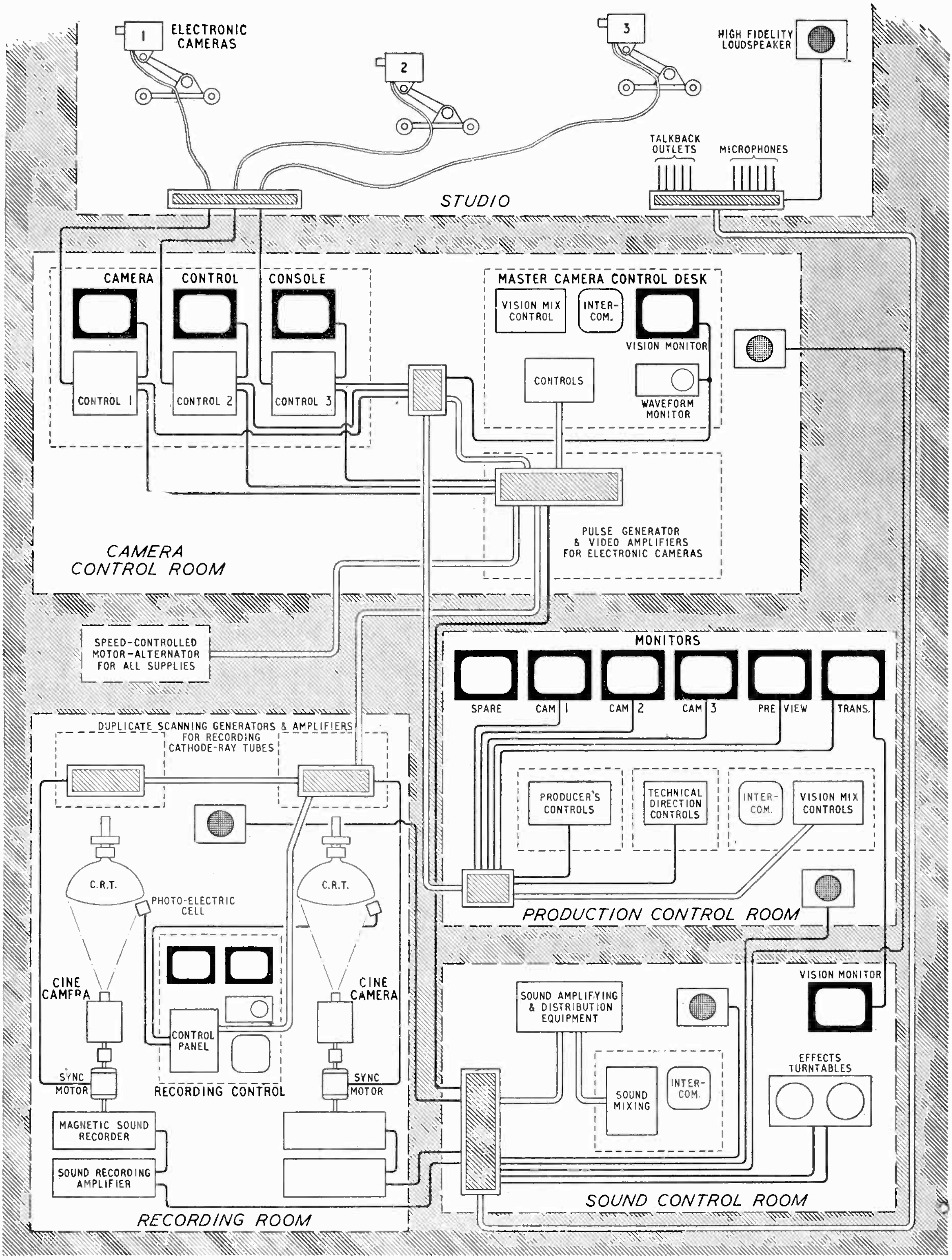
In consequence of these limitations, it seems fairly clear that this "half-way" process can never compare in time-saving and efficiency of production with the "all-out" electronic system advocated by the author, There is ample justification for pressing forward with the development of the system.

Technical Considerations

It is obvious that, to be an acceptable substitute for orthodox direct photographic methods, the electronic film-making process must be indistinguishable in quality from the result obtained by normal processes. To achieve the requisite standard of quality poses severe but not insoluble problems.

When considering the problems of generating television images, it is extremely difficult to think in terms other than those of television broadcasting where many factors, both economic and practical have to be studied. Many of the limitations imposed by broadcasting, however, can be disregarded when the whole of the work is carried out on "closed circuit" within the confines of the studio.

Consider first the question of definition. It is well



Block schematic of the general arrangement of the equipment used in the system of electronic film-making described by the author. By using a number of c.-r. tubes in parallel several negatives may be produced simultaneously.

known that the transmission of a television picture involves the transmission of a very wide band of frequencies. Broadly speaking, the wider the band of frequencies, the better the definition of the picture. There are limitations to the bandwidth which can be transmitted and the broadcasting engineer has, in fact, to make a compromise between what he would like to do and what he can do.

In the first place there is the question of ether space, which is extremely limited. Consequently a band of only five megacycles wide can be allocated in the ether for each transmitting station. Into this has to be fitted television picture and television sound (with enough spacing between them to avoid mutual interference) and guard bands on each side to avoid interference with adjacent channels. As a result of this limitation the picture is bound to be of low definition in terms of cinematographic standards.

Next, there is the cost of transmission of television signals over coaxial circuits. If the vision signal consists, as it does in this country, of a band of frequencies 3 Mc/s wide, the cable repeaters have to be spaced about 12 miles apart which, with the cost of the cable, represents a very substantial item. If the band of frequencies were extended appreciably, the number of repeater stations would go up until, in the absurd case, there would be one continuous line of valves, anode to cathode from one end of the country to the other.

Again, the cost of television receivers is greatly increased if the definition standards are raised substantially, and they become too expensive to command extensive sales.

Standards of Definition

As a result of all this, the standards of definition used for broadcast television must of necessity be kept comparatively low.

On the other hand, the electronic process for film production described is subject to no such limitations. Working on a closed-circuit system and operated under laboratory conditions, there are no limitations to the bandwidth which may be used, there is no radio link, no long cable and no television receiver. Instead, any standard of definition that appears desirable and any signal waveform that may be convenient can be used. There is no necessity to mix in synchronizing information to form a composite signal; synchronizing signals may be kept entirely separate and sent down a separate cable to the reproducing monitor, which materially eases the operation of the apparatus.

As regards the actual standards of definition required to produce by electronic means a picture on film which is indistinguishable from one taken by normal cinematography, opinions differ over very wide limits.

The writer, however, reasoned on these lines. In the average motion-picture negative the limiting resolution on axis is about 40 lines per mm. and is degraded to about 25 lines per mm. in the release print. This appears to represent a value which has been determined empirically over many years as being acceptable to the public. No doubt it would be extremely uneconomic to work to a significantly higher standard, and the resultant picture would probably be considered too sharp and hard for artistic portrayal of many scenes.

If 40 photographic lines per mm. are taken as an average figure for motion-picture definition, this corresponds to 80 conventional television lines per mm. or about 1,300 total for the frame. Actually there are certain corrections which can be applied. For example, the fine definition response of a television system can be maintained by "top boost," whereas under conditions used in motion film photography it tails off fairly steeply to the extinction point. The author, therefore, considers that it may not be necessary to use so many lines but that a 1,000-line picture with depth of modulations maintained right up to cut-off frequency might be sufficient for the purpose in hand.

The production of such a picture does not present any very serious difficulties, as electronic systems capable of resolving 1,500 to 1,800 lines are a demonstrable possibility to-day.

Contrast Range

Turning to the question of contrast; broadcasting imposes severe limitations due to such things as the high electrical interference level from motor cars, etc., in all but the areas of high field-strength, and the electrical overload capacity of the transmitter. These limit the dynamic range usefully available in the transmission, with the result that both the black and white ends of the transmitted tonal scale must be crushed, if the radiated signal is not to be continuously undermodulated, to the detriment of all but the viewers near the transmitter.

In electronic film-making no such limitations exist, and any desired range of contrast can be realized with complete freedom from the crushing of any part of the tonal characteristic. In fact, compensation can be introduced to straighten the far from linear overall transfer characteristic of the photographic processes from master negative to release print. For this reason more faithful results can, in theory, and indeed in practice, be achieved, once the immensely flexible electronic link has been introduced into the picture. It has been suggested that electronic film-making can do for the motion picture what electronic recording has done for the sound disc, a view with which the author confidently concurs.

Prior to the development of high-definition electronic methods of film-making, the cost of making pre-filmed programmes for television by orthodox optical camera methods has been too high for wide use even if the utmost despatch in studio production is achieved. It is firmly believed, however, that the use of electronic methods, probably in conjunction with 16-mm film, will enable programmes to be pre-filmed at a sufficiently economic cost and with a standard of technical quality to satisfy the most critical observer.

In this way, the establishment of an exchange of television programmes throughout the world becomes practicable; the introduction of sound tracks in different languages being an already known art should not be difficult.

From this it is but a short step to the application of the electronic process to films for theatrical release, and the extension of the process to colour film is not far off.

In conclusion, the author is convinced that in the development of this process, with its manifold applications, a new and tremendously flexible tool is being forged, which will have great potentialities in both the film and television industries.

Cushion that Switch-on Surge in AC/DC receivers

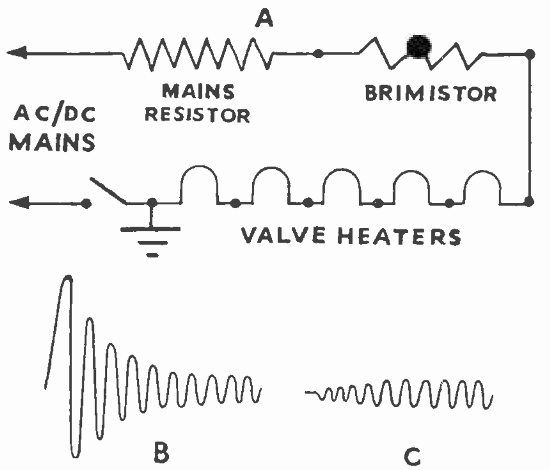


Diagram "A" shows the correct positioning of a Brimistor in the average circuit.

Diagram " B " shows an oscillogram of the normal " switch-on " surge which damages valves and dial lights.

Diagram " C ": this oscillogram shows the gentle rise of BRIMISTOR controlled current and complete surge suppression.

Wired in series with valve heaters . . . dial lights . . . BRIMISTORS hold the starting current at a low value, permitting it gradually to rise until working temperature is reached, thus ensuring maximum life for both valves and lamps.
When cold the resistance of a BRIMISTOR is high. As it warms up with the passage of current, however, this resistance falls *gradually* to a very low level which usually can be ignored. At the very most a small reduction in the line cord or other voltage dropping resistance will provide the necessary compensation.

OTHER USES

1. Wired in series with the lead to the reservoir condenser, Brimistors can be used to reduce the voltage surge associated with directly heated rectifiers.
2. Connected in series with a choke or focus coil, the negative temperature co-efficient of a Brimistor may be used to compensate for the positive temperature co-efficient of the coil.

CHARACTERISTICS OF BRIMISTORS

Type	Cold resist-ance at 20° C.	Resistance with the following currents flowing				Max. Current	Price List
		0.1 amp.	0.15 amp.	0.2 amp.	0.3 amp.		
	ohms	ohms	ohms	ohms	ohms	amp.	
CZ1	3,000	180	100	75	44	0.3	*3/6d
CZ2	5,500	170	90	66	38	0.3	*3/6d
CZ3	1,500	100	50	35	—	0.2	*1/6d
C4	760	—	—	—	—	1.25	*5/–d
CZ6	3,000	200	120	80	45	0.45	*3/6d

* Brimistors are not subject to Purchase Tax.

Use CZ1 for 0.3 amp. and 0.1 amp. valves.

Use CZ2 for 0.15 amp. and 0.2 amp. valves.

Wire type CZ3 across the dial lamp (in conjunction with a CZ1 or CZ2 as above).

Notes on the use of BRIMISTORS

1. Owing to the high operating temperature (up to 250° C.) Brimistors must be spaced away from coils and waxed components.
2. They should be inserted in the " live " end of the heater chain—i.e. between mains resistance and rectifier valve heater.
3. At least ½in. of wire must be left at each end before soldering to a tag.

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BRIMISTOR
RESISTORS

BRIMISTORS are used in all popular AC/DC Television Receivers—ADD SOME TO YOUR STOCK

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Phase-Angle Measurements

A Note on the Accuracy of the Various Methods

By F. A. BENSON,*
M.Eng., Ph.D., A.M.I.E.E., M.I.R.E.

THE CATHODE-RAY tube still finds application for determining the phase angle between two quantities. In making the measurements two voltages are produced proportional to the quantities, one voltage (maximum value V_1) is then applied to the vertical deflector plates of the tube and the other (maximum value V_2) to the horizontal plates. If voltage V_2 leads voltage V_1 by an angle θ an ellipse will result, provided the voltages are sinusoidal, which is bounded by a rectangle with sides 2X and 2Y (Fig. 1) and which has major and minor axes of lengths $2a$ and $2b$ respectively.

Two well-known methods have been given by Carter and the author[1] for determining θ from the ellipse and they have made estimations of the magnitudes of the maximum errors likely to be caused by trace thickness and any harmonics present. In the first method BC and AD are measured (Fig. 1) and $\sin\theta = BC/CD$. For the second method the major and minor axes of the ellipse are measured together with 2X and 2Y. Then $\sin\theta = (2a)(2b)/(2X)(2Y)$.

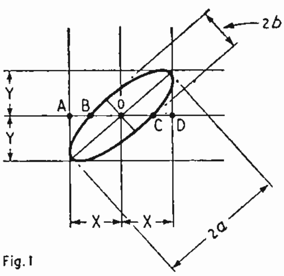


Fig. 1

A note has been published recently[2] showing that θ can be calculated from the simple expression $2\tan^{-1}(2b/2a)$ provided that the horizontal and vertical quantities produce equal-amplitude deflections. It follows that here the angle subtended by the minor axis at the end of the major axis is the phase angle. It is stated in the note that this method does not appear to be generally known but this is thought to be unlikely since it has been given already, along with a proof by Fleming[3], as early as 1925 and by Glaser[4] in 1952. Attention has also been drawn to the method by Bainbridge-Bell[5].

It is interesting to calculate the maximum errors likely to be produced by trace thickness for this final method, however, and to compare the results with those previously published[1] for the first two methods. In making such calculations it will be assumed that no harmonics are present and the amplitudes of the two quantities are made exactly equal although it will be appreciated that this condition may be difficult to obtain in practice and will lead to additional errors in determining the phase angle. In making any measurements on the screen of the cathode-ray tube errors are introduced due to the thickness of the trace at either end of each dimension involved. It will be assumed, as previously[1], that the position of the end of each dimension can be estimated to within 0.5 mm since a trace thickness of about 1 mm is typical of ordinary oscilloscopes. The errors in phase angle can then be written down. Thus, since θ is calculated from $2\tan^{-1}(2b/2a)$, the maximum and minimum values of θ, θ max and θ min respectively, are given by:—

$$\tan(\theta_{max}/2) = (2b + 1)/(2a - 1)$$

$$\text{and } \tan(\theta_{min}/2) = (2b - 1)/(2a + 1)$$

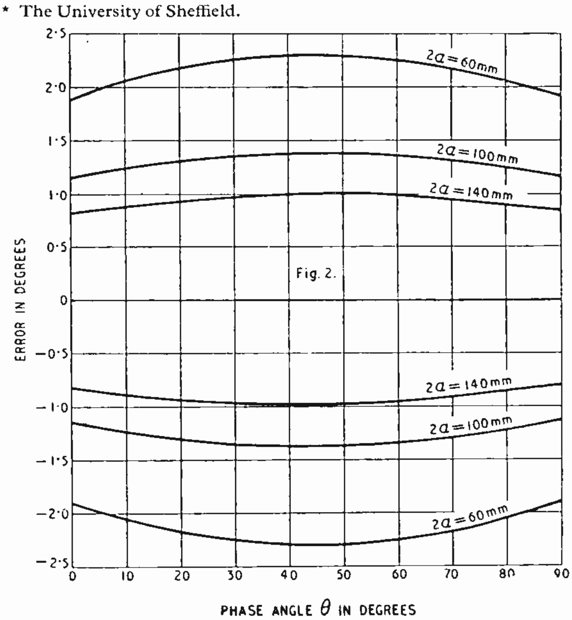
where $2a$ and $2b$ are expressed in mm. The curves of Fig. 2 show the variation of error with θ. The errors have been calculated from the expression:—

$$\delta\theta = \pm(1 + \tan\theta/2)/[a(1 + \tan^2\theta/2)]$$

for values of $2a$ equal to 60, 100 and 140 mm, which are suitable for screen diameters of about $2\frac{1}{2}$ in., $4\frac{1}{2}$ in. and 6 in. respectively.

It is seen that the maximum errors in the three cases are $\pm 0.99°$, $\pm 1.38°$ and $\pm 2.31°$ respectively and occur at 45°. Thus, the present method shows considerable improvement over the other two methods for phase angles above 20° providing the assumption of equal amplitudes can be justified in practice and further that the graticule used for measuring $2a$ and $2b$ can be positioned accurately on the face of the cathode-ray tube screen. The latter condition will almost certainly present difficulties and lead to additional errors which may be large compared with the trace-thickness errors calculated.

* The University of Sheffield.



[1] Benson, F. A., and Carter, A. O., *Electronic Engng.*, June 1950, Vol. 22, p. 238.
[2] W. T. C., *Wireless World*, October 1952, Vol. 58, p. 432.
[3] Fleming, J. A., *J. Instn. Elect. Engrs.*, November 1925, Vol. 63, p. 1045.
[4] Glaser, J. L., *Electronics*, March 1952, Vol. 25, p. 206.
[5] Bainbridge-Bell, L. H., *Electronic Engng.*, August 1950, Vol. 22 p. 356.

Saving Television Bandwidth

Must We Transmit ALL the Information in the Picture?

LESS than a year after R. V. L. Hartley had published his now-famous theory on the relation of information to bandwidth, the principle was invoked—perhaps unknowingly—in an interesting suggestion for reducing bandwidths in television systems. This was in 1929, when the old Nipkow scanning disc was still the rule. In the words of the Patent specification[1]: "It has been customary in the past to transmit successive complete images of the transmitted picture. This method of picture transmission requires a band of frequencies dependent on the number of images transmitted per second. Since only a limited band of frequencies is available for picture transmission, the fineness in the detail of the transmitted picture has therefore been determined by the number of picture elements and the number of pictures transmitted per second. In accordance with the invention, this difficulty is avoided by transmitting only the difference between the successive images of the object. By this mode of operation no signal is transmitted when there is no change in the image of the picture or object and its fineness of detail is limited only by the speed of the action to be transmitted."

This proposal recognized the important fact about television that, as a result of the scanning process, a lot of the information transmitted by the signal consists of useless repetition. In the language of Information Theory, the signal contains a large amount of redundancy. The only really new information is represented by the changes in the picture—the amount by which each picture differs from the previous one (Fig. 1). By transmitting only these differences, or "error signals," the amount of information to be conveyed in a certain time—the rate of information—could be reduced considerably, and this would make possible a corresponding reduction in bandwidth.

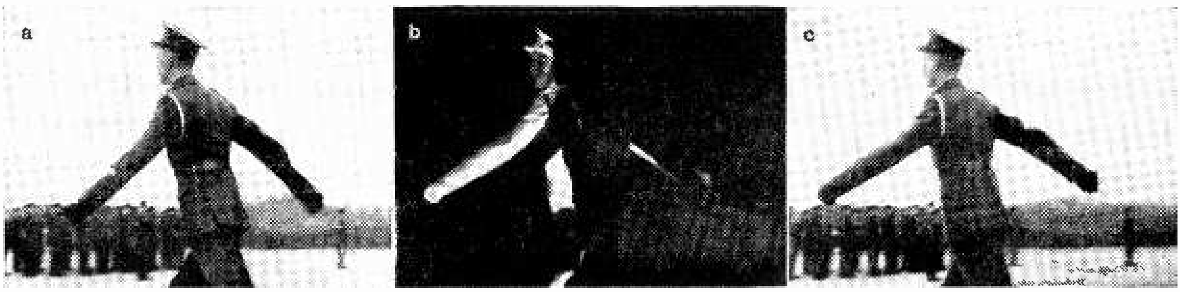
The method suggested for doing this was quite simple (see Fig. 2). The signal from the photo-cell was applied to one half of the primary winding of a transformer and to the other half through a delay network. The delay introduced by this was equal to the complete scanning cycle of the Nipkow disc. On the first scan the complete picture was transmitted through the top half of the transformer. But during the next scan, S_0, the delayed version of the first scan S_{-1} was present in the bottom half of the transformer in phase opposition; so if the next scan was exactly the same as the first the two cancelled out and no signal was transmitted. If the next scan was different, then a corresponding difference signal was induced in the transformer secondary and transmitted.

Of course, nothing was actually done about reducing bandwidths along these lines. But now that the bandwidth problem is becoming more and more acute a great deal of fresh attention is being paid to the subject. The new approach has been greatly influenced, if not actually stimulated, by the development of Hartley's ideas into modern Information Theory, for information is undoubtedly at the heart of the matter. The average television channel, in fact, regarded as a means of conveying information, proves to be grossly inefficient.

The central problem, then, is the large amount of repeated information, or redundancy, in television signals and how it can be reduced to make possible a saving in bandwidth. The 1929 proposal was concerned with the long-term redundancy caused by the similarity, or correlation, between successive pictures. This is very great because of the repetition in time necessary to achieve continuity of vision—especially in backgrounds, which do not change very often.

[1] British Patent No. 341, 811.

Fig. 1. Illustrating the technique of transmitting only the changes in the picture: (a) represents the first scan, and (c) the second, while (b) shows the amount by which (c) differs from (a) as a result of the figure moving to the left.



Nowadays, a great deal of interest is being shown in the short-term redundancies caused by the similarity of adjacent picture elements. This correlation has to do with the repetition necessary to build up the picture spatially, in two dimensions, rather than with the repetition necessary to give continuity of vision in time. It is highest, of course, in the flat unchanging areas of the picture, the areas containing the least amount of detail. For practical purposes it can be analysed into two dimensions—the redundancy between adjacent elements along a line, or horizontal redundancy, and that between adjacent elements in successive lines, or vertical redundancy. But, of course, there is no significant difference between the two, except that the vertically adjacent elements are in different line scan periods.

By working on this correlation between adjacent elements Kretzmer[2] has attempted to measure the total redundancy in various pictures. He estimates from his results that if it could be eliminated a 50 per cent reduction in bandwidth should be made possible. This, however, does not seem to be the limit of possible achievement. Gouriet, for example, has adopted the opposite approach to the problem. He has measured the amount of information in various pictures and compared it with the maximum possible information that could be in them—the amount allowed by the bandwidth. The discrepancy is then a measure of the redundancy. The amount of information is measured in terms of the brightness changes in the picture, while the maximum possible information is represented by the maximum possible number of brightness changes—a 3-Mc/s chequer-board pattern. Even with a highly detailed picture the information rarely exceeds 5 per cent of the maximum possible. This suggests a redundancy of something like 90 per cent to be exploited. The great problem is how to do it. Can we really achieve a ten-to-one reduction in bandwidth?

Statistical Approach

A fresh attack has been made on the problem recently,[3] more or less along the lines of the original 1929 proposal. That is, to transmit only error-signals representing the changes in the picture. In this case, however, the error-signals are not the differences between successive pictures but between adjacent picture elements. So the redundancy eliminated is of the short-term kind associated with the two-dimensional structure of the picture, as explained above. Moreover, this latest method has been influenced somewhat by the statistical approach which modern science is nowadays adopting towards so many problems. The original method *predicts*, in effect, that the next picture element will be exactly the same as the corresponding one in the previous picture—and any discrepancy in this prediction is transmitted as an error-signal. But the new method works on the principle that the next element will probably follow the general *trend* of several previous elements. Which, of course, is a more likely situation. So the error-signal transmitted is the difference between the actual next element and a predicted next element derived from the statistics of the ones before.

The apparatus which does the job (Fig. 3) is very similar to that in the early proposal. It uses a delay

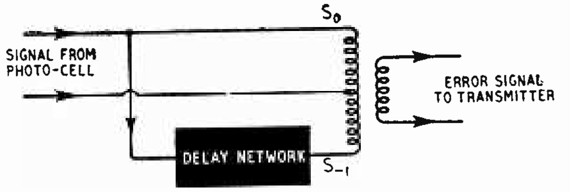


Fig. 2. Proposed system for transmitting only the differences between successive pictures (circa 1929). The scene is scanned by a Nipkow scanning disc and the light variations are picked up by a photocell.

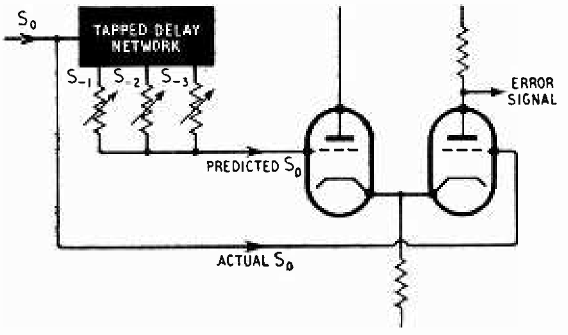


Fig. 3. An improved modern version of the Fig. 2 system. The actual value of a picture element is compared with its predicted value and the difference is transmitted as an error signal.

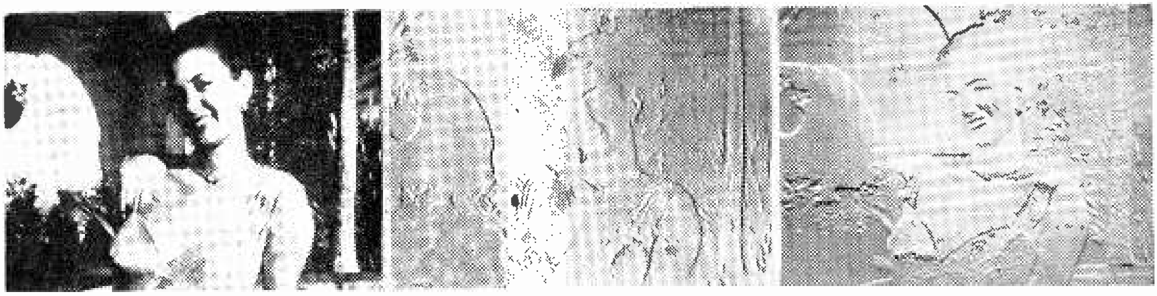
network, to hold up the previous elements until the next element arrives for comparison, and a cathode-coupled differential amplifier (instead of the transformer) to produce the difference signal. The significant modification is that the delay network has now been extended to give delayed versions of several previous elements instead of one. The delays are such that the signals all combine at the grid of the valve and the resulting composite signal amounts to a prediction of what the next element, S_0, will be. The attenuators merely adjust the relative contributions of the various signals to this prediction.

As this system is designed to work on the correlation between adjacent picture elements, the delays introduced by the network are made equal to the time intervals between these elements. That is, between adjacent elements along a line or between corresponding elements in successive lines, depending on whether it is the horizontal or the vertical redundancy which is to be removed. Fig. 4 shows how the error signals appear. By using a combination of two such "decorrelators" one with element-to-element delays and the other with line-to-line delays, it is possible to remove both the vertical and the horizontal redundancy.

At the receiving end, of course, some system is needed to restore the redundancy, so that the picture can be presented in its original form. In other words, a certain amount of the received information has to be repeated; and in practice this means that it has to be stored in some way. In the 1929 system the receiving screen consisted of a mosaic of little reflectors which were moved in and out of the light by the signals. The first scan set them all in their appropriate positions and they remained there permanently until moved by the error signals representing the changes in the picture. Thus the information was stored and,

[2] "Statistics of Television Signals." *Bell System Technical Journal*, July, 1952.

