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A MINISTER FOR SCIENCE

ENGINEERS have noted with considerable interest the British Government's appointment of a Minister for Science. The new Minister, the Rt. Hon. Viscount Hailsham, M.A., Q.C., will be responsible for "ensuring that science and technology play a larger part in the nation's life," and will continue to have the same responsibilities which he had as Lord President of the Council; namely, for the Research Councils (D.S.I.R., Medical Research, Agricultural Research, etc.), and for the British space research programme—notwithstanding the new Government's formation of a separate Ministry of Aviation.* The only change would seem to be that Lord Hailsham will now also be responsible for the Atomic Energy Office.

Addressing science correspondents on 21st October last, Lord Hailsham said that he viewed his task essentially as a long term project requiring the fullest collaboration from other Government departments. He continued: "I do not think it is necessarily a disadvantage that I am not a professional scientist. In the main, Parliamentary Government is Government by amateurs advised by experts. I believe that the appointment of a non-scientist as the first Minister will compel scientists to do the most urgent thing, that is, to share in the thought about scientific policy themselves.

"In some ways the focus of scientific opinion in this country is the Royal Society. But for the purpose of advising the Government, the Advisory Council on Scientific Policy provides one of the keys to the present situation, composed as it is of a unique connection of Government and non-Government scientists under an independent Chairman. I shall endeavour to rely more than ever upon the A.C.S.P. for generalized advice on questions of scientific policy."

Membership of the House of Commons has for some years shown increasing representation from the legal and medical professions and for an even longer period has included a fair muster of business men and trade union officials. In more recent years a few scientists and engineers have successfully embraced political life, but the number has been comparatively small.

At all events, the professional radio and electronics engineer may derive particular satisfaction from the fact that electronics was especially mentioned in the terms of reference announcing the new appointment.

Engineers and scientists have, of course, been drawn into corporate participation in Parliamentary matters affecting science and technology through the Parliamentary and Scientific Committee. Although the proportion of M.P.'s belonging to this body is not large (180 members of both Houses) it does provide an opportunity for those who do so to learn of scientific matters from authoritative sources. The Institution is proud of having been one of the first professional bodies to obtain membership of the Parliamentary and Scientific Committee, and of being associated with the arrangements for the Committee's first Conversazione which will be held at the Royal Society on 9th December next. This occasion will provide an opportunity for scientific matters to be discussed and so create within Parliament the informed body of opinion which must exist if the Minister for Science is to put his long term policies into effect.

* This is a new department which has taken over civil aviation from the Ministry of Transport and Civil Aviation, and military aviation from the Ministry of Supply which has now ceased to exist.

INSTITUTION NOTICES

H.M. Queen Elizabeth the Queen Mother visits Reed's School

Her Majesty Queen Elizabeth the Queen Mother visited Reed's School, Cobham, on Wednesday, November 11th, and opened the new boarding houses.

Members will know that through the Benevolent Fund the Institution has supported Reed's School for many years, and the Trustees of the Fund have been responsible for the admission of several children of deceased members.

Until 1955 two Schools existed—one for girls in Hertfordshire, and one for boys in Surrey. Unfortunately, rising costs and lack of sufficient funds forced the girls' school to be closed. This decision was obviously taken with great reluctance and was much regretted by all who supported the Schools. Nevertheless, it was appreciated that it would be far more beneficial to apply available financial resources to maintaining a high standard of accommodation and education at one school, rather than endeavouring to maintain the two schools with reduced standards.

The Governors have, therefore, been able to concentrate on much needed improvements to the Boys' School, culminating in the building of the new boarding houses. The School is now able to accommodate 250 boys of grammar school standard, and education is provided up to G.C.E. Advanced Level in arts and science subjects.

The Institution was represented at the Opening Ceremony on November 11th by the President. Professor E. E. Zepler had the honour of being presented to Her Majesty.

Additional Institution Meetings in London

The Programme and Papers Committee has arranged for a particularly notable paper to be presented on Wednesday, 13th January next, in place of the previously announced discussion meeting. Dr. G. T. Wright, of the University of Birmingham, will read his paper entitled "A Proposed Space-Charge-Limited Dielectric Triode." This is the first disclosure of information outside Birmingham on the extension of the author's work to the design of a triode.

The Committee is also pleased to announce that on Thursday, April 7th, Mr. H. A. Binney, C.B.E., Director of the British Standards Institution, will speak on "The Work of the B.S.I. in relation to the Radio and Electronics Industry."

Both these meetings will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, starting at 6.30 p.m. Details of other arrangements for the second half of the session, as well as the programme of Local Sections, will be sent to all members during December.

The 1960 List of Members

The 8th issue of the List of Members of the Institution contains the names of all corporate members, Companions, Associates and Graduates, and will be sent free of charge to these members at the end of next month. Registered Students, whose names are not included in the List, may obtain copies from the Institution, price 5s. each. To facilitate despatch, Students are requested to complete the special order form included in the October issue of the *Journal*.

Physical Society Exhibition

The 1960 Physical Society Exhibition will be held at the Royal Horticultural Society's Halls, Westminster, London, S.W.1. from Monday, 18th January to Friday, 22nd January, 1960. The hours of opening will be as follows.

Monday,	10.30 a.m. to 7 p.m. (Members of the Society and sister institutions only, 10.30 a.m. to 2 p.m.).
Tuesday,	10 a.m. to 9 p.m.
Wednesday,	10 a.m. to 7 p.m.
Thursday,	10 a.m. to 7 p.m.
Friday,	10 a.m. to 3 p.m.

The Opening Ceremony will be performed in the New Hall on Monday, 18th January, at 11 a.m. by the President of the Society, Mr. J. A. Ratcliffe, C.B.E., M.A., F.R.S.

As in previous years, the Physical Society kindly offers special admission tickets to enable Brit.I.R.E. members to visit the Exhibition on the morning of Monday, 18th January. Members who wish to take advantage of this offer should write to the Institution without delay; requests for general tickets admitting at other times may also be made now. It should be noted, however, that tickets will *not* be despatched until a few days before the Exhibition.

A Gating Circuit for Single-gun Colour Television Tubes †

by

K. G. FREEMAN, B.SC., GRADUATE‡

A paper read on 3rd July 1959 during the Institution's Convention in Cambridge.

Summary: The requirements of an ideal gating circuit for use with single-gun colour television tubes and the limitations of some existing circuits are discussed. A new type of gating circuit which employs low-level gating of the red, green and blue video signals in conjunction with a wideband amplifier is described. Such a circuit is believed to have a performance superior to that of most existing circuits and by fairly simple modification is applicable to either reversing colour sequence, continuous colour sequence or to colour difference operation.

1. Introduction

For several years considerable interest has been shown in single-gun colour television display devices — in particular, the so-called Lawrence and "Apple" tubes—since they do not suffer from the problems of image registration, electron-gun characteristic-matching and black-level drift which are an unavoidable feature of three-gun displays such as the Shadowmask tube and three-tube projection systems. However, the three-gun display is able to operate directly from red, green and blue video signals, whereas the single-gun tube requires a more complex video signal in order to produce a satisfactory colour picture.

In a single-gun tube the electron beam must be shared sequentially between the three colour phosphors and the RGB signals have to be processed so that they are of a similar sequential nature. (In the Lawrence tube beam sharing is achieved by spot-wobble of the beam across the horizontal colour phosphors (giving a Reversing Colour Sequence e.g. the sequence RGBGRGBG) while in the Apple tube it is obtained by the horizontal passage of the beam across a vertical phosphor stripe structure giving a Continuous Colour Sequence, e.g. the sequence RGBRGB . .). Since frame and line sequential systems are unsuitable with existing standards—on account of brightness-flicker and line-crawl respectively—a dot-sequential signal must be used. This can be achieved in two ways.

(1) By "sampling" or "gating" the three primary colour signals at a high video frequency in synchronism with the passage of the electron beam over the phosphor stripes. A gating circuit can provide independent control of the three primary images in a manner similar to that of the three guns in a Shadowmask tube.

(2) By means of a "direct-decoding" system in which a composite video signal consisting of a luminance signal and one or more colour sub-carriers is used. The decoding of the composite signal is carried out as a result of the synchronous relationship between the chrominance signal and the sequential sharing of the beam between the colour phosphors. Tubes for this operation must be designed to give white light of the correct chromaticity when a constant signal is applied to the gun. The video circuit simplifications of the direct-decoding system may be considerable compared with the requirements for a Shadowmask or three projection-tube type of display.

Fundamentally, "direct-decoding" operation is the more logical way of using a single-gun tube, and the "sampling" or "gating" method may be regarded as an artificial simulation of the three-gun type of display.

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† Manuscript received 17th March, 1959. (Paper No. 524.)
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U.D.C. No. 621.397.334

In the early stages of development of a single-gun tube, phosphors with their efficiencies balanced to give white light under equal-excitation conditions may not be available. Moreover, the additional colour errors that are a feature of direct-decoding operation may make it very difficult to assess the inherent potentialities and limitations of the display device proper. In such circumstances it is therefore usually more informative to simulate three-gun operation by means of a gating circuit. This permits much greater flexibility of signal control, although—and this must be emphasised —such a technique is less efficient, and is too complex to be of much practical significance from a commercial point of view.

In order to retain definition in the final picture the sequential sharing of the electron beam between the three colour phosphors and the gating of the video signal must be carried out at a high video frequency. From considerations of dot-interlace and circuit simplicity it is usually most convenient to make the fundamental gating frequency the same as the colour sub-carrier frequency—which is 2·6578125 Mc/s for the British 405-line form of the N.T.S.C. system. However, it is possible that any multiple of the sub-carrier frequency which would produce dot-interlace (e.g., 7/5 times sub-carrier) might also be suitable.

2. Gating Circuit Characteristics

In order that the appraisal of the single-gun display device shall not be limited by shortcomings in the gating circuit it is necessary that the latter should have certain characteristics. Although, as will be seen, an absolutely perfect gating circuit is in practice neither necessary nor reasonably obtainable. The features which determine the quality of the picture derived from the circuit are as follows.

2.1. *Absolute Gamma*

Ideally the overall transfer characteristic of the gating circuit should be linear, i.e., the absolute gamma should be unity, so that the reproduction of a grey-scale by the gating circuit should be identical with that produced by a normal video amplifier on a standard monochrome cathode-ray tube. However, a small departure (say $\pm$ 10%) of the gating circuit gamma from unity would not be important.

2.2. *Differential Gamma*

It has been shown[1] that the limits of tolerance to gamma differences between the three channels are very small. Ideally all three channels should have identical absolute gamma, but in practice differences of the order of 4 per cent. would appear to be tolerable in laboratory work.

2.3. *Efficiency, Duty Cycle and Pulse Shape*

It is clearly most desirable that a gating circuit should produce sufficient output to give adequate picture brightness without loss of definition (other than that due to the tube itself), and in this respect there are several controlling factors.

(i) Since the tube must not be driven into grid current, the maximum drive to it is determined by the size of the grid base.

(ii) Because of increase in spot size with beam current, the definition is largely determined by the peak current.

(iii) The brightness of a given uniform area in the picture is determined by the mean beam current in that area.

In order to obtain maximum picture brightness with minimum loss of definition the peak/mean ratio of the sampling pulses must be as small as possible. The minimum peak/mean ratio for a sampling pulse of given width is unity and is obtained with rectangular pulses. For a train of such pulses the pulse width must be as large as possible.

A typical method of Lawrence tube operation is to use sine-wave switching of the beam across the horizontal phosphor stripes in conjunction with a Reversing Colour Sequence gating circuit. Figure 1 shows diagrammatically the switching waveform and pulses. In the absence of guard bands, or spaces, between the phosphor stripes, and with the switching amplitude as shown the theoretical gating pulse widths, in terms of a cycle of the switching waveform, are 120 deg. for each of the outer phosphor stripes, and 60 deg. for each of the two transitions

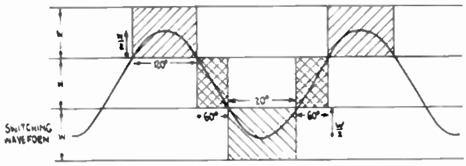


Fig. 1. Diagrammatic representation of reversing colour sequence operation of "Lawrence" tube.

across the central stripe. (For an ideal Continuous Colour Sequence gating circuit the pulse widths would be 120 deg. for each colour.) With 2·66 Mc/s switching frequency the pulse durations are approximately 120 and 60 millimicroseconds respectively. For the pulses to be substantially rectangular, rise-times of only a few millimicroseconds are therefore necessary. Such pulses are not very easily produced, and any circuits following their production would need to have a bandwidth of at least 100 Mc/s.

However, in practice it is usual to insert guard bands, or spaces, between the phosphor stripes to improve colour purity, and larger rise-times are then permissible. The circuit to be described was designed to have an overall rise-time of about 20 millimicroseconds, which enables the requisite amplifier gain to be obtained without recourse to distributed-amplifier techniques—the guard bands accommodating most of the rather slow pulse edge, as well as providing for the effect of finite spot size.

2.4. *Colour Cross-talk*

To some extent the requirement of freedom from colour cross-talk is a compromise with the requirement of high efficiency. If the pulses are too wide or their edges too slow cross-talk of one pulse on to the next will occur, leading to colour pollution. (This may also happen as a result of over-compensation in the amplifier stages following pulse formation.)

By making the pulses slightly narrower than their theoretically correct values (which are 120 deg. and 60 deg. for RCS operation) and ensuring that the guard bands can accommodate the edges, the colour purity requirement is not difficult to satisfy.

2.5. *Flexibility of Control*

It is evident that if high-quality simulation of three-gun operation is to be achieved the gating circuit controls should have adequate flexibility. The video drive and black-level controls of the three channels must be completely independent. The correct phase relationship between the colour selection by the beam and the gating pulses should be easy to achieve.

2.6. *Stability*

The circuit should be highly stable over long periods of time and fairly independent of valve capacitances or characteristics. Adjustment should be non-critical, e.g., the gating-process should not be highly dependent on the incoming reference frequency amplitude nor on the gain of pulse forming stages.

3. Limitations of Some Existing Gating Circuits

Several types of gating circuits have been described in the literature but they all have similar limitations so only the most important and widely known one, the Chromagate, and its derivations will be discussed briefly.

3.1. *The Original "Chromagate" Circuit*[2]

A number of versions of this circuit have been described, but in most cases the methods of operation are substantially the same. Reversing Colour Sequence gating is carried out at a high level in three output valves with a common anode load. In the earliest version the red, green and blue video signals were applied to the control grids of 6CD6 beam tetrodes, and gating performed by the application of a sine-wave signal to the screen-grids. In subsequent versions the video signals and gating waveforms are applied additively on the control grids of the output valves (6CL6 or EL84, for example). Fig. 2(a) is a block diagram of the circuit

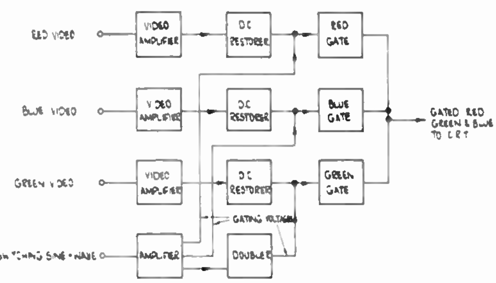


Fig. 2. (a) Block diagram of original Chromagate circuit.

and Fig. 2(b) shows how the output pulses are derived. Sine-wave of amplitude equal to twice the grid base is applied to the control grid of the gating valve, which is biased so that in the absence of a video signal the valve remains just cut-off. The presence of video raises the instantaneous bias voltage and the valve conducts

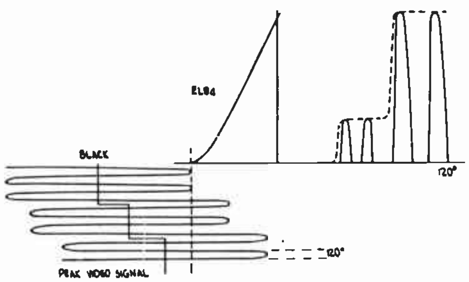
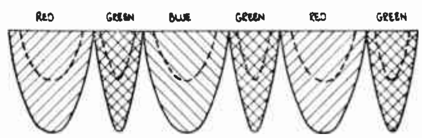


Fig. 2. (b) Derivation of gated pulses in Chromagate.



——— Peak Video Signals — — — Half Peak Video Signals

Fig. 2. (c) Output pulses from original Chromagate circuit for green centre stripe operation.

on the positive-going peaks of the sine-waves—120 deg. conduction occurring on peak video signals which drive the valve to zero grid voltage. (For reasons discussed in Section 2.4 a conduction angle slightly less than this is used in practice.) Fig. 2(c) shows the composite output waveform for equal red, green and blue video signals of peak and half-peak amplitude. For green centre-stripe operation the green gating valve is, of course, operated at twice the fundamental colour selection frequency.

This type of gating circuit has very severe limitations and does not meet the requirements previously stated for several reasons.

(a) Using 6CL6's or EL84's the peak output is limited to about 60 volts—which, in view of the low efficiency (a maximum of 68 per cent. on peak video) resulting from the pulse shape, is barely adequate for operation of a Lawrence tube.

(b) To obtain this 60 volts of output necessitates the use of the whole of the grid base of the output valve. In the case of the EL84 an additional absolute gamma of about 2·2 is introduced.

(c) The sine-wave pulse shape and the variation of conduction angle with video drive introduce additional overall gamma into the system, which is, however, largely mitigated by the presence of the gating valve and cathode-ray tube gammas—see Appendix.

Another consequence of using this type of pulse is the fact that the system does not in fact follow a true power law—see Appendix—and this may lead to differential gamma errors near black.

(d) The difficulty of accurately matching the characteristics of the three-gating valves can lead to the further introduction of differential gamma—which may be even more serious than that due to the gating pulse shapes.

(e) In practice the mutual inductance method of applying the sine-waves to the grids of the gating valves makes correct adjustment of the gating pulse phases and amplitudes very difficult.

(f) The performance of this circuit depends on the use of a constant gating sine-wave amplitude. This, together with the absence of independent black level controls, the difficulty of ensuring freedom from cross-talk, and the high gamma, make the circuit very unsatisfactory.

3.2. *Improved form of Chromagate Circuit*

An attempt was made to improve the performance of the Chromagate. Modifications included the addition of two sets of double-diode black-level clamps; individual black level controls, video gamma correctors and a built-in line-frequency sawtooth generator for rapid setting-up of the gamma correctors which appeared subject to drift.

The resulting complicated circuit, though better than the original Chromagate, was still unsatisfactory. The gamma correctors improved the absolute gamma, but introduced further differential gamma. Although better gamma correctors are now available, the other defects of the original circuit remain and there seems little to be gained by attempting further improvements.

3.3. *Colour Difference Gating Circuits*

It has been seen that one of the difficulties encountered in RGB gating is differential gamma error, which affects the grey-scale tracking. A method of overcoming this is to employ colour-difference-signal gating. A Chromagate circuit has been modified to operate in this way by Gow and Dorr[2]. The colour difference signals $R-Y$, $G-Y$, $B-Y$—derived from a decoder or matrix—are gated sequentially in the usual way and applied to the cathode of the c.r.t., whilst the luminance signal (Y) is applied to the c.r.t. control grid. Since the colour difference signals vanish for a monochrome signal the differential and absolute gamma of the gating circuit become of minor importance. However, since colour difference signals may be either positive or negative, the gating-circuit must be modified to take account of this—which involves increasing the signal handling capacity by at least 33 per cent., operating about the mid-point of the gating-valve characteristics and (preferably) balancing of the gating-circuit to give zero output for zero input colour-difference signals.

Fundamentally this type of circuit is better than the RGB gate, but its satisfactory operation necessitates phosphors with their efficiencies balanced to give white in the absence of the colour difference signals. The circuit therefore has a rather limited application.

4. The Low-Level Gating Circuit

It is clear that existing circuits suffer from a variety of defects, especially as regards output amplitude, efficiency and absolute and differential gamma.

The type of circuit likely to give a good performance is one in which the gating is carried out at a low-level, for example, by the sequential switching on-and-off of three linear amplifiers with a common anode load, followed by a wideband video amplifier with a bandwidth of the order of 30 Mc/s.

For the gating process it appeared possible that fast gating-pulse edges and linear performance could be obtained by means of some form of dual control valve, but most existing and readily available types are unsuitable on account either of the transfer characteristic shape or of the inter-electrode capacitances. (The latter had already been found a severe obstacle to an attempt to develop some form of cathode-coupled gate.)