[3] "Experiments with Linear Prediction in Television." *Bell System Technical Journal*, July, 1952.



(Courtesy Bell System Technical Journal.)

Fig. 4. The results of reducing redundancy. At (a) is the original picture, while (b) shows, in two-dimensional form, the error signals produced by horizontal decorrelation and (c) the error signals produced by vertical decorrelation. Note the absence of horizontal contours in (b) and vertical contours in (c).

in effect, repeated in a succession of picture periods. Nowadays the process could be done electronically, and a picture storage tube would be used in place of the mechanical mosaic.

One very obvious advantage of transmitting only error signals, as in Fig. 4, is that their power is very much lower than that of the actual picture waveform: they only represent the brightness *changes.* But this does not constitute a bandwidth saving as such. The sharpness or harmonic-content of these error signals is still as great, and requires as much bandwidth, as in the original signal. But the power-saving can be translated into bandwidth saving by a suitable method of coding. In other words, the information in the brief error signals can now be spread out over a greater length of time—we can take more time in transmitting them. As a result of this "smoothing out" process we can obtain a continuous and very much lower rate of information. And with the lower rate of information our bandwidth can be made correspondingly smaller. A coding device, then, is an essential part of the television channel.

"Smoothing Out" the Information

There are various methods of coding or "smoothing out" the flow of information, and one of the most promising was described recently in an I.E.E. paper by Cherry and Gouriet[4]. This system is really intended for decorrelating, or reducing the redundancy, in the original television waveform, but it could equally well be used as a means of coding the error signals produced by the "prediction" method of decorrelation. The principle is simply to vary the speed of the scanning system so that more time is taken to transmit the high-information parts of the picture and less time to transmit the low-information parts. The high-information parts are the sharp transitions between different brightness values, which are represented by correspondingly sharp transitions on the camera mosaic and in the waveform (see Fig. 5); so the velocity of the scanning beam is made to vary according to the sharpness or slope of the waveform. The apparatus suggested for doing this is shown in Fig. 6. A differentiating circuit measures the slope of the waveform and controls the scanning velocity accordingly. Thus the high slope of a sharp edge tends to slow down the beam, and as a result the slope is itself reduced until it settles down to an equilibrium value. Similarly a low slope causes the beam to go faster. The arrangement is really a self-adjusting or servo system in which the beam velocity is controlled by a function of itself. Fig. 7 shows the effect on the television waveform. In the receiver, the velocity of the scanning beam of the c.r. tube is varied in synchronism, and the information for doing this is derived from the modified slopes of the received waveform.

To use this system for coding the error signals produced by the "prediction" method of decorrelation it would be necessary first to store the error signals on the target of an electrostatic storage tube so that they could be scanned. But, as stated above, the system is, in itself, a decorrelator, as well as being a coding device. One can see from the waveforms in Fig. 7, for example, that very little time is wasted on transmitting the flat redundant parts of the picture—a time saving which is in fact used for sending the sharp transitions in the picture at a lower speed.

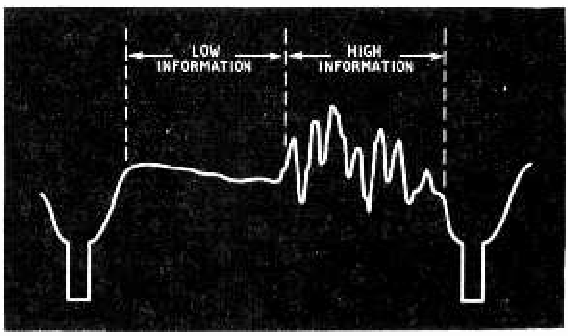


Fig. 5. Line waveform showing low-information parts and high-information parts.

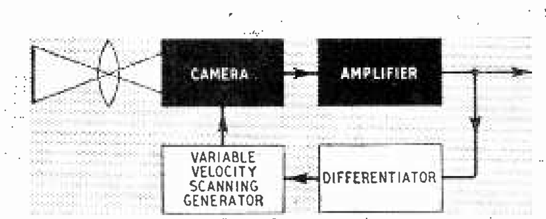


Fig. 6. System for controlling the velocity of the camera scanning beam according to the amount of information in the picture.

[4] "Some Possibilities for the Compression of Television Signals by Recoding." *Proc. I.E.E.*, Part III, January, 1953.

Of course, with the Fig. 6 arrangement the decorrelation is done only along the lines—in the horizontal dimension. The vertical redundancy, between adjacent lines, remains. Gouriet and Cherry, however, have pointed out that this vertical redundancy could actually be reduced in a similar way. The modified line scan waveforms (Fig. 7(b)) would be stored in a picture storage tube in the form of a horizontally-decorrelated electrical image of the picture. This would be done by the "writing" beam of the tube. The "reading" beam would then scan the stored image in the vertical direction, and it would use the same variable-velocity system so that this time the vertical redundancy would be removed. The output waveform would look very much like Fig. 7(b) but owing to the horizontal redundancy having already been reduced the differences between successive line waveforms would be much greater. At the receiving end the same process would be done in reverse, using a storage tube with a variable-velocity "writing" beam to restore the vertical redundancy and a variable-velocity "reading" beam to restore the horizontal redundancy.

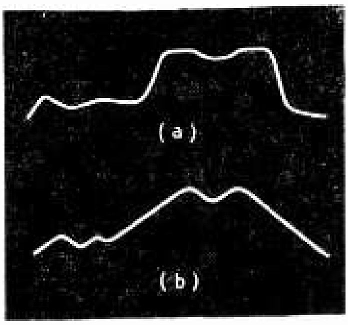


Fig. 7. At (a) is a normal line waveform while (b) shows how it would appear with variable-velocity scanning as in Fig. 6.

Matching to the Eye

These bandwidth saving schemes are, of course, all based on the general argument that there is no point in transmitting more information than is needed to reassemble the picture on the receiving screen. But the matter does not really end there. One could also argue that there is no point in presenting on the screen more information than the human visual system is able to cope with. At the moment it seems that we are doing just that. In other words, it is probable that we could make further reductions in the rate of transmitting information, and hence in bandwidth, by taking more advantage of the limitations of the human visual system. The screen should be "matched" to the eye.

One way of doing this would be to reduce the scanning rate—either the number of pictures per second or the number of lines per picture. The number of lines per picture is, of course, an old problem and everybody has different ideas on the subject. In practice it has been a matter of using as many lines as possible without making the bandwidth too unreasonable. This has been based on the assumption that the more lines there are in the picture the sharper it will appear. But in fact this assumption is only partly true. The subjective sharpness increases rapidly with number of lines up to a certain point, but after this the addition of further lines makes very little difference. In other words, after this point an extra expenditure of bandwidth brings no worthwhile returns in subjective sharpness and so is largely wasted. The French 819-line pictures certainly do not look twice as sharp as our 405-line pictures. The optimum point is actually in the region of 400-500 lines, so in the British and American systems, at any rate, a reasonable matching of screen to eye has already been achieved, and little more can be done in this direction.

There remains the possibility of reducing the number of pictures per second. At the moment, in the British system, we have 25 pictures per second. But we do not really need this picture frequency to achieve continuity of vision, for the human visual system is still incapable of separating successive images when they are presented at a rate as low as 10 per second. (This may have something to do with the 10-c/s electrical alpha rhythm of the brain which is thought to be a kind of physiological scanning mechanism.) So it seems that we could quite safely halve the picture frequency to $12\frac{1}{2}$ per second and thereby make possible a 50 per cent reduction in bandwidth.

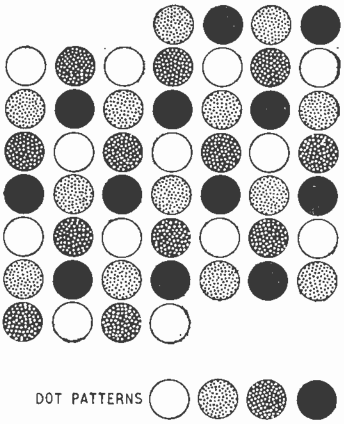


Fig. 8. Illustration of the dot-interlace system of television in which the picture is built up from four sets of dots.

The only difficulty in this is that although the eye may only need $12\frac{1}{2}$ pictures per second for continuity of vision, it becomes very sensitive to flicker at anything below 50 per second. In the present system, of course, we have overcome this difficulty by the ingenious expedient of presenting the 25 pictures per second as a series of interlaced half-pictures, or frames, at 50 per second. As a result of this interlacing the flicker is transferred from between successive pictures to between adjacent lines. This is just right for the eye, since the only part of the retina which is capable of resolving the lines (the fovea in the centre) happens to be insensitive to flicker. The parts of the retina which *are* sensitive to flicker (the peripheral regions) are incapable of resolving the lines and so cannot see it.

The logical thing to do, then, is to extend the interlacing principle and halve the picture frequency to $12\frac{1}{2}$ per second, while still keeping the flicker frequency at 50 c/s. In other words, each picture would now consist of four frames instead of two[5]. This, in fact, is the principle of the dot-interlace system of television, in which each picture is built up from four interlaced sets of dots (see Fig. 8); each set contributes a quarter of the total picture information. Dot interlacing could therefore be used in this way to halve the bandwidth by halving the picture frequency. (Alternatively, of course, with the existing bandwidth

[5] For example, the system developed by DuMont Laboratories. See *Wireless World*, Dec. 1st, 1938, p. 480.

it could be used to double the definition.) Another method of halving the picture frequency while keeping the flicker frequency at 50 c/s is to use a picture storage tube. In other words, each picture is stored and flashed on the screen four times before changing to the next picture—a principle which has already been utilized in certain film projectors. The main disadvantage of reducing the picture frequency is that fast-moving objects appear as multiple images when the necessary measures have been adopted in order to overcome flicker.

There is also the possibility of exploiting the limitations of visual acuity, or resolving power of the eye, as it is sometimes called. Jesty and Phelp have shown, for example, that visual acuity falls off rapidly with reduced brightness and contrast[6]. This suggests that it might be possible to reduce the amount of information in the shadowy parts of the picture without anybody being any the wiser—and such a reduction would certainly enable a bandwidth saving to be made. Then again, visual acuity is also very much lower at the edges and corners of the picture, since these are the parts which are projected on to the insensitive peripheral regions of the retina. It is true that we are free to focus the sensitive fovea of the retina on to these parts but, generally speaking, we keep it at the centre of the picture. So, again, a reduction of information might be made towards the outer edges of the picture. Another interesting feature of visual acuity is that it seems to fall off as the screen is brought nearer to the eye. This suggests that a small and near picture can satisfy the viewer with less information than a large and distant one subtending the same angle at the eye. Or, for the same bandwith, the small and near picture will look sharper. Unfortunately this physiological effect seems to work in the opposite way to the psychological effect described by C. Burns in the January issue, by which the bigger picture appears to be the sharper of the two.

Colour Television

With colour television, of course, the bandwidth problem is even more acute, for there is so much more information to be transmitted. Various methods have been proposed for reducing the bandwidth by successive sampling of the three colour components, but a new idea put forward recently by Valensi seems to get much closer to the heart of the matter. In this, the components of the colour are not transmitted at all, but just a code signal representing the colour itself. The colours are analysed in the usual way by three pick-up tubes with filters in front, and the voltage outputs from these form a combination which actuates the transmission of the appropriate code signal.

The fact that a person's visual acuity is about 50 per cent lower with colour pictures than with black and white has already been exploited in the "mixed highs" system of colour television. Since there is no point in describing the high-information parts of the picture in colour when the eye cannot see the result, the bandwidth of the colour channel can be reduced by about 50 per cent without any noticeable difference in the picture. The high-information parts are made visible to the eye by being reproduced in black and white. Again, the visual acuity with blue is very much lower than with the other two colour components, so this makes possible an additional bandwidth reduction in the blue channel.

[6] "The Evaluation of Picture Quality with Special Reference to Television." *Marconi Review*, 3rd and 4th Quarters, 1951.

BOOKS RECEIVED

Principles of Radar, by Members of the Staff of the Radar School, Massachusetts Institute of Technology. Third Edition, by J. F. Reintjes and G. T. Coate. Extensively revised test book of the basic concepts and and techniques of radar. Pp. 985 +XV; Figs. 642. McGraw-Hill Publishing Company, 95, Farringdon Street, London, E.C.4. Price 55s 6d in U.K.

Sound Reproduction (Third Edition), by G. A. Briggs. Revised and enlarged survey of loudspeakers, recording and allied subjects Pp. 368; Figs. 315. Wharfedale Wireless Works, Bradford Road, Idle, Bradford, Yorks. Price 17s 6d.

TV Manufacturers' Receiver Trouble Cures, Volume I, by Milton S. Snitzer. More than 300 troubles met with in current American television receivers, and the cures recommended by their makers. Pp. 115; Figs. 51. John F. Rider Publisher, 480, Canal Street, New York, N.Y. Price $1.80.

Television and Education in the United States, by Charles A. Siepmann. Sociological study of the influence of television viewing on the school work of American children. (A UNESCO pamphlet.) Pp. 120+xi; Her Majesty's Stationery Office, Kingsway, London, W.C.2. Price 6s.

Manufacturers' Literature

Portable Disc Recorder containing a four-stage amplifier with push-pull output of 8 watts. Illustrated brochure with specification and response curves and a leaflet describing the ribbon microphone that goes with the equipment, from E.M.I. Sales & Service, Hayes, Middlesex.

Diamond Wheels in various shapes and sizes for cutting and grinding ceramics and glass. Leaflet giving general information and describing improved method of manufacture, from Colton & Company (Lapidaries), Diamond Tool Division, Walpole Road, London, S.W.19.

Electronic Measuring Instruments for laboratory and test purposes. A brochure giving short descriptions and photographs of the complete range available from Philips Electrical, Century House, Shaftesbury Avenue, London, W.C.2. Also a leaflet on the Philips range of variable transformers.

Hi-K Ceramic Capacitors; a technical bulletin (No. 27, series 2) giving specifications of wire-ended and screw-base tubulars and lead-through and miniature-bead types, from the Telegraph Condenser Company (Radio Division), North Acton, London, W.3.

Components, accessories and construction kits; a selection of more popular items from the general stock list of City and Rural Radio, 101, High Street, Swansea, Glam.

Fractional Horse-Power Motors and others; an abridged list with prices of the types available from Higgs Motors, Witton, Birmingham, 6.

Megohmmeter with a range of 0.3-20,000,000 MΩ, enabling changes in resistance to be measured without adjustment of controls. This and other electronic measuring instruments described briefly in an illustrated broadsheet from Electronic Instruments, Red Lion Street, Richmond, Surrey.

Stabilized Power Supply with d.c. output voltage continuously variable from 200 V to 350 V and stability of ±0.5% for ±10% mains variations. Specification in a leaflet from Harvey Electronics, 273, Farnborough Road, Farnborough, Hants. Also a leaflet describing their **Production Facilities** available for precision mechanical and electro-mechanical work.

Batteries; h.t. and l.t. for receivers and hearing aids. A brochure giving voltage tappings, weights, sizes and prices from Siemens Electric Lamps and Supplies, 38 and 39, Upper Thames Street, London, E.C.4.

Gramophone Amplifiers, 4 W and 10 W outputs, with tone controls but no output transformers. Descriptive leaflet and list of accessories from Ian M. Ross, Electro-Acoustic Laboratories, Knockbreck Road, Tain, Ross-shire, Scotland.

Resistance and Ratio Boxes, d.c. bridges and similar instruments for the laboratory; brief specifications on an illustrated leaflet from Croydon Precision Instrument Company, 116, Windmill Road, Croydon, Surrey.

THE "BELLING-LEE" PAGE

Providing technical information, service and advice in relation to our products and the suppression of electrical interference

R.E.C.M.F.

Readers of this page, receiving invitations, will be visiting the R.E.C.M.F. Exhibition from the 14th to the 16th April.

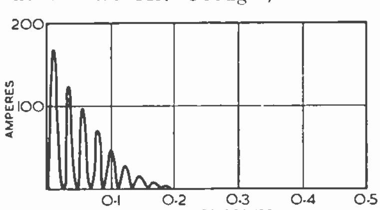
As most readers are aware, this is a private exhibition, held under the auspices of the Radio & Electronic Component Manufacturers Federation, and as in recent years, will take place at Grosvenor House, Park Lane.

The majority of those receiving invitations will be representatives of the Services and Supply Ministries. Industrial concerns and technical establishments will be represented by designers, technicians and engineers, together with a very large number of overseas buyers.

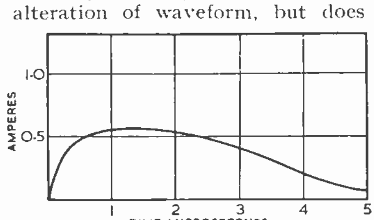
We hope any readers who may be present, will come and see us and what we have to show, on Stand No. 52.

Ignition Suppression of Motor Cars, etc.

Lately the correspondence columns of "*The Autocar*" have carried a number of very interesting letters on this subject, and we have the Editor's and the Author's permission to reproduce one letter which appeals to us. We have never met Mr. Goodger, but his letter disposes of a common misconception in a very concise manner, as in it, he refers to the alteration of waveform, but does not illustrate this. The two curves shown above are our contribution.



The oscillatory nature of the ignition capacity spark current is shown above.



Introduction of a suppressor resistor effectively eliminates the oscillations of the spark current.

"***Alteration of Current Waveform*** (64652)—Is your correspondent (64627) really correct in assuming that the insertion of a suppressor—a resistor of, say, 5,000 ohms—in the h.t. lead at the distributor necessarily reduces the voltage at the spark gap?

Don't forget that, until the actual moment of the spark jumping to earth, the circuit is not completed and what the resistor does, surely, is to enable the voltage to build up to maximum before jumping the plug gaps.

The suppressor does not work as such by lowering the voltage by any appreciable extent, but by altering the waveform of the h.t. current.

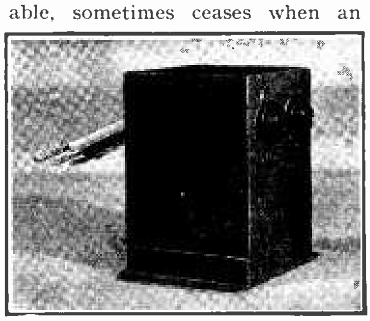
An electrical current which rises quickly to maximum and peaks sharply will radiate much more interference than one which builds up comparatively gradually and collapses in the same way. Hence the resistor at the distributor. And what about side items, like longer plug life and easier starting from cold?

I own a somewhat lethargic 8 h.p. saloon and, since fitting a suppressor some while ago, I have noticed no drop in performance or increase in petrol consumption, but, contrariwise, I have noticed a very slight but definite increase in the engine's ability to pull at low speeds. B. Goodger."

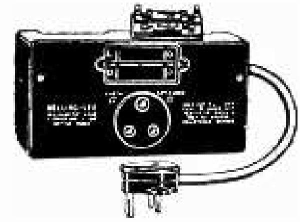
Oswestry, Shropshire.

Electric Cooker as an Interference Suppressor

This is a hardy annual: we are often asked why it is that interference which makes radio intolerable, sometimes ceases when an electric cooker is switched on. This was given quite a lot of publicity recently in one of our daily papers which has a very wide circulation. The answer is, that by its nature, a cooker has a very considerable capacitance between each line and earth, and this by-passes the unwanted H.F. interference to earth. Naturally this rather large "capacitor" is only effective when in circuit, i.e., when switched on, and is therefore an "expensive" suppressor. A similar effect may be expected from a standard capacitor suppressor such as the "Belling-Lee" L.750 which measures 3¼in. × 2½in. × 3in. and of course passes no current. When used in this way, it is generally fitted where the mains enter, i.e., at the meter board between neutral and live, the centre point being earthed. A set lead suppressor (containing chokes) is often preferred; this is L.300/3 and is fitted, as its name implies, between the supply point and the receiver.



"Belling-Lee" Capacitor Suppressor L.750



"Belling-Lee" Set Lead Suppressor L.300/3

Ever Hopeful

Recently, one of our engineers had occasion to visit places rather remote from the bustle and strife of London. Television was something that was likely to arise "in a few months time." He heard of a prospective viewer who would only buy a broadcast receiver that had a loudspeaker grill large enough to take a television screen when the time came!

STOP PRESS

ALL EFFICIENT new cars have at least one ignition resistor fitted as standard.

Bring your car up-to-date for 2/6d. Fit a "Sparkmaster" for controlled spark, easier cold starting, reduced pinking and plug burning.

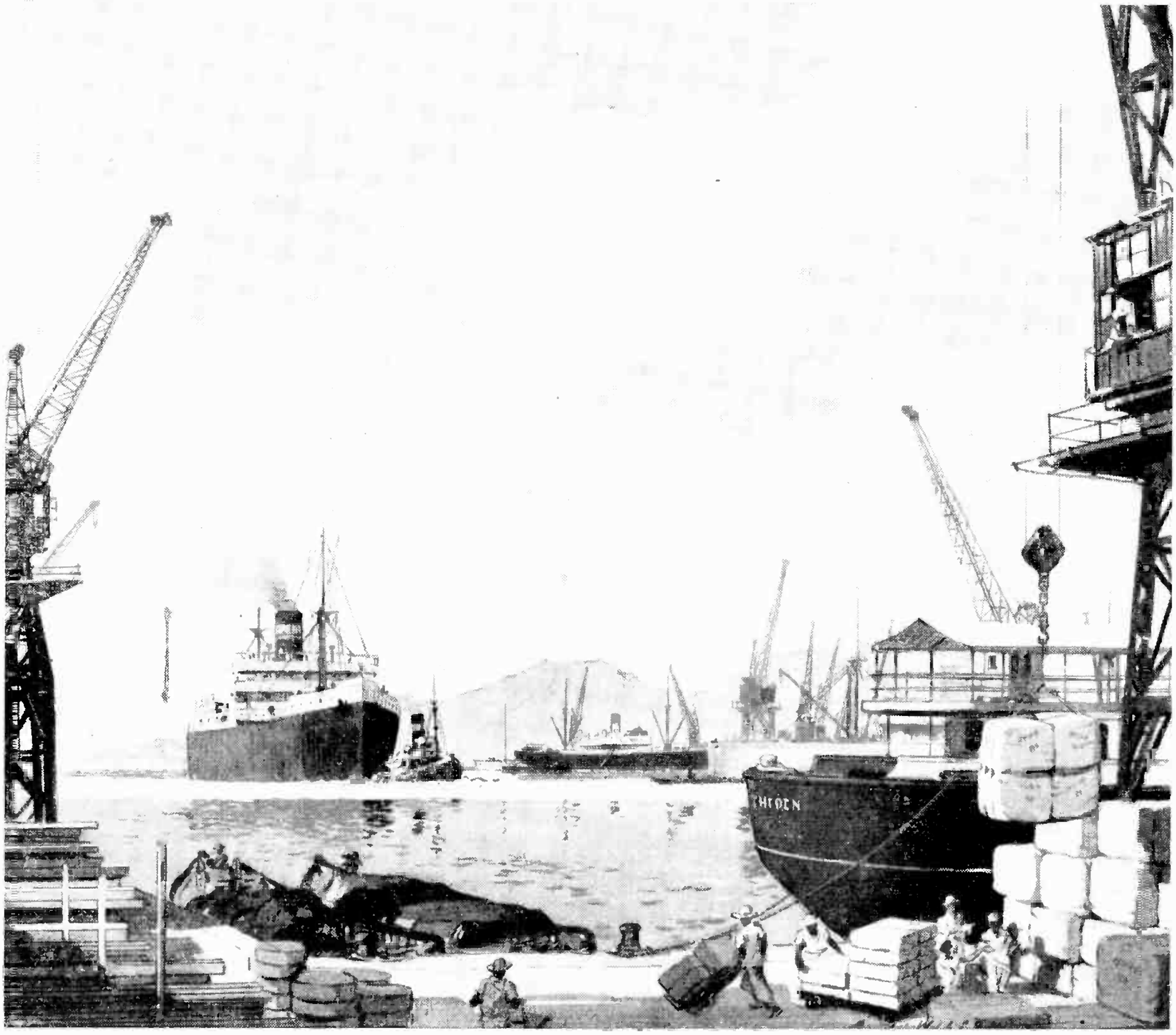
Cars so fitted do not interfere with T.V. reception.

It will pay you to fit a "Belling-Lee" "Sparkmaster" to-day.

Written 28 February, 1953.

BELLING & LEE LTD
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND

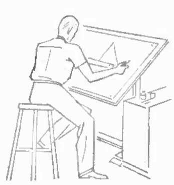
MARCONI communication systems



serve mankind

Before Guglielmo Marconi's invention of wireless, a ship out of sight of land was literally cut off from the world. Today you can, in a matter of minutes, contact a ship in mid-Atlantic. Such is the measure of his service to communications and safety at sea. Such too, is the measure of his ideals, which still inspire the Company he founded.

SURVEYED



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MARCONI'S WIRELESS TELEGRAPH COMPANY LTD · CHELMSFORD · ESSEX

Presenting Technical Information

Six More Writing Awards by the R.I.C.

THE NEED for more articles making known to executives and administrators, as well as to technicians, new and interesting developments in radio, television and electronics in this country is stressed by Vice-Admiral Dorling, director of the Radio Industry Council, in announcing six further awards of premiums for technical writing. It is the writing of this type of article that the R.I.C. wants to encourage and Vice-Admiral Dorling emphasized that it is almost essential when preparing a highly technical article to start with a "simple, concise explanation of the aims and applications of the techniques described. . . . Greater attention should also be paid to clarity."

Four awards of 25 guineas will be made to the authors of each of the following articles published during 1952:—

P. H. Parkin, B.Sc., A.M.I.E.E., who is principal scientific officer in charge of the sound insulation and acoustics section of the Physics Division at the D.S.I.R. Building Research Station, and **P. H. Taylor**, A.M.I.E.E., technical director of Pamphonic Reproducers, Ltd., for their article "Speech Reinforcement in St. Paul's Cathedral," published in the February and March issues of *Wireless World*.

T. Somerville, B.Sc., M.I.E.E., F.Inst.P., head of the Electro Acoustics Group of the Engineering Research Department, B.B.C., and **C. L. S. Gilford**, M.Sc., F.Inst.P., head of the acoustics section of the Group, for an article in the *B.B.C. Quarterly*, Spring, 1952, on "Composite Cathode Ray Oscillograph Displays of Acoustic Phenomena and their Interpretation."

J. A. Jenkins, M.A., M.Inst.P., who is in charge of the Photoelectric Division of the Mullard Vacuum Physics Research Laboratories, and his chief assistant, **R. A. Chippendale**, B.Sc., for "Some New Image Converter Tubes," published in the July, 1952, issue of *Electronic Engineering*.

W. R. Stamp, on the staff of the Admiralty Research Laboratory, Teddington, for an article in *Discovery*, September, 1952, on "Underwater Television."

Ex gratia awards of £10 each are made to:—

T. W. Bennington, who is engaged in ionospheric and short-wave propagation work in the Research Department of the B.B.C., for his article on "Propagation of v.h.f. *via* Sporadic E," (*Wireless World*, January, 1952), and

G. N. Patchett, Ph.D., B.Sc., A.M.I.E.E., M.I.R.E., A.M.Brit.I.R.E., head of the Electrical Engineering Department, Bradford Technical College, for his contribution on "Faulty Interlacing," (*Wireless World*, July and August, 1952).

The awards will be presented at a luncheon in London on April 9.

An interim award of 25 guineas was made at last year's Radio Show.

Full details of the scheme for encouraging technical writing, which provides for the awarding of up to six 25-guinea premiums each year, are available from the Secretary, R.I.C., 59, Russell Square, London, W.C.1.