4.1. *The 6BN6 Gated-beam Valve*

The requirement is fairly well met by the 6BN6 gated-beam valve, which provides a method of low-level high-speed video-gating, yielding pulses with fast edges and flat tops. Developed originally as a single valve f.m. limiter-discriminator, the 6BN6 is a dual-control valve of unusual design and performance[3]. Its chief feature is the fact that the first and third control-grids—known respectively as the limiter and quadrature grids—have similar characteristics—see Figs 3(a) and (b)—and a swing of about ten volts on either grid is sufficient to change the valve from a completely cut-off condition to one in which it behaves as a

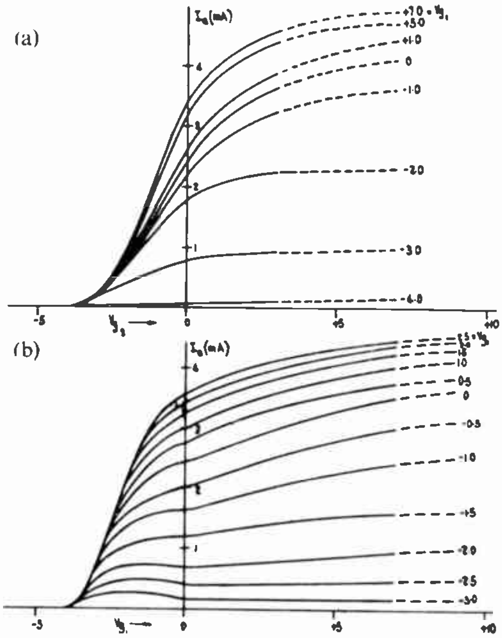


Fig. 3. 6BN6 characteristics $V_A = V_{G2} = 90V$. $V_{EK} = 0$.

(a) Quadrature characteristics.

(b) Limiter grid characteristics.

normal amplifier when modulation takes place on the other grid.

4.2. *Use of 6BN6 for Video Gating*

Figure 4(a) shows the basic circuit of the low-level gate using the 6BN6 and Fig. 4(b) the output pulses so obtained after wideband amplification. Half-sine-wave pulses are supplied to the limiter grid and clamped video to the quadrature grid respectively. Pure sine-wave is not recommended as the larger amplitude of fundamental present in this case leads to greater "break-through" on to the anode, which also occurs if the gating waveform is applied to the quadrature grid, due to the large g_3–anode capacitance (5 pF compared with g_1–anode capacitance of only 0·01 pF). As the limiter grid can be driven into appreciable grid-current a large amplitude of half-sine-wave pulse can be used, and since only a small portion of this is actually used to turn the valve on-and-off, output pulses with a rise time of about 15 millimicroseconds are obtained. The required output pulse width can be obtained by suitable bias of g_1, which is normally provided by the flow of grid current in the limiter grid-leak.

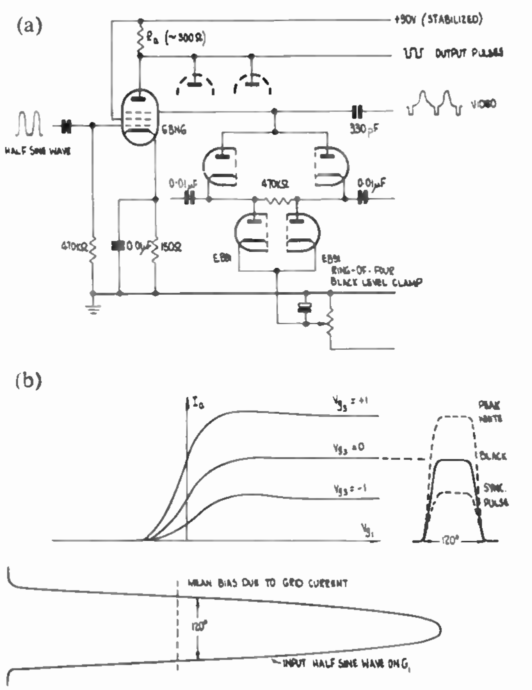


Fig. 4. (a) Basic gating valve circuit
(b) Method of obtaining gated pulse with 6BN6.

The methods of obtaining the half-sine-wave pulses will be described in Sections 5 and 6 since they differ for RCS and CCS operation.

4.3. *The Clipping Stage*

It will be seen that to obtain linear operation the quadrature grid must be biased in such a way that large residual pulses are produced in the absence of video information. This residual "black-level pedestal" makes true black-level clamping at the grid of the output stage of the wideband amplifier (see below) rather difficult to obtain, since a conventional clamp would operate with respect to the mean level of the "pedestal". To remove this pedestal from the composite signal a diode is used to catch the commoned anodes of the 6BN6's at a predetermined potential. Since a low capacitance diode with a forward impedance of only a few ohms is necessary two OA5 gold-bonded diodes in parallel were used as being the most satisfactory arrangement—see Fig. 5. However, the forward characteristic of the diodes has an absolute gamma of less than unity and this contributes to the overall absolute gamma with maximum "clipping". In the absence of clipping the quadrature grid characteristic of the 6BN6 produces a pulse envelope gamma of slightly less than unity. A level of clipping therefore exists which gives a substantially linear overall characteristic and with this most of the black-level pulse is removed. The residual pulse has not, in practice, proved very embarrassing, and with RGB gating is, of course, finally removed by the grid base of the cathode-ray tube. For colour difference opera-

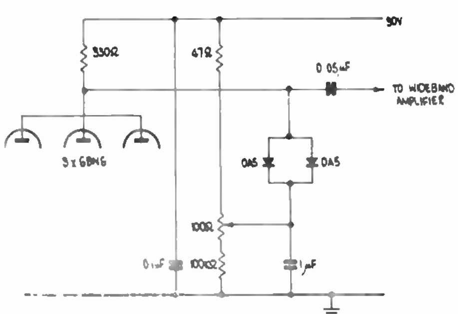


Fig. 5. The "clipping" circuit.

tion (to be described in Section 7) where negative signals need to be handled, clipping is not required.

4.4. *The Wideband Amplifier*

The 6BN6 is capable of handling up to $1\frac{1}{2}$ volts of video signal without significant distortion, but the low value of common anode load necessary to conserve the output pulse shape results in negative-going output pulses from the gate of only about $\frac{1}{2}$ volt peak amplitude. The design requirements for the wideband amplifier are therefore as follows:

(a) A gain of 200 to give 100 volt pulses on the c.r.t. cathode—which should be sufficient to meet all likely requirements.

(b) An overall rise time of about 15 millimicroseconds—giving an output pulse rise time of the order of 20 millimicroseconds.

(c) Linear amplitude response—to avoid introduction of absolute gamma.

(d) A negative-going output signal for driving the c.r.t. cathode.

Although a distributed amplifier is perhaps the obvious solution a four-stage cascade amplifier with a suitable output valve is simpler to construct and is capable of meeting the requirements. The use of clamped positive-going pulses on the grid permits the most economical use of the output valve. This is necessary as the total load capacitance (c.r.t., leads and strays) is about 15 pF, and the output anode load must be only about 400 ohms.

A current swing of 250 mA is therefore necessary to give the desired 100 volts of output. The QQVO6-40A double tetrode transmitting valve is very suitable in this respect as each section has an output capacitance of only 3 pF and provides a useful current swing of about 150 mA.

4.5. *Output Stage Black-Level Clamp*

In video amplifiers used in laboratory work on colour tubes it is desirable to employ black-level clamping. Although this can be done at the c.r.t. cathode it is more convenient in this case to clamp the control-grids of the QQVO6-40A, since much smaller clamp pulses are necessary and the valve is used more economically.

Unfortunately valves of this type tend to pass reverse grid-current. With the conventional form of black-level clamp the grid is virtually open-circuited except for the brief period when the clamp diodes are made to conduct, with the result that the flow of reverse grid-current causes a change of grid potential during line scan and hence a variation in black-level across the reproduced picture.

The insertion of a cathode-follower between the clamp (a ring of four diodes) and the QQVO6-40A grids obviates this difficulty since the grids then have a relatively low-impedance path to earth. It also has the added advantage of unloading the 22 pF input capacitance of the QQVO6-40A from the anode of the previous stage—enabling a 2 : 1 increase in wideband gain to be obtained.

The black-level pedestal is not completely removed by the clipping stage and the insertion of a 2·66 Mc/s trap between the cathode-follower grid and the upper end of the ring of clamp diodes has been found to improve the effectiveness of the clamping process.

4.6. *The Clamp Pulse Generator*

This is fairly straightforward in design. Separate valves (V21A and B) are used to produce the clamp pulses for the output stage of the wideband amplifier and for the quadrature grids of the 6BN6's respectively. The pulses are reasonably rectangular with a duration of about 4 microseconds (see Fig. 6).

5. The Reversing Colour Sequence Gating Circuit

Figure 6 shows the complete circuit of the reversing colour sequence form of the low-level gate. Most of its features have already been described apart from the methods of producing the half-sine-wave pulses applied to the 6BN6 limiter grids and of setting up the incoming sub-carrier amplitude using an indicator valve.

5.1. *Gating Pulse Formation*

Incoming sub-carrier (or other suitable colour-selection frequency) is amplified by V15 (see Fig. 6) and applied to V16 which has a double-tuned transformer, T1, in its anode circuit. The secondary has an earthed centre tap and the sine-wave potentials at each end are rectified by the OA81 diodes D2A, D2B, to give the half-

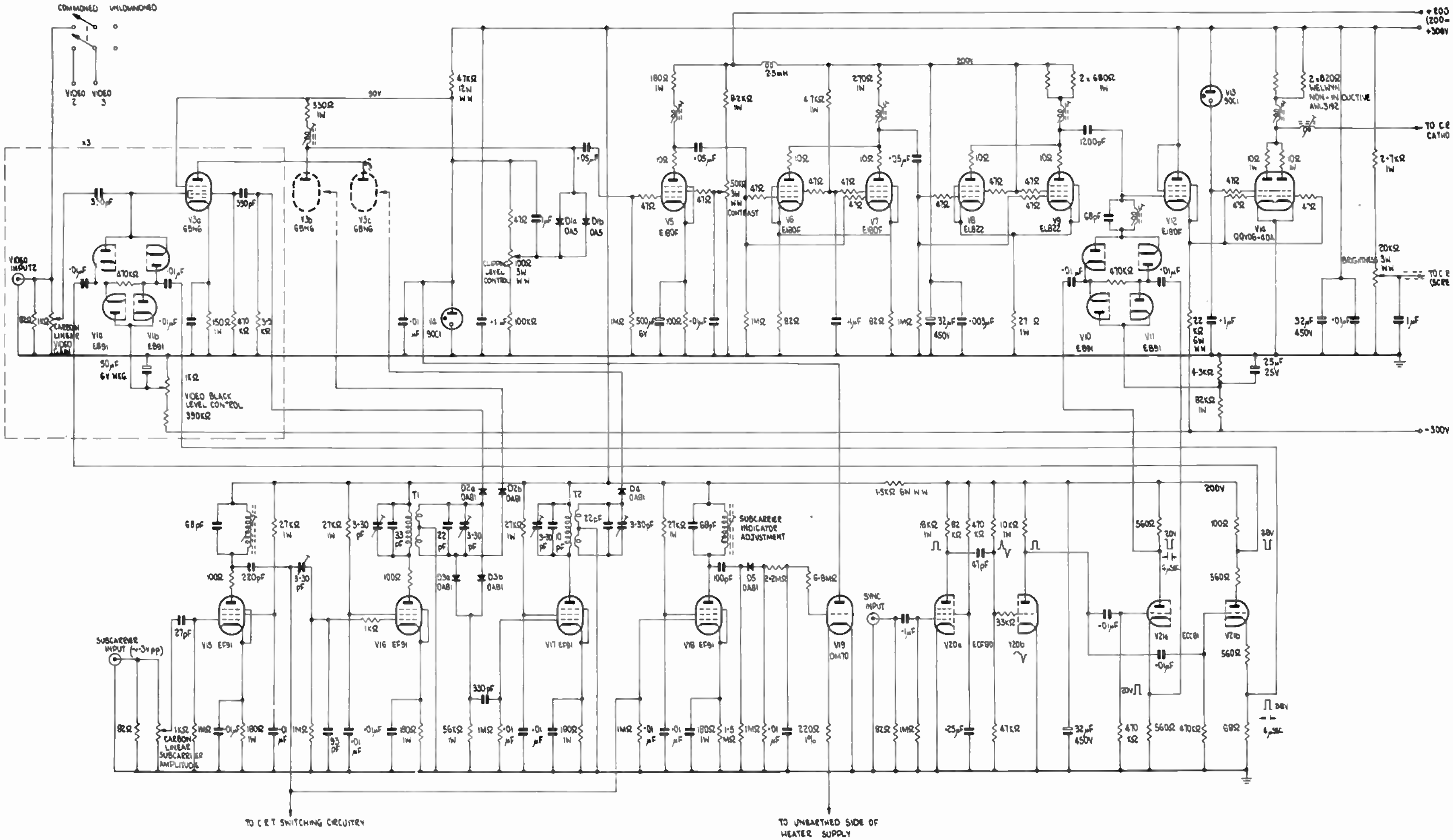


Fig. 6. Complete reversing colour sequence gating circuit.

sine-wave pulses described in Section 4.2. These pulses are in anti-phase and are used to gate the "outer-stripe" video signals. A second pair of diodes D3A, D3B supply both sets of pulses to V17, which has in its anode a similar transformer, T2, tuned to the second-harmonic of the colour selection frequency. From one side of the secondary T2 the diode D4 produces

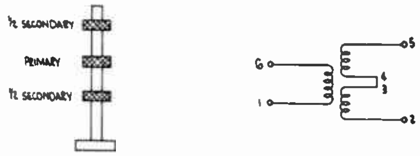


Fig. 7. Details of "pulse" transformers. Standard Aladdin former. Wire—40 SWG EN SS covered. Coil width 3/16". Douglas Wave Winder Gears: A, 48; B, 32; C, 34; D, 50; E, 40; F, 80.

Number of Turns.

	Fundamental Coils.	*Double Frequency Coils.*
Primary	90	70
Secondary (each half)	50	30

half-sine-wave pulses at the second-harmonic frequency which are used to gate the "centre-stripe" video signal. Since V17 introduces a 180 deg. phase-shift at the second-harmonic frequency—which is 90 deg. at the fundamental—no additional phase-shift is necessary to obtain correct RCS operation. Fig. 7 gives construction details of the two transformers.

5.2. *The Sub-carrier Indicator*

Although the performance of the pulse generator and gate is not critically dependent upon the amplitude of incoming sub-carrier it is nevertheless necessary to be able correctly to adjust the amplitude to give satisfactory performance and to accommodate appreciable variations in sub-carrier amplitude (e.g., in changing from local to B.B.C. sub-carrier sources). This is achieved by means of an input potentiometer in conjunction with a simple sub-carrier amplitude indicator. The latter consists of a further tuned amplifier (V18) the output of which is detected by the diode D5 and used to operate the DM70 tuning indicator (V19). In operation the input amplitude is increased until the main fluorescent column of the DM70 is just extinguished—this criterion being preset by suitably detuning or damping the tuned circuit of V18 when the sub-carrier amplitude is such as to give correct gating.

5.3. *Limitations of the RCS Gating Circuit*

The chief limitation of the circuit in its present form is the shape of the "central stripe" output pulses. With 2·66 Mc/s gating the pulse width is about 60 millimicroseconds, and as the pulses have an overall rise time of about 20 millimicroseconds the consequence is that although the "outer-stripe" pulses are reasonably rectangular the central-stripe pulses are almost triangular in shape. This results in a loss of efficiency for the central-stripe colour, but this is not important if an efficient central phosphor is used, and it otherwise appears to have little effect upon the final picture quality.

The overall absolute gamma of each channel has been measured and is approximately unity.

6. The Continuous Colour Sequence Gating Circuit

Apart from the method of production of the half-sine-wave gating pulses this circuit is the same as that for RCS operation. In normal CCS operation the electron beam spends equal times on the three phosphors, e.g., in the sequence RGBRGB. Thus a gating circuit for CCS operation need only produce a continuous sequence of pulses, each about 120 deg. wide. CCS operation can therefore be obtained by

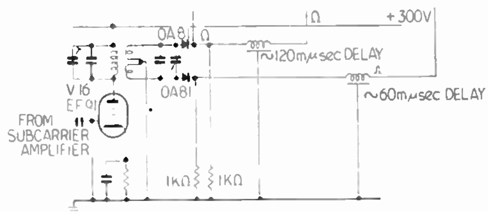


Fig. 8. Circuit for producing C.C.S. gating pulses.

taking a fundamental half-sine-wave pulse and using appropriate lengths of delay cable to obtain the three gating-pulses in the correct phase relationship. Apart from the slight effect of the delay cable the three half-sine-wave pulses will be identical.

Figure 8 shows the complete circuit modifications necessary to convert the RCS gating circuit to CCS operation. The delay cable used has a characteristic impedance of 1000 ohms and gives a delay of approximately 70 millimicrosec/ft with an attenuation of 0·3 db/ft at 10 Mc/s.

Although it is fundamentally better to obtain all three gating pulses by appropriate delay of a single pulse, it was found more convenient in practice to obtain the third pulse by delaying the pulse produced at the other end of the transformer secondary as shown. This enabled the delays of the second and third pulses with respect to the first to be more easily and independently adjusted without the need for several feet of delay cable.

7. The Colour Difference Gating Circuit

Where tubes with balanced phosphor efficiencies are available a further improvement in picture quality may be obtained by colour difference operation of either form of low-level gate. As pointed out in Section 3.3, differential and absolute gamma in the gating circuit is then of only secondary importance, since on monochrome picture areas the luminance signal is handled entirely by the separate luminance amplifier driving the grid, which being of normal video bandwidth may be made very linear. Since the colour difference signals may be positive or negative the gating circuit must be modified to take account of this by operating the 6BN6 gating valves and the QQVO6-40A output valve at the centre of their characteristics.

Although any combination of proportions of the red, green and blue signals may be chosen as the luminance signal the best choice is one which permits the most economical use of the gating circuit. For example, the use of the conventional luminance signal defined by $Y = 0{\cdot}30R + 0{\cdot}59G + 0{\cdot}11B$ is not the best choice since it leads to colour difference signals with a maximum excursion of $1{\cdot}78Y$ in the $B{-}Y$ channel. The most economical luminance signal is the so-called M-type defined by $M = \frac{1}{3}(R + G + B)$. The maximum excursion of the colour difference signals $R{-}M$, $G{-}M$, $B{-}M$ is then $^{4}/_{3}M$.

It is desirable that the output from the colour-difference gating-circuit should vanish on monochrome signals but in practice this does not appear absolutely necessary provided the output is constant. It is clear that on monochrome signals the output from the gating circuit will consist (for correct adjustment of colour-difference black-levels) of a train of pulses of constant amplitude, the peaks of which will correspond to black-level in the luminance channel.

The master gain control in the wideband amplifier in this case, of course, becomes the chroma gain control, and the gain control in the luminance amplifier (which follows monochrome practice apart from producing a positive going signal) performs the task of monochrome contrast control.

This colour difference operation of the low-level gating circuit is seen to be still far from perfect, but it has been used in Reversing Colour Sequence form on a balanced-phosphor Lawrence tube and excellent results have been obtained from this arrangement, the picture quality being limited only by the inherent disadvantages of the display device itself.

8. Noise

It is an inherent feature of gating circuits that high frequency noise in the video signal beats with the gating frequency to produce an unpleasant low-frequency shimmering effect. This is particularly noticeable on telecine operation, on account of the noise produced by the red-channel photomultiplier. The effect may be considerably reduced by the insertion at the input to the gating circuit of gating-frequency notch-filters, which need to be no more than simple series resonant circuits.

9. Conclusions

A new gating circuit for use with single-gun colour tubes and capable of providing near-rectangular video pulses up to 100 volts in amplitude has been described. Although not perfect, the new gate has been found to give a performance believed to be superior to that of existing types and is adequate for laboratory appraisal of single-gun colour tubes. Bright pictures with correct colour and grey-scale rendering are easily obtained.

From a study of the requirements and circuits that have been described it seems that in the absence of a revolutionary new technique, the provision of cheap and simple gating circuits for domestic single-gun colour tube receivers is only possible at the cost of severe degradation of picture quality.