NEWS FROM THE CLUBS

Brighton.—"Sub-miniature Equipment" is the subject of a talk to be given by a representative of Multitone Electric, Ltd., to the Brighton & District Radio Club on April 14th. On April 28th F. R. Canning will speak on "Designing a Simple Transmitter." Meetings are held at 7.30 at the Eagle Inn, Gloucester Road, Brighton, 1. Sec.: R. T. Parsons, 14, Carlyle Avenue, Brighton.

Chester.—The April programme of the Chester & District Amateur Radio Society, which meets each Tuesday at 7.30 in the Tarran Hut, Y.M.C.A. Grounds, Chester, includes: a discussion on a top-band transmitter (7th); "Problems of Transmitters in North Africa" by Capt. Carpenter, MD2B (14th); and a discussion on radio interference (21st). Sec.: N. Richardson, 1, Victory Villa, Newton Lane, Upton, Chester.

Cleckheaton.—At the meeting of the Spen Valley & District Radio & Television Society on April 8th A. Smith, B.Sc. (G2BOO), will speak on "Nuclear Physics." The club meets on alternate Wednesdays at 7.30 in the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds.

Coventry.—Members of the Coventry Amateur Radio Society will be given a "Radio Reader's Digest" at the meeting on April 13th. A lecture-demonstration on "A Multi-purpose Power Supply" will be given by Ray Bastin (a member) on April 27th. The club meets on alternate Mondays at 7.30 at the Y.W.C.A., Queen's Road, Coventry. Sec.: K. Lines, 142, Shorncliff Road, Coventry.

East Brighton.—We have been informed by F. J. Walton, secretary of the East Brighton Short Wave Club, that owing to lack of support, the affairs of the club are being wound up.

Manchester.—The new secretary of the South Manchester Radio Club (M. Barnsley) will show members the Mullard Film Strip No. 5 on April 10th. Meetings are held on alternate Fridays at 7.30 at Ladybarn House, Mauldeth Road, Fallowfield, Manchester, 14. The club transmitter (G3FVA) is on the air on 3.5 Mc/s on alternate Fridays. Sec.: M. Barnsley (G3HZM), 17, Cross Street, Bradford, Manchester, 11.

Peterborough.—P. J. Walker, of the Acoustical Manufacturing Co., will give a lecture-demonstration on "High Quality in Small Rooms" to members of the Peterborough Radio and Scientific Society (G3DQW) on April 9th. The club meets each Thursday at 7.30 at its headquarters in St. Paul's Road, Peterborough. Sec.: S. Woodward, 72, Priory Road, Peterborough.

Portsmouth.—Meetings of the Portsmouth & District Radio Society, which is affiliated to the Royal Marine Signal Club, are held each Tuesday at 7.30 at the Royal Marine Barracks, Signal Club, Portsmouth. Sec.: L. Rooms (G8BU), 51, Locksway Road, Milton, Portsmouth.

Southend.—The lecture programme of the Southend & District Radio Society includes "The Diode Detector" by K. J. Varcoe, A.M.I.E.E., on April 17th. "The Principles and Use of the Cathode-Ray Oscilloscope" by S. F. Asquith, A.M.Brit.I.R.E., and "The Manufacture of Piezo-Electric Crystals" by Dr. C. P Fagan of Cathodeon, Ltd., are among the forthcoming events. Also visits are planned to the Cable and Wireless station at Brentwood, North Foreland station and the Rochford Aerodrome. Sec.: G. Chapman, Bell Hotel, 20 Leigh Hill, Leigh-on-Sea, Essex.

Designing a Tape Recorder

By J. M. CARTER, B.Sc.*

2—The Amplifier and its Associated Oscillator and Level Indicator

ALL STUDIO TYPE tape recorders employ separate record and playback heads, each function occurring simultaneously, so that the playback head provides a continuous monitoring of the recorded signal. In this case, therefore, two separate amplifiers are necessary for record and playback. For almost all other non-professional applications, however, this is not strictly necessary as with a good instrument it is extremely rare for anything to go wrong with the recording process. For this reason, and also because of the saving in space and cost, the majority of commercial equipments use a combined record-playback head, and with the addition of the appropriate switching the amplifier is also made to serve both purposes. What are the main requirements for such an amplifier, and how may they most easily be met?

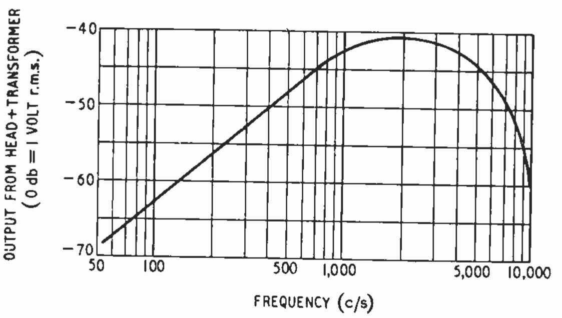


Fig. 2. Frequency response curve (uncompensated) of head and transformer, from a recording made under constant-current conditions.

The first essential is high overall gain. Assuming that the combined record-playback head is of the usual twin-track type and is used with a step-up matching transformer to the first valve grid, the gain at 50 c/s from this point to the output will require to be roughly 110 db. With this order of gain hum can become a major problem, especially when a metal-cored inductor, i.e., the head, is connected to the input! However, a carefully planned layout of the components, and some special precautions, can reduce it to a negligible value. The head matching transformer should preferably be of the "astatic" type, to assist hum pick-up cancellation, and, in addition, be completely screened in a Mumetal case, it is also advantageous to mount it so that it can be rotated to the position of minimum hum pick-up. This rotatable feature is also desirable with the mains transformer, as often just a few degrees of movement of the main flux axis can effect a marked reduction in hum. These adjustments, will be made, of course, when the equipment is completely assembled, and with the motors running, in case a slight amount of hum "bucking" is necessary.

To exclude the possibility of internally generated valve hum in the low level stages, only valves with a "bifilar" heater should be used, and as an additional safeguard the heater winding on the mains transformer

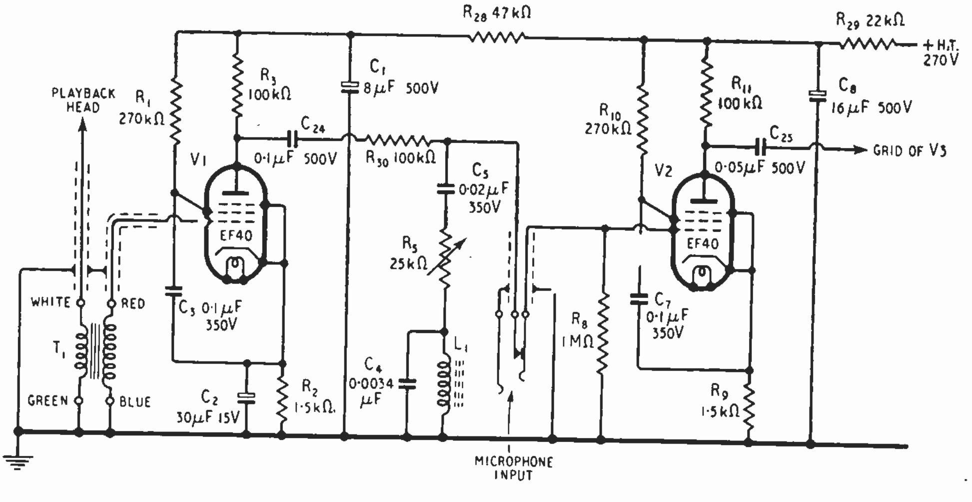


Fig. 3. Playback equalizing circuit. Fixed resistors can all be of ½-watt rating, but R_3 and R_{11} should be of the high-stability type. A silvered-mica capacitor should be used for C_4. Transformer Type 977 and choke Type 727, made by Wright and Weaire, can be used for T_1 and L_1 respectively.

* Wright and Weaire Ltd.

should be centre-tapped to chassis. The first and second valves must also be free from microphony, and the compact form of the modern all-glass miniature type is a decided advantage in this respect, although if a "lock-in" base is employed it is advisable to mount the valveholder assembly on rubber and use flexible leads to the valveholder tags, to avoid transmitted vibrations from the chassis. To avoid chassis currents, a single chassis "earth" for all the earth return leads of the first two valves, input transformer and playback head is essential. Another desirable feature in connection with the first two valves is the use of high-stability anode load resistors to eliminate resistor noise.

The amplifier must also be equalized to accommodate the varying response from the head on playback, which occurs when recording is made under virtually constant-current conditions in the usual way (Fig. 2). This may be done in several ways, but the method shown in Fig. 3 is recommended for its simplicity, stability and possibility of adjustment to almost any unequalized tape response.

Equalizer Design

As can be seen, it takes the form of a combined potentiometer-shunt circuit across the output from the first valve anode load resistor. When the CRL network between points A and B has a high impedance, which occurs at low audio frequencies, and also at the high audio frequencies in the region round the resonance point of L_1C_4, the maximum voltage will be tapped from the potentiometer formed by its series connection to the 100-kΩ resistor R_{30} and the coupling capacitor C_{24}. At the same time the shunting effect of the whole network across the anode load of V1 will be a minimum. In the middle audio-frequency range, say 1,000-5,000 c/s, the impedance of C_5 and L_1C_1 will be low (the latter being well off resonance), and the value of the variable resistance R_5 will form the greater part of the total impedance, which will be at its lowest value. Hence a much smaller voltage will be tapped off the potentiometer network, and the shunt effect also will be at its maximum. The resonance point of L_1C_4 is usually fixed between 11 and 13 kc/s and forms the upper limit to the frequency response, after this point the response falling away rapidly. To avoid hum pick-up, the inductor L_1 should either be screened in Mumetal or be of astatic construction.

The second valve V2 is connected as a straight RC-coupled amplifier, with the cathode resistor not bypassed, to provide some measure of current feedback and further improve the linearity.

From the anode of V2 the amplifier can follow any prescribed pattern to the output stage, providing (a) that the remaining amplification is linear and adequate, and (b) that some 13 volts or so of undistorted signal are available at some point for recording.

Main Amplifier

Perhaps the simplest output stage fulfilling these conditions, and also providing 3 watts of output at 3 per cent distortion, is that shown in Fig. 4. The output from V2 is fed via the volume control R_{12} to the last two valves V3 and V4. A "loop" embracing some 14 db of negative feedback is run from the secondary of the output transformer T_2 to the cathode of V3 and, as previously stated, enables 3W of audio power to be extracted from V4 at a low percentage distortion. It also ensures a very flat response from 40–15,000 c/s from the microphone or radio jack to the output transformer secondary.

When the amplifier is used for recording, the action of plugging the microphone into the microphone jack (Fig. 3) automatically disconnects the first stage and the equalizing circuit, and V2, V3 and V4 then provide a gain of approximately 8,000 to the anode of V4. As the voltage required for the peak recording level will only be about 13, this means that a signal of 1.6 mV from the microphone will fully load the tape. The "Radio" input jack should be used when a large recording input of perhaps 100 mV and upwards is available, as very large inputs would overload the grid of V2. If the source of this larger input is of a high-impedance nature, a shorting plug should be inserted in the microphone jack to prevent any first stage noise coming through; if of low impedance it will, of course, shunt the noise output from the first two stages, and this trouble will not arise.

The amplified signal to be recorded will appear at the anode of V4 and from there will pass through the isolating capacitor C_{27} to the recording network which consists of a 51-kc/s trap (L_4 and C_{13}) and the main series recording resistor R_{19} and its associated pre-emphasis capacitor C_{12}. The 3,400-pF capacitor C_{11} is merely to depress the feedback "hump" in the supersonic region.

The 51-kc/s trap is a parallel resonant LC circuit tuned to the bias frequency by means of a dust core in the coil and serves two purposes: (*a*) to provide an effective block to bias volts appearing at the anode

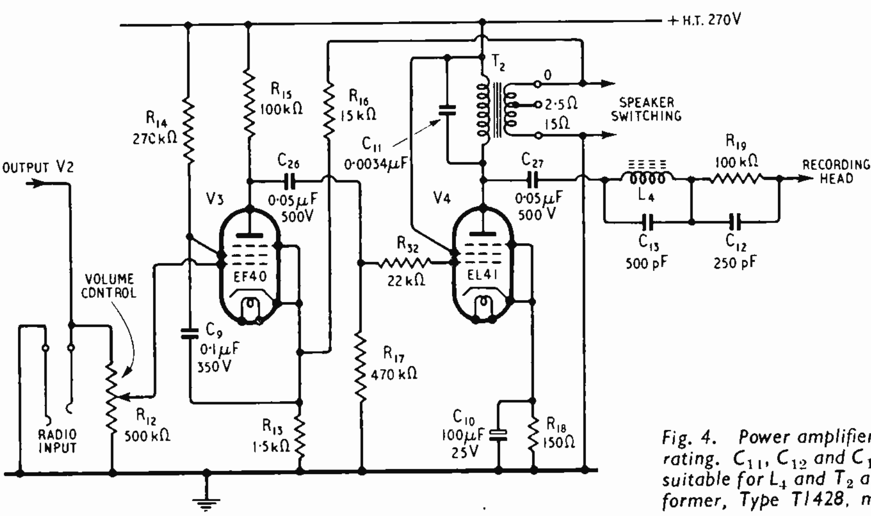


Fig. 4. Power amplifier circuit. Resistors are of ½-watt rating. C_{11}, C_{12} and C_{13} are silvered mica. Components suitable for L_4 and T_2 are the choke Type 666 and transformer, Type T1428, made by Wright and Weaire.

of V4, and consequently its output network, and (*b*) to maintain a high impedance to 51 kc/s across the signal winding of the head and so prevent its feed circuit from imposing too great a reflected shunt load on the bias winding and supply. R_{19} has a value of 100kΩ and C_{12} of 250 pF, and as the head impedance reaches a maximum of 12,000Ω at 10,000 c/s, this ensures that the recording current through the head is essentially constant up to the higher audio frequencies, where C_{12} provides an increase which serves to neutralize the extra head losses and also provides some degree of treble boosting.

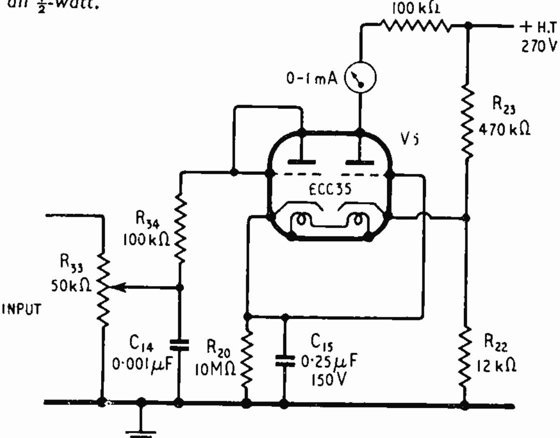
Recording Level

To obtain the best signal-noise ratio the tape must be recorded to that intensity which gives the maximum permissible distortion on subsequent playback. Too low a recording level will result in a lower signal output from the tape requiring more gain from the amplifier and thus, inevitably, more background noise. This monitoring of the recording voltage applied to the head is done by some form of visual indicator. "Magic eyes" which deflect, or neon lamps which glow on the audio peaks are often used. For close control on professional equipment, however, a form of meter is always used and the simple valve voltmeter shown in Fig. 5 can easily be built into the amplifier at little extra expense to provide an excellent peak level indicator.

Part of the signal is taken from the potentiometer R_{33} and applied through R_{34} to the strapped anode and grid of one triode half of V_5. C_{14} has a value of 1,000 pF and is intended to prevent any stray bias volts causing a "permanent" meter deflection. R_{34} is to prevent diode "clipping" on playback when a large voltage may appear across the 10-MΩ resistor, R_{20} and cause current to flow between the grid and cathode of the second triode half of V_5 and thus through the 12kΩ resistor R_{22} to earth. R_{20} and C_{15} form the diode load and their values are chosen to have a fairly large time constant, so that the meter needle will "hang" on even the most transient peaks. The second triode half of V_5 is backed off to zero anode current (at the no input condition) by the potentiometer chain R_{22}, R_{23}.

By adjusting the setting of R_{33}, the peak recording level, the setting of which will be described later may be made to correspond to any convenient deflection or marked point on the meter scale.

Fig. 5. Level-monitoring valve voltmeter. Fixed resistors are all ½-watt.



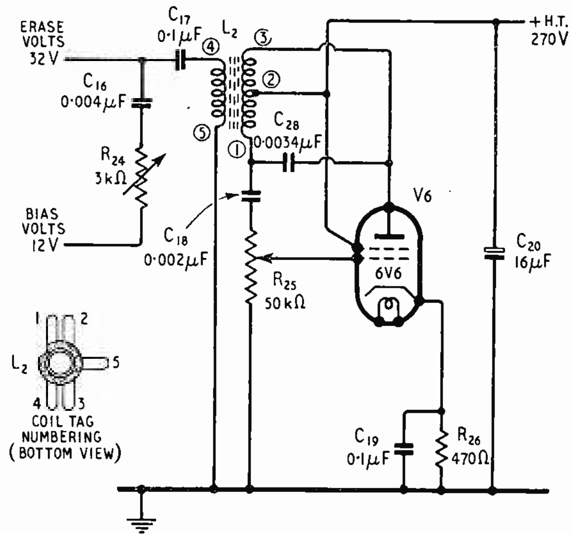


Fig. 6. Bias oscillator circuit. R_{26} should be rated at 1 watt. Tag markings for L_2 relate to the Wright and Weaire Type 579 coil.

Turning now to the oscillator section, there are several requirements to be met. If the frequency response is to extend to 10 or 12 kc/s, the bias frequency should be at least five times this, to avoid the production of whistles due to possible harmonic interference from the audio signal. The waveform of the bias should be pure, to prevent a noisy background appearing on the recording, second harmonic distortion being especially bad in this respect. The grid drive, and, if possible, the anode current waveform of the oscillator valve also should be free from distortion, to prevent the radiation of high-order harmonics which, though small, may be of comparable magnitude to radio signals and cause undesirable whistles when recording these. Finally, it must be arranged that the bias will "die" slowly when the oscillator is switched off, as otherwise a sudden break will often result in a "polarized" head and consequent noisy background to recording and playback.

When correctly set up, the oscillator circuit shown in Fig. 6 conforms to these requirements and has proved satisfactory and reliable in practice. It uses a coil with a movable dust core, so that if, in spite of all precautions, an interference whistle is produced between the oscillator and a radio signal being recorded, it may be used to tune out the offending beat-frequency note.

By means of the potentiometer R_{25} the grid drive volts should be made the maximum possible without distortion becoming evident when the waveform is viewed on a cathode ray tube, this being done, of course, with the normal load connected. The h.t. is supplied across C_{20}, which is a 16-μF electrolytic, and is switched beyond this so that the capacitor acts as a reservoir and ensures that a slow dying of the oscillations takes place. C_{17} is intended to prevent any hum getting through from the oscillator to the record and erase heads, and C_{16} is to prevent any shunting action of the oscillator output circuit on the signal winding, by reflection through the head.

(*To be concluded*)

LETTERS TO THE EDITOR

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

Broadcast Transmitter Distortion

IN reply to a complaint regarding severe distortion manifesting itself as a transient "rattle" heard throughout a large number of broadcasts in recent months, I have been informed by the B.B.C. that "All our domestic service transmitters of 10 kW and over have had compression introduced into the audio chain in order to offset the interference from foreign stations. This means that the transmitter will peak to 100 per cent modulation more frequently than is usual in a broadcasting system, and distortion, particularly on transients, is bound to occur."

I imagine that no high-power transmitter can handle such high modulation under *any* conditions without considerable distortion being introduced, and when to this is added the product of a.f. compression, the result is intolerable.

In recent years a greater number of people than ever before have given their efforts to designing, and their money to purchasing, receivers capable of giving a really high quality of reproduction from broadcast transmissions; their intentions are stultified when violent rattles are radiated by the transmitter, while the result of the "average" commercial receiver trying to cope with high modulation levels needs no description!

Automatic compression has been spurned in good recording practice for some time on account of its essential accompaniment of distortion, and it would seem that the B.B.C. is compromising too much with quality in return for a but fractional gain in signal-to-noise ratio. Surely equivalent results could be obtained by manual monitoring, the quietest passages being boosted. This would not seem to require excessive trouble on the part of the producer, and would entirely avoid the severe disadvantages of the present method.

The B.B.C. should not forget that some of its listeners are able to receive its transmissions under reasonable conditions—and, anyway, I can assure them that, other things being equal, a clear and undistorted signal sounds better "through" background mush than a muzzy one.

London, N.10. IAN LESLIE.

"Geared to Greenwich"

IN the March issue of *Wireless World* there are several references to the MSF standard frequency transmissions, including an editorial comment in which some disappointment is expressed that the 24-hour transmissions planned for the future will not be modulated continuously by 1-c/s impulses. Although no official announcement has yet been made about the revised programme I can say that the information you give is substantially correct, and I hope this letter will explain why it is not proposed to transmit pulses continuously, and will also clear up one or two misunderstandings that appear to exist.

The transmissions form part of an internationally co-ordinated experiment designed to discover the best means of securing world-wide reception at a useful level of a standard frequency. Although frequency standardization is the primary object, as much useful information as possible is added in the form of various modulation frequencies. The programme of modulation could be changed to meet new requirements, and any suggested alternatives will be considered in relation to other, and possibly conflicting, requirements, and to other services of standard frequency transmissions. It will be appreciated that compromise solutions may have to be adopted.

It is stated in the editorial comment that the continuous transmission of 1-c/s impulses would make practicable a truly radio-driven clock for anyone who cared to set up a radio receiver; but this is an over-simplification of the problem. The carrier frequencies available are, of course, allocated by international agreement and although for this country a lower frequency would be more suitable, the difficulties of securing such a channel will be well understood. It is hoped that ultimately at least one of the available frequencies from one or other of the transmitting stations will be well received at any time of the day; but it is expected that automatic selection of the frequency giving the strongest signal would have to be used. Until the service has reached this stage and until it is decided that the rather complicated reception and control equipment is economically reasonable for application to pendulum clocks, there is no advantage in transmitting the pulses continuously and thereby making the service less suitable for other purposes.

The statements made about the service in the article "Time and Telearchics" are also somewhat misleading. The transmissions are the responsibility of, and are monitored by, the National Physical Laboratory, although the very high standard of performance that has been achieved depends on the close co-operation of the Post Office and the Royal Observatory. The 1-c/s impulses are obtained directly from the quartz standard controlling the carrier waves and the accuracy of time interval is, therefore, the same as that of frequency. The impulses are not independently phased except on rare occasions when on the first day of the month adjustments of 50 ms or 100 ms are made to bring the actual time of transmission nearer to uniform time. During the last year it has not been necessary to make any adjustments. This uniform time is not quite the same as astronomical time but has the effect of a small periodic variation in the rotation of the earth removed. The discrepancy between the time of the impulses and astronomical time may therefore approach 100 ms. In order that there should be only one value of absolute time in use throughout the country the results given for MSF in *Wireless Engineer* include the time-difference between the 1-c/s impulses and the Rugby, GBR, time signals.

National Physical Laboratory, Teddington. R. S. J. SPILSBURY.

"Magnetic Powder Cores"

THE excellent article by Champion and Wilkins in your February issue was very interesting although, to me, a little disappointing in one respect.

I was hoping to find some reference to a very important effect which I observed during investigation into the reason for the rejection of too high a percentage of small powder-core r.f. transformers. I refer to the change in the permeability of the core through shock. An effect which does not seem to have been treated anywhere, although it must have been noticed by others.

In the investigation referred to all the usual factors were carefully eliminated; i.e., the accuracy of test gear, testing personnel, manufacturing tolerances and materials. Then a "passed" specimen of a completed transformer was taken straight from test, re-tested and found to be well within the tolerance figures. The main parameter was the primary inductance. The transformer was then subjected to a sharp shock by the simple expedient of dropping it three feet on to a concrete floor. A re-check showed that the inductance had increased sufficient to take it outside the tolerance limits. Other specimens were then given a sharp tap on the core with a hammer with a similar result.

It was first thought the change was due to a variation taking place in the air gap (the moulded cores were E's and I's) so it was decided to measure the permeability of the E's alone, and in nearly every case there was a *rise* in the permeability as a result of the E being struck with a hammer.

In these days when apparatus is being subjected to more shocks than ever before, especially in guided missiles where acceleration of the order of several times *g* are not unusual, it might be revealing to have a more thorough investigation of the subject than was possible during the pressure of wartime production.

It is assumed that the change is brought about by re-orientation of the magnetic particles in the core material by being shock-excited in the earth's magnetic field. But it may not be.

Cambridge. C. H. BROAD.

Resistor Colour Code

SOME time ago "Diallist" called attention to the risk of errors in the interpretation of the colour code for resistors, now laid down in BS1852 : 1952. Even the four-ring or "Group-Captain" display is not foolproof, as he showed; but the "tip" method, which is allowed as an alternative, seems to leave considerable scope for ambiguity.

For example, quite a likely value for a resistor is 12 kΩ. The appropriate code is a brown body, red tip, and orange spot or ring. But what about the tolerance, indicated by the colour of the other tip? If the colour is regarded as "none" then the tolerance would be taken as ±20%, but if regarded as brown it would be assumed to be ±1%—a significant difference. Meanwhile, someone looking at the resistor from the other side would see it as brown-brown-orange-red, meaning 11 kΩ ±2%!

It is all very well for BS1852 : 1952 to say "The positions of the coloured markings shall be such that no ambiguity can arise in their interpretation"; an officially approved system ought to be inherently unambiguous.

Bromley, Kent. M. G. SCROGGIE.

More Interference

VERY shortly there will be installed all over the country thousands of flashing illuminated beacons on zebra crossings. In addition, the Minister of Transport is reported to be about to permit flashing direction indicators on cars.

It is understood that the beacons will be fitted with suppressors to prevent interference with radio and television reception; but when it is realized that the beacon flashers will have to operate continuously day and night at the phenomenal rate of 57,600 times per day, one can only hope that the suppressors will be effective when the flasher contacts have become pitted, as they inevitably must under such arduous conditions of service.

It would appear essential for arrangements to be made to service these devices frequently, not only to ensure that they are flashing properly, but to check that they are not causing interference due to deterioration of contacts.

The problem will be intensified if the Ministry of Transport permits flashing car indicators. These will also require efficient interference suppressors, but it is difficult to see how the requirement can be enforced. It is to be hoped therefore, that the Minister will not give his blessing to so doubtful an innovation.

Uppermill, Lancs. JOHN BAGGS.

"Flywheel Synchronization"

I WAS very interested to read B. T. Gilling's article in the March issue. One important advantage of the balanced circuit such as he has described is the neutralization of impulsive-type interference due to equal conduction of each diode across a common load impedance. In this way the circuit becomes almost immune to the magnitude of the interfering signal and only responsive to its phase relationship with the required synchronizing pulse. This is an advantage not shared with the many, often complex, circuits, previously described in several American journals.

There are, however, a few points of comment and question that I should like to raise, if I may, in connection with the operation of the circuit described.

The first is one of terminology and concerns the use of the expression "frequency discriminator" used throughout the article. Surely the arrangement involved is that of a phase discriminator, its purpose being constantly to compare the phase of the incoming synchronizing pulses with that of a wave-form derived from the line scanning circuit and to provide a potential difference between two terminals whose magnitude is directly proportional to this difference in phase? This idea of phase discrimination is borne out by the fact that the control voltage generated by the discriminator can only vary to a positive or negative maximum over a phase angle, dependent on the duration of the line flyback period (as we do not wish the synchronizing blanking to occur during the scan period). This will be of the order $\pm\frac{\pi}{10}$ radians for a 405-line system.