10. Acknowledgments

The author would like to acknowledge the assistance given to him by Messrs. T. Jacobs and P. L. Mothersole at various stages of the development of this circuit.

The author also wishes to thank the Director of Mullard Research Laboratories and the Directors of Mullard Limited for permission to publish this paper.

11. References

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3. R. Adler and A. P. Haase, "The 6BN6—A gated beam tube", *Proc. Natl. Electronics Conf.*, **5**, p. 408, 1949.

12. Appendix

The Gamma of Sine-Wave Gating Pulses

The absolute gamma introduced into the system by utilizing cut-off portions of a sine-wave as gating pulses, as used in the Chromagate, is not a simple function and is worth considering in detail.

In the first place the area of these gating pulses is not a true power-law function of the video signal producing them so that strictly speaking it is meaningless to refer to the gamma of the pulses since this varies with pulse amplitude. However, the departure from a power law is only significant at video signals of less than 0·2 peak, so for purposes of comparison it is sufficiently accurate to regard the "effective gamma" as the mean value of "gamma" between half-peak and peak video signal.

A second, and more interesting feature of this type of gated pulse is the fact that the effective contribution of the pulses to the overall system gamma is a function of the total gamma following pulse formation. The pulses consist of the tops of a constant amplitude sine-wave, 120 deg. conduction being obtained on peak video. The pulse equation is therefore

$$\varnothing = [\sin\theta - (1 - \tfrac{1}{2}V)]$$

for

$$\sin^{-1}(1 - \tfrac{1}{2}V) < \theta < \left\{180^\circ - \sin^{-1}(1 - \tfrac{1}{2}V)\right\}$$

where the video amplitude V varies from 0 to 1.

Suppose that the pulse formation point is followed by a total circuit-gamma—including that of the c.r.t.—of γ_f. Then the instantaneous light output (neglecting constant factors) has the form

$$\varnothing_{out} = \left\{\sin\theta - (1 - \tfrac{1}{2}V)\right\}^{\gamma_f}$$

Hence the mean light output over a gating pulse cycle has the form

$$L(V) = \int_{\sin^{-1}(1-\frac{1}{2}V)}^{\pi/2} \left\{\sin\theta - (1 - \tfrac{1}{2}V)\right\}^{\gamma_f} d\theta$$

This expression has been evaluated for a number of values of following gamma. The mean overall "effective absolute gamma" between half-peak and peak video signals has been calculated and the effective contribution of the gating pulse shape to the overall absolute gamma deduced—see Table 1.

It will be seen that the effective gamma of the gating pulses decreases as the following gamma is increased. Since the cathode ray tube has a gamma of about 2 and the gating circuit following pulse formation introduces additional gamma (~2·2 with EL84 output valves), the effective contribution of the pulses to the overall gamma will be substantially unity.

Table 1

Calculation of "Effective" Chromagate Pulse Gamma

Following Absolute Gamma		1	2	3
$L(V)$	$V = \frac{1}{2}$	0·238	0·0475	0·0102
	$V = 1$	0·685	0·272	0·116
Mean overall effective absolute gamma		1·52	2·52	3·51
Effective pulse gamma		1·52	1·26	1·17

# of current interest . . .

Centenary of A. S. Popov

Among the scientific centenaries celebrated during 1959 is one of particular interest to radio engineers, namely, that of the birth of Professor A. S. Popov, the distinguished Russian scientist. Professor Popov is best known for his early work on the reception of electrical perturbations in the atmosphere due to lightning, and it is interesting to note that reference was made to this work in the Inaugural Address of Dr. C. C. Garrard*, who was President of the Institution in 1941-42. Dr. Garrard pointed out that in 1895 Popov had detected spark discharges at a distance of over 5 kilometres. He was more interested in atmospheric electricity than in wireless, although he had expressed the hope that his apparatus might be adapted for the transmission of signals when a sufficiently powerful transmitter was developed.

The name of Professor Popov is commemorated in the title of the A. S. Popov Technical Society of Radio Engineering and Telecommunications, which publishes the journal *Radiotekhnika*. This year the Society presented the A. S. Popov Gold Medal to Dr. Louis Essen of the National Physical Laboratory for his work on precise measurement of time by electromagnetic means; it was the first time that this award had gone outside the Soviet Union.

Research at Birmingham University

The new building of the Department of Electrical Engineering at the University of Birmingham is now nearly completed and two "Open Days" were arranged recently to show to industry and the teaching profession the facilities available and the research work being carried out. The extensive research programme into different branches of radio and electronics and allied subjects is of course of special interest to members of the Institution. The Department conducts Graduate courses leading to the M.Sc. degree in Information Engineering and the laboratories concerned with this course contained examples of research projects.

The Echo Ranging Laboratory is investigating methods of improving underwater echo ranging techniques; the development of electronic sector scanning, described in papers by Professor D. G. Tucker and members of the Department in the *Brit.I.R.E. Journal* holds particular promise and is likely to be applicable to radar as well. Other work in this laboratory relates to frequency modulated echo sounding for detecting shoals of fish within two fathoms of the sea bottom, i.e. for trawling, and fundamental investigation of the spectrum of reverberation from an acoustic signal in water due to bubble movement.

Investigations into target detection on displays used with radar or asdic systems are proceeding in the Display Laboratory. These include the problems of obtaining subjective information on the threshold signal/noise ratio; the advantages of correlation techniques (side by side presentation) over integration (linear adding of successive traces) have been confirmed in another series of experiments.

Other laboratories are concerned with circuits and communications and computers. The proposal for television bandwidth reduction by transposition and interleaving of the higher video frequencies between the lower frequencies has attracted considerable interest, particularly since the presentation of a paper describing the equipment at the Institution's 1959 Convention.

The Materials Laboratory is carrying out research on space charge limited dielectric devices and a dielectric diode has already been developed as a laboratory model. The dielectric triode is currently in the "design study" stage, but Dr. G. T. Wright, who is responsible for the work, is to give further details in a paper read before the Institution in London in January.

New Valve Manufacturers' Group

A new trade association—to be known as the Electronic Valve and Semi-conductor Manufacturers' Association—V.A.S.C.A.—has been formed by the British Radio Valve Manufacturers' Association; its aim is to provide facilities for mutual discussion and co-operation between manufacturers of semi-conductors and industrial electronic valves and tubes other than valves of the normal domestic receiving types and television cathode-ray tubes. The B.V.A. has up to now afforded full facilities for manufacturers to exchange technical opinions

* *J. Brit.I.R.E.*, **2**, pp. 67-71, September 1941.

on matters affecting the development, production and use of valves, tubes and semiconductors. This has included discussion on problems arising with Government departments, B.S.I., I.E.C., etc.

V.A.S.C.A. will consist of five broadly defined Sections which are to be autonomous in organization, although there will be some interrelationship. The Sections will deal separately with: Transmitting, including microwave, valves; Semi-conductors, including rectifiers up to a rating yet to be defined; Industrial receiving valves; Gas-filled devices; Industrial cathode-ray tubes, photo-electric and photo-sensitive devices.

The new Association's offices are at the same address as those of the B.V.A., namely, Piccadilly House, 16 Jermyn Street, London, S.W.1. The Chairman of the Association is Mr. G. A. Marriott (Immediate Past President), and Mr. W. R. West, the Secretary of the B.V.A. is also Secretary of V.A.S.C.A.

Careers Forum

A recent innovation in giving help to young people is the Careers Forum established by the Youth Employment Officer of the Ministry of Labour at Bromley. This Forum has been organized on behalf of the Bromley Grammar School for boys and the Bromley High School for girls, and representatives of a large number of professions attended its first meeting to help and advise boys and girls and their parents.

Nearly all the recognized Engineering Institutions were represented, and on behalf of Brit.I.R.E. the Education Officer attended and found considerable interest shown in careers in radio and electronic engineering. The meeting enabled the boys to discuss the training requirements of the various professions in which they were interested. As far as engineering was concerned the girls were conspicuous by their absence!

Hayes Memorial Medal

The Council of the Institution of Radio Engineers Australia has announced that the award of the 1959 Norman Hayes Memorial Medal is to be made to Mr. Ross F. Treharne, B.Sc., M.E. His paper on "Analogous Transistor System Design and Nodal Methods of Construction with Applications to Research Equipment and Prototype Evaluation," which was published in the July 1958 issue of the *Proceedings of the I.R.E. Australia,* was considered to be the most meritorious paper published during that year. The adjudicators were the Institute of Radio Engineers of New York; members will know that the Brit.I.R.E. acts as adjudicators in alternate years.

Mr. George Crowe

Members who either have read Physics at the University of Cambridge, or have attended the Institution's Conventions at the Cavendish Laboratory, will remember Mr. George Crowe, the chief laboratory assistant. This is the reason for making reference to a non-member of the Institution who has rendered invaluable service to very many members. In particular, the Institution, as a body, has thanked Mr. Crowe for his very real help in assisting Conventions held in Cambridge to run so smoothly.

On 30th September Mr. Crowe retired after 51 years at the Cavendish Laboratory. On 31st October the honorary degree of Master of Arts of the University was conferred upon him. This distinction crowned a career in which he had been the right-hand man to Lord Rutherford and other notable occupants of the Chair of Experimental Physics in the Cavendish Laboratory.

Fifty Years of G.P.O. Coast Radio

This year marks the jubilee of the British Post Office's chain of coast radio stations. With a nucleus of eight stations purchased from the Marconi Company and Lloyds the Post Office started its marine radio communication system in 1909. In those early days there were only 286 British ships equipped for radio communication and the small staff of the stations dealt with some 50,000 messages a year. Today, 850,000 messages are handled and the stations act as the shore link with 6,300 British and 3,000 foreign ships.

The coast stations operate medium range radio telegraph and radio telephone services from eleven stations around the British Isles. These stations use the medium frequency band but in order to free some of this part of the waveband during peak periods, v.h.f. stations are being installed at several coast stations.

APPLICANTS FOR ELECTION AND TRANSFER

As a result of its October meeting the Membership Committee recommended to the Council the following elections and transfers.

In accordance with a resolution of Council, and in the absence of any objections, the election and transfer of the candidates to the class indicated will be confirmed fourteen days after the date of circulation of this list. Any objections or communications concerning these elections should be addressed to the General Secretary for submission to the Council.

Transfer from Associate Member to Member

MARSDEN, Bernard. *London, N.W.8.*

Direct Election to Associate Member

ALLENDEN, Dennis. *Reading, Berks.*
*DIBDEN, Edgar Henry Kenneth, M.A., B.Sc. *Cambridge.*
HAWKINS, George Allan. *Malvern, Worcs.*
KEMP, Ralph. *Bognor Regis, Sussex.*
LOGUE, Hugh. *Northwood Hills, Middlesex.*
NEWLAND, Cyril Maurice. *Chelmsford, Essex.*
SHAYLER, Jack Stratford, B.Sc. Tech.(Hons.). *Bedford.*
TARR, Captain Graham Charles, R.E.M.E. *Malta, G.C.*
TAYLOR, Sqdn. Ldr. Alan. R.A.F. *Crowborough, Sussex.*
YOUNG, William Alexander Passmore. *Basingstoke, Hants.*

Transfer from Graduate to Associate Member

BEEFTINK, Johan. *Reading, Berks.*
HOLT, Alan George James, Ph.D., Dip.El. *Newcastle-upon Tyne, 1.*
IBUKUN, Lawrence Olu, B.Sc.(Eng.), D.I.C. *Ibadan, Nigeria.*
OLD, William Desmond, B.Sc. *Camborne, Cornwall.*
ROW, Edward Francis. *Basingstoke, Hants.*
SMITH, John Frederick. *Basingstoke, Hants.*

Direct Election to Associate

BAKER, William Herbert. *Walsall, Staffs.*

Transfer from Associate to Graduate

HALLIDAY, Douglas Frank. *Isle Steps, Dumfries.*

Direct Election to Graduate

ALLENDER, Kenneth. *Thetford, Norfolk.*
BAFFOUR, Richard Kobinah. *London, W.C.2.*
BARNES, Anthony Charles. *Cardiff.*
BEDWELL, Eric Charles. *South Croydon, Surrey.*
CORLESS, Norman Fergie. *Stevenage, Herts.*
CURTIS, Brian William. *Ruislip, Middlesex.*
FAIRBROTHER, Leslie Ronald. *London, N.W.9.*
FEATHERSTONE, David Hooton. *London, N.20.*
FRANKLIN, Kenneth Vincent. *Crawley, Sussex.*
HODGKINSON, Raymond Thomas. *Greenford, Middlesex.*
HORTON, Frederick Henry Patrick. *Twickenham, Middlesex.*
HOUGHTON, James Glen. *Birkenhead, Cheshire.*
HOULDING, Michael Alfred. *Sheffield.*
LANGLEY, Ivan John, B.Sc. *Stevenage, Herts.*
PEABODY, Christopher John. *London, S.E.19.*
POWELL, David Norman. *Bicester, Oxon.*
REED, Rodney Charles Ernest. *Southall, Middlesex.*
ROBERTS, Edward Robert. *Dartford, Kent.*

Transfer from Student to Graduate

BARONTINI, Derek Howard Roland. *Crawley, Sussex.*
BHALLA, Narendra Pratap. *London, W.14.*
BRIGHTY, Paul Francis John. *Hayes, Kent.*
HUNG CHEUNG LOY. *Hong Kong.*
KIRKUS, John Rodger. *Hornsea, E. Yorks.*
MANN, Richard Barnaby. *Cambridge.*
MITRA, Gobinda Lal. *Bombay.*
PARROTT, Edward James. *London, S.E.15.*
PUTLEY, Derek Edward. *Cheltenham.*
WALLIS, Arthur Robert. *Sutton, Surrey.*
WHITE, Graham. *Abingdon, Berks.*

STUDENTSHIP REGISTRATIONS

The following 80 students were registered at the June, July and September meetings of the Committee. The names of a further 67 students registered at the September and October meetings will be published later.

BRADLEY, Harold Leonard. *Havant, Hants.*
FERNANDO, Udriappuwaduge Cannol Nimal. *London, N.15.*
JAMES, Leslie Gwyn. *Swansea.*
MOHAN RANGA RAJ, G. V., B.Eng. *Bangalore, India.*
MOORE, Arthur David. *Cambridge.*
NAGARAJAN, G., B.A. *Madurai, India.*
NARAYANA, Rathnagiri Krishna, B.Sc. *Kolar, India.*
O'BRIEN, Bernard. *Cardiff.*
PATHRE, Vijay Eknath. *Bombay, India.*
PULANTHIRAN, E. *London, W.2.*
STEPHEN, William John. *Surrey Hills, Australia.*
TUBB, David Alexander. *London, S.W.10.*
VINAY, Charles David. *Johannesburg.*
WHITE, Graham. *Abingdon.*

McGUIRE, Patrick. *London, W.1.*
MALWIYA, Suresh Chandra. *Dhar, India.*
MARLOW, Jeffrey. *London, E.10.*
MARSHALL, Robert. *Chertsey.*
MARUTHACHALAM, Annamalai. *Bhavani.*
PAKIANATHAN, Theyathason Chelliah. *Johore Bahru.*
PETERS, Ronald William. *Ilford.*
PILLAI, Puthuppanathu Krishna Narayana. *Tranvancore.*
RODEN, Ronald. *Estado da Bahia, Brazil.*
RUBAROE, Gramini Tissa. *London, S.E.27.*
SAGE, Michael John. *Pinner.*
SCHINDLER, Andrew. *Plymouth.*
SISAY, Alusine Jabbi. *London, S.E.19.*
STRAUPENIEKS, Jekabs. *Birmingham.*
TENDULKAR, Chandrakant Vinayakrao. *Poona.*
VOGHERA, Ferruccio. *Ramat-Gan, Israel.*
WILLIAMS, David James. *Auckland.*

DIXEY, Graham Edward. *London, N.W.9.*
DODDS, Douglas Wilfred. *Capetown.*
DOUGLAS, David Walter, B.Sc.(Tech.). *Manchester.*
FRANCIS, Lionel Robert. *Aberporth.*
FRASER, Maxwell Joseph Struthers. *Johannesburg.*
GENT, Leslie Frederick. *Stevenage.*
HAILU, Mariam G. *London, N.7.*
HARBANS LAL DEVGON. *Kanpur.*
HASLER, Derek. *Laval, Canada.*
HUNTER, Thomas. *South Shields.*
JONES, Richard Edward. *Llandudno.*
KENT, Derek Wilfred. *Enfield.*
KEYLOCK, Norman Alfred. *Swindon.*
KHOO POON TONG. *Singapore.*
KITCHEN, Dennis Frederick. *Swindon.*
KUMAR, Govind. *Bangalore.*
LEVELL, Roy William. *Bournemouth.*
LOADER, Arthur Charles, B.Sc. *Reading.*
MILLWARD, Hubert Riley. *St. Annes-on-Sea.*

BRUTON, David. *Barnet.*
BULSON, Roy Edward. *Chippenham.*
DENNY, Ronald Henry. *Saffron Walden.*
FALOMO, Olumuyiwa. *Ilesha, W. Nigeria.*
GANGULY, Sashi Kumar, B.Sc. *London, N.4.*
GLASSBOROW, Neville. *Gloucester.*
KORB, Hans Arno Fritz. *Ennetbaden, Switzerland.*
LAWRENCE, Peter John. *Chelmsford.*
LEASK, Alexander. *Cheltenham.*
LLEWELLYN, Ivor William Henry. *Northampton.*

ADEBOYEJO, Michael Oluseyi. *London, W.9.*
ANN, Rupert Ru-Pern. *London, S.W.5.*
ASHLEY, Ernest Charles John. *Aylesbury.*
AVELLINO, Joseph. *Poulton-le-Fylde.*
BAKKER, Auke. *Johannesburg.*
BEDWELL, Peter. *Wirral.*
BEST, Leslie Philip. *Bellshill.*
BEVERTON, Keith Alan. *Doncaster.*
BOGHOSSIAN, Garabed Hagop. *London, W.8.*
CLARK, Anthony Harold. *Southsea.*
DAS CHOUDHURY, Bhabatosh. *Bangalore.*

MISRA, Satya Prakash. *Cochin.*
NIZAMUDDIN, Khwaja. *Hyderabad.*
OGUNLEYE, George Agged. *London, W.12.*
OLAIYA, Solomon Kayode. *London, S.W.2.*
ONIANWA, Christopher Afamefune. *London, N.7.*
PINKHAM, Cyril Leslie. *Chester.*
RICHARDSON, Kenneth Charles Smart. *Kilbarchan.*
RIVKIN, Philip. *Bedlington Station.*
ROE, Patrick. *Cheltenham, South Australia.*

* Reinstatement.

Underwater Echo-Ranging with Electronic Sector Scanning: Sea Trials on R.R.S. *Discovery II*†

by

Professor D. G. TUCKER, D.Sc., MEMBER‡, V. G. WELSBY, PH.D., MEMBER‡, L. KAY, B.Sc.‡, M. J. TUCKER, B.Sc.§, A. R. STUBBS, B.Sc.§, and J. G. HENDERSON, B.Sc.‡

Summary: Sea trials of an electronic sector-scanning asdic equipment were conducted during October 1958 in R.R.S. *Discovery II* with the particular purpose of determining the general performance of the equipment and its ability to detect and give information relating to fish shoals. A description is given of the design of the equipment and of the results obtained. It is shown that very considerable success was achieved.

1. Introduction

The principles of a new system of electronic sector-scanning, and of its application to an underwater echo-ranging system, have been described in a previous paper[1]. The present paper describes the design of a complete equipment and its sea-trials in the Royal Research Ship *Discovery II* during October 1958. The electronic parts of the equipment were made in the laboratories of the Electrical Engineering Department of the University of Birmingham and the transducer itself was made at, and fitted by, the National Institute of Oceanography. The object of the equipment was primarily the detection and identification of fish shoals, and this it was proved able to do quite satisfactorily. The equipment was, however, purely experimental and in no *strict* sense operational, for (due to various other requirements) the transducer beam had, in the horizontal plane, an inconvenient fixed position at right angles to the ship's axis; and the display used was, for reasons of economy, only an ordinary laboratory oscilloscope.

The description of the principles of the system given in the previous paper was quite full, and in view of its recent publication it is not thought necessary to give a detailed description of the principles in the present paper. The system is a pulse echo-ranging system with a transmission beamwidth approximately equal to the width of the sector to be scanned, and a receiving beamwidth equal to the angular resolution required. The receiving beam can be deflected from its normal axis by the connection of phase-shifting networks between the terminals of the successive sections into which the receiving transducer is divided in the plane of scanning (these networks are most conveniently regarded as a delay line along which the various transducer sections are tapped); and since the phase-shifts in the delay line vary with frequency, the beam deflection is directly controlled by the frequency applied to the delay line. Thus the angle of deflection may be made to range over the scanned sector by frequency-changing the received signal before it is applied to the delay line, using a local oscillator whose frequency is swept over a range by a scanning waveform which is synchronized with the bearing time-base of a cathode-ray B-scan display. If the whole range of deflection, from one edge of the sector to the other, is covered in less time than the duration of one pulse, then effectively simultaneous information is received from the whole sector and no information is lost. (In an ordinary asdic, by contrast, the pulse has to be transmitted and received back in one particular narrow beamwidth before the transducer(s) can be mechanically rotated to the next beam position, so that the scanning of a sector is a very slow operation.)

† Manuscript received 20th January 1959. Publication delayed at authors' request pending security clearance. (Paper No. 525.)

‡ Electrical Engineering Department, University of Birmingham.

§ National Institute of Oceanography, Wormley, Godalming, Surrey.

U.D.C. No. 538-14:621.396.677

D

The present paper is concerned with the actual design and performance of the equipment. Part 1 shows how the scanning equipment itself was made, and Part 2 discusses the very important matter of the main amplifier which must have an automatic control of its gain to suit the varying levels of signal and background during each pulse repetition period. The transducer used in the trials operated at 37 kc/s and had a beamwidth, between 3 db points in the horizontal plane, of about 1·5 deg; it is described in Part 3. As its beamwidth in the vertical plane was only about 12 deg, it was necessary to stabilize the axis of this beam against the very considerable rolling motion of the ship, and the stabilizing equipment is described in Part 4. The results of the trials in operational terms are described (and illustrated by photographs of the actual displays obtained) in Part 5.

Part 1. THE SCANNING SYSTEM

by V. G. Welsby.

2. General Description

The scanning operation is carried out by introducing time-varying phase shifts into the outputs of the receiving transducer elements. It is explained elsewhere[1] how this can be done by first of all applying the scanning time-function, as a frequency modulation, to the carriers of all the received signal inputs and then passing these through various portions of a common delay line. (See Fig. 1.) The scheme adopted for the experimental 8-channel system is based on that chosen for the original laboratory model[1] but is not the only one which could have been used; in fact, practical experience has now shown that the choice of a double modulation system of this type is likely to lead to undue difficulty in filter design. Although only eight channels were used (one element of the 9-element transducer array being reserved for transmission), the equipment actually provided nine complete channels with one extra spare channel unit and one extra spare pre-amplifier.

3. Pre-amplifier Unit

This unit contains ten identical 2-stage negative feedback amplifiers of conventional design, each giving an overall voltage gain of 400 (see Fig. 2). The variable capacitor shunted across the secondary of each input transformer is used to tune the combined reactance of the trans-

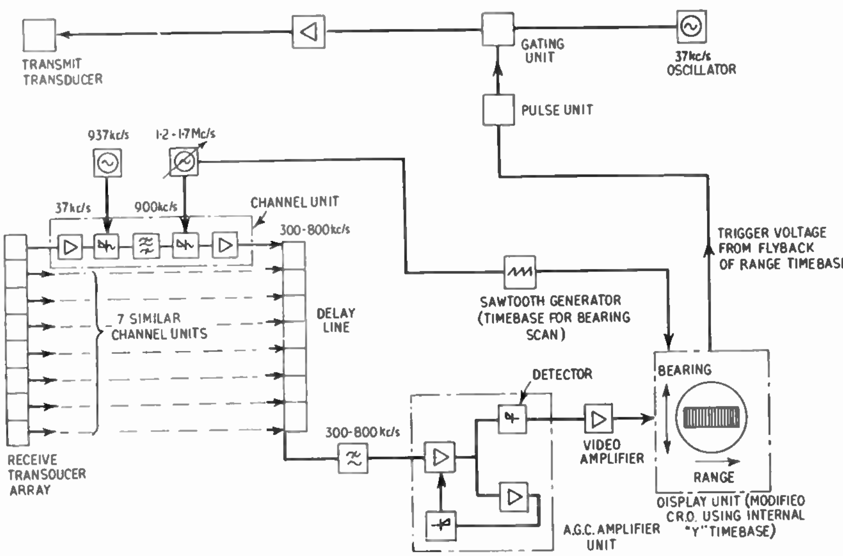

Fig. 1. Block schematic of asdic system with electronic sector-scanning.

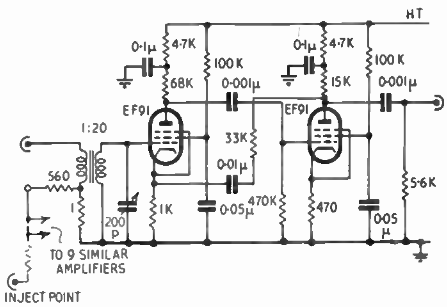

Fig. 2. Circuit of pre-amplifier unit.

ducer, the lead-in cable and the transformer to the optimum operating frequency (37 kc/s for the transducers used). Provision is made for a known small signal e.m.f. to be injected in series with the input of each pre-amplifier to enable this tuning adjustment to be carried out and also to assist in the lining-up of the whole scanning system. It has been found that, due to stray capacitances between the transducer elements and the sea, and between the lead-in wires and the ship's hull, noise pick-up due to circulating earth-currents may cause trouble. This can be avoided by screening the lead-in cable and inserting longitudinal chokes in each pair at the pre-amplifier input. A further improvement would be obtained by adding an inter-winding screen to each input transformer.

4. Channel Unit

This unit translates the received 37-kc/s signals into pulses which retain the same envelope shape but have a carrier frequency which varies between 300 kc/s and 800 kc/s. As shown in Fig. 3, each channel unit contains two modulators, the first fed with a fixed 937-kc/s carrier and the second with a time-varying carrier frequency which sweeps from 1,200 kc/s to 1,700 kc/s during each scan. Between the modulators is a bandpass filter which serves to suppress the carrier leak from the first modulator together with other unwanted frequency components and to pass the required signal band centred on the difference frequency of 900 kc/s. No further filtration is carried out in the channel unit, the unwanted upper sideband and carrier leak from the second modulator being suppressed later by a common low-pass filter which follows the delay line. The design of the channel unit presents little difficulty except for the bandpass filter which has to meet somewhat severe requirements with regard to both attenuation and phase shift. Although the type of modulator used provides some degree of carrier suppression, it is necessary for the filter to produce a loss, relative to its pass-band, of at least 40 db at the carrier frequency. The width of the pass-band is, of course, determined by the minimum signal pulse length and although the shortest transmitted pulse used during the trials was 0·5 msec, the system was designed to have a nominal bandwidth of 10 kc/s, thus enabling considerably shorter pulses to be used if desired. The pass-band of the filter therefore extends from 895 to 905 kc/s with a required relative loss of not less than 40 db at 937 kc/s.

The difficulty lies, not so much in the realization of the required attenuation characteristic but in the fact that it is necessarily accompanied

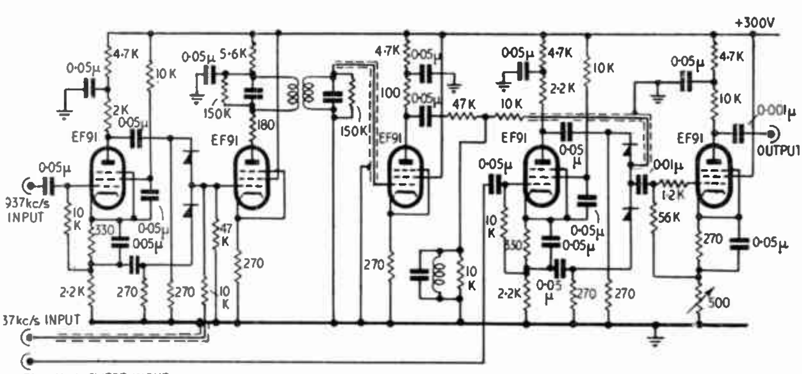

Fig. 3. Circuit of channel unit.

by a rapid change of phase with frequency with the result that small changes in component values (due for example to temperature coefficients) tend to show up as phase errors which may upset the directivity pattern of the receiving array. The coupled-circuit filter, followed by a single tuned stage, was chosen because it requires fewer components than a ladder-type filter and also because it provides a convenient adjustment to eliminate residual phase differences between the channels. A simple way of doing this to tune all three circuits to give maximum output at the mid-band frequency and then to correct the phase by slightly detuning the third stage, an adequate range of adjustment being available in this way without any appreciable change in the gain/frequency curve.

The overall gain of the channel unit is approximately unity and can be adjusted by means of a potentiometer which varies the amount of negative feed-back applied to the final amplifier stage. The maximum output level is about 500 mV r.m.s. Carrier leak (from the first modulator but shifted by the second modulator into the signal frequency range) amounts to about 1mV r.m.s. at the output.

5. The Frequency-swept Oscillator

After several experiments with L-C oscillators using various reactance-valve circuits to carry out the frequency modulation, a satisfactory solution, shown in Fig. 4, was found in which an R-C oscillator has each of the three resistive elements of its phase-shift network replaced by the output impedance of a variable-mu cathode-follower. Variation of the bias voltage of the latter changes the effective resistance and hence the frequency of oscillation. The sawtooth modulating voltage waveform is then superimposed on the fixed bias and the required frequency modulation thus obtained. By a suitable choice of circuit values it is possible to obtain a sufficiently linear static relationship between frequency and applied modulating voltage.

One of the difficulties experienced is in preventing the higher frequency components of the sawtooth waveform from being injected, via the cathode-follower stages, into the feedback loop of the oscillator. The filtration required for this purpose (represented by the 0·001 μF capacitance and 10 kΩ resistance in the grid circuit and the 20 mH inductance in the cathode circuit of each cathode-follower), tends to cause distortion of the effective modulating waveform as the fundamental frequency of the latter is increased.

In the circuit described, this effect begins to become appreciable at scanning speeds above about 2,000 scans per sec. As this limit is exceeded, the error shows up first as a time-delay of the whole scan which is then accompanied by serious distortion of the scanning pattern as the speed is still further increased.

6. The Delay Line

This consists of a simple low-pass ladder network, with *m*-derived terminating half-sections to reduce reflections, terminated at each

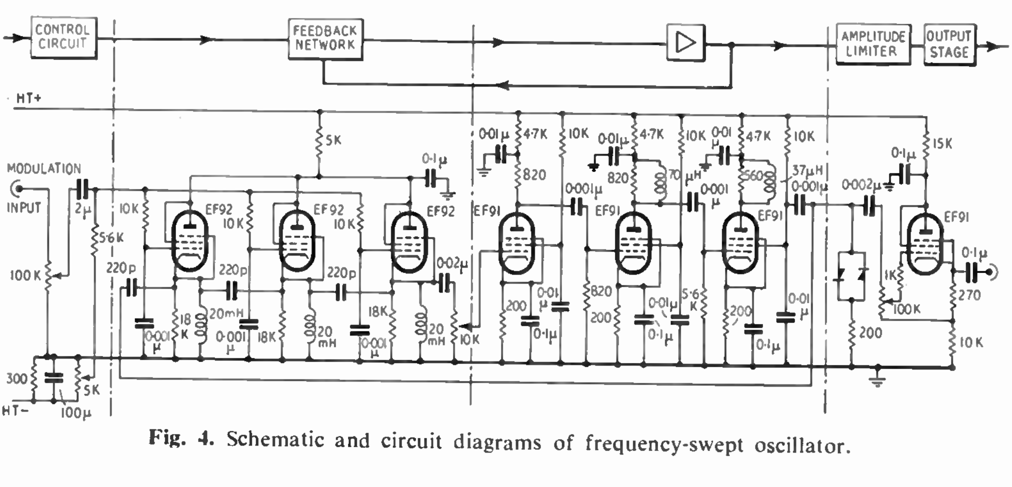

Fig. 4. Schematic and circuit diagrams of frequency-swept oscillator.

end by its nominal design resistance. A word of explanation is necessary here to avoid confusion of terminology. The arrangement of the scanning system corresponds to the "bandpass" system described in ref. 1. For convenience however the bandpass filter, having zero phase shift at the mid-sweep frequency, has been replaced by a lowpass filter having a phase shift of 2π radians at the mid-sweep frequency.

7. Adjustment of Scanning Pattern

The diffraction polar diagram of an array of eight equally-spaced point receivers of equal sensitivity is given by

$$D(p) = \frac{\sin 8p}{8 \sin p}$$

where $$p = \frac{\pi d}{\lambda} \sin \theta$$

(d is the spacing between the elements, λ is the wavelength and θ is the angle of reception, measured from a direction normal to the array).

The correct operation of the scanning system can be checked by injecting a common 37-kc/s signal into all eight channel inputs simultaneously and displaying the output of the system on a c.r.o., synchronized at the scanning speed. If the channels are all lined up to give the same amplitude and phase, the result will be a repeated pulse whose envelope corresponds to

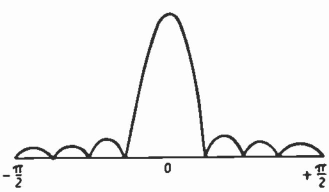

Fig. 5. Graph of directional function.

the function $|D(p)|$ (see Fig. 5). It will be noted that, ideally, the pattern should show four equally-spaced zeros on each side of the centre lobe (counting those at both end of the sweep). In general, phase errors will cause undesirable distortion of the pattern and should be avoided as far as possible. Deviations from equality of amplitude, on the other hand, may improve the results, particularly with regard to the reduction of the side lobes relative to the main lobe. Although no attempt was made during the trials to apply any particular form of "taper" [2] to the array, it was found possible to obtain an appreciable improvement of the pattern merely by a trial-and-error adjustment of the variable gain trimmers, provided on the channel units, whilst observing the result on the c.r.o. display. Figures 6 and 7 show typical results obtained by this method.

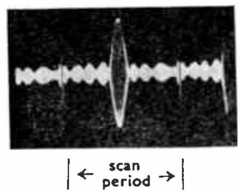

Fig. 6. Directional pattern with equal amplitude.

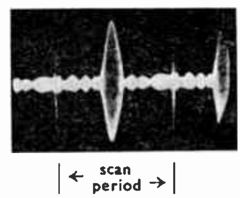

Fig. 7. Directional pattern with amplitude settings adjusted to reduce side-lobes.

In practice the array does not consist of point receivers, each element actually having a length approximately equal to the spacing d. As a result, the true polar diagram, expressed as a function of p, is obtained by multiplying the diffraction pattern by $(\sin p)/p$.

The scanning action deflects the diffraction pattern only, this occurring without change of pattern, irrespective of the initial channel adjustments; that is, if the pattern obtained during the lining-up procedure is distorted, this distorted pattern will remain unchanged as it is deflected. The $(\sin p)/p$ factor remains undeflected and results in a variation of the effective sensitivity of the system throughout each scan. Both this variation and the corresponding one due to the intrinsic directivity of the transmitting transducer can be corrected by means of a suitable attenuation/frequency equalizer network connected between the scanning system and the a.g.c. receive amplifier. The slight variation of background intensity across each scan which is visible in Fig. 17(a) is in fact due to lack of equalization at the beginning of the trials of the experimental equipment and does not represent any fundamental defect in the system. It was very largely corrected in all subsequent observations.

Part 2. THE MAIN AMPLIFIER AND TRANSMITTER

by L. KAY.

8. The A.G.C. Amplifier

In underwater echo-ranging systems the input signal may vary over a range of many decibels and it is necessary for the amplifier to have a gain control system incorporated which will compress this variation so that the limited dynamic range of the display can be efficiently used. Conventional acoustic fish-finding equipments use paper recorders for displaying the information from a single-beam system, and the dynamic range of these may be quite large, if suitable chemical paper is used. A cathode-ray tube, however, is essential in the present application, and its dynamic range is generally considerably smaller. Much attention must therefore be paid to the form of gain control used if the best performance is to be obtained.

Time Varied Gain (t.v.g.) control has been suggested as being a very suitable system, as this gives good results when used for acoustic mapping of the sea-bed, i.e. for demarcation of large features. However, it has two disadvantages in commercial applications. It is necessary for an operator to be constantly adjusting the control to keep the output variation of the amplifier well within the dynamic range of the display, and it is difficult to set the level so as to use the best part of the display characteristics.

Consider first the nature of the signal at the input to the main amplifier. The acoustic beam can be looked upon as rapidly scanning the arc covered by the transmission beam. Following the transmission of a pulse, sound energy will return continuously from the multiplicity of reflecting objects suspended in the medium and on the sea-bed and from the uneven surface of the sea. The amplitude of the signal at the output of the delay line is a sample of these returns as the beam sweeps across the arc. Because the returns vary in bearing and a different value is generally obtained for each beam-width moved by the beam, the period of variation can be as small as $1/n$th of the pulse duration. In the present application n is 8, the number of sections in the transducer.

If part of the arc of transmission covers a patch of high level returns, say stones or shells on a normally sandy bed, the signal to the main amplifier will rise and fall in sympathy as the beam scans between the low and high level portions of the sector, and in this way a picture of the sea bed will be built up on the display as the pulse of transmitted energy traverses the medium. It is because of this variation during a scan that an a.g.c. amplifier can be used without fear of losing information about the signal. Provided the amplifier gain does not change during the period of one scan (one millisecond in this case) the change in signal level during a scan will be correctly displayed. This, however, cannot be perfectly achieved, otherwise there would be no change in range either, to correct for the fall in the signal level due to attenuation and spreading; but by making the "operate time" (time for the output level to be restored to normal following an increase in the signal level) long compared with $1/n$th of the pulse duration, a good compromise can be reached where the change in gain during a scan is not noticeable. The "recovery time" (time for the output level to be restored to normal following a decrease in the signal level) on the other hand should be comparable with the scan time. It should not be shorter, otherwise the contrast between high and low levels during a scan will be reduced; and yet if too slow it is possible to produce "shadows" following high level signals which have reduced the amplification. These two time-constants can be independently chosen and therefore do not affect one another although they are obtained with some common components. It should be noted that it is only because the beam is scanning that the information about the sea bed is not destroyed; if the system used only a single beam, an a.g.c. amplifier could easily destroy some of this information although in some applications much of it may not be required and the degradation of wanted information (which may be a single target echo standing out against random background) may not be significant.

The input signal, as explained in Part 1, varies in frequency during the scan period from 300 kc/s to 800 kc/s, and clearly the response of the amplifier over this range must be flat.

Adequate data about the sensitivity of the transducer was not available at the time of starting the design of the amplifier, so a maximum amplification of 10,000 was chosen with a control range of 60 db, from 500μV to 500mV at the input, over which range the output would remain constant to within ±1 db referred to 500mV for c.w. tone. This was known to be more than necessary but a good margin was allowed in this first experimental model.

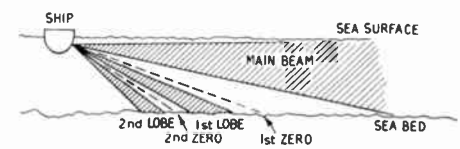

Fig. 8. Diagrammatic representation of acoustic beam in vertical plane.

The signal returns due to the random scatterers on the sea-bed and those suspended in the medium are used to control the amplifier gain, and the level of these returns depends both on the sound intensity insonifying the relevant section of the medium and, in the case of bottom returns, on the angle the beam makes with the bottom.

From Fig. 8, which is a very simplified illustration of the sound rays resulting from a narrow beam transmission in the vertical plane, it can be seen that the secondary lobes produce high and low regions of sound intensity at short range. Between the first lobe and the main beam there is a region of low sound intensity which, neglecting loss due to spreading and absorption is gradually replaced by an intensity increasing with range as the influence of the main beam increases. This rise in level with increasing range partly affects the loss due to attenuation, making the rate of decay of sound intensity less than that experienced with transmission in a wide vertical beam. The total effect must also include vertical beam response of the receiving transducer. The effect of secondary lobes (in the vertical beam) "hitting the bottom" can be seen in the short range flashes in Figs. 9 and 17–19.

Although the variation of the signal level with range is unpredictable because of the sea bed variations the results of the trials showed that it did not exceed 40 db for this application (maximum range 800 yd.).