I observe from the waveforms shown in Figs. 3 and 4 (which, incidentally, do not agree, the former showing a negative going sawtooth, whilst the latter has a positive going slope), that the waveform at the anode of the line output valve is shown as a sawtooth of potential. In a line time-base designed for magnetic deflection, such as in the *Wireless World* receiver, the anode load of the output valve is predominantly inductive. As a consequence, if a sawtooth of current is required in the load impedance the waveform of potential appearing across it will be a pulse wave having a mark/space ratio of roughly 1:10. In point of fact, due to resistance and transformer core losses, the waveform will have a very small sawtooth component, but of an amplitude considerably smaller than that of the positive pulse[1]. In order to compare the phase of this pulse waveform with that of the incoming synchronizing pulses it is necessary to convert the former into a sawtooth waveform. This may be achieved by coupling the line output circuit with the discriminator *via* a CR integrating circuit whose time constant is made large with respect to the pulse repetition frequency[2]. This circuit has been included in Fig. 5, and indeed is commented upon, where the need to maintain this time constant at a large enough value to ensure sufficient integration is stressed by keeping R10 at a high value.

Finally, from the operation of the discriminator shown in Fig. 3, it will be seen that when the phase discrepancy has zero value (3b) then the commencement of the line flyback period occurs slightly before the arrival of the leading edge of the synchronizing pulse. The amount of this delay is dependent on the width of the line synchronizing pulse and more particularly on the period of time required by the line time-base circuit to complete the flyback (assuming no phase shift in the synchronizing separation circuit.

Should this delay prove excessive then a portion of the picture on the right-hand side of the screen will be lost and provide brightness modulation to the cathode ray tube for the first part of the flyback period; i.e., a "fold-over" effect will be observed.

A method for the correction of this phase error has been described by Wendt and Fredendall[3] and involves delaying the integrated pulse waveform from the line output circuit, by an appropriate amount to ensure a portion of the blanking period appearing on the right-hand side of the picture.

Coventry. K. G. BEAUCHAMP.

[1] "Scanning and E.H.T. Circuits for Wide-angle Picture Tubes," by Emlyn Jones. *Journal Brit. I.R.E.*, January, 1952.
[2] "Automatic Frequency Phase Control of Television Sweep Circuits," by E. L. Clark. *Proc. I.R.E.*, May, 1949.
[3] "Automatic Frequency and Phase Control of Synchronization in Television Receivers," by Wendt and Fredendall. *Proc. I.R.E.*, January, 1943.

WORLD OF WIRELESS

Extending Television Service • Production and Export Figures • New SOS Frequency

Brighton "Booster"

THE TEMPORARY low-power television booster to be installed near Brighton to improve reception in the coastal area between Brighton and Worthing will be in operation before the Coronation.

The transmitter which will operate in channel 3, eventually to be used by the permanent station at Rowridge in the Isle of Wight (56.75 Mc/s vision and 53.25 Mc/s sound), will be set up on Truleigh Hill, 3½ miles north of Kingston-upon-Sea. The temporary station will employ vertical polarization and use the asymmetric side-band method of transmission, as will the permanent Isle of Wight station.

A design for a converter, which will enable sets at present tuned to Alexandra Palace to receive the booster station and eventually the Isle of Wight transmitter, will be given in our next issue. Viewers in the area who receive a satisfactory signal from Alexandra Palace need not, of course, make any change.

News in Morse

A REVISED SCHEDULE of the London Press Service transmissions of news in Morse having been introduced at the beginning of March, we tabulate below a summary of the details. In addition to the bulletins listed, which are transmitted at 20-27 w.p.m. by the Post Office stations, there are a number of Hellschreiber transmissions.

G.M.T.	Call	Freq. (kc/s)	Area
0030–0230 *M*	GIR	5,715	1
	GDI	7,780	2
0130–0300 *w*	GKU4	4,025	3
	GPE26	6,977.5	4
0130–0300 *d*	GPT28	8,192.5	5
1315–1415 *w*	GDZ	13,910	8
1600–1700 *M,Sa*	GAY29	9,332.5	7
	GDT29	9,310	6
1700–1800 *w*	GAY29	9,332.5	7
1715–1815 *w*	GAH	8,065	6
1815–1930 *d*	GIJ	6,985	7
	GAH	8,065	6
1845–1945 *w*	GDG	6,912	3
	GAY29	9,332.5	4
1945–2215 *w*	GBD2	5,885	7
	GAD6	7,355	6
2000–2115 *M,F*	GIH	10,650	2
2015–2100 *M,Sa*	GPT	9,270	5
2045–2200 *S*	GBD2	5,885	7
	GAD6	7,355	6
2100–2200 *w*	GPT	9,270	5
2115–2215 *w*	GIH	10,650	2
2230–2300 *M-F*	GDI	7,780	2
2245–0230 *w*	GIR	5,715	1
2300–0030 *S*	GPT	9,270	5
2300–0230 *w*	GDI	7,780	2

d, daily; *w*, weekdays; *S*, Sunday; *M*, Monday; *F*, Friday; *Sa*, Saturday.

The numeral in the fourth column of the table indicates the area to which the transmission is beamed: 1, N. America; 2, S. America; 3, distant Europe; 4, Middle East; 5, Africa; 6, N. E. Asia, Australia and New Zealand; 7, S.E. Asia; 8, China.

These transmissions are not intended for reception in this country, but there is no restriction on the use outside the U.K. of the material broadcast.

Two Million Viewers

THE LARGEST INCREASE in any month (110,617) brought the number of television licences in force in the U.K. at the end of January to 2,003,449. The total number of broadcast receiving licences (both sound and vision) on January 31st was 12,868,183.

The total includes 179,544 licences for car radio sets. Incidentally, under a new Road Vehicles Regulation, which came into force at the beginning of March, motorists are being asked when applying for vehicle licences whether car radio is fitted.

T.A.C. Sub-Committee

THOUGH obtained from an official source, the list of members of the technical sub-committee of the Television Advisory Committee, as published in our last issue, proves to have been inaccurate. The corrected list is: Dr. W. G. Radley (engineer-in-chief, G.P.O.; chairman), H. Bishop (B.B.C.), H. Faulkner (G.P.O), R. T. B. Wynn (B.B.C.), Dr. R. L. Smith-Rose (D.S.I.R.), Professor Willis Jackson (Imperial College), G. E. Condliffe (E.M.I.), B. J. Edwards (Pye) and K. I. Jones (Cossor).

Distress Frequency

A WORLD-WIDE radio-telephony maritime distress and general calling frequency of 2,182 kc/s will be introduced on May 1st in place of the present 1,650 kc/s used in the European region.

This is in compliance with the maritime mobile frequency plans drawn up at the Extraordinary Administrative Radio Conference in Geneva in 1951, which provides for all maritime mobile stations to operate within the band 1,605-2,850 kc/s. The introduction of the plan will also necessitate a change of frequency for coast stations, and it is hoped to publish a list of British stations next month.

Set Production

TELEVISION RECEIVERS became a significant factor in the British radio export figures for the first time last year, when 6,000 were sold overseas. Production of television sets rose by 14 per cent during the year and the sale of receivers in the United Kingdom reached 782,000.

The production of domestic broadcast receivers and radio gramophones fell by 41 per cent (compared with 1951) to 1,228,000. Home sales accounted for 789,000 and export sales for 523,000.

These figures were given at the annual general meeting of the British Radio Equipment Manufacturers' Association by P. H. Spagnoletti, who was re-elected chairman.

Exporting Television

TRANSMITTING equipment, as well as receivers, for television is now a "significant" British export.

Marconi's, who have already supplied mobile and studio equipment for the first two television stations in Canada (Toronto and Montreal), are to install 5-kW vision and 3-kW sound transmitters in Ottawa. The equipment is to be installed temporarily in the building housing the existing medium-wave transmitter in time for viewers to see telefilms of the Coronation. Initially, it will use a single-stack aerial, but when erected on the permanent site it will employ a 12-stack array, which, it is claimed, will increase the radiated power to about 55kW.

Pye's are to supply complete equipment for two studios for the Belgian television service operated by the Institut National Belge de Radiodiffusion. The Belgian service is planned to operate on both 819 and 625 lines and an outstanding feature of the Pye equipment is that by a simple switch the necessary changeover can be made.

Television Costs

THE CAPITAL COST of each of the five permanent low-powered television stations scheduled for Plymouth, Isle of Wight, Pontop Pike, Belfast and Aberdeen, was given by the Assistant Postmaster-General as of the order of £150,000-£200,000. In reply to a further question in the House he stated that the booster station at Brighton, which was "sanctioned as an experimental station and is being constructed as such," would cost under £10,000.

The G.P.O. link between London and the Isle of Wight, which will probably be by cable, is estimated to cost about £125,000, while the radio relays linking Plymouth with Wenvoe and Aberdeen with Kirk o'Shotts will each cost approximately £200,000.

Figures were not given for the link to Pontop Pike—it is, of course, on the existing radio chain between Manchester and Kirk o'Shotts. The temporary Belfast station will rely on direct radio reception of the Kirk o'Shotts transmitter for rebroadcasting; the permanent link between Northern Ireland and the mainland has not yet been approved.

The Assistant P.M.G. stated it was estimated it would take approximately two years to construct each of the five permanent low-powered stations from the time resources are made fully available. Since that statement was made, the B.B.C. has ordered from Marconi's the 5-kW vision and 2-kW sound transmitters for three of the stations.

Licensing Set Manufacturers

NEW PATENT LICENCES are now available to manufacturers of receivers from the Broadcast Licensing Pool (F. C. Topham, Marconi House, Strand, London, W.C.2).

The Grantors who contribute their present and future patents for the period December 1st, 1953, to December 31st, 1957, are: B.T-H., Cintel, E.M.I., G.E.C., Marconi's W.T., Murphy, Philips, Pye and Standard Telephones.

The two licences which will be issued are:—

Licence A7-T, which will relate to broadcast television receivers and all combined instruments incorporating television receivers. The basic royalty on television receivers will be 3 per cent of the manufacturer's net turnover in such apparatus, with, however, a reduction in the cases of combined instruments and export.

Licence A7-S, which will relate to broadcast sound-only receivers and radio-gramophones. The royalty proposed for the present is 0.5 per cent of the net turnover, with a reduction for export.

PERSONALITIES

H. L. Haslegrave, M.A., Ph.D., M.Sc.(Eng.), M.I.E.E., at present principal of the Leicester College of Technology, has been appointed principal of Loughborough Institute of Technology. Dr. Haslegrave, who was from 1938-1943 head of St. Helen's Municipal Technical College, will be the first principal of the Loughborough I.T., which was the title given to the Engineering and Science Departments of Loughborough College when they were recently reorganized by the Ministry of Education as a separate establishment.

Guy R. Fountain, chairman of the Tannoy group of companies, who is on a two-months' tour of America and the West Indies, will also visit Canada, where he plans the formation of a Canadian Tannoy company.

Robert Telford, B.A., A.M.I.E.E., has been appointed to the new post of general works manager of Marconi's Wireless Telegraph Co. He graduated at Cambridge in 1937 and the same year joined Marconi's. Two years later he became assistant to the works manager. For four years from 1946 Mr. Telford was managing director of the subsidiary Companhia Marconi Brasileira in Rio de Janeiro and in 1950 became assistant to the general manager at Chelmsford.

C. G. White, director and general manager of the Marine Division of Kelvin & Hughes, Ltd., has been re-elected vice-chairman of the R.C.E.E.A.

L. W. D. Sharp, M.A. (Cantab), A.M.I.E.E., who joined the Plessey Company in 1948, has been appointed chief engineer, Components Division. For the past two years he has been chief radio engineer, Telecommunications Division, engaged in the development of mobile radio equipment. Prior to joining Plessey's, Mr. Sharp was with E. K. Cole, Ltd., where he was for some time responsible for the development of car radio equipment.

(Left)
ROBERT TELFORD

(Right)
L. W. D. SHARP

J. P. Wykes, A.M.I.E.E., who joined the Marconi Marine Company as a sea-going wireless operator in 1918, will continue as works manager of the Marconi Works at Chelmsford. During the war he was manager of the crystal manufacturing department and in 1946 became chief of the Test Division.

E. B. Greenwood, A.M.I.E.E., has been appointed works manager of Marconi's factory now being built at Basildon New Town, Essex. A graduate of Leeds University, he held appointments with Murphy Radio, Ltd., and E. K. Cole, Ltd., before joining the Marconi Company in 1951.

Dr. Vladimir K. Zworykin's "outstanding contribution to the concept and design of electronic components and systems" was cited by the American I.E.E. in awarding him the 1952 Edison Medal. Now vice-president and technical consultant of the R.C.A. Laboratories at Princeton, N.J., he has been associated with R.C.A. since 1929 and was a pioneer in the development of "all-electronic" television, inventing the iconoscope in 1923. Dr. Zworykin, who was born in Moscow in 1899, has been domiciled in the U.S.A. since 1920.

William Davies, M.B.E., who was the first official sea-going wireless operator having joined the Marconi Marine Company in 1902, has been awarded the Marconi Memorial Medal of Service by the Veteran Wireless Operators' Association of America.

T. E. Goldup, M.I.E.E., has been elected chairman of the Radio Communication & Electronic Engineering Association for 1953 in succession to K. S. Davies. Mr. Goldup, who is a director of Mullard, Ltd., which he joined in 1923, is a vice-president of the Institution of Electrical Engineers and chairman of the governors of the Ministry of Supply School of Electronics, Malvern.

Leslie Cooper, G5LC, the new president of the Radio Society of Great Britain (see last issue), is works manager of the Phœnix Telephone and Electric Works, Ltd., manufacturers of telecommunications equipment, and of its associate companies which include Correx Communication (1949), Ltd.

OUR AUTHORS

T. C. Macnamara, contributor of the article in this issue on the use of electronics in film making, has been technical director of High-Definition Films, Ltd., since it was formed in 1951 to develop the use of electronic apparatus in the film industry. From 1923 to 1950 he was with the B.B.C. and was largely concerned with the establishing of such transmitting stations as Droitwich, Ottringham and Alexandra Palace. During his last three years with the Corporation he was head of the Planning and Installation Department. On leaving the B.B.C. he joined Scophony-Baird, from which he resigned a year ago to devote himself exclusively to development work with High-Definition Films, Ltd.

P. J. Harvey, who contributes the article on television booster stations in this issue, graduated B.Sc., A.C.G.I., in 1941 and from 1942-47 served as signals officer in the R.A.F. He subsequently joined E. K. Cole, Ltd., specializing in the development of communication equipment and was largely responsible for the design of the prototype television booster referred to in the article.

A. Poliakoff, managing director of Multitone, Ltd. which he joined in 1931 soon after the formation of the company, contributes an article on hearing aids in this issue (p. 182). He studied physics at University College, London, and is a member of the B.S.I. Committee on hearing aids and audiometers.

OBITUARY

It is with regret that we record the death of **John Satchell Smith** on February 21st at the age of 64. Until his retirement in 1950 he was manager, North West Area, for the Marconi International Marine Communication Co., which he joined in 1910. He was at one time Marconi Marine representative in New York.

We record with regret the death of **James H. Webb**, principal of the British School of Telegraphy, where wireless operators have been trained since 1906. During the two world wars radio instruction was given under Mr. Webb's supervision to large numbers of men for the fighting Services. Training of students for the Postmaster-General's certificates is to continue under the present staff of instructors.

IN BRIEF

Dry Batteries have been reduced in price by about 10 per cent. In announcing this in the middle of March, the Association of Radio Battery Manufacturers stated that reductions in the cost of raw materials, notably zinc, have made this possible. A 120-volt battery is now 17s 1d (inc. p.t.) instead of 19s 1d.

Medium-wave Coverage of Germany by the B.B.C. has been improved by the use of the high-power transmitter at Osterloog, near Norden, operated by the Nordwestdeutsche Rundfunk. This transmitter, which is now being used for the B.B.C. European Service instead of the station at Ottringham, Yorks, is radiating on 1,295kc/s (231.7m). The programmes are fed by line from London.

Television Test Transmissions from B.B.C. stations have been extended by an hour each week-day until June 1st. The transmissions during the third hour (1200-1300) consist of Test Card C with 440 c/s tone on the sound channel.

Fortieth Anniversary of the founding of the Radio Society of Great Britain on July 5th, 1913 (then known as the London Wireless Club), is to be celebrated by holding a dinner in London later in the year.

Retailers' Conference.—The first national conference of retailers, organized by the Radio and Television Retailers' Association, will be held at Eastbourne from April 27th to 29th. Particulars of the conference are obtainable from the Secretary, R.T.R.A., 26, Fitzroy Square, London, W.1.

Ferguson.—A series of technical discussions on Ferguson television receivers has been arranged by Thorn Electrical Industries, Ltd. The fourth in the series will be held at the Royal Hotel, Dundee, on April 7th and 8th, and the fifth at the Kensington Hotel, Belfast, on April 8th and 9th. Sessions are from 2.0-5.0 and 7.0-10.0 each day. Admission is by invitation, and those wishing to receive invitations should apply to Ferguson Sales Division, Thorn Electrical Industries, Ltd., 233, Shaftesbury Avenue, London, W.C.2.

Decca Radar was used to check the series of timed runs over the Newbiggin measured mile when heavy mist prevented a visual check of the markers being made during the acceptance trials of the m.s. *Camellia.*

B.R.E.M.A.—The following 12 member-firms forming the executive council of the British Radio Equipment Manufacturers' Association were re-elected at the recent annual general meeting (the representative's name is in brackets): A. J. Balcombe (E. K. Balcombe); Bush Radio (G. Darnley-Smith); E. K. Cole (G. W. Godfrey); A. C. Cossor (H. Roberts); G.E.C. (M. M. Macqueen); Gramophone Co. (F. W. Perks); Kolster-Brandes (P. H. Spagnoletti); McMichael Radio (C. G. Allen); Philips (A. L. Sutherland); Pilot Radio (H. L. Levy); Pye (C. O. Stanley) and Ultra Electric (E. E. Rosen). P. H. Spagnoletti and E. K. Balcombe were re-elected chairman and vice-chairman, respectively.

Communication Theory.—A week's course of lectures on the theory of communication has been organized by D. A. Bell (Reader in Electromagnetism at Birmingham University) from July 20th-25th at the Centre for Continued Studies, Primrose Hill, Selly Oak, Birmingham, 29. A syllabus of the course, for which the fee is £3, excluding meals and accommodation, is obtainable from the director of Extra-Mural Studies, The University, Birmingham, 3.

EXHIBITION NEWS

American Buyers are chartering a plane to bring them to this country for the R.E.C.M.F. exhibition which opens at Grosvenor House, London, W.1, on April 14th. The party is being organized by Leonard Carduner, president of the British Industries Corporation, of New York, in co-operation with W. T. Ash, secretary of R.E.C.M.F. Visits to a number of radio factories, including Garrard, Multicore and G.E.C., are being arranged for overseas visitors to the exhibition.

WHALING BUOY. Lightweight version of Venner's standard radio-transmitting dahn buoy (see Nov. 1952 issue, p. 468) for marking whales after the kill to facilitate recovery by the parent ship. It has a range of 30 miles and radiates for 22 hours.

B.I.F.—For the first time since the war all three sections of the British Industries Fair (normally restricted to trade buyers) will be open to the public every afternoon and all day on Saturday. The fair opens at Castle Bromwich (Birmingham) and at Earls Court and Olympia (London) on April 27th. Each section will be open daily from 9.30 to 6.0 until May 8th.

Electronics Exhibition.—The eighth annual electronics show organized by the North-Western Branch of the Institution of Electronics will be held at the College of Technology, Sackville Street, Manchester, from July 15th to 21st. In addition to the usual commercial section there will be a section devoted to exhibits from research establishments. One portion of the research section will cover the electro-medical applications of electronics. The organizing secretary is W. Birtwistle, 17, Blackwater Street, Rochdale, Lancs.

Navigation.—An exhibition, "Navigation Today," is being held at the Science Museum, South Kensington, London, S.W.7, from March 31st until the middle of September. The navigator's problems and some of the methods and equipment used by mariners and airmen to solve them are being shown.

Radio and Models Show.—The London Radio Group of the Institution of Post Office Electrical Engineers will be holding its second radio and models exhibition in the Metropole Hall, Northumberland Avenue, London, W.C.2, on May 7th, 8th and 9th, from 11.0 to 8.0. Although there will be some commercial exhibits, the emphasis will be on home construction.

PUBLICATIONS

New Audio Journal.—Thirty papers presented at the last annual meeting are printed in the first issue of the *Journal of the Audio Engineering Society*, which appeared in March. There will be four issues in a year, and the subscription rate to non-members is $8.00. The editor is Lewis S. Goodfriend, P.O. Box 12, Old Chelsea Station, New York 11, U.S.A.

"Television Oscilloscope."—A reprint is now available of the articles by W. Tusting on the design of a television oscilloscope using a 5-in cathode-ray tube, which appeared in the June and July, 1952, issues of *Wireless World.* "Television Oscilloscope" is obtainable from our Publishers price 9d (postage 1½d).

Interference Suppression.—A "Code of Practice" in draft form on the general aspects of radio interference suppression has been issued by a joint committee of the I.E.E. and the British Standards Institution. Copies of the code, CO(ELE)6125, which is mainly for the guidance of those installing and using interference-producing devices, may be had from B.S.I., 24, Victoria Street, London, S.W.1, at 2s.

British Standard for synthetic-resin-bonded paper tubes of circular cross-section for use at r.f. has been issued as B.S.1951:1953. The electrical and physical properties covered by the specification include the power factor and permittivity; insulation resistance along laminæ; density; water absorption; cohesive strength between layers and dimensional tolerances. Copies of the Standard are obtainable from the B.S.I., Sales Branch, 24, Victoria Street, London, S.W.1, price 2s 6d.

Our Raw Material.—Each of the 70 domestic, commercial, industrial, farm and miscellaneous tariffs for electricity supplied by the various Area Boards of the British Electricity Authority are given in the "Electricity Tariff Handbook" published by Electrical Review Publications, Ltd., price 7/6.

BUSINESS NOTES

African Broadcasting.—Transmitting and studio equipment for the extension of the broadcasting services in the Colonies has been ordered by the Crown Agents for the Colonies from Marconi's W.T. Co. A 20-kW h.f. transmitter, to supplement the two existing low-power stations, together with four complete studios, is to be installed at Accra, Gold Coast. H.F. transmitters have also been ordered for Lagos (20kW), Enugu (2½kW) and Kaduna (7½kW) in Nigeria; Dar-es-Salaam (20kW) in Tanganyika; and a 7½-kW station for Uganda. Studio and o.b. equipment is to be installed in Nairobi, Kenya.

Large-screen television projectors have been supplied by Cinema-Television, Ltd., to the German cine-equipment manufacturers U.F.A. for installation experimentally in a cinema in Düsseldorf. Standard equipment, which has been or is being installed in eight cinemas in this country, will be used. In this country, of course, it operates on 405 lines and the change to 625 lines (the standard adopted by Germany) can be made "in less than a minute."

Ten Tankers—16,000-ton motor vessels—under construction on the Clyde, Wear and Tyne for the Lowland Tanker Co., are to be equipped with radio communication and navigational gear by the Marconi International Marine Communication Co. Eight new tankers being built for the British Tanker Co., the largest of which is 32,000 tons, are also to be fitted with Marconi radio equipment. The company is also installing communication and navigational gear on the 7,000-ton Norwegian passenger steamer *Leda* on behalf of its associated company Norsk Marconikompani.

Ekco Electronics, Ltd., has been registered as a subsidiary of E. K. Cole, Ltd., for the marketing of the company's electronic equipment.

Telephone number of Marris & Cartin, Ltd., 42, Brook Street, London, W.1, was misquoted in the advertisement on page 139 of our February issue. It should be Grosvenor 5571.

Lancs., not Yorks.—The address of Holiday and Hemmerdinger, Ltd., was incorrectly given as Leeds, instead of Manchester, on p. 118 of our March issue.

MEETINGS

Institution of Electrical Engineers

Radio Section—"Special Effects for Television Studio Productions" by A. M. Spooner, B.Sc.(Eng.), and T. Worswick, M.Sc., on April 9th.

Discussion on "The Relative Merits of Broad-Band Transmission by Beam, Cable and Waveguide," opener: E. C. H. Organ, O.B.E., on April 13th.

"An Investigation of the Characteristics of Cylindrical Surface Waves" by Professor H. M. Barlow, Ph.D., B.Sc. (Eng.), and A. E. Karbowiak; and "Surface Waves" by Professor H. M. Barlow, Ph.D., B.Sc.(Eng.), and A. L. Cullen, Ph.D., B.Sc.(Eng.), on April 22nd.

Measurements Section. — "Digital Computers at Manchester University" by T. Kilburn, M.A., Ph.D., G. C. Tootill, M.A., M.Sc., D. B. G. Edwards, M.Sc., and B. W. Pollard, M.A.; "The Construction and Operation of the Manchester University Computer" by B. W. Pollard, M.A., and K. Lonsdale, B.Sc. Tech.; "Universal High-Speed Digital Computers: A Decimal Storage System" by T. Kilburn, M.A., Ph.D., and G. Ord, M.Sc.; and "Recent Advances in Cathode-Ray Tube Storage" by Professor F. C. Williams, O.B.E., D.Sc., D.Phil., F.R.S., T. Kilburn, M.A, Ph.D., G. N. W. Litting, B.Sc., D. B. G. Edwards, M.Sc., and G. R. Hoffman, B.Sc., on April 14th.

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

North-Western Centre.—"The London-Birmingham Television Cable System" by T. Kilvington, B.Sc.(Eng.), F. J. M. Laver and H. Stanesby, at 6.15 on April 14th at the Engineers' Club, Albert Square, Manchester.

South Midland Centre.—"The Devising of Examination Questions" by Professor G. W. Carter, M.A., at 7.0 on April 9th at the College of Technology, Electrical Engineering Dept., Birmingham.

"Electronic Telephone Exchanges" by T. H. Flowers, M.B.E., B.Sc., at 7.15 on April 21st at the Winter Gardens Restaurant, Great Malvern.

South Midland Radio Group.—The Transmission of Pictures by Radio," by A. W. Cole and J. A. Smale, B.Sc., at 6.0 on April 27th at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Southern Centre.—"Television Broadcasting Stations," by P. A. T. Bevan, B.Sc., at 6.30 on April 22nd at the South Dorset Technical College, Weymouth.

London Students' Section.—Visit to the B.B.C. Monitoring Station, Tatsfield, Surrey, at 2.30 on April 25th.

British Institution of Radio Engineers

London Section.—"Lens Aerials for Centimetric Wavelengths" by Lt.-Col. J. P. A. Martindale, B.A., at 6.30 on April 8th at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Scottish Section.—"The Principle and Applications of the Telescribe" by C. A. Gilbert at 7.0 on April 2nd at the Department of Natural Philosophy, Edinburgh University.

"Remote Control Devices and Servo Mechanisms" by A. E. W. Hibbitt at 7.0 on April 9th at the Institute of Engineers and Shipbuilders, Glasgow.

North-Eastern Section. — Annual General Meeting followed by a demonstration of stereophonic reproduction at 6.0 on April 8th at the Institute of Mining and Mechancial Engineers, Neville Hall, Westgate Road, Newcastle-on-Tyne.

British Sound Recording Association

London.—"Sound Reproduction" by D. T. N. Williamson at 7.0 on April 17th at the Royal Society of Arts, John Adam Street, London, W.C.2.

Manchester Centre.—"Practicalities of Recording" by G. F. Budden (B.B.C.) at 7.30 on April 27th at the Engineers' Club, Albert Square, Manchester.

Institution of Electronics

North-Western Branch.—"Present Technique of Colour Television" by J. A. Darbyshire, M.Sc., Ph.D., F.Inst.P., A.M.I.E.E. (Ferranti, Ltd.), at 7.0 on April 24th in the Reynolds Hall, College of Technology, Manchester.