A circuit diagram of the automatic gain controlled amplifier is given in Fig. 10. The first four stages V1 to V4 constitute the main amplifier and V5 is a cathode follower output to the control amplifier V8 as well as to the final output stages V6 and V7. As the frequency of operation is high it was thought that the amplifier might tend to be unstable if the d.c. control voltage was derived from the carrier, and in any case extra care would be required in the design and layout of the feed back loop, so a departure was made from conventional a.g.c. systems. The modulation on the carrier is proportional to the carrier, and, since the variations in the d.c. control voltage are to be slow compared with the modulation frequency (about 10 kc/s) it was thought the modulation, if amplified instead of the carrier, would give equally good control and allow the loop gain at 500 kc/s to be kept much less than unity under all conditions. The RC network following the delay diode MR2 smooths the carrier and passes only the modulation. In addition the gain of the a.g.c. amplifier V8 is very low at 500 kc/s compared with that at 10 kc/s. The double RC network following V9 introduces the "operate time constant" of the amplifier control loop; a double network is chosen to reduce the initial rate of change of gain for a sudden change of signal level at the input. To speed up the "recovery time" a double diode V10 was connected across

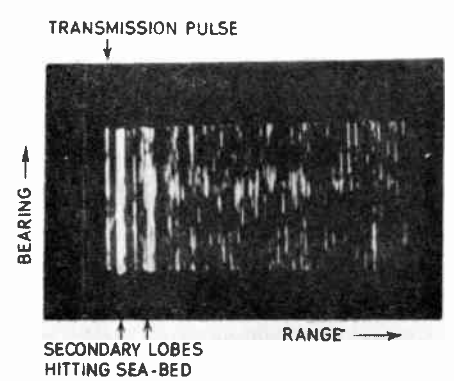

Fig. 9. Illustration of the effect of secondary lobes when using a narrow vertical beam.

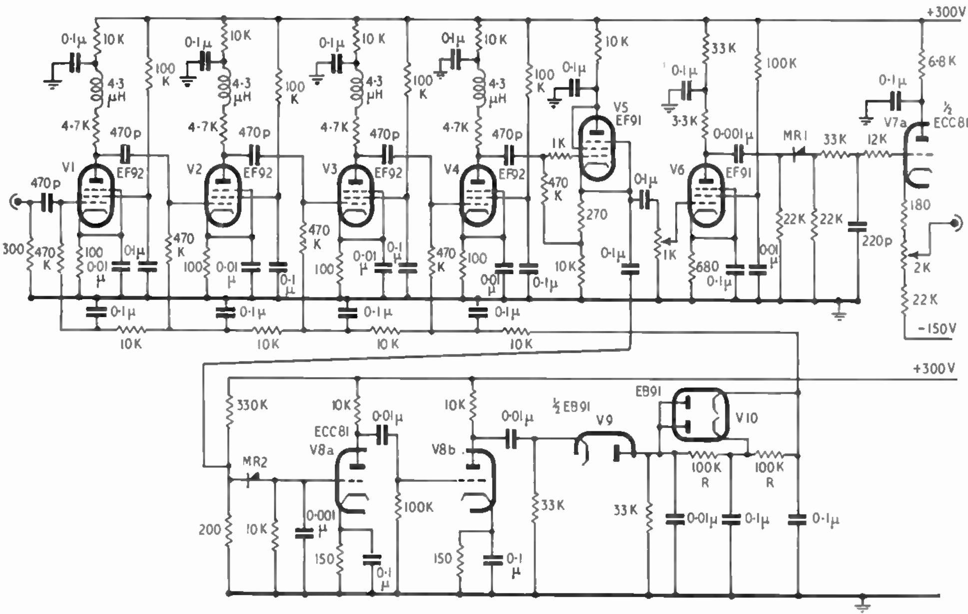

Fig. 10. Circuit of automatic-gain-controlled amplifier.

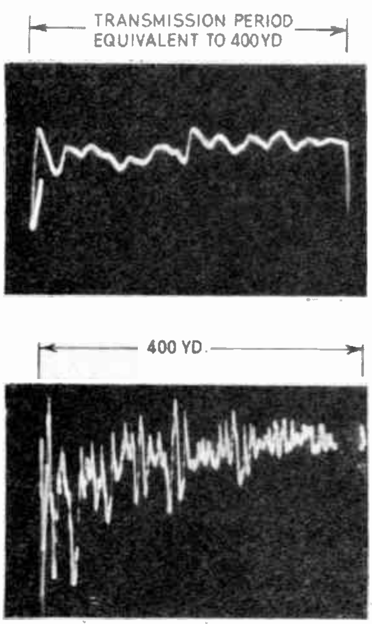

Fig. 11. Variation in control voltage for two values of C in the RC network in the control path. (a) $R = 100\ \text{k}\Omega$, $C = 0{\cdot}5\ \mu\text{F}$ (b) $R = 100\ \text{k}\Omega$, $C = 0{\cdot}1\ \mu\text{F}$.

this RC network. These time constants are not critical, and quite a wide variation can be tolerated without any noticeable change on the display picture, but of course much depends upon the detailed requirements of the system. The components used gave good results, and it was found that an increase in the capacitor value of five times showed little change. This, however, may not apply under all circumstances. "Operate" and "recovery" times are not quoted as these are difficult to define (depending upon the instantaneous condition of the amplifier) and vary during the operation of

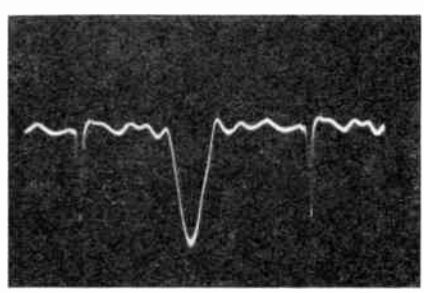

Fig. 12. Output of a.g.c. amplifier for an input as shown in Fig. 7.

the system. Instead, two traces of the a.g.c. line voltage variations are shown in Fig. 11 for different values of R and C in the feed back network for an output similar to that shown in the display picture of Fig. 9.

The output stages V6 and V7 simply increase the signal before detection in the linear detector MR1, and provide a low impedance output to the display amplifier. It will be noted that a directly-coupled output is provided; this was for test purposes and is followed later by suitable a.c. coupling to the display. The output of the a.g.c. amplifier for an input such as that of Fig. 7 is given in Fig. 12.

9. The Transmitter

This was conventional in all respects but is briefly described for the sake of completeness.

The display range time-base was used to give the master timing pulse from which was derived a rectangular pulse of 1 millisec duration. This pulse operated a balanced diode gate allowing a 1 millisec pulse at transmission frequency to pass from the oscillator to the transmitter amplifier and power output stages. The transmission peak power was approximately 100 watts at 37 kc/s into one horizontal section of the transducer (of full depth) to illuminate an arc of about 12 deg.

Part 3. THE TRANSDUCER

by M. J. TUCKER and A. R. STUBBS.

10. Introduction

The transducer, which was of the magnetostrictive type, was not designed solely for the present trials, but was intended for some more general investigations in echo-detection of fish and for acoustic surveying of the sea bed, for which it was essential to have the axis of the acoustic beam perpendicular to the ship's course. Since the cost of making the transducer trainable in azimuth was prohibitive, it was unfortunately necessary to use the abeam-pointing transducer for the trials described in this report. In a commercial installation in a fishing-boat the transducer would almost certainly look ahead, but for an experimental trial of a technical rather than an operational nature this was not so important.

The choice of frequency for an echo fish-detector is governed by several factors. Those concerned with the target strength of the fish are not well understood, and for a narrow-beam equipment it is in practice largely a compromise between the high cost of a low-frequency transducer, and the absorption of high frequencies by the water. For a range of 800 yards, a frequency in the range 30 to 50 kc/s is suitable, and since enough 37 kc/s stacks were readily available, this frequency was chosen.

With the acoustic beam pointing sideways from the ship, stabilization against roll is required if consistent pictures are to be obtained. The stabilizer is described in Part 4 of this paper. The stabilizing servo motor is inside the hull of the ship and turns the transducer by means of a shaft passing through a gland in the ship's hull. Stabilization might also prove to be necessary if an ahead-pointing transducer were used.

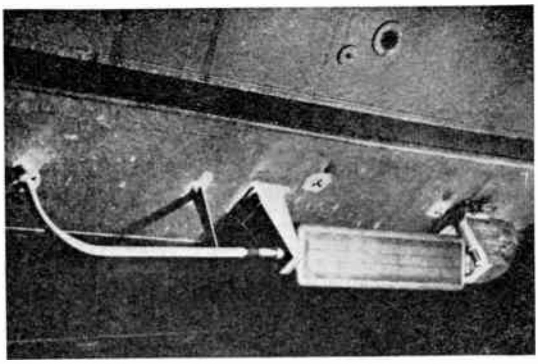

Fig. 13. View of transducer mounted on hull of R.R.S. *Discovery II.*

The general arrangement of the transducer and its mounting can be seen in Fig. 13.

11. Construction and Mounting of the Transducer

The transducer is made from 864 stacks of Permendur stampings, each stack having an individual polarizing magnet. These are assembled into sections of 32 stacks (8 × 4) with a common winding and an active face of approximately 6·3 cm × 17·4 cm. The complete transducer consists of three rows each of nine sections fixed end to end, the rows being separated by 1·3 cm. Thus the active face has overall dimensions of approximately 156 cm × 21·5 cm. The weight is about 400 lb.

The sections are mounted three at a time on monel plates, these in turn being mounted in a gunmetal casting with trunnion bearings at each end. The transducer is mounted so that it can rotate about its long axis which is aligned fore and aft. It is carried on brackets welded to the hull, approximately 13 ft below water line, and is 14 inches away from the hull. A shaft passing through a gland in the hull of the ship carries a stainless steel worm which engages with a bronze wheel at one end of the transducer, and which is driven from the servomechanism inside the ship; the reduction ratio of the drive is 18 : 1. The transducer is free-flooding, but is protected by a fibre-glass window over the active face. Mechanical stops limit its rotation to between +45 deg and −135 deg (axis of beam relative to horizontal).

Each section is wound with a single length of p.v.c. insulated wire joined to a flexible 55-core cable in a "pickle-bottle" type junction box inside the after bearing. The 55-core cable leaves this axially and is protected by a hose-pipe sleeving and supported by a tube until it enters the hull.

12. Characteristics

An individual section has beam-widths between 3 db points of 15 deg in plan and 40 deg in elevation. If all sections are connected in parallel, the minimum beam-widths of 1·6 deg and 12 deg are obtained.

The impedance of a section as measured at the junction box at 37 kc/s is approximately 12 + 37j ohms. The component of this due to motional impedance is approximately 5·5 ohms.

Part 4. ROLL-STABILIZATION OF THE TRANSDUCER

by J. G. Henderson.

13. Introduction

The operational requirements were that the transducer should be able to be tilted to radiate at any desired angle between the horizontal direction, 0 deg, and vertically downwards, −90 deg, and it had to be stabilized in any such position against the rolling motion of the ship.

The nominal accuracy of position-control that was required for fish-finding and bottom-survey work permitted a maximum error of about ½ deg when responding to a 10 deg roll, but it was also desirable that control of the transducer should be retained throughout an extreme roll of 25 deg.

14. Specification of the Control System Performance

The rolling motion of R.R.S. *Discovery II* has a characteristic angular frequency of 1 radian/sec and inspection of its amplitude of roll/frequency spectrum[3] showed that the maximum duty of the motor controlling the transducer can be based on sinusoidal rolling at this frequency.

Thus taking into account the accuracy requirements of ½ deg error on a 10 deg roll the minimum acceptable loop-gain of the control system is 20 at $\omega = 1$ rad/sec.

The original version of the transducer for which this control system was designed had its axis of rotation displaced from its centre of gravity and it was estimated by the National Institute of Oceanography that the net torque required on the training shaft, having taken into account the torque due to the off-balance load and that due to the flow of water past the transducer, would be approximately 70 lb-ft. The transducer that was actually fitted on the ship was a mechanically-balanced unit and the operating torque required was appreciably less than that for which the system was designed. Some test figures for this are included in Section 16.

The maximum speed of the transducer training-shaft during a 25 deg roll is 75 rev/min and in association with the 70 lb-ft. torque required to tilt the transducer the estimated peak power of the motor is 1 h.p.

15. The Control System

The general arrangement of the control system used is shown by the block-diagram of Fig. 14. The upper portion comprises a simple magslip position-monitoring system whilst below it is shown the main elements of the automatic control-system.

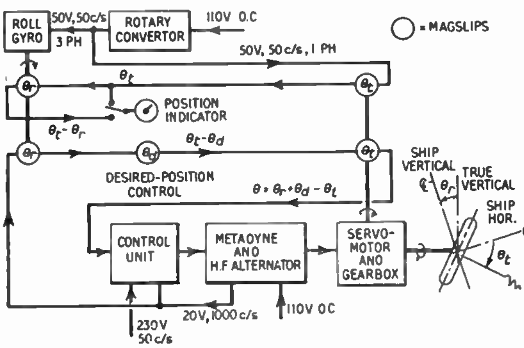

Fig. 14. Schematic of stabilizing equipment.

15.1. *Position measuring-systems*

The kernel of the stabilizer is a bottom-heavy gyro which provides a vertical datum against which the roll-angle of the ship θ_r is measured.

The "error" measuring system of the control-system consists of a roll transmitter measuring θ_r, a "follow-through" transmitter by means of which the desired angle of radiation, θ_d, with respect to the horizontal is included, and a coincidence transmitter which measures the transducer-shaft position, θ_t. These magslips are so phased that the output-signal is proportional to the error in alignment $\theta = \theta_r + \theta_d - \theta_t$. Provided that the control system can maintain θ substantially zero the transducer position relative to the ship is $\theta_t = \theta_r + \theta_d$ and on allowing for the roll-angle θ_r, the angle of the acoustic radiation will be at the desired angle of θ_d with respect to the horizontal.

The position-monitoring system is arranged to display:

(a) the position of the transducer relative to the ship, that is θ_t, the changes in which are an indication of the amount the ship is rolling

and

(b) the angle $\theta_t - \theta_r$ which is equal to $\theta_d - \theta$, that is, it displays the angle of acoustic radiation less the angular error of the control system, which gives an indication of how well the system is performing.

15.2. *Design of the output-stage*

The output stage of a position-control system is largely governed by the power-rating of the servo-motor—in this case approximately 1 h.p. This is rather a large power to develop by means of a field-controlled d.c. motor and as a metadyne-generator of 1·2 kW rating was available from the University laboratories it was decided to use this to control a d.c. servo-motor by means of its armature-voltage. The attractive feature of this generator is that it has a "constant-current" type of load-characteristic as shown in Fig. 15 which provides a limit to the stalled-torque of the servo-motor and also a limit to its no-load speed.

As there was an element of uncertainty in the estimate of the dynamic load on the transducer and as the system was required to operate

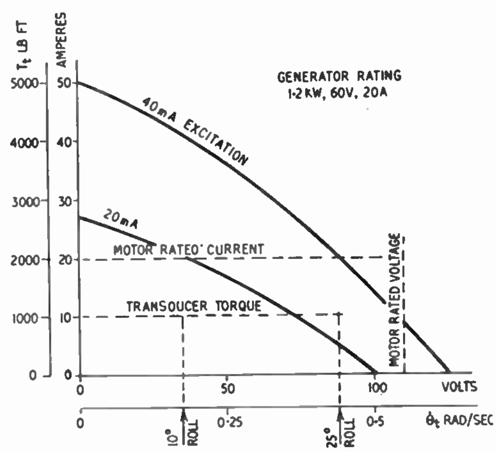

Fig. 15. Metadyne/servo-motor characteristics.

without fail, during a specific period of sea trials, without the opportunity of preliminary measurements, a 2 h.p., 110V, 1,425 rev/min motor was chosen. This was used to drive the training-shaft through a 15:1 gear, thus giving a total reduction of 270:1 between the motor shaft and the transducer.

It is well known that the torque T and speed

$\dot{\theta}$ developed by a d.c. shunt motor may be expressed by the equations

$$T = K.I \quad \text{and} \quad \dot{\theta} = \frac{V}{K}$$

where I is the armature current, V the armature voltage and K is the electromechanical constant of the motor. Thus it is permissible to scale the V–I axes of the metadyne characteristics directly in terms of transducer-shaft torque and speed as shown. Superimposed on the graph are

(a) the nominal transducer operating-torque $T_t = 1050$ lb-ft.

and

(b) the maximum shaft speeds corresponding to 10 deg and 25 deg rolls.

It can be seen that these co-ordinates are within the capabilities of both the motor and the generator.

The overall transfer-function between the field-current, I_f of this generator and the transducer position, θ_t is

$$\frac{\theta_t}{I_f}(j\omega) = \frac{3 \times 10^{-2}}{j\omega\left(1 + j\frac{\omega}{6}\right)\left(1 + j\frac{\omega}{15}\right)} \text{ rad/mA}$$

The system designed to meet the given specification is based on this transfer-function and it can be seen from the log amplitude/log frequency plot of Fig. 16 that the system can be stabilized by two phase-advancing networks with the overall transfer-function

$$\frac{\left(1 + j\frac{\omega}{10}\right)}{\left(1 + j\frac{\omega}{100}\right)} \cdot \frac{\left(1 + j\frac{\omega}{15}\right)}{\left(1 + j\frac{\omega}{30}\right)}$$

These give a phase-margin of 30 deg at $\omega = 25$ rad/sec and permit a useful loop gain of approximately 40 at $\omega = 1$ in comparison with the required minimum of 20.

Thus the electronic control-circuit is required to have a transfer-function of output-current, I_f in response to error signal θ of

$$\frac{I_f}{\theta}(j\omega) = 1{\cdot}33 \times 10^{3} \frac{\left(1 + j\frac{\omega}{10}\right)}{\left(1 + j\frac{\omega}{100}\right)} \cdot \frac{\left(1 + j\frac{\omega}{15}\right)}{\left(1 + j\frac{\omega}{30}\right)} \text{ mA/V}$$

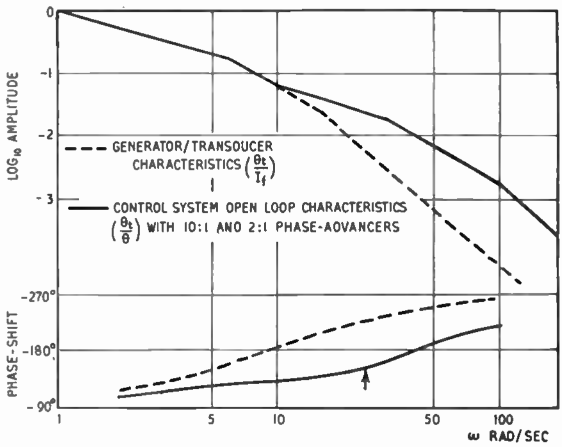

Fig. 16. Amplitude/frequency and phase/frequency characteristics.

15.3. *The electronic control-circuit*

The electronic control-unit consists of a full-wave, phase-sensitive detector, a single-stage d.c. feedback amplifier which is used to effect stabilization and a balanced d.c. output-stage which supplies a maximum differential current of 40 mA in the fields of the metadyne-generator.

The single-stage feedback amplifier provides the 10:1 phase-advancing transfer-function by having appropriate capacitors shunted across the input and feedback resistors. The additional stabilization is obtained by making potential-dividers which feed the output-stage into 2:1 phase-advancers; these serve to maintain the phase-margin over a wider range of frequency and render the system stability less sensitive to gain changes.

The resulting system has a natural frequency of 4·0 c/s and exhibits a 20 per cent. overshoot in response to a step-function input.

15.4. *Auxiliary circuits and protective features*

The linear-range of the control system is limited to error signals of ±1 deg and as is well known in control-system practice such a system will exhibit several overshoots before settling down, whenever it is required to run into alignment from a large initial displacement.

To prevent this non-linear oscillation from occurring it is arranged to give the system a dead-beat response to large misalignments by altering the method of stabilization to that of equating the square-root of the error voltage to a voltage proportional to the velocity of the transducer shaft.[4]

As the transducer and 18:1 reduction gear are on the outside of the hull it is essential to avoid damaging them by incorrect operation of the system. The principal protective feature is the use of an auxiliary field in the metadyne-generator to provide regenerative braking of the servo-motor whenever incorrect operation occurs. A limit switch is connected to the transducer position-monitoring shaft and this is arranged to apply the regenerative braking whenever the transducer position exceeds +25 deg or −115 deg.

Further control-circuits are interlocked with this limit-switch so that it is essential to have the supplies switched on to the gyro and to the electronic control-unit and the limit-switch closed before it is possible to close relays which apply h.t. to the output-stage and disconnect the auxiliary, regenerative-braking field. Conversely, failure of any of these supplies will apply regenerative-braking and bring the motor to a standstill.

Provision is made for manual control of the transducer by feeding the generator fields directly. In this way control can be regained after the limit-switch has opened.

16. Operating Experience

This roll-stabilizer was used throughout the sea-trials of the fish-detection equipment described in other parts of the paper and in the simultaneous trials of a surveying asdic system and was instrumental in contributing to the success of these experiments.

The measured error in response to 10 deg rolls was approximately ¼ deg. Simultaneous measurements indicated that the torque required to train a balanced transducer is approximately 400 lb-ft. referred to the transducer shaft. It is therefore quite feasible to control such a 400-lb transducer by means of a split-field d.c. motor of ½ h.p. rating.

Part 5. RESULTS OF TRIALS AND LESSONS LEARNED

17. Results of Trials

The electronic sector-scanning equipment worked successfully on R.R.S. *Discovery II* during the two-week's cruise in October 1958. It had, of course, many limitations compared with what would be provided in a fully-operational system. Nevertheless, the theoretically-expected performance was achieved and fish were detected.

After all the lining-up operations described in previous Parts of this paper were completed, the first tests made were of angular and range resolution. A steel sphere, of 18 inches diameter, partly air-filled and very slightly buoyant, was attached by a thin steel wire to a sinker, and dragged by a small rowing boat so that it could be placed in various positions in the scanned sector at a depth of approximately half the depth of the water. It was confirmed, firstly, that such a small target could be reliably detected above the level of the random reverberations, and, secondly, that when the brilliance of the display was so adjusted that there was no visible response from the secondary lobes of the scanning pattern, then the echo was confined to one beamwidth and one unit of pulse duration. Photographs of the display, showing the sphere in about 25 fathoms of water near Falmouth and in about 10 fathoms in Weymouth Bay, are reproduced in Fig. 17 (a) and (b).

In judging such photographs of the display, it should be remembered that the photographs cannot possibly reproduce the actual visual effect, whereby the target is positively identified against the background of reverberation by its constancy (or relative constancy at the larger ranges) from pulse to pulse: this contrasts vividly with the randomness and lack of repetition of the reverberation.

Another point to be noticed in all the photographs of horizontal-beam operation is that the first part of the range (typically about 100 yards in the English Channel and North Sea) is partially obscured for detection purposes by the strong echoes from the sea-bottom received along successive secondary lobes of the vertical beam-pattern. The bottom echo is strongest on

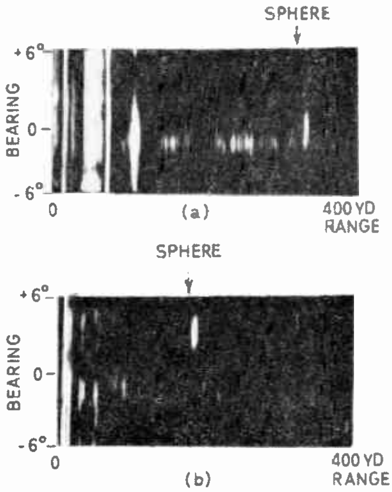

Fig. 17(a). Showing 18-inch diameter sphere at a range of about 350 yards in depth of 25 fathoms near Falmouth (range scale 400 yards). (b) Showing 18-inch diameter sphere at a range of about 150 yards in depth of 10 fathoms in Weymouth Bay, (range scale 400 yards). Several pulses are superposed in both photographs and, as the ship was swinging, the target shows up as rather too large.

the more nearly vertical lobes since the angle of incidence is there much greater than for the main beam and lobes near it. This was inevitable with the transducer used, which had uniform sensitivity across its vertical axis; and indeed it was specifically desired for some other work which was being done simultaneously using the same transducer. But in an operational system there might be some advantage in designing the transducer so as to make these vertical side-lobes negligible; that part of the range between the ship and where the main beam first strikes the sea-bottom would then be clear for the detection of fish, etc., in mid-water. The existence of an echo in this part of the range would be strong evidence of a mid-water rather than a bottomed target.

Figure 18 shows some sea-bottom features, such as ridges and rocky outcrops.

Figure 19 shows some displays of small fish shoals in the Southern part of the North Sea. The spread and strength of the echoes indicates a number of fish in a shoal—they were almost certainly herring—and they could be distinguished from features on the sea-bed by their movement and inconstancy of shape.

Figure 20 shows the result obtained by turning the transducer so that the axis of the beam was vertically downwards. The range scale has been opened out so that maximum resolution in the 20-fathoms depth is obtained. A number of small groups of fish are clearly seen in mid-water, and it is just possible that some individual fish are shown by the smaller echoes. It is clear that the equipment achieves the performance for which it was designed.

18. Lessons Learned

It is difficult to be quite definite about all the apparent defects and virtues of the equipment on the basis of one short trial lasting only two weeks. There is, however, no doubt that the equipment will detect fish effectively, and probably more effectively than any existing equipment. The higher information rate of the scanning system as compared with single-beam systems is of very great value both in initial detection and in determination of the nature of the object producing the echo. If some method of simple, immediate and permanent recording of the displays could be devised, the system would probably fulfil all requirements.

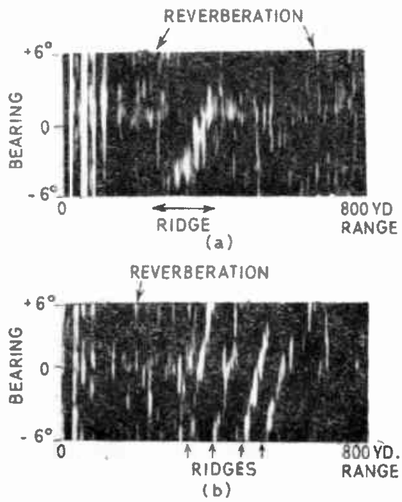

Fig. 18(a). Showing a ridge on the sea-bottom off the South Coast (range scale 800 yards). (b) Showing parallel ridges off the Dorset Coast (range scale 800 yards).

The experimental equipment, as such, had some defects which can be readily corrected in an engineered model now that they are appreciated. Among these are, in addition to some already mentioned

(a) Lack of equalization of the response over the bearing scan which gives rise to the striated nature of the display as shown in the photographs. This is due fundamentally to the fact that both the transmitted directional pattern and that within which the receiving sector is scanned[1] are, in a simple system, of a type which droops to half-power at the edge of the sector, so that the display would be 6 db down at the edges of the bearing scan compared with the centre. In the experimental equipment this was largely compensated by adjustment of the amplitude/frequency response of the wide-band circuit following the delay line, and the improvement so obtained is clearly shown in Fig. 17(b) where the equalizer was connected, and Fig. 17(a), where it was not connected. As the dynamic range of the cathode-ray display is not large, better equalization is desirable, but this should not be difficult to obtain.

(b) Inadequate stability of channel phases. The filters used in the channel units have phase-shifts which are too dependent on temperature. It would be wiser to use more

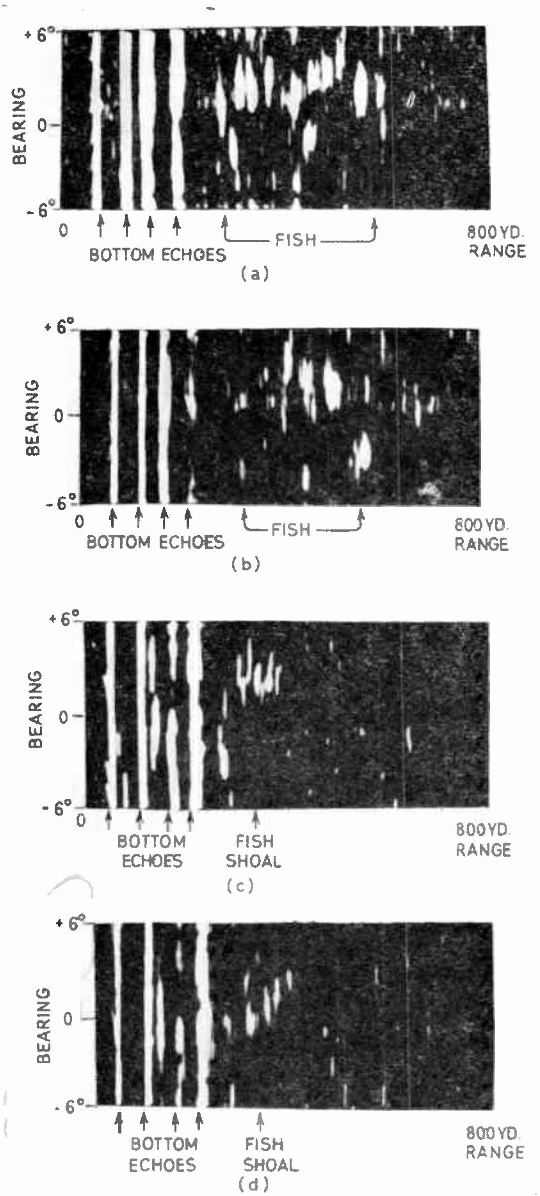

Fig. 19. (a) and (b). Showing small fish shoals in the North Sea (range scale 400 yd., beam tilted 10° down).

(c) and (d). Photographs, taken only a minute or so apart, of a small fish shoal in the North Sea, showing the change of outline (range scale 400 yards, beam tilted 10° down).

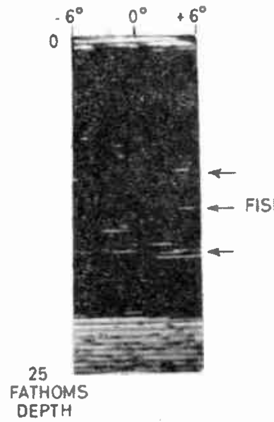

Fig. 20. Use of equipment as a scanning echo-sounder, showing small groups of fish (possibly even individual fish) (range scale 50 yards).

stable arrangements; and the quadrature modulation method described in ref. 1, but applied to the band-pass operation, would probably be very suitable as a substitute for the double-modulation method used.

(c) Operationally, the use of a fixed sector centred on the normal to the ship's axis is not the most satisfactory arrangement. An ahead sweep would be better in enabling a target to be observed for a longer period, and to be located *before* the ship has passed it. The fixed arrangement used in the trials was dictated by special circumstances.

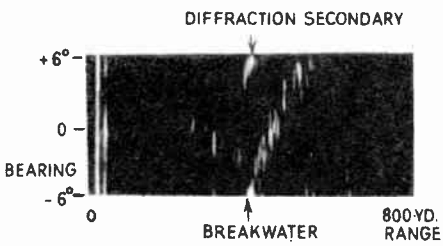

Fig. 21. Outer breakwater of Portland Harbour, showing effects of the diffraction secondary.

(d) "Diffraction secondary" beams were, on occasions, a nuisance. This was discussed in ref. 1, and is manifested by the fact that a target just moving off at one edge of the display begins to show (ambiguously) at the other, but as the movement proceeds further, the false echo extends with ever-decreasing strength. This is illustrated in Fig. 21, where the breakwater of Portland harbour, falling away at an angle to the ship's course, is such a large target that the diffraction secondary causes confusion. It is not serious for most purposes, but can be avoided by sacrificing some of the sector by placing a mask over the edges of the display, or, of course, by reducing the frequency-sweep of the frequency-swept oscillator.

(e) It would almost certainly be worth while to provide more than eight transducer channels on the receiving side, so that the scanned sector could be more than eight times the 3 db beamwidth. It is however, doubtful if *very* large numbers of channels (e.g. 50) would be worth the extra cost involved.

19. Acknowledgments

The authors wish to record their appreciation of the help given by many colleagues in the Electrical Engineering Department of the University of Birmingham and at the National Institute of Oceanography—in particular Mr. N. Barnickle and Mr. A. Chatterjea of the former, and Mr. F. E. Pierce of the latter, who was responsible for the mechanical design of the transducer together with its mounting and the servo-motor unit. They are also very greatly indebted to the Captain and Officers of R.R.S. *Discovery II* for their friendly co-operation.

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DISCUSSION ON 1959 CONVENTION PAPER

"Transmitting Aerials for Television Broadcasting in the United Kingdom" †

E. Jamieson: May I ask Mr. Brown whether his scaling is straightforward dimensional scaling or whether he has to take into account the scaling of conductivity, dielectric constant or other quantities?

A. Brown (Associate Member) (*in reply*): Only the dimensions are scaled. At the frequencies in which we are interested, the effects of changes in conductivity and in dielectric constant are negligible.

J. H. Adams: I would like to ask Mr. Brown if he could give a little more detail about the picture distortion in the nulls of the radiation pattern near the aerial. I had some trouble when the Crystal Palace station doubled its power, as I live about half a mile from the aerial.

A. Brown (*in reply*): The photograph (Fig. 8) which is shown in the paper was obtained by simulating the conditions which were thought to exist at some points near the Crystal Palace transmitting station, and the effect may be similar to that which you have experienced. There are several possible causes of distortion at points near the null of the radiation pattern. (Mr. Wise's communicated comments are of interest in this connection). It must be borne in mind that it is difficult to calculate the amount of distortion which might be expected in a given case. There are several factors which cannot be calculated exactly; for example, the amplitude and phase of the wave reflected from the ground. In addition, very small differences in the amplitude and phase characteristics of the transmitters become very important in an area corresponding to a null in the radiation pattern.

Due to these difficulties some trouble was at first encountered in small areas near the Crystal Palace station, and it became apparent that the null-filling measures adopted were not quite sufficient. A cure was obtained by effectively feeding the two transmitters in parallel to the whole aerial system, and by slightly altering the power division between the upper and lower halves of the aerial.

† A. Brown, *J. Brit.I.R.E.*, **19**, p. 389, July 1959.

The questioner then stated that the effect of the distortion was variable, since sometimes there was a perfectly satisfactory picture.

A. Brown (*in reply*): This might be expected, since if there are two vectors nearly out of phase, then slight changes in transmitter tuning, propagation conditions, or ground reflections, which affect the amplitude or phase of one vector, may have an important effect upon the resultant.

P. S. Stanley: Mr. Brown suggests in his paper filling in the nulls of the radiation pattern with a view to preventing distorted pictures. In view of the trouble obtained is it true to say that this measure is insufficient, and that the approach to the problem is incorrect?

A. Brown (*in reply*): It depends upon what is meant by filling-in the nulls. One could conceivably have an aerial system with no ripples in its vertical radiation pattern. An example is given in the paper of the type of pattern which might be achieved in Band V. However, it may not be worth attempting to obtain this condition, because in doing so some loss of gain in the distant field must be accepted, and very often a small amount of "filling-in" will give quite a good service in regions near the mast. In the particular case of the Crystal Palace station, it happened that the filling-in was not sufficient to give good service in a few small areas, but I do not think that the approach to the problem is therefore wrong. At the start, a more pessimistic assumption regarding the various conditions could have been made and the nulls filled in more completely, in which case no trouble would have been experienced.

G. R. F. Metcalfe (Associate): Would not a simple way out of this problem be to put smaller aerials perhaps half-way down the mast which could "sprinkle" the shadow area of the array, and could be parasitically coupled to the main aerial?

A. Brown (*in reply*): This solution offers no advantage. At a particular point, the field from a supplementary aerial may still be in opposition to the field from the main aerial, thus creating a null.

H. V. Sims (Member): Would it be possible to skew slightly the lower dipoles to allow viewers in the vicinity to use horizontally-polarized aerials?

A. Brown (*in reply*): This is certainly a possibility. If the aerial is skewed, it is equivalent to mounting a supplementary horizontal aerial at some point on the mast, and feeding it with a part of the transmitter output, but because the polarization is horizontal, no extra nulls will be produced. There may, however, be mechanical difficulties, and in this particular case the method was considered undesirable.

H. V. Sims: I would make one further point: I believe that the distortion caused is due to the change in the pattern with modulation frequency. If null-filling is carried out, I assume it is true that this effect is reduced?

A. Brown (*in reply*): It is indeed reduced. This effect, however, is only one of several possible causes of distortion.

F. H. Wise (Graduate) (*Communicated*): Mr. Brown refers to reception difficulties at locations corresponding to nulls in the vertical radiation pattern of split aerial systems when two transmitters are used and an explanation is given on the basis of variation of relative carrier phase of the transmitter outputs with video frequency. Whilst this is one effect which can occur it must be pointed out that similar effects giving rise to distorted pictures are also possible.

Other effects have been investigated in an I.T.A. internal report by W. N. Anderson and myself. Summarizing the results, we found that distorted pictures may occur when, with a split aerial system and two transmitters, the following effects are present:

(1) The phase difference between the two picture carriers is modulation level dependent.

(2) The gain difference between the two transmitters is modulation level dependent.

The above effects may be video frequency dependent.

In the case where the distortion is independent of video frequency, the sympton is a distorted grey scale which, in an extreme case, may amount to a complete inversion, i.e. black appears as white and white as black. The sound channel may be distorted by the same mechanism.

Owing to the large number of variables associated with transmission paths, it is not possible to be specific about the regions which will be subject to the above distortions. An analysis of the problem, making certain simplifying assumptions, indicates that the principal region affected is that corresponding to the first null, i.e. the null region furthest from the transmitter. Using some representative figures, it is calculated that the principal region of severe distortion is one about 50 yards wide, and having a radius of 0·5 mile from the Authority's Croydon transmitter. In fact, the presence of reflecting objects causes the fields from the two transmitters to be modified considerably. If the fields are modified in amplitude to different degrees, then the amount of distortion is reduced. It is shown that, in a typical case, 0·4db difference in field is sufficient to prevent an inversion at any point on the grey scale. The result is that in practice the region becomes one of potential distortion in which the effect occurs in patches.

A preliminary investigation confirmed that connecting the two transmitter outputs in parallel, at the inputs to the two feeder systems, cures distortions due to differential gain and phase.

A. Brown (*in reply*): I agree that there are several possible causes of distortion at locations corresponding to nulls in the vertical radiation pattern of a split aerial system. It was not, however, practicable to include a complete discussion of the problem in this paper. It is hoped that a more detailed account of B.B.C. experience in this connection will be published elsewhere in due course. It is true that differences between the modulation characteristics of the transmitters can aggravate the difficulties. This is mentioned in Section 2.4 of my paper.

In discussing the effect of reflecting objects, Mr. Wise states that, in a typical case, if the fields are modified in amplitude to extents differing by as little as 0·4 db, inversion is avoided. I suggest that this figure is very dependent upon local circumstances, and that it may not be a truly typical figure for all cases.

Flame-Sprayed Ceramic Dielectric for Transducers†

by

G. V. PLANER, PH.D., M.SC.‡ and A. FOSTER, B.SC.(ENG.)§

Summary: A high speed electro-mechanical transducer system based on the Johnsen-Rahbek effect is described, in which a flame-sprayed ceramic of high permittivity replaces the conventional semi-conductor. Among advantages of the system are its operation at high pulse repetition frequencies, relatively large mechanical thrusts obtainable at low signal voltages, good wear characteristics, as well as ease and economy of producing large ceramic rotors.

1. Introduction

Investigations on the possible use in high-speed clutch systems of the Johnsen-Rahbek effect, that is the electrostatic attraction between a semi-conductor and adjacent metal electrode on application of an electrical potential, have been reported in the literature at various times during past years.

In one example of such systems described, use has been made of a semi-conductor consisting of fired, ceramic magnesium orthotitanate, Mg_2TiO_4, reduced by heating in hydrogen to render it conductive.[1] Flat plate clutches using this type of material against a hard steel rotor were however reported to be unreliable in regard to mechanical wear.[2] Another interesting system recently reported[3] utilizes a rotor consisting of a low conductivity compound essentially of carbon in an elastic synthetic resin matrix comprising asbestos filler. The compound, bonded to a rotating metal shaft is arranged to wear against a steel member held against the surface.

The new type of transducer to be described here is based on the discovery some time ago that dielectrics, and in particular high-permittivity ceramics may with advantage be used in place of the conventional semi-conductors.‖ The systems normally are in the form of cylindrical ceramic rotors metallized in the interior to constitute one of the electrodes and mounted on a metal shaft, the other electrode being a narrow steel brake-band embracing part of the periphery of the continuously rotating ceramic against which it is held by spring pressure. In the absence of the field the band remains stationary while on application of an electric pulse between the inner electrode and the brake-band the latter tightens around the rotor, and is consequently dragged momentarily in the direction of rotation. This movement is translated into a sharp mechanical thrust of a stylus attached at one end of the brake-band. On completion of the pulse the band and hence the stylus are returned to their original positions by spring pressure.