Institute of Physics

Symposium on "Practical and Theoretical Aspects of Ultrasonic Testing" at 6.30 on April 17th at 47, Belgrave Square, London, S.W.1.

Institute of Navigation

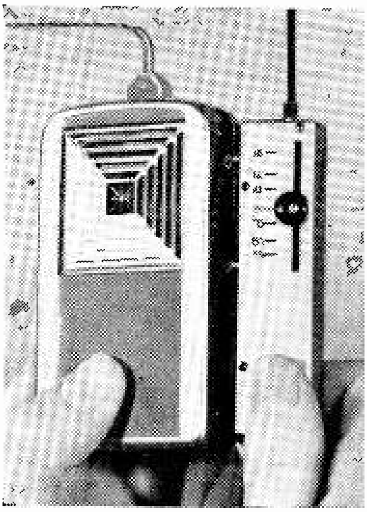
"The Use of Radar for Preventing Collisions at Sea" by Capt. F. J. Wylie, R.N. (Ret.), at 5.0 on April 17th at the Royal Geographical Society, 1, Kensington Gore, London, S.W.7.

RADIO UNIT FOR HEARING AIDS

MENTION WAS MADE in our March issue of a home-made detector unit for converting a hearing aid into a broadcast receiver. We now learn that a unit for this purpose is manufactured commercially by Acousticon, and that the hearing aids made by that firm are now fitted with sockets for connection of the adaptor.

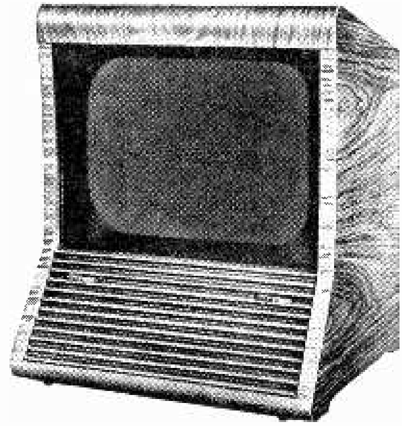
The "Radion" unit, as it is called, comprises a B.T.H. germanium diode and a coil with dust-iron core, adjustment of which provides tuning control over the range 550-1,500 kc/s. A short length of flexible wire plugged into the unit serves as an aerial at very short ranges. For greater signal pick-up, either a "random" or normal full-length aerial may be connected.

Though the tuner is only single-circuit, selectivity is greater than that of the old-fashioned crystal set, and is sufficient for all except the least favourable conditions.



Vision A.G.C.

Stabilizing the Picture Against Signal Fading and Aeroplane "Flutter"



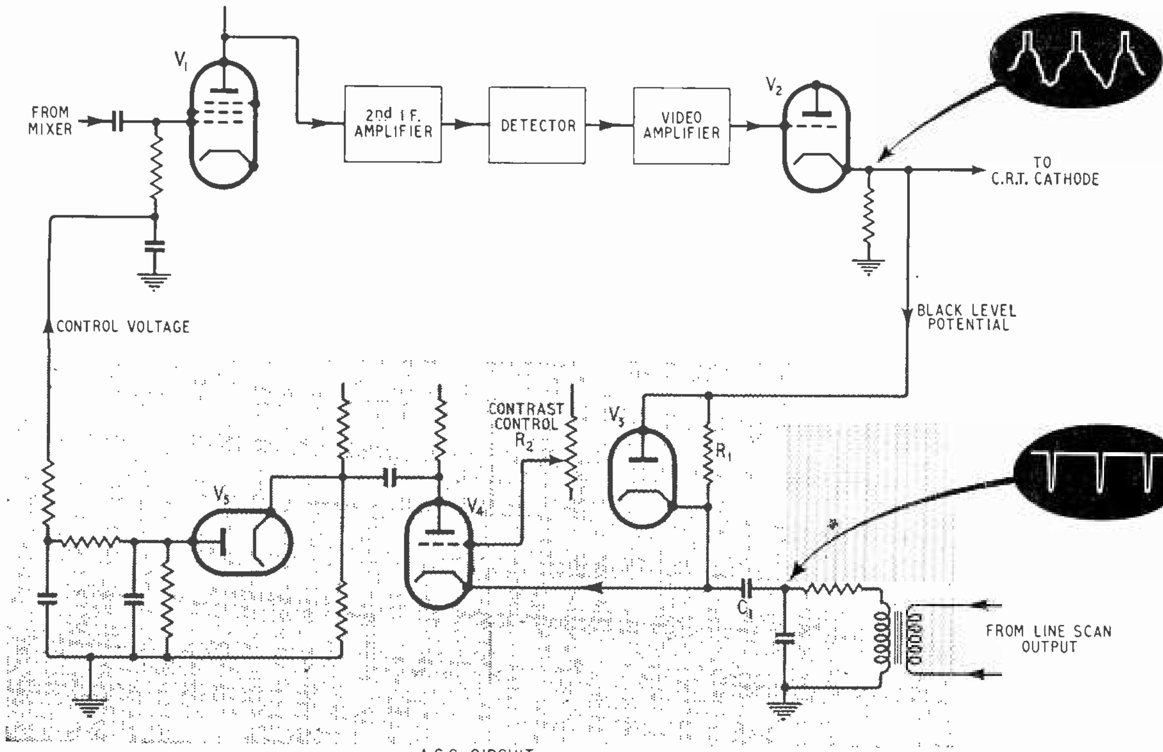
The Pye model V4 receiver incorporating vision a.g.c. It has flywheel sync and an inverter for suppressing interference pulses. Both the 14-in c.r. tube screen and the implosion guard are tinted, and the screen is tilted to face downwards away from the room lighting. The set has continuous tuning covering all the B.B.C. television stations.

THE problem of applying automatic gain control to the vision channel of a television receiver is not quite as simple as it may seem at first. Obviously the broad principle is the same as in a sound broadcast receiver —just negative feedback—but the difficulty comes in presenting the a.g.c. circuit with the right kind of information on which to work.

The main trouble lies in the peculiar nature of the television signal. In sound broadcasting the mean value of the carrier wave remains the same whatever the modulation. It only varies with the signal strength, so the a.g.c. circuit can use it for deriving its control voltage. But in television the mean value of the carrier wave is changing continually with the nature of the picture, so it never gives a really true indication of the signal strength. It can be used to give some measure of a.g.c., which is a good deal better than none at all, and in the October, 1952, issue G. Johnson described a simple type of circuit working on this principle. As this was, in effect, a negative feedback system stabilizing the mean value of the signal, it tended to keep the average brightness of the picture constant; consequently the contrast and black level were not always maintained as they should be.

There is, however, one part of the television signal which does give a true indication of the signal strength, and that is the black level, represented in the waveform by the so-called "back porch" following each line sync pulse. To make use of this it would

Fig. 1. Simplified circuit diagram showing the a.g.c. chain and how it is connected into the receiver circuit.



be necessary for the a.g.c. circuit to sample the signal at the correct instants and use these black-level samples to produce the control voltage. In adjusting the gain of the receiver to give correct contrast, its effect would be to maintain constant not the mean brightness of the picture, but the black level, which, of course, is just what is wanted.

This scheme has now actually been introduced into a commercial receiver, the Pye model V4, under the name of "automatic picture control." It does not, as one might suppose from this title, endow the set with any powers of æsthetic discrimination, but it will maintain constant the brilliance and contrast of the pictures, whatever they may be, against signal variations of up to 40db. This 40db represents the total range, so how the system behaves depends on where the mean signal voltage lies between the absolute upper and lower limits. If it comes in the middle, the picture will be stabilized with signal variations of up to ±20db; if it is a lower voltage the signal can increase more than 20db; if it is higher the signal can decrease more than 20db.

No doubt the system will be of most value in fringe areas, where fading is more troublesome, but it is also quite effective against the "flutter" caused by passing aircraft, which can be bad in any area. It is sufficiently quick-acting to counteract this flutter up to a frequency of about 50 c/s, and anything above this is not perceptible to the eye anyway.

For the purpose of sampling the black level of the signal, a large pulse is derived from the flyback of the line scan waveform. This is done by means of a small pulse transformer, as shown in Fig. 1, fed from a winding on the line scan output transformer. Since the pulse comes from the flyback it occurs at the same time as the line sync pulse in the received signal, so it has to be delayed a few microseconds to make it coincide with the back porch following the sync pulse. The delaying is done by the RC network connected to the transformer secondary.

This sampling pulse, which is negative-going, passes through C_1 to the cathode of the diode V_3 and causes it to conduct. As a result the diode acts as an electronic switch and connects the video output of the cathode follower, V_2, to the cathode of V_4 during the black level period. The video output signal is inverted (the sync pulses being positive with respect to the picture) so the situation that occurs can be depicted as in Fig. 2. The sampling pulses coming through C_1 are d.c. restored by V_3 to the d.c. value of the black level in the video output waveform. In other words, what would normally be negative peaks in an a.c. waveform are now held at an absolute positive potential of about 100V. And, of course, when

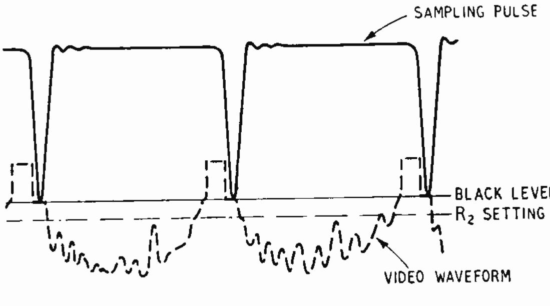


Fig. 2. Showing how the sampling pulses are d.c. restored to the black level potential of the inverted video waveform from the cathode follower.

the black level potential fluctuates with changes in signal strength the sampling pulses ride up and down with it.

Thus the absolute positive potential of the sampling pulse peaks now becomes a true indication of the signal strength, and the pulses can be used to produce a proportional negative bias voltage for controlling the gain of the receiver. They are actually rectified by the diode V_5 and smoothed by the associated RC network, the resultant bias voltage being applied to the grid of the first i.f. amplifier, V_1, as shown.

Before this happens, however, the pulses are amplified in V_4. The cathode of this valve therefore receives a series of negative pulses d.c. restored to a positive potential representing the black level—in other words it receives a positive potential with troughs in it. The grid of V_4 also has a positive voltage applied to it, as bias, by the potentiometer R_2, but this is somewhat lower than the cathode potential so the valve is normally cut off until a pulse comes along and drives the cathode negatively; then current flows in the valve and a corresponding negative pulse appears at the anode. Thus the setting of R_2—represented by the chain line in Fig. 2—determines the input voltage below which the pulse is amplified. In other words it determines the amplitude of the pulse at the anode, hence the value of the negative bias voltage and hence the gain of the i.f. amplifier for a given signal strength. So R_2 acts as a manual gain (or contrast) control quite independently of the automatic gain control.

Thus when the signal strength falls the black level in the video output waveform goes more positive, the sampling pulse is d.c. restored to a higher positive potential, a smaller amount of pulse is amplified by V_4 and the resultant negative bias control voltage is reduced. The gain of the first i.f. stage is thereby increased and the video output restored to its original amplitude. Similarly, if the signal strength rises; the black level positive potential falls, more of the sampling pulse is amplified and the negative control voltage increases so that the gain is reduced.

One valuable feature of the system is that it is not affected by interference pulses which may occur during the black level period. Since the interference pulse will be negative-going on the video output waveform, the diode V_3 acts in its capacity as an electronic switch and cuts off, the time constant of $C_1 R_1$ being too long to allow the cathode to fall to a comparable potential during this brief period. Thus the sampling pulse applied to V_4 is not d.c. restored to the lower positive potential produced by the interference pulse—it remains more or less at the true black level. In other words the system simply "misses a beat" and the resultant negative control voltage is not affected.

Of course, since the object of the system is to keep the picture stable, one is not aware from the screen that anything is happening when the signal strength varies. The effect of the system is very obvious, however, when the V4 receiver is compared with another set which is fed from the same aerial but has no a.g.c. If changes in signal strength are introduced by a variable attenuator in the common aerial lead, the picture on the ordinary set can be varied from a blacked-out condition to a grossly overloaded condition, but the picture on the V4 receiver is not noticeably affected. One is only aware of what is happening by watching the noise level, which, of course, becomes rather more noticeable at the lower signal levels.

VORTEXION TAPE RECORDER

FEATURES WORTH NOTING . . . . . .

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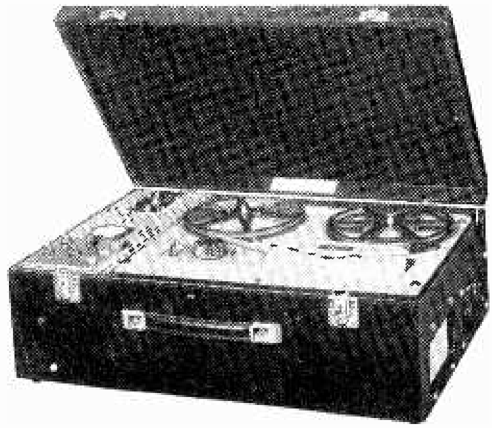

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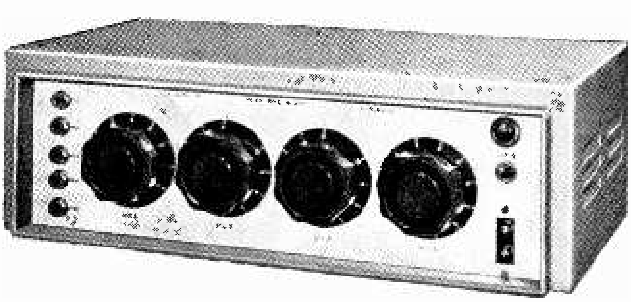

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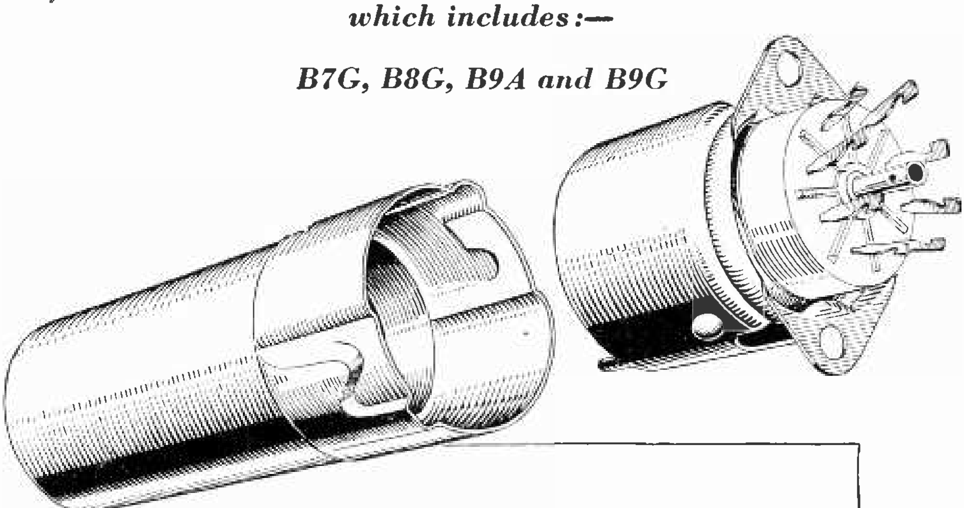

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TRANSISTORS

By THOMAS RODDAM

3—Earthed-emitter and Earthed-collector Circuits as Amplifiers and Oscillators

ANY HISTORICALLY MINDED young engineer might find it interesting to search through the literature to see how long it was before the users of valves tried unusual connections. Terman gives a 1928 reference for what I prefer to call a diminisher circuit, with anode input and grid output, no reference for the cathode follower (would this be about 1936 ?) and 1940 for the earthed grid. All the early progress, in fact, seems to have been made by shouting for better valves. In the transistor circuit field there has been no such delay. The circuit designers have applied themselves from the beginning to a study of almost every conceivable way of connection and interconnection of the transistor electrodes. In the previous article we considered the equivalent circuit for the fundamental earthed-base connection of the transistor. We can, of course, equally well connect either emitter or collector to earth, and in particular we shall often find it useful to apply the input to the base and take the output from the collector in the earthed-emitter circuit. It is necessary, therefore, to make a fairly close examination of the equivalent network which can be used.

The circuit shown in Fig 1(a) is the one discussed in last month's article and is for the earthed-base connection, but the transistor part of it, shown in Fig. 1(b) has no earth connection inherent in the equivalent circuit, so there is no reason why it should not be twisted round. This is quite an important matter, and really deserves to be reached by a much longer and more ponderous discussion. The transistor equivalent network made up of the four resistance elements r_e r_c r_b and r_m is a true equivalent for three-terminal working, not an approximation for special conditions of use like the ordinary valve equivalent.

Of course, it is still an approximation in another sense, because the r's are not constants, but are dependent on the actual currents in the elements of the transistor. We know how to deal with this, though, because we have the same problem with ordinary valve circuits. I suspect that we sometimes exaggerate the importance of the non-linearities when we are being theoretical. Our amplifiers are usually worked in regions where the non-linearity is not more than 5 per cent, which should not be enough to complicate the theory, and circuits in which the non-linearity is used, like multivibrators, are designed on quite a different principle. For sine-wave operation we can say that the network of Fig. 1(b) is a complete and accurate equivalent for the point transistor.

We can immediately apply this equivalent to study the earthed-emitter amplifier shown in Fig. 2.* The basic equations are

$$i_1 (R_G + r_e + r_b) + i_2 r_e = v_G$$

$$i_1 (r_e - r_m) + i_2 (R_L + r_e + r_c - r_m) = v_L$$

In deriving this it must be remembered that the current which appears in the generator $r_m i_e$ is here $-(i_1 + i_2)$. Just as we did at the end of the previous article, we can take $v_L = 0$ or $v_G = 0$ and solve to find the input and output impedances. The results are :

Input impedance

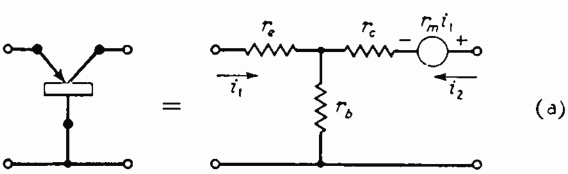
$$R_{11} = r_b + r_e + \frac{r_e (r_m - r_e)}{R_L + r_e + r_c - r_m}$$

Output impedance

$$R_{22} = r_c + r_e - r_m + \frac{r_e (r_m - r_e)}{R_G + r_b + r_e}$$

As before, just as you would expect, the input impedance includes a term in the load, R_L and the

* Based on Fig. 10, p. 376 of "Some Circuit Aspects of the Transistor" by R. M. Ryder and R. J. Kircher, *B.S.T.J.* Vol. XXVIII. July 1949.



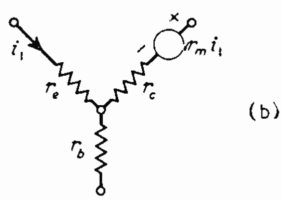
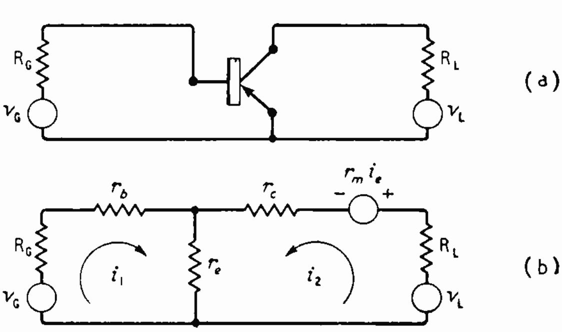


Fig. 1. The equivalent circuit shown in (a) need not necessarily be regarded as an unbalanced four-terminal system. Drawn symmetrically as in (b), the earth can be connected anywhere.

Fig. 2. Earthed-emitter amplifier (a), and its equivalent circuit (b).



output impedance includes a term containing R_G.

The condition for stability is that the total impedance in either the input loop or the output loop should be positive. It does not matter which we take, because, as you can check for yourself, the same answer is obtained. Choosing $R_{22} + R_L > 0$ we have

$$(R_L + r_c + r_e - r_m) + \frac{r_e(r_m - r_e)}{R_G + r_b + r_e} > 0$$

or,

$$(R_L + r_c + r_e - r_m)(R_G + r_b + r_e) + r_e(r_m - r_e) = \Delta > 0$$

If this way of using the transistor is unstable it must be because $(R_L + r_c + r_e - r_m)$ is negative, in the first place, and because the second bracket, the one containing R_G, is too large. This, of course, depends on the known smallness of r_e compared with r_m. Forgetting r_e and r_b wherever possible, the stability depends on

$$(R_L + r_c - r_m) R_G + r_e r_m$$

This very approximate expression shows how a sufficiently large R_L will make the circuit quite safe. Very often we shall find that we are trying to work with $R_L = r_c$ and that r_m is approximately equal to $2r_c$, so that $(R_L + r_c - r_m)$ is zero. Everything is then satisfactory at low levels, but with a large input signal the transistor swings into a region where r_c is reduced and r_m increased. If this happens we may get momentary instability.

We can manipulate our two equations to give the forward power gain $G_F = 4R_GR_L\left(\frac{r_m - r_e}{\Delta}\right)^2$

where Δ is the long expression given earlier, which must be positive for stability.

In this arrangement it is sometimes of interest to use the circuit backwards, with the input applied to the collector and the output taken from the base. The backward power gain can be obtained by manipulating the two basic equations. It is

$$G_R = 4R_GR_L.\left(\frac{r_e}{\Delta}\right)^2$$

Not surprisingly, this way of using the transistor gives more gain than the earthed-base connection. The reason is that, like it or not, you have positive feedback provided by R_G, which is in the base lead. An advantage of this connection, however, is that local negative feedback can be provided by adding resistance in the emitter lead, just like the cathode resistor in an ordinary valve circuit. In many ways, indeed, the problems resemble those of a high-frequency tuned-grid tuned-anode amplifier, but this analogy must not be pushed too far.

The third way of operating the point transistor is with the collector connected to earth. The circuit and its equivalent are shown in Fig. 3† and the equations are

$$i_1(R_G + r_b + r_c) + i_2(r_c - r_m) = v_G$$

$$i_1 r_c + i_2(R_L + r_e + r_c - r_m) = v_L$$

Performing all the algebraic operations as before, we find that for stability we need:

$$(R_G + r_b + r_c)(R_L + r_e + r_c - r_m) + r_c(r_m - r_c) = \Delta > 0$$

The input impedance is

$$R_{11} = r_b + r_c + \frac{r_c(r_m - r_c)}{R_L + r_e + r_c - r_m}$$

and the output impedance

$$R_{22} = r_e + r_c - r_m + \frac{r_c(r_m - r_c)}{R_G + r_b + r_c}$$

The power gain using the base as input and the emitter as output electrode is

$$G_F = 4R_GR_L\left(\frac{-r_c}{\Delta}\right)^2$$

and in the opposite direction

$$G_R = 4R_GR_L\left(\frac{r_m - r_c}{\Delta}\right)^2$$

The power loading at the emitter is usually quite a lot lower than the permitted collector input, and without having made any tests I would expect to find that reasonably low distortion would give a limit around 1 mW for this connection. For an average point transistor there is one very interesting feature of this arrangement: r_m is about twice r_e so that the two gains are roughly equal. This means that it is possible to make an amplifier which can be put in a telephone line and will amplify the signals in both directions. The gain of 6-12 decibels which can be obtained is considered well worth while by telephone engineers, especially as the microphone current is available to supply the amplifier. I expect to see amplifiers of this kind fitted in my telephone some day. The economic value lies in the saving of copper by the use of thinner wires from the telephone subscribers to the exchange.

With this classical background to the transistor, we can turn for the remainder of the article to some oscillator circuits. It is an interesting thing that oscillators represent in some ways the simplest and in other ways the most complicated of the circuit problems with which communication engineers are concerned. To make an oscillator work you need only produce an amplifier with a gain of rather more than

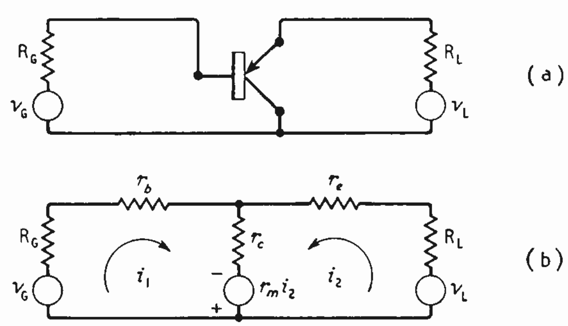
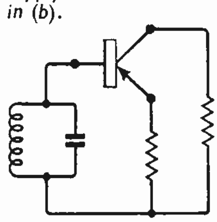
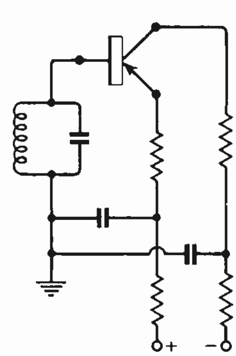


Fig. 3. Earthed-collector amplifier (a) and its equivalent circuit (b).

Fig. 4. This circuit oscillates because the anti-resonant impedance in the base lead supplies positive feedback. The theoretical circuit (a) requires supply connections as shown in (b).





(a) (b)

† Based on Fig. 11, *loc. cit.*

unity, put in a tuned circuit somewhere, and connect input to output. Apart from the necessity to watch that there isn't a 180-degree phase shift, the circuit will oscillate. On the other hand, if you want an oscillator which is not affected by the supply voltages, valves, weather and the cost of living, the design problem is much more complicated, and even "Cathode Ray" has been known to express doubts. Transistors do not make good oscillator circuits, because they are rather lacking in gain, but it is certainly possible to get a stability of one part in a thousand for a wide range of supply voltage.

The special feature of the point transistor which makes some of the oscillator circuits so simple is the possibility of getting a negative resistance by choosing the external resistances properly. Let us take some simple numbers which we can use for calculation purposes. A hypothetical transistor, operating at low currents, might have:

$r_e = 200$ ohms $\quad r_b = 200$ ohms

$r_c = 10{,}000$ ohms $\quad r_m = 30{,}000$ ohms

We might choose to match the output at the collector, and make $R_L = 10{,}000$ ohms. This should give the maximum power from our oscillator. Then if we use the earthed-emitter circuit, the input impedance will be, from the equation given earlier

$$R_{11} = 200 + 200 + \frac{200\,(30{,}000 - 200)}{20{,}200 - 30{,}000}$$

$$\simeq 200 + 200 - 600 = -200 \text{ ohms}$$

This means that if we connect a circuit in the base lead which has an impedance of 200 ohms at one frequency, the system will be unstable. A normal parallel-tuned circuit could be used, with an impedance at the anti-resonance of, say 250 ohms. But if we have a Q of 50, which is not unreasonable for an oscillator frequency determining circuit, the reactance of the coil and the capacitor would have to be only 5 ohms at the working frequency. This means a very small inductance and a relatively enormous capacitance. Fortunately there is an easy way out of the difficulty. Let us put, say, 5,000 ohms in the lead between emitter and earth. This increases the effective value of r_e to 5,200 ohms, and makes the input impedance at the base about − 25,000 ohms. This is just about the right sort of impedance magnitude for conventional tuned circuits of good Q. The circuit shown in Fig. 4(a), using a 100-mH inductance with a Q of 50 at 800 c/s will just oscillate nicely with a good transistor and suitable supplies. The resistance in the emitter lead can be used as a regeneration control. The modifications needed to connect the supplies are shown in Fig. 4(b).

There is an alternative form of this circuit shown in Fig. 5(a), which avoids this use of the emitter resistance by tapping across a small portion of a conventional tank circuit to get the 250-ohm anti-resonant impedance. It would, of course, be at 1/10th of the turns of our 100-mH coil in the example chosen. I prefer, however, to get the impedance-stabilizing effect of the emitter resistance. Another variant is obtained by moving the earth connection, as shown by the two circuits in Figs 5(b) and 5(c). These circuits seem to offer some difficulties in applying the proper bias, and I have not yet tried them.