This type of system, utilizing a drum of high-permittivity titanate ceramic, is proving successful as a high-speed electro-mechanical transducer where rapid translation of electrical pulses into a mechanical output is required.

Among the advantages of the system are the relatively large mechanical thrust realizable at low input voltages, rapid response, as well as the remarkable wear characteristics under correct operating conditions.

The ceramic originally tried consisted of an extruded or moulded, fired titanate composition with a permittivity of the order of 3,000 at room temperature. Among limitations of these ceramics was the difficulty and cost associated with the production to accurate dimensions of thin walled tubes of greater lengths, where a larger

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‖ Patents pending (International Computers and Tabulators Ltd).

U.D.C. No. 537.228.4:621.315.612.4:621-578

number of brake-bands were to be incorporated in one drum; this would therefore necessitate the use of drums composed of several shorter ceramic sections with consequent difficulties in alignment, etc. A further drawback of the extruded or moulded ceramic cylinders is the limitation of the wall thickness, which for example in the case of 1 in. dia. tubes cannot readily be made below about 60 mils under normal production conditions; this imposes therefore a maximum in the capacitance value attainable between the inner electrode of the ceramic and the brake-band at a given permittivity of the ceramic.

In view of these factors the possibility of replacing these extruded or moulded and fired ceramics by a flame-sprayed deposit of high-permittivity directly upon the suitably dimensioned metal shaft appeared attractive. Various ceramics can in fact be deposited by spraying from an oxy-acetylene or similar gun without the need of subsequent firing; for the present purpose, inherent difficulties of such methods were (a) a certain degree of porosity obtained by flame spraying, which in the case of high-permittivity materials would sharply affect the capacitance; (b) the surface finish of the sprayed ceramic would be expected to be poorer than that of a fired ceramic and this would result in a larger air gap between the ceramic and brake-band with again consequent reduction in effective capacitance, and (c) it had to be ascertained that ceramics of the type required for the present purpose could be applied by flame-spraying without degradation due to the spraying conditions and that adequate adhesion to the substrate could be obtained.

The methods derived and discussed in the following sections do in fact satisfy (c) and in regard to (a) and (b) it has been possible to minimize the drawbacks enumerated to the extent where they are outweighed by the effect of the thinner ceramic layers obtainable by flame-spraying, so that the capacitance against the brake-band in the latter case can in fact exceed that for the conventional ceramic. The wear characteristics for the sprayed rotors, as in the case of the fired ceramic, appear to be very satisfactory, wear tests under pulse conditions having been continued to 850 hours without apparent deterioration of the rotor.

2. Nature of the Ceramic

Various high-permittivity ceramic compositions can be used successfully, either by application from a powder- or a rod-type spray gun. In the former case the material has to be prepared in the form of a fine powder of good flowing properties and preferably high packing density. Normal oxy-acetylene spray guns with suction feed have been found suitable. In the case of the rod-type gun the ceramic powders have first to be sintered or compounded with an organic binder into rods which are fed into the gun, again using oxy-acetylene as the fuel gas and compressed air as the propellant. Although either types of gun may be used, the best results were obtained with a powder gun, this obviating moreover the need of preforming the special rods referred to.

Different compositions based on barium titanate have been found suitable and for example good results are obtained with a barium titanate-zirconate solid solution comprising a proportion of manganese or nickel oxide to eliminate any tendency to chemical reduction during spraying. Among other materials used were compositions of barium titanate with small additions of lanthanum oxide, La_2O_3, these having given good results also in the case of moulded ceramic rotors; the advantages of this particular ceramic are its hardness and hence wear-resistance, as well as its favourable permittivity-temperature characteristic.

However numerous other ceramic mixes can also be used provided that they can be prepared in the form of a powder with the requisite properties or rods of adequate mechanical strength; in addition the material must of course have a relatively high permittivity, preferably above 1,000, with reasonable constancy over the working temperature range, or at least there should be no undue fall in permittivity over this region.

To obtain optimum results the preparation of the ceramic, e.g. in pulverized form for powder-spraying, involved a double firing technique; the procedure comprises the stages of wet mixing of the raw-powders, drying, firing (e.g. at 1,200° C.) re-milling, drying and firing at a temperature slightly above that of the first treatment; thereafter the material is once more ground to the required particle size for spraying. While this method results in more complete interaction of the constituents and hence a higher permittivity and density, a single firing stage can be used where economy of the process is an important factor.

In the case of thin ceramic deposits, namely up to about 3 or 4 mils, no special surface treatment of the metal substrate is required other than normal degreasing or cleaning. In the case of thicker deposits, it is normally indicated to apply some form of roughening treatment, e.g. turning or shot-blasting to ensure reliable adhesion. In experiments, steel shafts were used as a substrate and the coating thicknesses applied were in the range of 5 to 10 mils. If desired, the substrate may be protected with an electroplated layer of, for instance, nickel, rhodium or the like before spraying to avoid possible deterioration of the interface between metal and ceramic.

3. Surface Treatment of the Rotor

After flame application of the ceramic, the surface of the latter is generally fairly rough and since the efficacy of the transducer depends on the smallness of the air gap between ceramic and brake-band, a high degree of surface polish of the ceramic is essential. In practice, the surface is normally ground at first with a diamond or carborundum wheel followed by further grinding and polishing with emery paper, metal polish and jewellers rouge.

4. Performance

The type of test-rig used to study high speed transducers of the present type is seen in Fig. 1, showing a ceramic rotor with steel brake-bands and provision for lubrication of the track, also comprising for test purposes a piezoelectric accelerometer as an anvil to monitor the mechanical output.

The system can be operated with d.c. pulses as well as pulsed a.c. Using a pulse length of 100 microsec with a pulse front of approximately 9 microsec and amplitude of 115V, the total period of oscillation was observed to be just below 200 microsec, so that ideally the maximum frequency of operation could be as high as 5 kc/s.

Applied to a drum of 1 in. rotating at 1,400 rev/min, the excursion of the stylus was between 5 and 10 mils. From tests using an accelerometer as an anvil the maximum force exerted by the stylus was of the order of 200×10^3 g cm/sec^2.

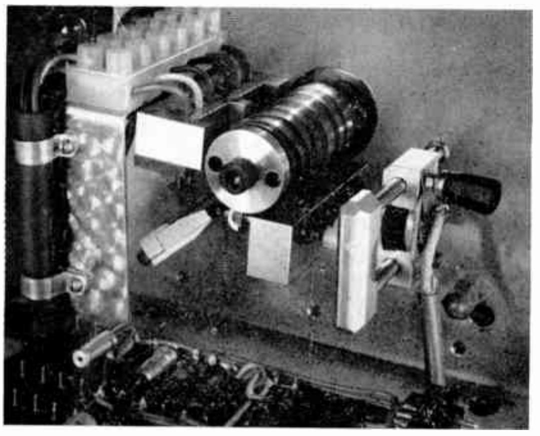

Fig. 1. Test rig for ceramic rotors.

To derive a comparative value of the capacitance of the flame sprayed rotors, i.e. between the inner electrode and the brake-band, as well as an approximate measure of the width of the air-gap between the latter and the ceramic, a standard procedure was adopted of measuring capacitance with the brake-band embracing 270 deg of the circumference of the rotor under a known pressure. In addition a second value was obtained of the effective capacitance of the flame sprayed ceramic utilizing the substrate as one electrode and a fired-on silver paint as the other. In this way a comparison could be obtained between the moulded and fired ceramic rotor of the usual thickness of 0·06 in. on the one hand and the flame sprayed units of the average thickness of 0·005 in. on the other (Table 1).

The air-gap in the case of the sprayed ceramic is therefore rather larger, since the surface finish although good cannot approach that of the fully fired ceramic; nevertheless due to the thinner layer applicable by spraying, the capacitance against the brake-band which is of course the most important factor is some 35 per cent.

higher. The effective permittivity of the flame sprayed deposit is from these figures approximately 1,500.

Table 1

	Moulded/ fired rotor	*Sprayed rotor*
Capacitance against brake-band (pF/cm^2)	1,320	1,780
Capacitance of metallised ceramic (pF/cm^2)	1,760	10,560
Estimated mean air-gap between ceramic and brake-band (microns)	0·15	0·4

With regard to the effect of temperature on the capacitance over the operating range of the device, Fig. 2 shows the type of curve obtained for one of the ceramic compositions used, from which the permittivity may be seen to be still reasonably high even at 140° C.

Mechanical wear tests under pulse conditions have been continued on flame sprayed rotors for 850 hours at a frequency of 1 kc/s without any noticeable deterioration of the dielectric or its functioning, this being equivalent therefore to a total number of 3,000 million brake operations. Tests over a range of humidity conditions have shown no variation in performance in this respect.

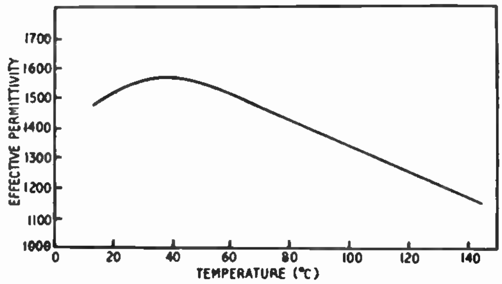

Fig. 2. Effective permittivity–temperature relation for flame-sprayed ceramic.

5. Acknowledgments

Acknowledgment is made to International Computers and Tabulators Limited for permission to publish this paper.

The authors are much indebted to Mr. P. R. Chen, Mr. R. W. Windebank and Dr. R. M. Glaister of G. V. Planer Ltd. for their contributions to this investigation.

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DISCUSSION ON 1959 CONVENTION PAPER

"Assessment of X-radiation from Television Receivers" †

E. G. Goodhew: In Appendix 2 Mr. Ciuciura states "Unfortunately, the prospects of development of an improved equipment for use in the factory in the near future are small." In fact during the I.E.C. Convention at Copenhagen in July 1958 we had a demonstration of Oosterkamp's equipment (which is described in reference 9 to the paper) and one of British manufacture. Whereas Oosterkamp's was rather a research laboratory set-up to show that this could be done, that of British manufacture was properly engineered testing equipment and seemed to cover what we needed. Admittedly, there are great difficulties and Mr. Ciuciura has found that the National Physical Laboratory is not yet ready or able to provide a standard at this sort of level. This means that the equipment, while it can be sold and used, cannot be standardized in a satisfactory manner.

My second point refers to the relationship between voltage and radiation. Mr. Ciuciura says that it is proportional to the square of the voltage but does not produce any theoretical argument for this. At an earlier discussion on X-radiation from television receivers arranged by the British Radio Valve Manufacturers' Association it was authoritatively stated that radiation was proportional to a power of V, and suggested that it was an odd, high power, namely 7 or 9. In Mr. Ciuciura's Fig. 5 we find for approximately a 10 per cent. increase in voltage there is a ten-fold increase in radiation and I am sure that this is a higher power than 2.

The difficulty in this subject is that it needs the co-operation of experts from a wide variety of fields. Therefore, when reading this paper one needs to be very careful and it requires expert guidance. To quote from a comment in a National newspaper: "Of different sets tested between one in a hundred and one in five produced unsafe X-rays." Now that is the truth, it might be considered as nothing but the truth, but it certainly is not the whole truth. If one looks at Mr. Ciuciura's Table 4 and finds where this figure of 20 per cent. is quoted, it is seen to be for 18 kV design centre with a spread of 4 kV, an internal resistance of the source of one megohm, and a beam current of 500 microamperes. I believe that no where in this country or in Europe is any receiver operating in that range being offered for sale to the public. I would say that receiver manufacturers have been aware for a long time of this hazard, have sought advice on its effects and methods of measurement and by that means have established reasonable limits. They have assured themselves that the equipment sold to the public now is safe and by means of investigations like Mr. Ciuciura's are equipping themselves for a future which might include operating conditions that require some safeguard.

A. Ciuciura (*in reply*): I have seen Oosterkamp's equipment and would agree that it is not adaptable for factory use. The second equipment was originally based on the scintillation counter principle although the company developing it has since adopted a proportional counter. When used in its simplest mode of operation the equipment has much better sensitivity than the instrument described in Appendix 2, but there is no reason why its accuracy should be greater. In so far as I am aware, the equipment has not been available commercially as yet.

Theoretically the amount of radiation produced is proportional to V^2; unfortunately, at low voltages the relationship is not well established. When we talk about cathode-ray tubes we are concerned with radiation which is outside the tubes, and which is entirely dependent on the attenuation characteristics of the glass used. This attenuation is of a very large order and its characteristics are such that as the potential applied to the cathode-ray tube is lowered its value increases. As a result of this there is a very rapid reduction in the amount of X-radiation with the reduction of potential applied. For the graphs given in the paper I tried to evaluate the law governing distance and obtained really very large powers, powers so large that I was not prepared to quote them. I am fairly confident that the measurements are

† A. Ciuciura, *J.Brit.I.R.E.*, **19**, p. 469, August 1959.

correct, because they were made on two distinctly different instruments, and gave the same order of values.

I think Mr. Goodhew's final point is very important. I did not intend to produce a review of the present state of X-radiation: this Table came as a result of my calculations on the possible number of receivers that exceed the permissible dose rate. In this Table are compiled all possible conditions that could be acceptable within the present published data limits. I quite agree with Mr. Goodhew that those conditions would not necessarily be acceptable to the receiver manufacturer. As far as this country is concerned I am not aware of any commercial receiver with a voltage of 18 kV although I believe on the Continent there are one or two. We operate at 16 kV or less where the receiver design is orderly and the spreads are small. Hence as is apparent from the paper there is no possible danger of X-radiation. However if the e.h.t. is increased and design discipline released, the situation will be less satisfactory.

B. W. Osborne (Associate Member) (*Communicated*): I see that B.S.415 gives a radiation limit of 0·5 milliroentgens per hour. If this limit applies to peak radiation levels, as is implied, then it appears that there is a further practical safety factor, the extent of which depends on the internal impedance of the e.h.t. supply (as shown by Fig. 8 of the paper).

If the maximum radiation from a receiver is at the B.S.415 level, the effective mean level is lower. It is the mean level, over a long period of time, with which we are concerned in considering the harmful effects of X-rays on the human body. I would like to ask Mr. Ciuciura if he considers that the Standard is too stringent in this respect.

A. Ciuciura (*in reply*): In the receivers used in this country, the internal impedance of the e.h.t. varies between 5 megohms and 10 megohms. In Fig. A the results of Fig. 8 in the paper are replotted as a function of beam current. Under evening viewing conditions a fair average peak beam current would be about 1000 microamperes with average current of about 100 microamperes.

I do not recollect any quantitative analysis of television waveforms as a function of amplitude: oscilloscope examinations show that the bulk of information is transmitted at fairly low peak currents. Thus, taking into account the results of Fig. 8 one can expect only a slight difference between peak and mean value of X-radiation—a factor of 2 to 3, at the most.

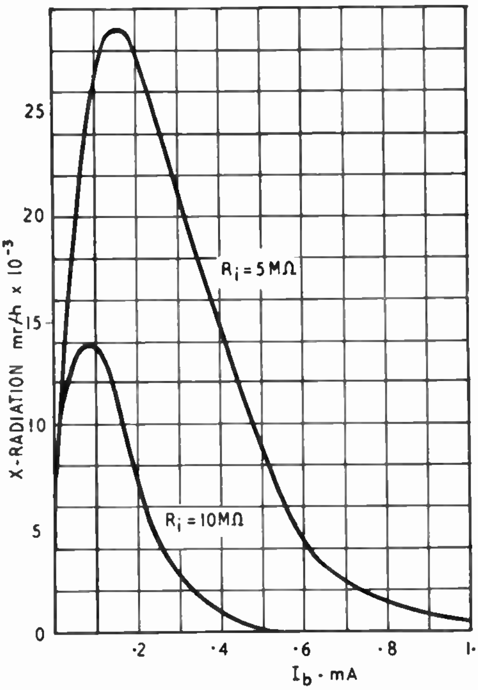

Fig. A. X-radiation as a function of beam current. (E.H.T. = 18 kV.)

For a specification to be of value, it must be supported by a simple measuring technique. With the present recommendation a d.c. beam current may be used and the controls adjusted for maximum radiation. If the principle of average X-radiation level were adopted, it would be very difficult to define the receiver operating conditions.

Some Aspects of the Design of a Small Television Station†

by

AUBREY HARRIS, ASSOCIATE MEMBER ‡

A paper read on 1st July 1959 during the Institution's Convention in Cambridge

Summary: Some of the factors governing the choice of equipment for use in small commercial television stations in isolated areas are discussed. Specific reference is made to two different types of installation at station ZBM-TV, Bermuda, using the same basic equipment. The two systems described relate to (a) a combined television centre containing both studio and transmitter in the same building; and (b) separate studio and transmitter sites. The equipment used included vidicon telecine and studio cameras and a 500W vision transmitter; details are given of these items and also of vision, sound and control facilities.

PART 1

1. Introduction

The operation of a small television station is not, as may be imagined, simply a scaled-down version of a large television installation. Many factors are involved which affect the amount and the type of equipment to be employed and also the uses to which the equipment will be put.

Of prime consideration is the amount of programme material to be "imported" either by networking or by the use of telerecorded or filmed programmes. In small, isolated communities, particularly oversea, a number of which are now installing television services, programmes made up of filmed items will be in the majority and may even be used exclusively. This indicates that the telecine reproduction facilities should be of the most reliable available, should be able to be operated by staff with a minimum amount of technical training, and should require very little maintenance. It would be desirable to have standby, duplicate telecine equipment installed; however, economic factors may preclude this luxury.

For the installation where there is some local live talent available or where news bulletins, weather forecasts and simple interview items are to be produced, one or two live cameras would be required. Here again, equipment simple to operate and maintain is essential and the camera using the photo-conductive type of tube (Vidicon) is ideal, despite its need for large amounts of light. A single broadcast-quality vidicon camera fitted with a zoom lens is a very versatile piece of equipment for the small studio and many programmes may be produced in their entirety with one such camera. However, there is always the eventuality of faults occurring at the most critical moments during or just before such a programme, and the installation of two studio cameras is considered essential. It is interesting to note that a high proportion of faults on studio camera chains occur in the electronic viewfinder circuits associated with the cameras.

Synchronizing generators should also be provided in duplicate as these form the very basis of the whole technical operation. An arrangement is also required whereby the output pulses from either generator may be switched at will to the camera and associated equipment.

Only the simplest vision mixing equipment is required. In most cases a three or four input mixer working on the "A-B" principle, providing facilities for cutting, mixing and fading, will be adequate.

Transmitter power, aerial type and siting depend, of course, on the particular location and terrain and no generalizations can be made. The number of technical and programme staff will be limited in the small television station and it is sometimes an advantage

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‡ Formerly with the Bermuda Radio and Television Company Ltd., now with the Ampex Corporation.

U.D.C. No. 621.397.72

to concentrate all control operations in one area; in this way it is possible to operate with a very small number of operators. The installation described in Part 3 of this paper indicates how the entire control room operation may be carried out with a staff of three, even for live studio productions.

As a practical illustration of the application of the principles outlined above the remainder of this paper will describe in detail the commercial television operations in Bermuda.

2. General

The television installations of station ZBM-TV in Bermuda provide the opportunity for the study of two different types of commercial television operation, namely, (a) a combined studio-transmitter centre and (b) separated studio and transmitter locations. Originally, as a temporary measure, the studio equipment and associated apparatus, together with the transmitter, were installed in the ZBM radio building in Hamilton; the transmitting aerial and its tower were mounted above the transmitter, on the roof of the building. Some seven months later, the transmitter was moved to its permanent site on higher ground approximately 1½ miles away and a new vision aerial, mounted on a 270-foot tower, was brought into service. The transmitter was then modified to work on an unattended, remotely controlled basis.

The vision signal was conveyed to the transmitting site by a microwave link and the accompanying sound signal was relayed by land line. At the time of the change of site of the transmitter certain modifications were made to the method of operation at the studio centre necessitating changes in control room layout.