A modified circuit of the type shown in Fig. 4(a), has been made to oscillate at frequencies up to 300 Mc/s. I have used the word "modified," but the actual modification consisted of the use of a special

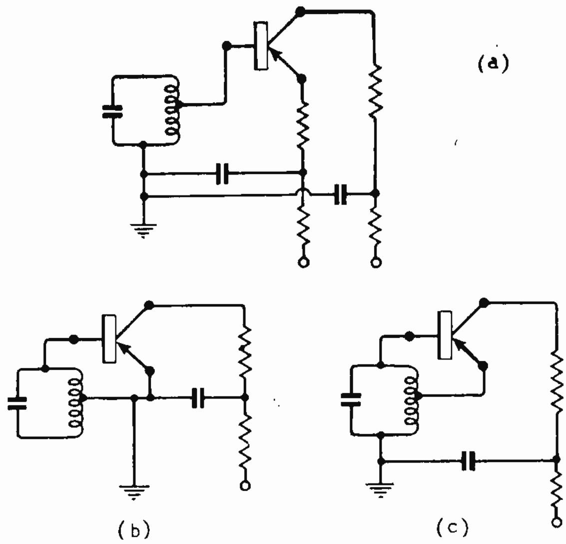


Fig. 5. Variants of the base-controlled oscillator circuit.

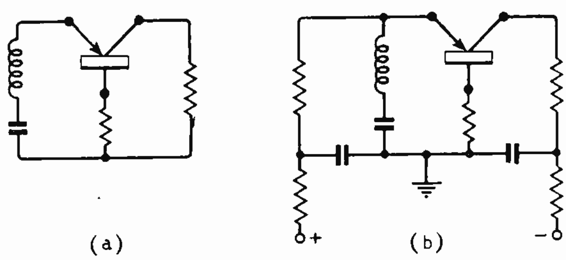


Fig. 6. Oscillator circuit (a) using negative emitter impedance when the base load resistance is high enough, and (b) method of connecting supplies.

transistor, and the base-emitter capacitance plays an important part in the functioning of the circuit. This circuit does not, therefore, fall into the simple negative-resistance class we are discussing at the moment.

A second oscillator type is obtained by operating with an earthed-base connection, using the negative input resistance at the emitter. As we saw in the previous article, the input resistance is

$$r_e + r_b - \frac{r_b\,(r_b + r_m)}{R_L + r_c + r_b}$$

Using the same numbers as before, this is

$$R_{11} = 400 - \frac{200\,(30{,}200)}{20{,}200} \text{ or about 100 ohms.}$$

This will not do, but if we put an 800-ohm resistor in series with the base, we make the effective value of $r_b = 1{,}000$ ohms, and then

$$R_{11} = 1200 - \frac{1{,}000\,(31{,}000)}{21{,}000} \text{ or about } -300 \text{ ohms.}$$

It is very easy to design a circuit which will be 300 ohms at one frequency, and a higher impedance at other frequencies. A coil having a total loss resistance of 300 ohms and a series capacitor is all we need. For a coil giving a Q of about 30, we have $\omega L = QR$, or about 10,000 ohms. Choosing 798 c/s as the frequency, we find that a 2-H inductor is needed: a thoroughly practical value is obtained. The circuit is basically that shown in Fig. 6(a), and needs only

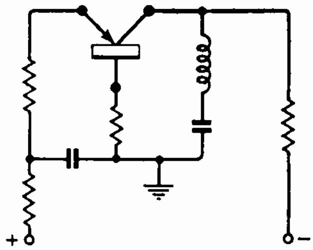
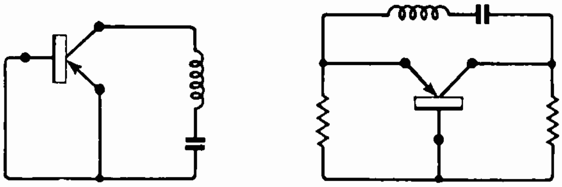


Fig. 7. The use of collector negative impedance, as in this circuit is not satisfactory if appreciable output power is needed.



(a) (b)

Fig. 8. (a) Shows a resonant circuit in the output (collector) loop of an earthed-emitter circuit. Re-drawn as in (b), with resistors added, it becomes an earthed-base amplifier with feedback from collector to emitter.

the additional resistors shown in Fig. 6(b) to provide the necessary supplies. This circuit can be controlled in amplitude by varying the resistor in the base lead. Theoretically it can use a thermistor in the base lead, so that increasing oscillation level reduces the regeneration. I say theoretically, because the immediate difficulty is obtaining a suitable thermistor. The base current will be only about 1 mA, so that the thermistor must work on powers of the order of 1 mW.

The two circuits described have the advantage that they are power oscillators: they leave the collector free to work with a normal load resistance, so that the full available output can be taken from the transistor. This output is enough for many jobs, and will always be enough to drive a push-pull transistor amplifier stage. There are two more interesting circuits which can be designed in the same way. One of these is shown in Fig. 7. It starts off from the equation for the output impedance of the earthed base circuit

$$R_{22} = r_c + r_b - \frac{r_b\,(r_b + r_m)}{R_G + r_e + r_b}$$

with R_G taken as zero, and r_b for convenience, increased to 1,000 ohms by adding an 800-ohm resistor in the base lead. Then

$$R_{22} = 11{,}000 - \frac{1{,}000\,(31{,}000)}{1{,}200} = -14{,}000 \text{ ohms}$$

This sort of negative resistance is sometimes useful in designing crystal oscillator circuits: it is not very good for conventional LC working. Another disadvantage is that there is nowhere to put in a load circuit, unless it is in series with the controlling LC circuit, and this is not desirable as it degrades the Q of the system and makes the frequency stability worse.

The final circuit in this class is obtained by considering the output impedance of the earthed-emitter circuit. We shall want to look at this in a rather different way later, but for the moment we can observe that the output impedance is

$$R_{22} = r_c + r_e - r_m + \frac{r_e\,(r_m - r_e)}{R_G + r_b + r_e}$$

With no external resistance at all this reduces to

$$R_{22} = 10{,}000 + 200 - 30{,}000 + \frac{200\,(29{,}800)}{400}$$

or about – 5,000 ohms.

A circuit of the type, shown in Fig. 8, will therefore oscillate, provided that the resonant circuit drops to a resistance of less than 5,000 ohms at resonance. This is crystal magnitude again, of course, but as before we have nowhere to take out the load. When we use this circuit, which turns out to be a very satisfactory one, we must rearrange it in the way shown in Fig. 8(b). Then the negative impedance calculation is not so simple, and we adopt a more normal amplifier approach.

This treatment of the negative resistance oscillators may seem rather scanty, but we shall be returning to the question of negative resistance circuits in a later article. For the moment, I want just to show the sort of circuits which can be produced, and the lines along which the design process must operate. Conventional oscillators, in which we feed back from an output electrode to an input electrode, and amplifiers must be considered before we look again at the very interesting negative-resistance circuits which can be used for pulse production, standardization and manipulation.

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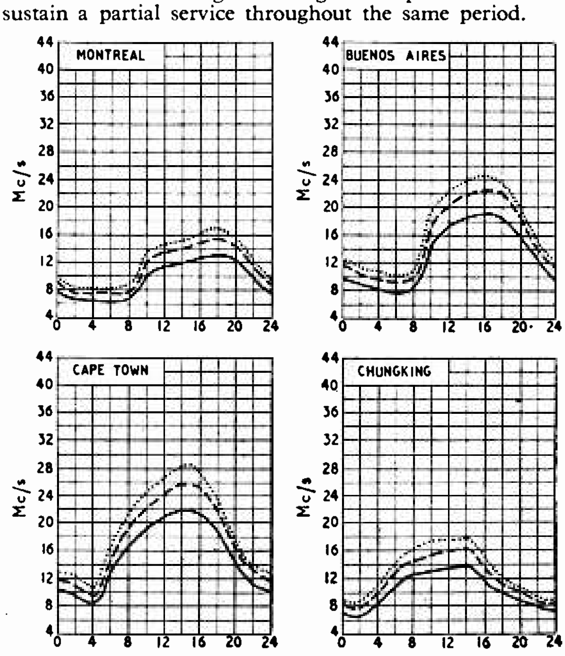

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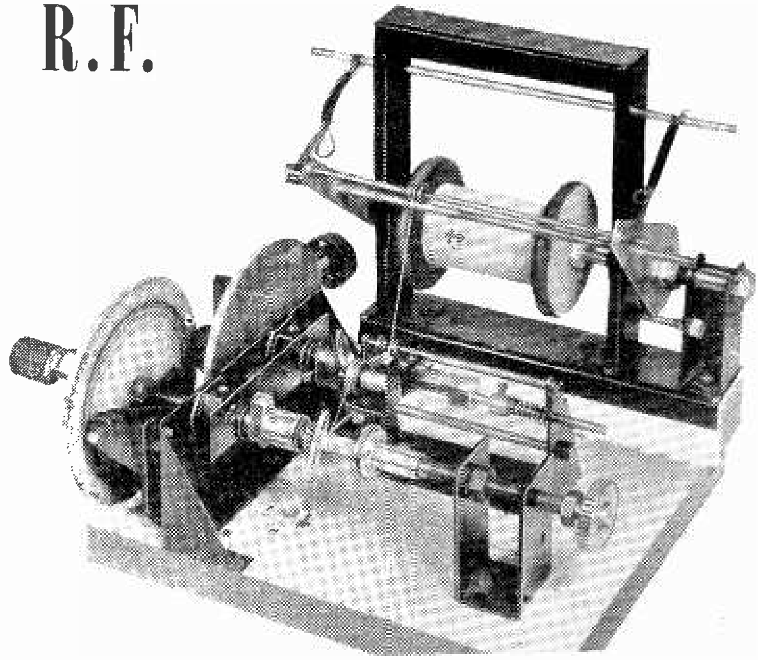
Multi-Layer R.F. Coil-Winder

Constructional Details of a Machine for Making Wave-wound Coils

By B. V. NORTHALL



The various parts shown separately in the drawings can be identified in this view of the finished winder. No special parts or tools are required for its construction.

WAVE-WOUND COILS are so extensively used that it is thought an account of the author's winding machine may be of interest. It is capable of winding coils up to ½ in wide and can accommodate formers 2 in long. The machine is of simple construction, does not require any specially machined parts and is made largely from pieces of scrap. Few detailed measurements only are given in the following description as the majority can be varied according to the materials available.

The basic design is shown in Fig. 1. A variable friction drive is used in place of a gear wheel. Rotation of the cam slides the wire-feed finger to and fro, the amount of travel being varied by adjustment of the cam-follower mounting in the direction *a-a*. Gear changes are made by adjusting the drive roller in direction *b-b*. The wire is fed to the finger over pulleys which may be used to operate a brake acting on the wire bobbin.

Typical paths traced out by the finger on the coil former are shown in Fig. 2. The gear ratios are actually adjusted to slightly more or less than the

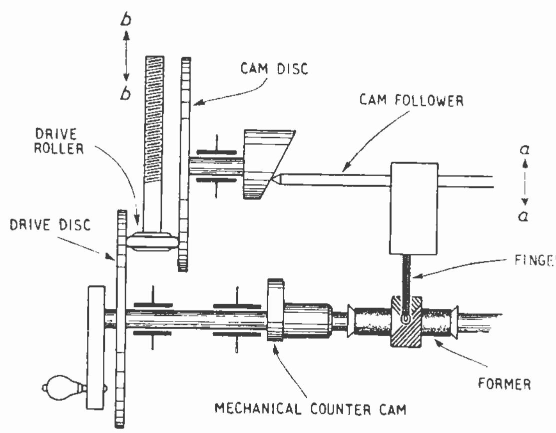
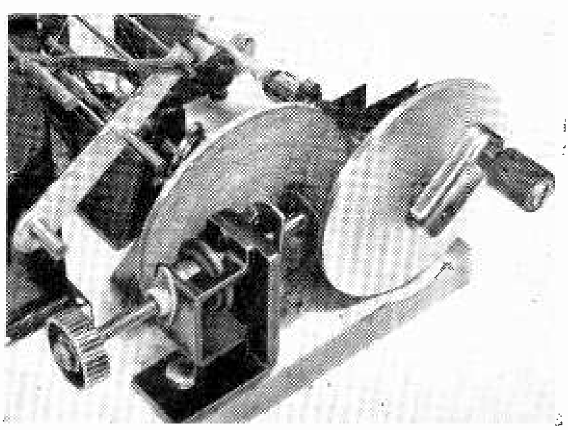


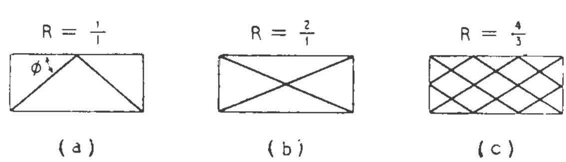
Fig. 1. Basic design of the winder for making wave-wound coils.



Left: The ratio between driving and driven friction discs determines the path traced out by the wire on the coil.

Fig. 2. Some typical types of wave winding possible with this machine. Coils up to ½ in wide can be wound.

$$R = \frac{\text{FORMER TURNS}}{\text{CAM TURNS}}$$



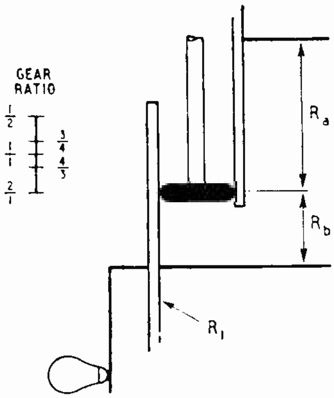
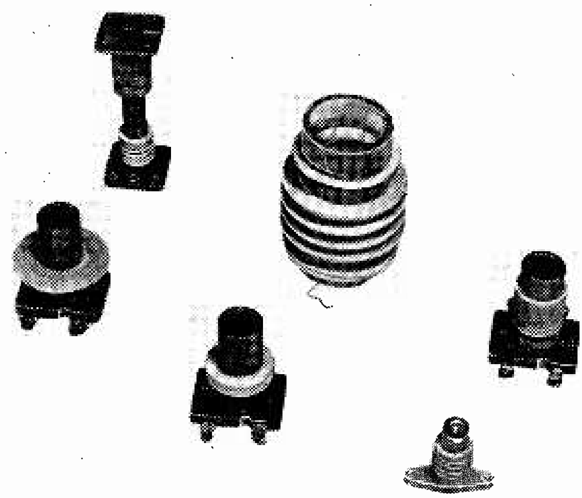


Fig. 3. Method of calculating the gear ratio.



Right: Some of the coils wound on this machine. The wide variety of shapes exemplifies its versatility

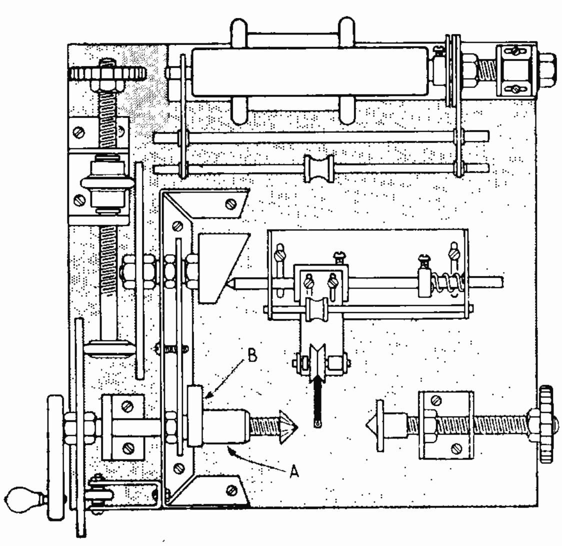
even figures quoted, so that successive wires lie side by side. The choice of gear ratio is influenced by the angle ϕ (Fig. 2a), which should not be too large or the initial turns may slip out of position on the former.

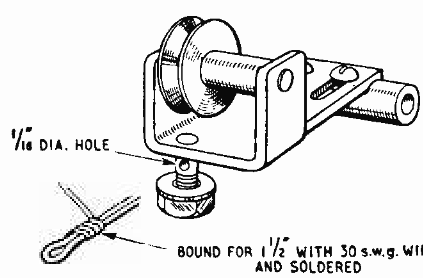
The gear ratio of the friction drive is given by R_a/R_b (Fig. 3). The machine is designed to have a maximum ratio of slightly over 2:1 and a minimum ratio of just below 1:2. For a gear ratio of 2:1 the radius of the circle described by the drive roller on the main drive disc (R_1) is half that described on the cam disc. To reduce the ratio to unity the drive roller is withdrawn a distance equal to half R_1 so that the two radii are equal. A further equal withdrawal reduces the gear ratio to 1:2. Fineness of control of gear ratio depends on the size of the disc, ease of adjustment increasing with disc size.

Details of the finished machine are given in Fig. 4. The various assemblies are mounted on a 8 in × 9 in wooden baseboard. Two 4¼-in diameter discs are mounted at 3 in centres on silver steel shafts. The discs should be keyed or threaded to the shafts to prevent slip, and 6-BA studs tapped into the shafts are used as keys on the machine. The driving sides of the discs are scored with fine lines to increase the grip. The main bearings are made from brass nuts soldered between two suitably cut and bent pieces of mild steel sheet. A further bearing made from an angle bracket supports the drive shaft. Jockey rollers are fitted to reduce side thrust on the bearings. The drive roller consists of a rubber washer mounted on a small ball-race which is a push fit on a ¼-in silver steel shaft. A BSF thread is used on the shaft to give fineness of adjustment. Driving friction is adjusted with the threaded brass collar (A; Fig. 4) mounted on the end of the shaft. A mechanical counter cam (B; Fig. 4) is used also to lock the friction adjustment. A bolt-head cut and filed to rose-bit shape forms the driving cone.

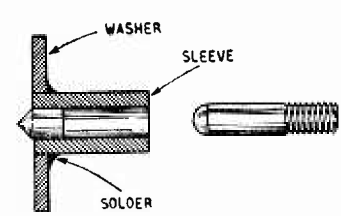
The best "lock over" of succeeding wires is pro-

Left: Fig. 4. Complete layout of the machine and (Right) Fig. 5. The wire-feed finger and traversing carriage.





Right: Fig. 6. Details of the tail stock.



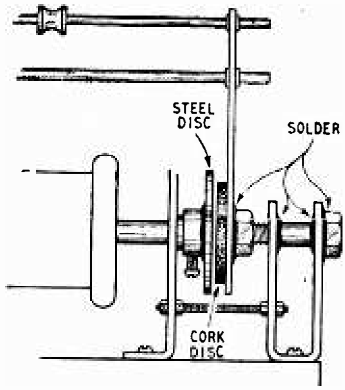


Fig. 7. Details of the tension-operated wire brake.

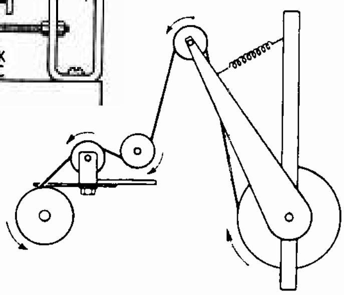


Fig. 8. Method of feeding the wire from the spool to the coil.

duced when the path traced out by the wire-feed finger on the coil former is linear and ideally the cam should be shaped to produce such a track. A cam with a plane surface produces a sine-wave track and a face-hardened cam of this type is used on this machine. The cam angle is 30 deg. The cam-follower is made from silver steel rod and ground to a point at one end, but not hardened, and is held against the cam by a coil spring and retaining collar. The mounting is made from mild steel sheet. The wire-feed carriage is mounted directly on the cam-follower shaft and is locked in position with a 6-BA screw. A pulley for the wire is loosely mounted on a length of silver steel rod just above and slightly in front of the cam-follower.

The wire-feed finger and carriage are perhaps the most important units and are illustrated in Fig. 5. The different gauges of wire require fingers having different sizes of "eye." Piano wire, bent to form an "eye," is bound with 30 s.w.g. tinned copper wire for approximately $1\frac{1}{2}$ in and soldered to give rigidity. The stud soldered to the carriage is drilled $\frac{1}{16}$ in to accommodate the finger which is locked in position with a nut and washer. A corresponding slot is filed in the mounting collar. The pulley guides the wire to the finger and the tension of the wire passing over it keeps the finger pressed against the coil.

Details of the tail stock are shown in Fig. 6. The centre cone is a push fit in the sleeve and the end of the silver steel shaft is rounded to reduce friction. The tail stock bracket is made from mild steel sheet. A lock nut is fitted.

The tension of the wire is important. Slackness produces spongy coils and over-tightness can produce electrical faults as well as increasing the risk of the wire breaking. At hand speed a simple friction brake on the wire bobbin with a sprung pulley compensating for variations in tension produces a satisfactory wind. A wire-operated brake, however, is used on this machine and the essentials of its design are shown in Fig. 7. A $\frac{3}{8}$-in Whitworth bolt is used so that only a small downward movement of the lever is required to release the brake. A spring consisting of a few thin strands of elastic holds the lever up (brake on) and is adjusted to give the required tension on the wire. Normally the bobbin tends to apply the brake when in motion. The method of feeding the wire is shown in Fig. 8.

Before using the machine, the cam-follower mounting is set to give the required width of coil, and the appropriate wire-feed is adjusted to approximately the centre of the former. The coil tension is checked and the required gear ratio selected. The critical angle (ϕ; Fig. 2a) at which the initial turns slip out of place varies with the size of the wire and covering, and a single turn of cellulose tape, adhesive side outward, is an assistance in keeping the first few turns in position on a smooth coil former. A few trial runs to make final adjustments should be made before a coil is wound. The gear may be adjusted so that the pattern builds up progressively or retrogressively, the latter pattern being more stable. Coil data is available in various publications, some that have been found useful being given in the references.

Mild steel sheet $\frac{1}{16}$ in thick makes mountings of adequate strength. The tools required for the construction of this machine are few and consist of:—a hand or breast drill, drills, taps, dies, hacksaw, files, vice and soldering iron. The hand drill, clamped in the vice, can be used as an improvised lathe for the turning of small parts, such as the wire guide pulleys and to true up the two large friction-drive discs.

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Radio-Controlled Boats

NOW that the Philips radio-controlled boats seem to have established themselves as almost a permanent feature of European radio exhibitions, many people will be interested in the appearance of a book which reveals all the technical mysteries of how they work. Under the title of "Remote Control by Radio," A. H. Bruinsma has written a very full description of his two boats in 94 pages, including four complete circuit diagrams, 28 pages of data on the valves used and various photographs and diagrams to illustrate the text.

The first part of the book deals with the smaller and simpler boat, which has a two-channel frequency-division radio system with amplitude modulation. Considerably more space is devoted to the *pièce de resistance* "Teleservilips VIII" which has so impressed everybody with its remarkable versatility. This has an eight-channel radio system working on the time division principle; the channels being provided by eight interlaced sets of pulses which are modulated in amplitude by the control signals.

Since the boats have been designed mainly for demonstration purposes, regardless of complexity or cost, the systems described in the book are not likely to be of much direct practical value to the amateur radio control enthusiast. The receiver of the larger boat, for example, uses 44 valves! Nevertheless, some of the individual techniques and devices within the systems are worth knowing about, and the book as a whole is a welcome addition to the somewhat scant literature on telearchics. It is published by the Philips organization at Eindhoven and is available in this country through the Cleaver-Hume Press at 8s 6d.

The Future of Hearing Aids

Battery Consumption and Other Problems: The Case Against Standardization

By A. POLIAKOFF*

IN THE AUGUST, 1950, issue of *Wireless World* the writer mentioned the complexity of the problem of amplifying sound for the hard of hearing and gave results of a survey undertaken by his company into the optimum volume requirements of the deaf. In the time that has elapsed since, an increasing number of health authorities in many countries have started laying down minimum requirements for performance of hearing aids, to which instruments must conform before they qualify for a grant-in-aid, free issue or even import permits. These requirements refer almost entirely to the response curve, the limits of which are given with varying precision and severity. Needless to say, the variations of requirements between country and country are so considerable that in one case at least, an instrument having a response curve recommended by the Medical Research Council in their Report No. 261, "Hearing Aids and Audiometers"—would not pass the test. These variations of requirements are not, however, fundamental. The fact remains that the majority of authorities now hold the view that an instrument made to a particular recipe is the best hearing aid for all cases.

This view is a technical heresy and its widespread adoption can only result in complete stagnation of hearing aid design and development.

In case we should be suspected of an anarchical bias, whether against health or any other authority, it is as well to stress that private industry, although more flexible than public bodies, has so far not gone nearly far enough into dividing the hard of hearing into a number of groups, according to their acoustic requirements, and providing each group with an instrument giving the optimum results for the members of that group.

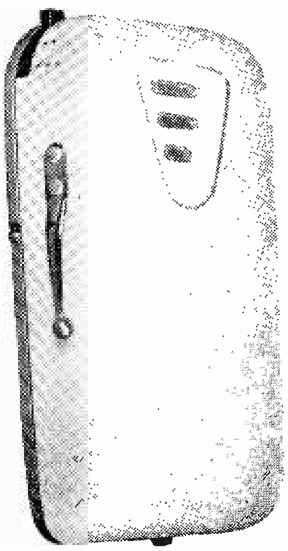
The wide variety of requirements of the hard of hearing present a particularly fascinating problem, and their satisfaction in the most logical manner is a real challenge to all those working in the field.

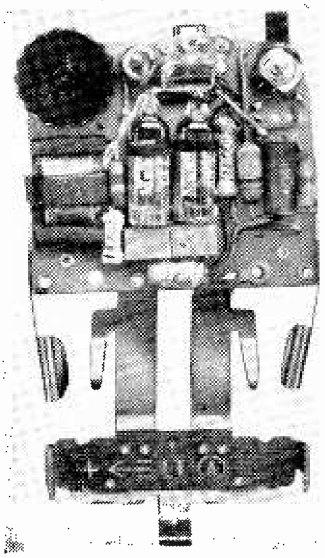
It must be made clear at the outset that the audiometric curve—that is the hearing loss of the subject measured at threshold at different frequencies—is absolutely no indication of his instrumental requirements. The knowledge that a particular case has a loss at 1,000 c/s of 40 db does not permit us to say that he needs an instrument with an amplification 40 db. He may actually be unable to tolerate more than 15 db. Cases with strong "recruitment," that is, non-linear deafness, need small amplification and small power output. Other cases need low power output but are able to make use of quite high amplification in certain conditions. Some deaf people who are able to hear when the words are shouted straight into their ear either directly or through a trumpet, need low amplification and high output. The very deaf need high output and the highest amplification they can have without "howlback."

An extremely interesting point is the variation in the amplification that can be usefully employed between cases having the same optimum volume requirement. We have come across people with moderate conductive deafness who had very modest optimum volume requirements combined with the ability, when provided with sufficient amplification, of hearing better in difficult conditions than a person of normal hearing. Their type of deafness is such that they can interpret speech quite easily in spite of the background noise and room reverberation. The perceptive case, on the other hand, has often a very limited range of useful amplification owing to the masking effect of background noise and room reverberation. Individuals vary, therefore, not only in their minimum, optimum and maximum power requirements, but also in what may be termed their

* Multitone Electric Company.

Multitone "Universal" hearing aid which is obtainable in three versions to meet individual power requirements. The type "Q" chassis of the 2-valve model is on the right.





resolving power, which sets a limit to the amplification that they can use.

It may be useful at this stage to list the main variables that the designer has to deal with:

1. Maximum output.
2. Mean amplification.
3. Shape of the response curve.
4. Automatic compression.
5. Conversion efficiency, the ratio of acoustic output to battery power consumed.

The problem, then, is to provide each individual with an instrument which fits most closely his requirements under the first four headings, and with the highest possible conversion efficiency. In addition, the individual preference between small bulk and higher battery replacement costs and large bulk and lower battery replacement costs must be met. The range of individual requirements is, as already indicated, very large indeed.

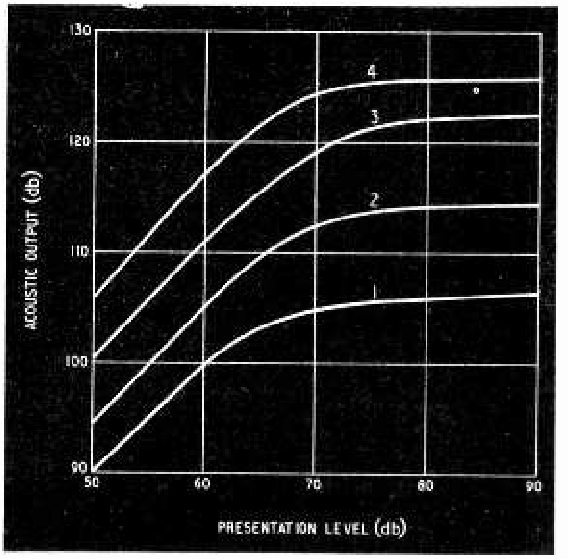
Taking the first variable, the power output, and expressing it in terms of electric energy delivered to the earpiece, we find that nearly half of all the hard of hearing cases tested by us are satisfied with the volume resulting from a power input to the earpiece of only 0.005 milliwatt or less. This has to be contrasted with maximum power output of the average commercial instrument of 5 mW, a difference of 30 db. Further, within the 0.005-mW group there is a proportion of cases unable to tolerate anything like the output resulting from 0.005 mW, which is the power required only by the deafest members of this group. A number of sensitive cases have a maximum of only 0.0005 mW. At the other end of the scale there are the very deaf needing as much as 50 mW or even more. The electric power output range is, therefore, at least from 0.0005 to 50 mW, a range of 50 db.

To attempt to deal with this range of outputs with the same fundamental circuit of a crystal microphone followed by two voltage amplifier valves, and an output valve does not appear, to put it in the mildest way, to be good design.

It means that the vast majority of cases have far more power than they need, while a small minority have insufficient. Over-provision of potential power on such a scale would undoubtedly be considered utterly irrational in any other field. Consider a car manufacturer who insisted on putting the same engine he used in a 10-ton lorry into the smallest passenger saloon and telling the unfortunate owner of the saloon that, after all, he has a throttle-control and there is no need to generate more power than he requires. The case of the hearing aid is actually worse, for in the vast majority of cases the power consumption of the aid is independent of the power delivered to the earpiece at any given moment. It follows, therefore, that the most of the deafened are consuming batteries at a rate far in excess of their own requirements.

The example of the throttle-control in a car brings us to a most important point, that of the purpose of the volume control in a hearing aid. The purpose of such a control should be to take up variations between different conditions of use by the user, and not to take up variations between requirements of different users. It is surely bad design to provide a control with 260 degrees of rotation and tell an individual user that the first 30 degrees are for his adjustment and the other 230 degrees for somebody else.

We have now seen that there is a very large variation in power output as well as amplification. What of the response curve? Its shape is not at all critical. Most



Performance of automatic volume control for the four settings of the level control in the Multitone "Selector" aid (0db = 0.0002 dyne/cm²).

cases are helped by absence of sharp peaks and a general rise towards the high end. This does not mean, however, that standardizing the response curve at, say, 6 db rise per octave up to 3,500 or 4,000 c/s is the right solution. There are a number of exceptions of which the most important is that of the very deaf. It is obvious that they should be provided with instruments having the highest conversion efficiency possible. The better the response curve in the higher frequencies the lower is the efficiency of the earpiece in the part of the response curve that a very deaf subject can hear. It is very rare for these cases to respond to 4,000 c/s at all. It is wrong, therefore, to saddle them with an "academic" response, the advantages of which they themselves cannot hear. Not only does this result in the very deaf being no longer able to hear with instruments using a 22½-V high-tension battery, and needing as much as 45 V, which cannot be conveniently incorporated in a reasonably sized "monopack" instrument, but it also makes it difficult for them to hear at all. It is extremely hard to obtain an effective seal between the earpiece and the ear at the higher frequencies. If there is a good high-note response the aid starts whistling as soon as the amplification is sufficient for the user to hear at all, and, not infrequently, he himself is quite incapable of hearing the whistle. One of our users before the war, an M.P., was asked to leave the Chamber on one occasion on account of a continuous whistle set up by his instrument of which he was completely unaware. The "howlback" does not merely cause a disturbance, but almost always overloads the output valve and spoils the amplification of sounds the user can actually hear.

Volume Compression

We now come to automatic volume compression. In most of the instruments manufactured by my company, and now a number of other manufacturers, the power output can be limited to a desired figure by automatic compression, while the amplification of weak signals is controlled by a manual volume control. The reason for the manual control is to take up large variations between noise conditions such as exist, for instance, between the cabin of an aeroplane in flight and a quiet room in the country.

Too much compression can be very objectionable, for not only will speech be flattened out, but pauses between words will be filled by the rush-in of the background noise. There is a considerable variation between the amount of compression preferred by different cases, which provides yet another variable for the designer, together with the selection of the most suitable "attack" and "decay" times.

Here is the problem, and it is difficult to see how it can be solved satisfactorily without designing special equipment for each of a number of groups.

I believe that the future of hearing aids lies in detailed study of these requirements coupled with the production of valves (later transistors) and batteries designed specifically for use for a particular group.

Having studied the volume requirements of the deafened, my company has now adopted a design policy for instruments to which we have given the name of "Fitted Power." Our new "Universal" instrument is available in three versions: the first version has only two valves, both voltage amplifiers, with a high-tension consumption of approximately a quarter of that of the average instrument with the same high-tension voltage (22½ V) and with a low-tension drain of half of that of a normal instrument. Its maximum amplification at 1,000 c/s is in the region of 40 db. Automatic volume control is provided, while the maximum output with the automatic volume control switched off is in the region of 119 db referred to 0.0002 dyne/cm^2 at 1,000 c/s. In cases for which the amplification is not enough a 3-valve version is available with the low high-tension drain of 0.2 mA. Where the power output is not sufficient, which, by the way, is extremely rare, a third instrument is available with a drain of 0.4 mA.

In our "Selector" instrument we have introduced "Fitted Power" by making the high-tension drain vary with the setting of the automatic volume control level selector. This instrument employs a 15-volt battery and the high-tension drain changes in four steps from 0.1 to 0.4 mA as the compression is varied through a range of 20 db. The accompanying graph shows the compression curves of the four positions of the level control.

The lower amplification obtained with the reduced high-tension drain is a great help with difficult perceptive cases. In the past we spent a great deal of time "calming" instruments by reducing amplification and maximum output from their standard values to deal with cases with pronounced recruitment.

Nothing has been said so far of the effect of these ideas on further miniaturization. It is obvious that instruments designed expressly for the less deaf group could be much smaller than those produced for the deafer groups. A far more radical approach, however, is required to produce really small instruments. The man who makes use of his instrument for special occasions only, such as theatres, and so on, does not need a battery that will last him longer than the duration of the play, with a little to spare, and it would be possible, with the help of the battery manufacturers, to produce a really minute instrument for him.

When it becomes possible to use transistors only in an instrument, thereby eliminating one of the batteries, miniaturization will receive a further impetus.

The transistor hearing aid is not here yet, although at least one manufacturer in the States has announced the production of the first transistor instrument. This, however, employs two valves and uses the transistor only in the output.

The principles set out above for the design of hearing aids are quite independent of the means by which amplification is obtained. Valves, transistors, or any other devices that may appear in the future all use energy and this should not be recklessly wasted, nor should individuals be supplied with instruments potentially far too strong for them, in order to enable somebody else to hear with the same device.

MANGANESE-BISMUTH PERMANENT MAGNETS

WHEN manganese and bismuth are melted together an inter-metallic compound (MnBi) is formed which exhibits strong magnetic properties when the particle size is small enough.[1] Recent investigations have shown[2] that magnets made from this compound can offer a practical alternative to conventional alloys of cobalt and nickel, and that, in particular, they have a coercivity higher than that of any other known magnet. This property is of particular value where the demagnetising force is high, as in magnets of short length. Coercivities higher than 3,000 oersteds have been measured, compared with 600-700 for alloys such as "Alnico" and "Alcomax," and the best MnBi magnets have a maximum energy product (BH) of 4.3×10^6 gauss-oersteds, which is of the same order as that of Alcomax. The remanence reaches 4,300 gauss compared with 7,500 for 6 per cent cobalt steel and 12,500 for Alcomax III.

Magnets are prepared by a powder-metallurgy technique, the Mn-Bi melt being first pulverized to an average diameter of 8 microns and then separated magnetically before being compacted (at a temperature of 300 deg C) in dies at pressures up to 3,000 lb/in^2 in a pulsating axial magnetic field with a maximum of 20,000 oersteds.

The processes are carried out in an inert atmosphere to guard against oxidation, and protective coatings for the finished magnet are necessary, particularly when they are to be used under conditions of high humidity.

[1] J. Frenkel and J. Dorfman: *Nature*, Vol. 126, p. 274 (1930).
[2] "A New Permanent Magnet from Powdered Manganese Bismuthide," by E. Adams, W. M. Hubbard and A. M. Sycles: *Journal of Applied Physics*, Vol. 23, p. 1207, Nov., 1952.

Standardizing Loudspeaker Sizes

TO facilitate the replacement or exchange of loudspeaker units, standardization of the size and distribution of fixing holes has long been advocated.

Now a British Standard Specification (BS1927:1953) has been issued for nominal loudspeaker sizes of 2½, 3½, 5, 6½, 8, 10, 12, 15 and 18in diameter and gives mounting circle diameters and the number, size and distribution of fixing holes.

It is also required that loudspeakers conforming to this specification should state the nominal fundamental resonant frequency, the nominal impedance (preferred values 3 and 15 ohms), and that one terminal should be marked red to indicate that when this terminal is positive the corresponding movement of the diaphragm is forward.

Details of the conditions of measurement of resonant frequency and nominal impedance are given and the specification, which is obtainable from the British Standards Institution, 24, Victoria Street, London, S.W.1, costs 2s.

RADIATION?

"CATHODE RAY" Clears Up Some Common Misconceptions About Fields

WHEN interference with broadcasting caused by electrical equipment in the home is being discussed, one of the ways by which such interference reaches the receiver is commonly referred to as radiation. Some of the people who talk about radiation in this connection probably realize—or would do, if they thought about it for a moment—that they are misusing the term.

What exactly is radiation ? BS.204: 1943 defines it quite briefly as "the emission of energy in the form of electromagnetic waves." Now the process we are considering is certainly the emission of energy. It is even true to say that part of the energy is in the form of electromagnetic waves. But it is usually an insignificant part, so "radiation" hardly seems to be the right word to describe the whole. However, if it were merely a matter of relative size it might perhaps be rather fussy to object. The reason I am objecting is that if the people who know better call this thing "radiation" others may be led to believe that it really is radiation and thereby get their ideas wrong. For this is not just some little by-way of science; it is an arterial road, and if the entrance is obscured by a fog of misunderstanding a lot of people are going to lose their way. The road leads to two fascinating fields—the electric field and the magnetic field. To the student these may seem vague and intangible things, compared with his clear-cut circuits carrying easily measurable currents. But in fact the energy of low-frequency or even d.c. circuits is in the surrounding fields rather than within the wires themselves. Circuit electricity is just a very special case of the more general electromagnetism, and although quite a lot of useful work can be done without bothering much about fields, this restricted knowledge soon leads to difficulty in radio—particularly, for example, with aerials. The circuit-minded man is hopelessly at sea—or should we say in the air ?—when he comes to aerials.

"Lines of Force"

Of course, everybody who studies electricity more than a very little learns something about fields. Mathematicians take to them like ducks to water. But I am not concerned with the minority of born mathematicians but the majority, who are not really happy about symbols unless they are accompanied by a clear mental picture of what they represent. And this is where fields are a difficulty. Of course, one has only to handle a pair of magnets or look at an electrostatic voltmeter in action to be convinced that very potent forces do exist in space, but so far nobody has been able to discover how they come to be there. If one is satisfied with bare mathematics, all right; but if not, the best that can be done is a rather artificial mechanical analogy, and unfortunately this is only too liable to give wrong impressions unless it is kept strictly in its place.

For instance, nearly all the instruction on the subject brings in "lines of force." One book, published only a few years ago, says "Attraction or repulsion (between electric charges) can be explained by studying the electric lines of force. There are electric lines of force emanating from the proton or positive charge, and if no other charges are present, these lines of force extend out to infinity in all directions." When a definite and unqualified statement like this is made on a fundamental principle by an author with eight lines of qualifications after his name on the title page, how can readers be expected to realize that it is quite untrue—a mere baseless figment of the imagination ? When we are informed in song that "You're the cream in my coffee" there is no serious risk of the statement being accepted as a literal fact, because metaphor is an understood convention in that kind of thing, and it is interpreted accordingly; but when a technical instructor uses poetic imagery he is under an obligation to give warning of it. I am not suggesting that because lines of force are non-existent there is no justification at all for introducing them—personally I find them very useful—but if they are introduced it should be made quite clear that they are purely a mental or visual representation, having no closer relationship to actual fields than an arrow on a weather chart has to a wind blowing in from the Atlantic. Just as a wind fills a whole region of space, not just where the arrow is drawn, so a field is continuous, not confined to separate lines.

Some while ago I saw an instructional film in cartoon form, in which the inflammable vapours given off by natural oil were represented as imprisoned demons seeking to escape and wreak vengeance. Now if that presentation succeeded in conveying an impression of the risk due to oil vapour and the need to guard against it, well and good. And if lines of force, flux-cutting, and all the rest of the field ideas help us to make use of electromagnetism, well and good; but to suppose that they are real is like believing that each barrel of oil contains a malevolent demon with forked tail. As a matter of fact, it is possible to substitute quite different ideas for magnetic fields and still get the same results; but I am not going to be as unconventional as all that.

Beginning, then, with well-known principles, there is the electric field, associated with a difference of potential—voltage—and the magnetic field, associated with an electric current. Theoretically it is possible to have either kind of field without the other. If you charge any well-insulated capacitor, there will be a difference of potential—and hence an electric field—between the two plates, though there is no perceptible current to set up a magnetic field. It is not so easy to demonstrate a magnetic field without voltage, because suitable circuits such as coils usually have resistance that needs an e.m.f. to keep the current going, but by cooling a lead ring sufficiently its resistance can be reduced to so nearly zero ("super-conductivity") that a current once started flows for hours and maintains a magnetic field without any e.m.f. or electric field. I am leaving out of account permanent magnets, because although it is now believed that their fields, too, are due to electric currents (within the atoms), their circuits cannot be seen and handled.

Note that a separate electric or magnetic field can only exist at zero frequency. The moment one starts to vary an electric field it is necessary to increase or reduce an electric charge somewhere, which means moving a charge, and that is an electric current, which sets up a magnetic field. And any variation of a magnetic field generates an e.m.f. in the circuit producing the field, so an opposite e.m.f. is needed to compel the variation, and the resulting difference of potential causes an electric field.

That is a most important thing to grasp. Important enough to look into more closely. Let us look into it with particular reference to the production of the varying magnetic field. (The whole statement can be converted to apply to the varying electric field by using the duality principle explained in the April 1952 issue.) All the apparatus we need is a coil connected to an a.c. generator, as in Fig. 1. To simplify matters let us assume that the a.c. has a pure sine waveform, and that the coil is surrounded by air. Then the field strength or flux is exactly proportional to the current, so its waveform is the same and is in phase. In fact, by using suitable scales the same curve can be used for both, labelled I and Φ in Fig. 2. E.M.F. is generated not by a constant field but by variation of field and is proportional to the rate of variation, represented by the gradient of the Φ wave. The steepest gradient is where the Φ wave cuts the horizontal axis, first upward (generating a peak of positive e.m.f.) and then downward (generating a peak of negative e.m.f.). The rest of the e.m.f. curve can be filled in by plotting its amplitude at every point proportional to the gradient of the Φ wave; the result (dotted in Fig. 3) is another sine wave, or rather a cosine wave, for although the shape is the same it is quarter of a cycle (90°) earlier in phase.

Direction of Flow

A little question of sign arises here. We have shown E as *positive* when the current is *increasing*, but that means nothing unless the direction around the circuit is specified. By Lenz's law, the field-induced e.m.f. acts in such a direction as to oppose the cause of the current change; so when the current is increasing it is positive *against* the direction of current increase. The only other voltage in the circuit is the generator e.m.f., which therefore must be exactly equal and opposite. So if the curve E in Fig. 3 is understood to refer to the *same* direction in the circuit as the current, it represents the generator e.m.f.

The reason for being so particular about getting the directions right is that they indicate the direction of power flow, which will be the next thing to be considered. In case you are wondering why we started with the current and worked back to the e.m.f. driving it, I can only say it is easier that way. Having done what we have done, we can say that if a sinusoidal e.m.f. is applied, say E in Fig. 3, the resulting current will be as shown by I in the same diagram, lagging 90° behind the e.m.f., as the books say. Of course, it must not be imagined that this lag is a time delay, each postive peak of current being caused in some way by the positive voltage peak that occurred quarter of a cycle earlier; the current peak is actually an accumulation over half a cycle of the continuous increase needed to generate an e.m.f. to oppose the continuously positive generator e.m.f. during that half-cycle, and has now flattened out at a summit because *at that same instant* there is no e.m.f. to be opposed.

An Eye on the Energy

One other side issue may be disposed of at this stage—the resistance of the circuit. Either it can be assumed to be zero, which simplifies the situation to the one described and illustrated, or alternatively, if that seems too unreal (super-conductivity demonstrations notwithstanding) the e.m.f. needed to overcome the resistance of the circuit can be assumed to be provided by an auxiliary suitably-phased series generator, which, with its e.m.f., we shall forthwith completely ignore—quoting as authority for this conduct the Superposition Theorem.

As I emphasized in January, 1952, voltage and current by themselves are less significant than *energy*, which is the result of the exercise of power in some direction or another for a period of time. In a purely resistive circuit, the current is in phase with the applied e.m.f., and as power is equal to voltage × current it is in this case positive in the direction of the current—meaning that power is going out of the generator and being dissipated in the resistance. But if we now draw a curve representing the power in our purely inductive circuit, finding its amplitude at every moment by multiplying together the E and I amplitudes, there are some moments when (as with resistance) both are positive, indicating positive power, and some when both are negative, indicating the same ($-1 \times -1 = +1$), and some when one is positive and the other is negative, indicating negative

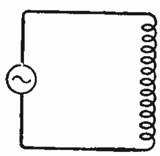


Fig. 1. The simple circuit considered —an a.c. generator driving current through a coil whose resistance is either negligible or overcome by another generator not shown.

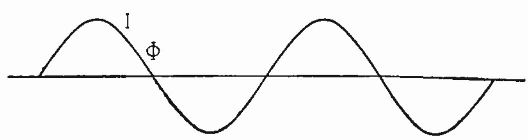


Fig. 2. The magnetic flux (Φ) set up by the current (I) is in phase with the current, so can be represented by the same curve.

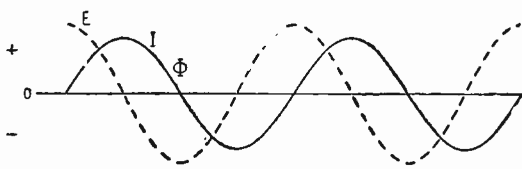


Fig. 3. The generator e.m.f. (E) needed to overcome the e.m.f. generated in the coil by the variation of Φ is 90° ahead of the current.

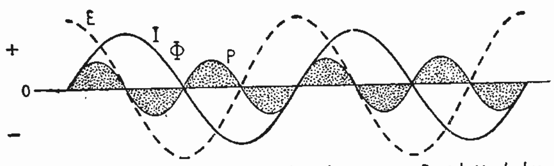


Fig. 4. Power is represented by the curve P, plotted by multiplying I by E ; and energy (= power × time) by the shaded areas, which are equally positive and negative in each cycle.

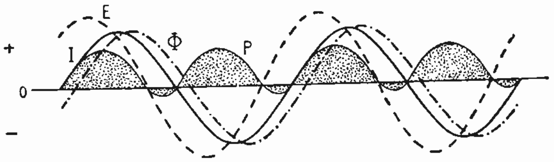


Fig. 5. If account is taken of the time lag needed to convey changes in field strength to a distance from the coil, the positive energy (leaving the circuit) is greater than the negative (returning to it).

power. If positive power means power going out, negative power must mean power coming back. The power curve, P in Fig. 4, shows equal positive and negative periods. The shaded areas represent power × time, or energy. So we see that in each current cycle there is first a wad of energy going out and then an equal wad of energy coming back. The circuit takes no energy as a gift; it borrows and then immediately repays in full. This, of course, is no virtue—merely lack of opportunity. The circuit has no means (such as resistance) for permanently disposing of any energy. To the question, where does it go temporarily, the answer is, into the magnetic field. A field—magnetic or electric—is stored energy. While the current is flowing *with* the generator e.m.f. it is building up a magnetic field—either positive or negative, according to the direction of the current through the circuit—and while it is flowing against the generator e.m.f. it is being driven by the energy of the now collapsing field.

Spread of the Field

Having been so critical of other people's inaccuracies, I must confess than the foregoing is not perfectly accurate, for it is based on an untrue assumption. The assumption is that the field is everywhere exactly in phase with the current, as shown in Fig. 2. But, theoretically, the field fills the whole of space, and the more outlying parts of space cannot know what the current is doing immediately it does it. At the very fastest, the news cannot travel quicker than light, for, according to Einstein, the universe is so constructed that no greater speed is possible. That is, in fact, the speed at which the growth of the field does spread out through empty space. Being 186,288 miles per second, it doesn't take long to spread the field to the greatest distance likely to be of practical interest. So the current in the circuit has to grow very rapidly indeed to catch any part of the neighbouring space by surprise, as it were.

Now this is the point where things tend to become rather difficult to grasp. Let us first consider how the magnetic field would be distributed if the current had been raised to a certain amount and kept there long enough for the momentary spreading effect to be past. Much the strongest part of the field is inside or close around the coil. Beyond that it falls off at an increasing rate, until when it is well outside—say five or six times the diameter of the coil—it is approximately inversely proportional to the cube of the distance. So at a hundred times the diameter it would be only about one-thousandth as strong as at ten times; at a thousand times, one-millionth; and so on. But we need hardly bother about the "and so on," for any of this steady field that lies much beyond, say, one thousand times the dimensions of the circuit maintaining it is for most purposes negligible. For example, the field from a 1-inch coil could be regarded as being all within a radius of 1,000 inches, or, say, 100 feet.

Exit Some Energy

Now consider what happens if the current is varied, by using a.c. instead of d.c. At a distance of 100 feet, the variation does not become effective until 1/(186,288 × 52.8) sec, or about 0.1 microsecond, later. So when the current has reached its maximum—and likewise the field close to the coil—the field at 100 ft has still 0.1 μsec in which to continue growing. This effect can be represented by a delay of the Φ curve, with a corresponding delay of the E curve. Whether or not this delay would be worth considering would depend on the frequency of the a.c. At 50 c/s it would be only one-hundred-thousandth of a cycle. But at 1Mc/s it would be one-fifth of a cycle, or 72 deg. That is not to say, of course, that the induced e.m.f. as a whole would be delayed by anything like this amount; the strongest components, due to the close-in field, would be delayed much less. But it seems inevitable that there would be some delay, increasing with frequency. In Fig. 5 it is shown as amounting to 45 deg, to make it clearly visible; and when the power curve is plotted it can be seen that the balance between outgoing and incoming energy, noted in Fig. 4, no longer applies. More is going out than coming back. Where is it going?

Maxwell gave the answer when he showed mathematically that it was being radiated off as electromagnetic waves. What this signifies we shall see more closely in a moment, but meanwhile let us take stock of the position so far. So long as current is unvarying (d.c.) no energy can be radiated, for there is no e.m.f. (except what may be necessary to overcome the resistance of the circuit). When the current is varying slowly (low-frequency a.c.) there seems to be a possibility of radiation, but to such a small extent as to be negligible. But as the frequency is raised, it looks as if sooner or later the current would vary rapidly enough to cause an appreciable phase delay, with corresponding loss of energy from the circuit.

Well, of course, this is far too over-simplified to be a "proof" of anything; for one thing we have paid no attention to what has been happening to the electric field. Not only is there the field lagging 90° behind the current (since caused by its rate of change), which field corresponds to the E curve in Fig. 4; there is also an electric component caused by the outward movement of the magnetic field, and therefore in phase with it and the current. This electric field plays an essential part in radiation. Without it, there would be nothing to keep the magnetic field in existence during its journey through space. But since a varying magnetic field generates an electric field, and a varying electric field generates a magnetic field, the two keep one another continually in existence. Half

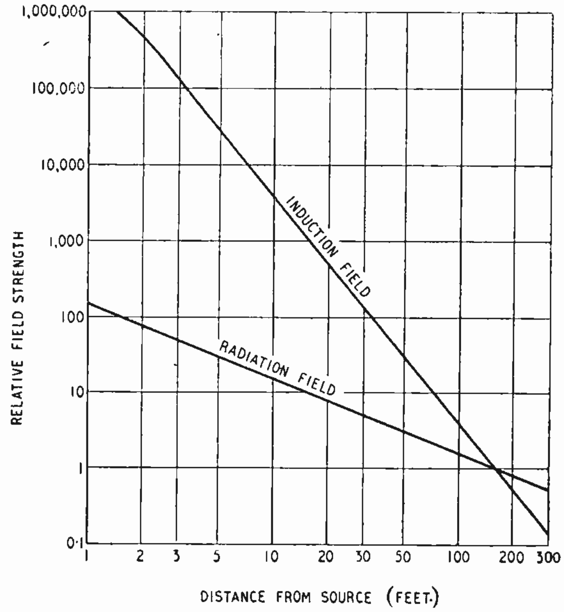


Fig. 6. Relative magnetic field strength at distances measured along the axis of a coil or loop 1ft in diameter energized by current at 1 Mc/s. The distance of the cross-over point (here 156 ft.) is proportional to wavelength.

the radiated energy in any piece of space is necessarily in the form of magnetic field and half in electric field. If one kind of field were in some way got rid of, the other would have to disappear, too. This is an important difference between radiated fields and induced fields (as the non-radiated variety is called) which as we saw can exist separately or in any proportion.

We have noted already that induced fields fall off very steeply with increasing distance from their source. Some books say inversely as the square, but that calculation does not apply to ordinary circuits, from which the fall-off is inversely as the cube of the distance. The energy locked up in a single radiated wave, if it is assumed to flow out equally in all directions like the surface of an expanding soap bubble, remains constant, but is distributed over an area proportional to the square of the distance from the source. Just as electrical energy is proportional to current × voltage, field energy is proportional to magnetic field × electric field, so either of these separately falls off in direct proportion to distance. Although close up to the circuit the induction part of the fields may be vastly stronger than the radiating parts, this situation becomes reversed at great distances. Suppose, for example, the source is a circuit 1ft in diameter, through which current is alternating at 1 Mc/s. Then Fig. 6 shows the relative strengths of radiation and induction at ranges up to 300ft along the axis of the loop. At 5ft the radiation is negligible, being only one-thousandth of the induction field strength. But at about 5,000ft or rather under a mile the proportions are reversed. The distance at which the cross-over takes place—where the induction and radiation fields are equal—is $\lambda/2\pi$, or a little less than one-sixth of the wavelength. In this case the wavelength is 300 metres, so the zone within which the induction predominates extends up to 156 feet from the source. On 1500 metres (Light Programme) it is 780 feet. Now it is quite exceptional for noise-making appliances to interfere seriously with broadcasting at greater distances than these, especially if it is remembered that the distance is not necessarily from the appliance itself but from the nearest wires, etc., connected to it. So radiation is seldom sufficient to cause trouble. The interference comes by induction.

"So what," you say, "as long as it comes?" Well, the difference between radiation and induction is not purely theoretical. The fields themselves are the same, of course. The difference is that whereas radiation *must* consist of equal electric and magnetic fields, induction can be both or either. Some kinds of screening protect against magnetic fields only or electric fields only; either will do against radiation, for radiated fields cannot exist separately. But this is not so for induction. A source of interference surrounded by an iron box has most of its outer magnetic field removed, to the great benefit of portable sets in the vicinity. But if the box is not earthed an appreciable electric field may remain, to the disadvantage of sets with "picture-rail" aerials. On the other hand, earthed graphite or tinfoil screening around a television set will greatly reduce the electric field from the line-scanning components, but the magnetic field from the deflecting coils will be practically unaffected, as the portable set with its frame aerial can show.

Motor ignition is rather a special case of interference source. It is most manifest on the television wavelengths, and $1/2\pi$ of a television wavelength is only about 3 feet. Viewers have no need to be told that the effective interference range of motor vehicles is not restricted to 3 feet. Therefore one can use the term "radiation" in this connection with complete confidence.

RAW MATERIALS OF RADIO

THE interplay of supply and demand is strikingly illustrated in the relations between the chemist and the radio technician, and the history of radio progress is punctuated by the advent of new materials, developed often to meet a specific demand, but not infrequently springing fortuitously from pure research.

Polyethylene, which had a profound influence on the wartime development of radar, was but one of a whole series of strange new products, synthesized by a very high pressure technique developed by I.C.I. for pure research. It owes it early recognition as a dielectric of outstanding performance to the fact that its mechanical properties resembled those of gutta-percha, for which it was first investigated as a possible substitute in submarine cables.

Nickel-iron alloys of high permeability and polycrystalline ceramic aggregates of various permittivities and temperature coefficients may be cited as examples of materials deliberately sought for specific requirements.

To facilitate the more rapid development of new radio materials, the Radio Research Board of the Department of Scientific and Industrial Research set up, in 1948, a committee on raw materials, to co-ordinate the efforts of academic, industrial and Government research laboratories in tackling the problems posed by the demand for materials having characteristics so far unattained.

Radio Research Special Report No. 25, "Selected Problems in the Preparation, Properties and Application of Materials for Radio Purposes" (H.M. Stationery Office, price 1s 6d), presents a survey of the position up to 1951, and serves the dual purpose of acquainting readers with existing special materials and of stimulating thought on possible new lines of development. It is divided broadly under the following headings: 1, Ceramics; 2, Organic polymeric dielectrics; 3, Magnetic materials; 4, Semiconductors. An appendix gives over 60 references to recent publications on these subjects.

Ignition Interference

Tolerable Limits at Television Frequencies; Effect of Suppressors on Engine Performance

A PAPER* read recently in London to a joint meeting of the Institutions of Mechanical and Electrical Engineers gave a fairly comprehensive survey of ignition interference as it affects television reception. Its causes have been extensively investigated and the customary means of suppression are discussed and from the motorist's angle the effect of fitting suppressors to motor car engines has been quite thoroughly investigated.

The exact mechanism of its generation is not always so well explained as it is in this paper. The energy stored in the self-capacitance of the plug, the high-tension cables and the ignition coil is very rapidly discharged and gives rise to an oscillatory current whose peak value may exceed 100 A, but lasting for less than a microsecond.

The interference radiated has the redeeming feature that, being a pulse type of signal at a very high frequency, its worst effects can sometimes be curbed by means of noise limiters in the receiver, but as there is a limit to what can be achieved in this way, suppression at the source is by far the most satisfactory cure. Thus a large part of the paper is devoted to this aspect of the problem.

Ignition System Layout

In the course of investigation it was revealed that interference from different types of vehicles varied between maximum and minimum levels of 6,000 and 20 μV per metre at 45-50 Mc/s. The curves reproduced show that of the tests made with a number of pre-1939 vehicles, those with the more compact ignition layout, exemplified by the coil mounted on the engine block (curve 2), produced appreciably lower interference fields than those vehicles with more spread-out ignition components. The corresponding curves for the post-1945 vehicles do not show the effect of different positioning of the parts, so that direct comparisons are not possible. However, there is only a slight general improvement in the curves for the newer vehicles and without suppressors of some kind the radiated interference exceeds the 50 μV per metre level at a distance of 10 metres from the source which is the maximum radiation now permitted from all motor vehicles manufactured after July 1st, 1953. It is defined in the latest regulations dealing with the suppression of interference, "The Wireless Telegraphy (Control of Interference from Ignition Apparatus) Regulations, 1952," and covers interference in the band 40-70 Mc/s.

It is mentioned as a passing comment that occasionally electrical equipment apart from the ignition system can be responsible for appreciable interference of a slightly different kind, but equally annoying. Screen-wiper motors, dynamos and such-like can all add their quota and this accounts for the complaints, often discredited, that diesel-engined vehicles sometimes interfere with television reception.

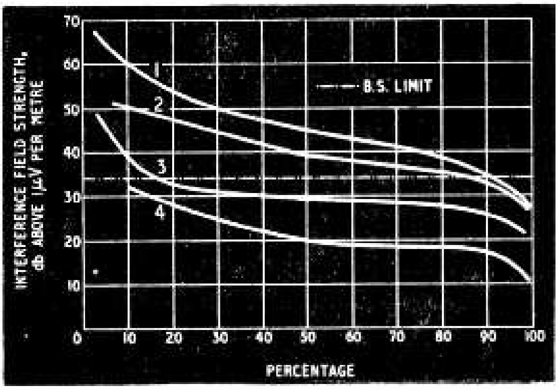
The effect of fitting resistance suppressors in the h.t. wiring of the ignition system is interesting and is stated to change . . . "the high-frequency discharge into a unidirectional one of much lower duration, with a reduction of peak current to less than one ampere. The amplitude of the current in the inductive or "flame" component (of the spark), on the other hand, is substantially unaltered since the normal parameters of the circuit limit it to milliamperes."

When discussing the question of the resistance values for ignition suppressors, it is stated that suitable values lie between 5,000 and 15,000 ohms, but that these are by no means critical.

It is significant that ignition component manufacturers are now considering embodying suppressors in the design of the component. For example, in one well-known make the high-tension brush consists of three parts, the two ends being of normal brush carbon and the centre of high-resistance material which forms the actual suppressor. This gives about the same degree of suppression as a single external resistor in the coil-distributor h.t. lead and satisfies most requirements.

With regard to the effect of suppressors on engine performance, it is stated that . . . "the evidence accumulated from carefully controlled tests made by engine and car manufacturers is that, for normal engines under normal operating conditions, suppression resistors have no effect on performance. Probably some of the prejudice against resistors has arisen from the effect they have in reducing the light in-

Field strength in db above 1 μV per metre of interference generated by pre-1939 motor vehicles on a percentage basis of vehicles tested. Curve 1, unsuppressed private vehicles; curve 2, unsuppressed vehicles with ignition coil on engine block; curve 3, with suppressor in coil-distributor lead and coil on engine block; curve 4, with coil-distributor and plug suppressors. The horizontal broken line is the 50 μV metre at 10 metres level.



* "Ignition Interference with Television Reception," by A. H. Ball A.M.I.E.E. and W. Nethercot, B.A., B.Sc.

tensity from the spark, but it cannot be emphasized too strongly, however, that the brightness of a spark is not a criterion of its incendivity."

Typical results on the effect of resistors on engine output are given in the table, which relates to a fairly high-performance four-cylinder overhead-valve engine of $1\frac{1}{2}$ litres capacity.

The general conclusions that emerge are that the effect of ignition suppressors on engine performance is negligible and that a single suppressor in the coil-distributor h.t. lead generally gives adequate suppression.

As in the great majority of cases fitting suppressors is still voluntary, an important inducement, if one should be needed, is that suppressors lead to a reduction in plug erosion and so give a longer useful life.

TABLE

Engine Speed r.p.m.	B.h.p. output	
	Without resistors	With 10-kΩ to 15-kΩ resistor at distributor and each plug
1,000	13.5	13.5
1,500	22.1	21.9
2,000	30.0	29.9
2,500	36.8	37.1
3,000	42.5	42.9
3,500	45.9	45.9
4,000	46.7	47.2

R.E.C.M.F. SHOW

WE give below a list of the 120 stand-holders at the exhibition of components, test gear, valves, materials and accessories to be held in the Great Hall, Grosvenor House, Park Lane, London, W.1, from April 14th to 16th. This is the 10th annual show organized by the Radio and Electronic Component Manufacturers' Federation, and it will follow more or less the pattern of its predecessors. It is essentially a private exhibition, admission being limited to those who have a professional, industrial or trade interest in the equipment exhibited. Tickets, which are gratis, are obtainable from the R.E.C.M.F., 22, Surrey Street, London, W.C.2.

The catalogue of the exhibition, which will be available at the show or from the R.E.C.M.F. (price 1s) includes a classified buyers' guide to the equipment manufactured by the members of the Federation.

	Stand No.
A.B. Metal Products	64
Advance Components	56
Aerialite	12
Antiference	50
Associated Technical Manufacturers	75
Automatic Coil Winder Co.	105
Bakelite	74
Belling & Lee	52
Bird, Sydney S., & Sons	78
Birmingham Sound Reproducers	15
Bray, Geo., & Co.	89
British Electric Resistance Co.	70
British Insulated Callender's Cables	73
British Mechanical Productions	66
British Moulded Plastics	114
Bulgin, A. F., & Co.	45
Bullers	5
Carr Fastener Co.	25
Clarke, H., & Co.	87
Collaro	19
Colvern	51
Connollys	76
Cosmocord	59
Daly	99
Dawe Instruments	32
De La Rue & Co. (Plastics)	108
"Diamond H" Switches	3
Dubilier Condenser Co.	68
Duratube and Wire	46
Edison Swan Electric Co.	62
Egen Electric	79
Electro Acoustic Industries	40
Electronic Components	93
Electronic Engineering	102
Electrothermal Engineering	83
English Electric Co.	95
Enthoven Solders	34
Erg Industrial Corporation	112
Erie Resistor	26
Ever-Ready Co.	103
Ferranti	37
Fine Wires	118
Garrard Engineering Co.	69
General Electric Co.	100
Goodmans Industries	31
Gresham Transformers	98
Guest, Keen and Nettlefold	101
Hallam, Sleigh & Cheston	85
Hassett and Harper	111
Hellermann Electric	71
Henley's, W. T., Telegraph Works Co.	2
Hunt, A. H.	22
Igranic Electric Co.	6
Imhof, Alfred	38
Jackson Bros.	4
London Electrical Manufacturing Co.	44
London Electric Wire Co.	110
Long & Hambly	11
Magnetic & Electrical Alloys	63
Marconi Instruments	96
Marrison & Catherall	104
McMurdo Instrument Co.	58
Micanite & Insulators Co.	113
Morganite Resistors	47
Mullard	20
Mullard Overseas	115
Mullard (Valves)	120
Multicore Solders	41
Murex	13
Mycalex Co.	86
N.S.F.	55
Neill, James, & Co.	116
Painton & Co.	24
Parmeko	21
Partridge Transformers	57
Plessey Co.	42
Plessey International	72
Pye	94
Reliance Electrical Wire Co.	10
Reslosound	29
Rola-Celestion	36
Salford Electrical Instruments	49
Scharf, Erwin	77
Scott, Geo. L., & Co.	84
Simmonds Aerocessories	82
Stability Radio Components	33
Standard Telephones & Cables	27
Standard Telephones & Cables (Valves)	67
Static Condenser Co.	92
Steatite & Porcelain Products	35
Suflex	8
Supply, Ministry of	97
Swift, Levick & Sons	107
Symons, H. D., & Co.	91
Tannoy Products	65
Taylor Electrical Instruments	1
Taylor Tunnicliff	117
Telegraph Condenser Co.	48
Telegraph Construction & Maintenance Co.	28
Telephone Manufacturing Co.	14
Thermo-Plastics	9
Transradio	90
Truvox	61
Tucker, Geo., Eyelet Co.	119
United Insulator Co.	7
Vactite Wire Co.	109
Vitavox	39
Walter Instruments	80
Wego Condenser Co.	30
Welwyn Electrical Laboratories	54
Westinghouse Brake & Signal Co.	23
Weymouth Radio Manufacturing Co.	16
Whiteley Electrical Radio Co.	18
Wimbledon Engineering Co.	81
Wingrove & Rogers	53
Wireless Telephone Co.	43
Wireless World and *Wireless Engineer*	106
Woden Transformer Co.	60
Wolsey Television	88
Wright & Weaire	17

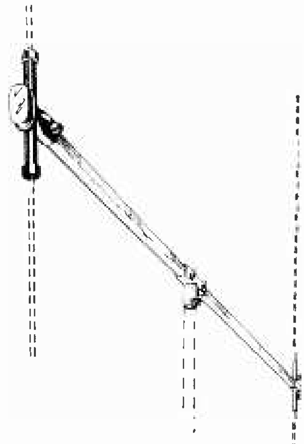
Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Television Aerial Developments

A MODIFICATION which, although apparently trivial, may have quite a marked effect on the general reliability of the aerial has recently been adopted by Wolsey Television, Ltd., 75, Gresham Road, Brixton, London, S.W.9. This consists in replacing the usual round-section "Tee" fittings on the ends of the crossarm and the pole-cap fitting by square sections.

The change is said to have the following advantage: with an "H"-type aerial the vertical elements cannot slip round the crossarm and become badly misaligned; the whole aerial cannot rotate on its pole and change its orientation and the two quarter-wave reflector rods can be assembled before leaving the factory. This last change means that the erection on the site is simplified since these elements have only to be turned to the



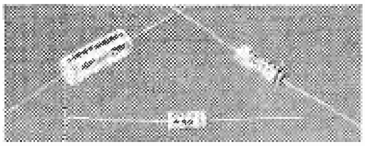
New square-section crossarm fittings used on Wolsey television aerials keep all elements properly aligned and the whole correctly orientated.

vertical and locked in position by two wing nuts. The supporting pole is secured by a bolt and wing nut.

Single element aerials will also benefit, but perhaps to a lesser degree except in the case of horizontal aerials for the low-power stations. The square ends may prevent the elements sagging. The same type of fittings are to be used on all Wolsey aerials.

Polystyrene Capacitors

ALTHOUGH polystyrene-insulated capacitors have been in existence for some time certain restrictions have been imposed on their use



Suflex polystyrene capacitators.

by the comparatively low operating temperature of this material.

By a new process of manufacture Suflex, Ltd., 35, Baker Street, London, W.1 have produced a polystyrene capacitor claimed to be stable over the range of temperatures −40 deg C to +85 deg C.

Other advantages claimed for this type are:—insulation resistance 10 million megohms; power factor 0.00025 and stability of capacitance 0.1 per cent. They are enclosed in moulded polystyrene and have end connecting wires.

The new capacitors are available in values ranging from 5 pF to 5,000 pF and for working voltages of 125, 250 and 500 d.c. A 500-V 1,000-pF type measures $\frac{15}{16}$ in long and $\frac{3}{8}$ in in diameter while one of 400 pF for 250 V is $\frac{15}{32}$ in long and $\frac{7}{32}$ in in diameter.

Conductive Ceramic

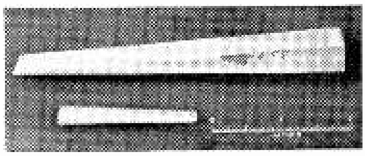
A NEW material for use as a dummy load, or as an attenuator, for absorbing power at centimetric and millimetric wavelengths in waveguides has been introduced by The Plessey Co., Ltd., Ilford, Essex.

It is a form of conducting ceramic called Caslode and is a homogenous substance of high intrinsic resistivity which does not contain dispersed conductive particles. At a wavelength of 3.2 cm its dielectric constant is about 20 and the loss angle 10 to 20 deg.

During manufacture the material is fired at a high temperature to form a structure which is stable under extreme conditions of temperature and humidity.

High-power dummy loads of this material have been used as matched terminations for waveguides without recourse to water cooling.

A Caslode attenuator pad is still in the experimental stage, but units have been produced having an attenuation of 28 db with a match of 0.95.



Wedge-shaped dummy loads of Caslode for use in waveguides.

RANDOM RADIATIONS

By "DIALLIST"

Cathodic Protection

MY BEST THANKS to the several experts in cathodic protection who have written to supplement my note in the February issue of *W.W.* My information came from a friend who, though not a technical man, has a better-than-average working knowledge of electricity. We discussed the subject at some length after his recent return from the Persian Gulf, but I was pretty sure that I hadn't got quite the whole story. Readers now tell me that the metal generally used for the negative elements is not aluminium, but a special magnesium alloy. I ought, anyhow, to have spotted that the action of sea-water on steel piers is *electro*-chemical. It's bound to be, when you come to think of it. Sea-water contains many salts in solution, the original molecules being dissociated into their component atoms and radicals in the form of positive and negative ions. When one considers that the negative ions must consist to an important extent of halogen atoms as eager to be up and doing as chlorine and bromine, and of such active radicals as SO_4, it's no wonder that unprotected steel piers suffer!

Electronic Fish-finding

SOME READERS have written asking me to say a bit more about electronic and electrical fishing. Well, here's a summary. Electronic gear is regularly and successfully used by our modern fishing vessels to enable them to locate shoals of fish. The echo-sounder gives quite good results, but the best gadget yet is the German Fischlupe (or "Fishscope"). In the "search" position this gives a small-scale picture on a c.r. tube of the water, from surface to seabed, in the neighbourhood of the vessel using it. A shoal of fish then appears as a luminous patch. Turning a switch changes the picture into a large-scale one of a small area and a knob enables the shoal to be centred on the screen. Its depth can be read direct from a scale and the kind of fish of which it is composed can be determined with fair certainty; for the shoal now appears as a collection of luminous points, each representing the echo from one fish. The depth of the shoal, its extent and shape, the formation in which the fish swim and their size as shown by the individual echoes, give the expert fisherman all the indications that he needs.

Another Fish Story

The actual capture of fish by the use of an electric field has not got beyond the small-scale experimental stage at sea. It has been used, however, in trout streams for some little time as the most effective method known of ridding such waters of cannibals, predatory fish, diseased fish and other undesirables. The principle is this: in a direct field fish are attracted towards the positive pole and repelled from the negative; if the field exceeds a certain intensity, they are temporarily stunned, recovering quickly when the field ceases to exist. One method is to connect the negative terminal of a generator on the bank to a vertical metal plate in the water by means of a cable; the positive terminal is similarly connected to a kind of large landing net, made of wire mesh and handled by a man in a punt. Fish swim into the net and the unwanted are easily disposed of. The other method uses a field strong enough to stun fish. The undesirables having been picked out, the generator is switched off and a move made to another stretch of the river. Neither method should be used before preliminary experiments on a very small scale have been made to determine the effects produced by fields of different intensity. Otherwise, there is a real risk of causing serious injury to immature fish—and even to the fisherman himself. It is interesting to note that the application of low-intensity fields has proved of great value in some of the salmon rivers dammed under the Scottish hydro-electric scheme. Salmon running up from the sea are kept out of the dangerous tail-races of power stations by negatively charged gratings, whilst positively charged gratings guide them irresistibly to the fish-passes provided for them. Similar arrangements prevent the young salmon smolts on their way down to the sea from being drawn into the intakes of power stations.

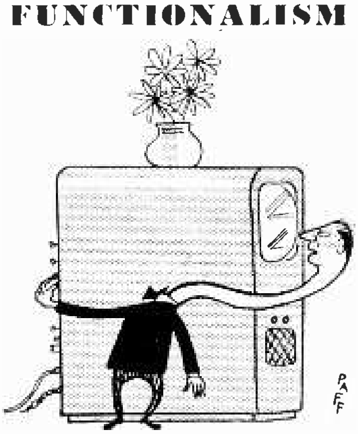
F.M./A.M. Reception

AT THE MOMENT I am busy arranging for the installation of a receiver for the B.B.C.'s transmissions from Wrotham. (I wonder, by the way, how many of *W.W.'s* far-flung army of readers are puzzled about the pronunciation of that queer-looking name! It's Root-um, the accent being on the first syllable.) I live inside the 3mV/m contour, which means that nothing very special will be needed in the way of an aerial; in fact, what I'm putting up is almost too simple to be true—but I think it will work all right. What I'm doing is just this. To a convenient chimney stack a piece of well-painted two-by-two wood, just over five feet in length, is being firmly fixed. From the frame of the window near which the set will stand a length of ordinary p.v.c.-covered flex runs up to the wooden cross-piece on the chimney. There, the two leads are separated. One runs out on small insulating cleats to the right; the other to the left. And there, provided the dimensions are right, I should have an effective weather-proof and cheap horizontal half-wave dipole. Useful formulæ for calculating the dimensions of dipoles are given in the *Wireless World* Diary.

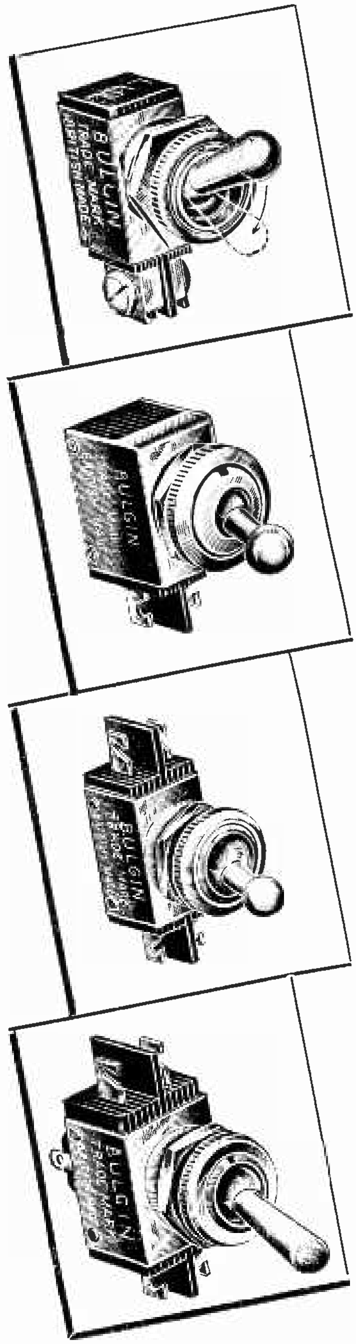
Widecombe Fair?

B.B.C. TELEVISION ENGINEERS tell me that a new O.B. unit will enable viewers to see events in the West Country and in Wales. That's first-rate news, for one of the most worth-while jobs that television can do is to show each half of our world how the other half lives. The West Country should be a rich hunting ground for O.B. producers. Right away I can think of Hungerford's Tutty Men, of the Floral Dance at Helston, of the Devon and Somerset Staghounds, of pilchard fishing, of Cornish wrestling, of Army and Air Force happenings on Salisbury Plain, of Widecombe Fair . . . I could go on and on. And then Wales, with its Eisteddfod, its industries, its mountain climbing, its hill farming and the marvellous bird-life of its off-shore islands. I've always maintained that broadcasts of interesting current events are one of the most attractive possibilities of television. Every use should be made of O.B.s and of mobile film units and their coverage of the whole country should be extended as rapidly as possible.

FUNCTIONALISM



After a while you grow used to the knobs at the back.



UNBIASED | By FREE GRID

Home Recording

IT WOULD appear from recent correspondence in the columns of *Wireless World* that for a long time I have been guilty of robbing authors, composers and others, whose works the B.B.C. broadcasts, of the few crusts that their toil brings. For a very long time I have used a tape recorder, operated by a time switch, for the sole purpose of enabling myself to enjoy the breathless excitment of Mrs. Dale's Diary in the evening when I got home. I have always regarded this as, in the words of the Editor, "a delayed method of radio reception."

Even if I am quite wrong in my views I intend to continue doing it. I make no pretence that I record daytime programmes for any other purpose than that of entertaining myself, Mrs. Free Grid and any friends that may be sharing my evening bread and margarine. If I am legally in the wrong I have little doubt that the injured parties will invoke the law to redress their grievances. If Mrs. Dale or her creator would like to make a test case of me I am perfectly willing that they should do so. There is no question of my recording items for private study, research, criticism or any other kind of hypocritical under-the-counter equivalent. I do it for entertainment and for that alone.

The time is coming when every radio receiver will have a built-in tape recorder and time switch so that pre-selected items can be recorded for later consumption by the set owner. The sooner the makers of laws and moral codes recognize this fact the better. I have often wondered why such all-in "receiver-corders" are not manufactured as there is no technical reason why they should not be. It is, I suppose, either patent rights or copyright which stands in the way. Probably it is a bit of both. It may be, therefore, that I am infringing patents as well as copyright and I must remember to ask the court to take this additional offence into consideration when assessing damages.

An additional offence.

S.O.S. on Land

NATIONAL DISASTERS involving great loss of life such as the Harrow train smash six months ago forcibly bring home to us what very poor use we make of modern radio communication technique. We have heard a lot of talk of costly automatic signalling systems, which will take a long time to install even if eventually decided upon, but nobody in authority seems to have pointed out that by the use of very simple radio methods a repetition of this type of disaster could be avoided.

Every train is already provided with its emergency communication cord whereby anybody on the train can quickly, and simply, bring it to a standstill. There seems to be no reason why this system could not be operated by a short-wave radio signal from any neighbouring signal box by applying well-known and well-tried telearchic techniques. The simplest of transmitters, set in action by merely pushing a button, is all that would be needed in the signal box.

It would also be possible for each platform of every station to be provided with two or three operating posts of the same type as the familiar street fire alarm. Operation of one of these by any railway employee who saw the approach of danger would set the signal-box transmitter at work. Had this been available at Harrow, the station master, who heard the third train approaching, would at least have had a chance of preventing the second collision.

Of course, the effect would be to bring to a standstill every train within range of the transmitter and a false call made by some unnecessarily anxious official could waste a lot of time and money. Such cases would be rare, however, and the wastage small compared with the benefits.

There are plenty of objections to the idea, both technical and otherwise, and it is up to those who see the snags to put forward improved ideas. One obvious objection is that if the receiver on a train failed through a minor fault the system would become valueless. There is, however, no technical difficulty in arranging that the radio relay on the train normally held the emergency brake in the "off" position so that the development of a fault would result in the stopping of the train.

Ar Hyd y Nos

WE HAVE read a lot in the newspapers about what is being done to enable the coronation pageantry to be seen by the privileged ones inside the Abbey and by those who can afford the price of a seat on the processional route, complete with champagne lunch. I see that some of the plutocrats of Pall Mall are to have jam on it, as a television set, complete with hooded screen to shut out the daylight, is to be fitted in front of each seat so that the ceremony in the Abbey can be seen as well as the procession.

But nothing whatever seems to have been done for impecunious proletarians like myself who will be compelled to spend a chilly night on the kerb daydreaming like an outward-bound sailor of the home comforts we are missing. It is true that the streets are to be liberally supplied with loudspeakers so that we bankrupt bacteria can be kept acquainted with the progress of the day's pageantry. Nobody seems to have suggested that these loudspeakers should be kept going throughout the preceding night to revive our flagging spirits and our flag-wag-weary bodies with music and song.

Home comforts.

I cannot doubt, however, that commercial interests will take advantage of such a splendid opportunity and I am taking my personal portable along to pick up Radio Luxemburg which, I feel sure, will be on the air. The programme sponsors will certainly have the good sense to start the night's entertainment with a choir of Welsh singers, and what more appropriate signature tune could they use than Ar Hyd y Nos ("All through the Night").