A description of the equipment and the combined studio-transmitter television centre is given in Part 2. Part 3 covers the installation of the transmitter at a site remote from the studio and describes the vision and sound link equipment, and remote control apparatus, together with details of modifications carried out in the studio control room.

PART 2

3. Local Factors

Bermuda is a group of small coral islands in the Western Atlantic Ocean, approximately 600 miles from the nearest land, situated at latitude 32° 15′N and longitude 64° 51′W. The group of islands covers an area of only 20½ square miles and its greatest dimension is about 15½ miles from end to end ; no point is further than ½ mile from the sea. (See map: Fig. 1). The terrain is generally rather hilly, but there is no ground more than about 250 feet above sea level. The civilian population is about 42,000; there are in addition approximately 10,000 service personnel and their families.

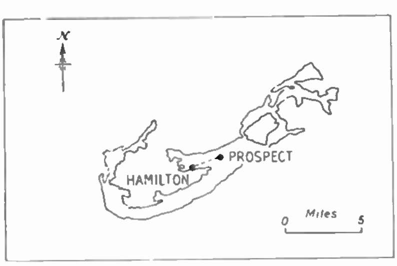


Fig. 1. Map: The Bermuda Islands.

Owing to the great distance from the nearest mainland it is not possible to take any programmes on a direct network basis ; thus all programmes must originate locally. Out of a total transmission time (excluding testing periods) averaging 46 hours per week, about 12-13 hours are produced on live camera. For the remaining time 16 mm. films or telerecordings are shown. Many live commercials are produced from the studio.

The transmission characteristics are based on U.S. standards, 525-line, 60 fields/second, with negative picture modulation and frequency modulated sound. As there are no nearby television transmitters, the possibility of adjacent channel interference is absent; therefore double sideband vision transmission may be used, and a vestigial sideband filter is not required. The radiated signals are horizontally polarized.

The television station was housed on the newly constructed second floor of the existing radio station building, situated on the western outskirts of Hamilton, the capital city of Bermuda. The total floor area available was 50 feet by 72 feet, and within this area were

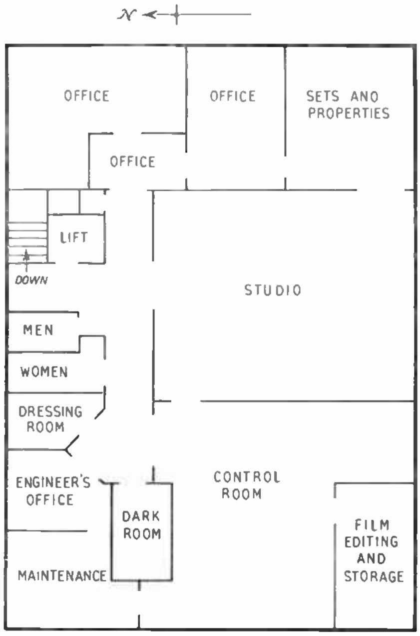


Fig. 2. Studio centre : floor plan

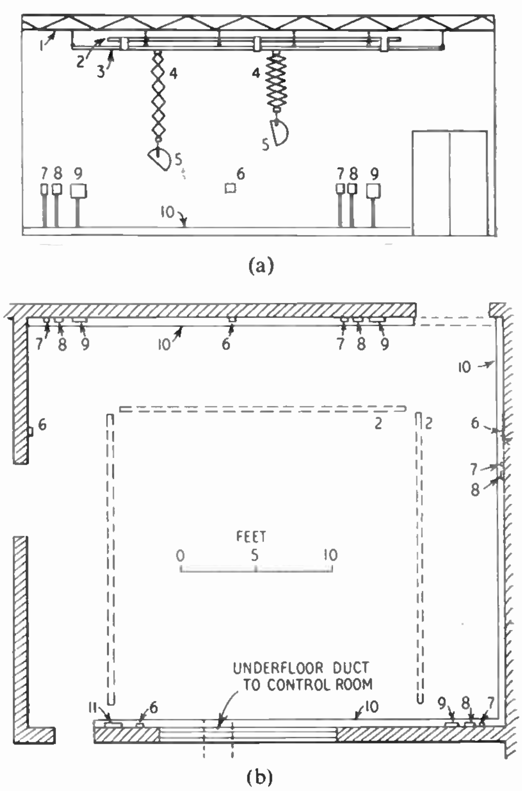
housed a 900 square feet studio, control room, film editing and storage room, dark room, offices, dressing accommodation, and a scenery/property store room. The engineering area was accommodated at the western end of the building as may be seen by referring to the floor plan (Fig. 2).

4. The Studio

The studio had a volume of approximately 13,500 cubic feet, the dimensions being 32 feet by 28 feet by 15 feet high. There was a 12 feet long window in the centre of one of the longer walls, allowing a view into the studio from the adjacent control room. A connecting door from the control room into the studio was provided in the same wall. On the opposite side of the studio there was direct access to the property and scenic store. An elevation and floor plan of the studio are given in Fig. 3.

The floor was of concrete covered with a $\frac{3}{4}$ inch smooth cement rendering to which was added a dark red dye to reduce light reflection. The walls of the studio were constructed of solid 8 inch thick Bermuda stone (this is a sandstone formed by the natural cementation of minute particles of coral) finished with a slush coat of cement rendering. On this surface was fitted 1 inch by 3 inch wood furring on 12 inch centres, attached to which was a 1 inch layer of Johns-Manville Banacoustic blanket with a 1 inch wire mesh covering. For reasons of appearance and also to provide additional acoustic damping, the walls were draped with heavy burlap curtains. These were provided in three colours, buff, grey and maroon; on camera these showed as light, medium and dark backgrounds, respectively. Each colour curtain was mounted on an individual running track enabling a complete wall to be covered easily and quickly with any one colour curtain. (Fig. 4).

Termination boxes providing suitable connection points for microphones, vision monitors, sound monitors and talkback headsets were fitted at a number of points around the



1—Roof truss
2—Lighting output strip
3—Lighting suspension grid
4—Pantograph
5—Lantern
6—Floor lighting outlet
7—Vision feed connector box
8—Microphone connector box
9—Miscellaneous connector box
10—Cable duct
11—Lighting switch board

Fig. 3. (a) Studio elevation (b) Studio plan

studio as shown in Fig. 3(b). These boxes were mounted directly on the wall, 3 feet 6 inches above the floor level and were connected to a feed trough by suitable conduit. The feed trough was a continuous section of 4 inches by 1¼ inch hardwood affixed on edge, rigidly, to the floor; the cover was of dimensions 6 inches by 1¼ inches and was fitted in

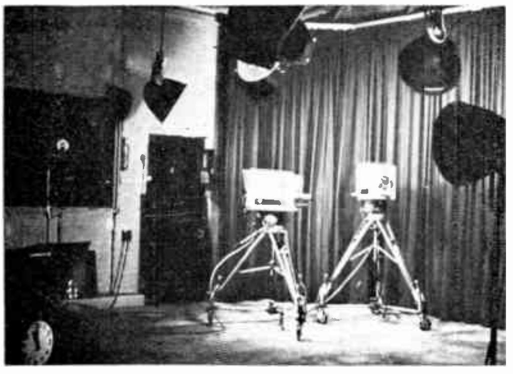


Fig. 4. View of Studio showing cameras, camera mountings, lighting switchboard and lighting units, etc.

4 feet removeable sections. A cross-sectional area of approximately 5 inches by 4 inches of useful space was obtained and this method of construction was found both convenient and economical. Where the cable runs had to cross doorways a channel was cut into the floor of similar dimensions to the feed trough.

Cabling was carried from the studio into the control room by a duct through the studio wall, at floor level, beneath the control console platform and thence in underfloor ducting to the rack equipment.

5. Lighting

The total lighting load installed in the studio was 22 kW with a possible maximum available capacity of 60 kW spread over three phases at 208 volts between phases (120 volts phase to neutral).

The lighting equipment is listed in Table 1.

A lighting grid, constructed of 2 inch scaffolding pipe at approximately 5 feet centres was suspended from the roof trusses about 13 feet 6 inches from the studio floor. Pantographs were hung from the grid so that the lighting units could be lowered to within about 5 feet from the floor.

Table 1

Details of Lighting Equipment

Number of Units	Lantern Type	Power Watts	Mounting
2	Spot	2000	Grid suspension
7	Scoop	1500	,, ,,
9	Spot	500	,, ,,
1	Effects Projector	500	,, ,,
3	Fluorescent Bank	150 (6 × 25W)	,, ,,
1	Scoop	1500	Mobile floor stand
1	Spot	500	,, ,, ,,
2	Spot	100	Portable. table stand

Control over the lighting units was exercised by miniature circuit breakers fitted on a two-panel switchboard mounted on the studio wall near the connecting door to the control room; there were no provisions for dimming.

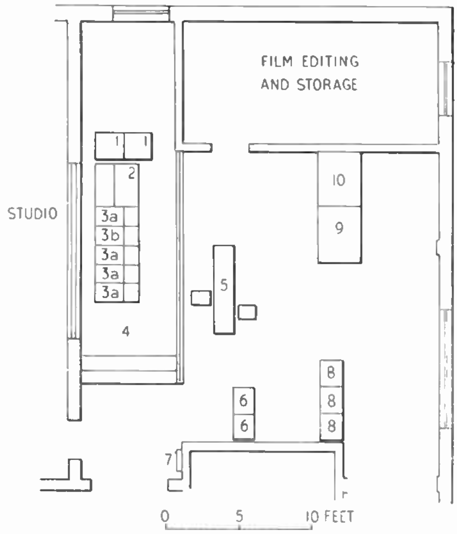
The switchboard fed three overhead seven-point outlet strips on the lighting grid and four twin outlet positions at 3 feet 6 inches above studio floor level, providing a total of twenty-nine separately controlled outlet points.

The outlet strips were fabricated of 4 inches by 4 inches steel trunking and were 20 feet long with seven hanging outlet tails evenly spaced along the underside. Taking account of the fact that most of the sets in the studio were used along three of the walls only, the control room window being kept unobstructed as far as practicable, it was found most useful to arrange one outlet strip parallel to and about 8 feet from each of these three walls a few inches above the lighting grid. In order to provide for speedy identification of lighting circuits each outlet strip and outlet position was given a particular notation by colour and each outlet point a particular number; the grid outlet strips were annotated red, blue and green (each with points numbered 1 to 7) and the studio floor positions brown, pink, yellow and grey (each with points numbered 1 and 2). Coloured tags with the appropriate numbers were attached to the lanterns connected to the respective outlets and the circuit breakers on the switchboard were similarly coded.

Incident light levels varied between 140 and 600 foot-candles, with average lens apertures of $f/4$.

6. The Control Room

The control room layout is shown in Fig. 5. It will be noted that this area accommodated all the vision and sound apparatus, including the transmitter and also the telecine equipment. Direct access to the film editing and storage room was provided.



1—Disc turntables
2—Sound control
3a—Vision control 3b—Vision mixer
4—Raised platform
5—Telecine
6—Sound racks
7—Power intake
8—Vision racks
9—Vision transmitter
10—Sound transmitter

Fig. 5. Floor plan: Combined studio-transmitter control room

In order to allow a good view into the studio, the vision and sound control equipment was mounted on a platform 1 foot 6 inches high directly in front of the control room studio window. On this platform five vision consoles were mounted, (Fig. 6) accommodating from left to right respectively.

(a) No. 1 studio camera remote control and picture and waveform monitor.

(b) No. 2 studio camera remote control and picture and waveform monitor.

(c) Telecine camera remote control and picture and waveform monitor.

(d) Vision mixer remote control and projector/slide remote control.

(e) Transmission picture and waveform monitor.

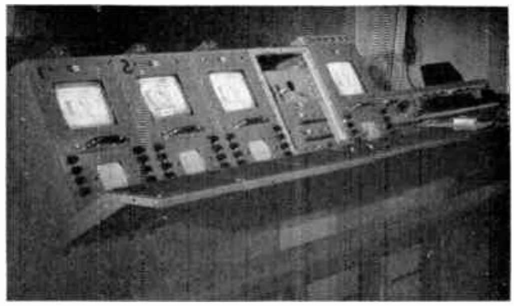


Fig. 6. Arrangement of Control Consoles: from left to right: No. 1 studio camera, No. 2 studio camera, telecine camera control positions; talk back, remote projector control and vision mixer; outgoing line picture and waveform monitor; and sound control panel

To the right of the vision control consoles was a table supporting the sound control panel and further to the right were placed two disc playback turntables.

This arrangement was intended to be operated by a staff of five, one operator for the three camera controls, a vision mixer operator, a sound operator, a programme director, or producer, and a telecine operator/film editor.

Three racks were used to house the vision equipment and two further racks contained the sound equipment.

7. Vision Facilities and Vision Equipment

7.1. *General*

A schematic of the vision facilities circuit is shown in Fig. 7. The main equipment consisted of two studio vidicon camera chains, a vidicon telecine camera chain and a four-channel vision mixer. Camera control chassis for each of the three cameras were identical and were rack-mounted; their passive remote control panels containing only five controls were fitted in the operating consoles together with individual picture and waveform monitors. A further similar monitor was used directly connected in the line from the vision mixer to the transmitter; this served as a final check on picture quality and for waveform appraisal on the outgoing signal. An additional picture monitor fed from a vision receiver was used to check the received picture signal.

The rack-mounted vision mixer had provision for four non-composite inputs, allowing these

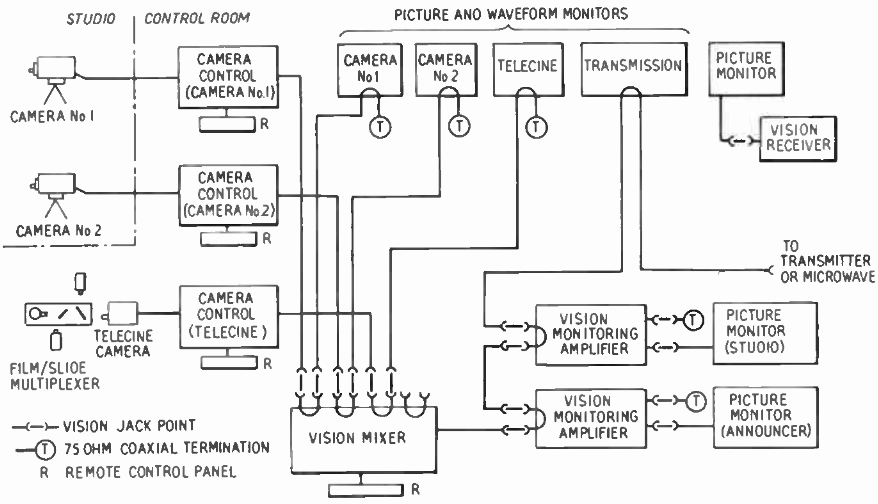


Fig. 7. Vision facilities diagram

signals to be switched, faded and intermixed with one another. Two vision monitoring amplifiers, each providing two 75-ohm matched outputs were included in the outgoing line and provided for the distribution of the programme picture signal (or other signal by suitable patching) to the studio or any other required area.

7.2. *Studio Cameras*

Each of the studio vidicon cameras consisted basically of a small camera head, mounted in a larger casing which housed the viewfinder and lens turret. The four-valve camera head contained the pick-up-tube, a cascode vision amplifier, and a cathode-follower output stage. A valve, relay and rectifier circuit was included to provide cut-off bias for the vidicon tube should the scanning waveforms be lost. Heater current was supplied at approximately 22 volts from the rack-mounted camera control unit, the valves (three 4-volt types, one 3-volt and the 6-volt pick-up-tube) being wired with their heaters connected in series. The scanning waveforms were generated in the camera control unit and were fed directly to the line- and field-deflection coils.

The viewfinder housing measured approximately 13 inches by 25 inches and 17 inches high; at one end was mounted a four-lens turret. The operation of this was directly controlled by a steel tube connected to a handle at the rear, below the 7 inch viewfinder tube. The lenses normally used on the turret were selected from those of focal lengths 13 mm., 16 mm., 25mm., 50 mm. and 75 mm.; for certain applications a 17·5–75 mm. zoom lens was used. The zoom operating control was a push-pull handle at the rear of the camera, fixed to a thrust rod working concentrically inside the turret change tube. The camera head rested on a ball-bearing mounting at the base of the viewfinder housing and was moved bodily towards or away from the lens turret for optical focusing by a handle on the right-hand side of the housing. The viewfinder-camera assembly was fitted upon a light duty pan and tilt head mounted on a tubular metal tripod with a three wheeled castor base. The wheels were fitted with individual brakes and could either all be locked in the same direction, for tracking shots, or allowed to swivel independently for greater manoeuvrability.

Also mounted in the viewfinder housing were the scanning generators, high voltage supply and the vision amplifier for the viewfinder tube. The input to the vision amplifier was bridged directly on to the camera head output; the vision amplifier contained six stages of amplification and included an aperture correction circuit, a d.c. restorer and a gain control for adjusting the viewfinder contrast in the final stage. Only two other operating controls were provided on the viewfinder housing, namely, viewfinder brightness and viewfinder focus.

The camera and viewfinder were coupled directly into the rack-mounted camera control by a 24-conductor cable. In this unit the following functions were carried out:—

(a) Vision signal amplification.
(b) Blanking addition.
(c) Black level clamping.
(d) White clipping.
(e) Pedestal level setting ; and
(f) Gain control.

The latter two were controlled remotely from the console position. Scanning waveforms for the vidicon camera tube were generated in the camera control, as also were the other supplies for the camera—focus current, centering current, 285 volts h.t. and – 105 volts for bias and vidicon beam control.

Preset controls on this unit included vidicon scan amplitudes, linearities and centering, vidicon coil focus current, and vision signal high-peaker. The controls needed during operation of the camera—beam, beam focus, target, gain and pedestal—were all located at the remote control panel, together with an on-off switch and indicator lamps showing " power on " and " camera on air." It should be noted that beam alignment was carried out on a pre-set basis by the adjustment of permanent ring magnets mounted directly on the vidicon tube.

7.3. *Vision Mixer*

The vision mixer chassis was rack-mounted and by the use of a remote control panel the input signals could be cut, faded or mixed, either manually, by the use of fader levers or automatically. Control of the functions of the mixer was accomplished from the remote control panel by adjustment of bias on the vision amplifier circuits. Three speeds of automatic fading and mixing, of durations one, two and five seconds respectively, were obtained by switching in networks of varying time-constant to the bias circuits. A potentiometer on the remote panel, by changing the bias on the sync amplifier in the rack-mounted unit provided remote adjustment of the sync amplitude of the composite output signal. No vision circuits were passed through the remote control panel, and only d.c. connexions were required between the control panel and the mixer proper.

Each of the four inputs of the vision mixer was fed to a separate 6BQ7A cascode amplifier circuit, the gain of which could be varied on the chassis by adjustment of cathode bias and also, remotely by varying the negative bias applied to the grids from the remote control panel. Mixed synchronizing signals were fed to a similar cascode amplifier circuit. The output from this amplifier was used for mixing with the vision signals in the output stage and also for driving the clamp-pulse generator. The outputs from the vision amplifiers were mixed in a common-anode circuit and then fed to the grid of the output valve where black-level clamping was also carried out.

7.4. *Telecine Equipment*

For film and transparency reproduction a vidicon camera was used which was multiplexed with two 16 mm. television film projectors and one 16-slide automatic-sequential 35 mm. slide projector.

The vidicon camera head was of the same design to that used in the studio camera housings, and the rack-mounted camera control unit and remote control panel were also of similar type.

The film projectors were fitted with 300 watt lamps and the slide projector with a 100 watt lamp. Sufficient light was available for the vidicon camera with the projector lamps run at about 8 to 10 per cent. below their correct voltage rating. This practice resulted in a great extension of lamp life. Two fixed semi-mirrors were used in the multiplexer, which also contained a 6-inch diameter field lens ; these three items were mounted in a dust-proof sheet metal housing, with glass ports. Two types of mirror were used, one of which reflected ideally 50 per cent. of light incident at 45 deg. to its surface, and transmitted the other 50 per cent. ; the other type reflected 33 per cent. of incident light at 45 deg., and transmitted 66 per cent.

Images of the three picture sources were projected onto and were arranged to fall superimposed at, the field lens ; the image here was projected on to the surface of the vidicon by a further lens at the camera. In operation only light from one source was normally allowed to be projected into the multiplexer at any time, although for special effects the slide projector and one film projector were used simultaneously.

The switching operations for the projection equipment were as follows:

Film Projectors
- (a) Motor Forward.
- (b) Motor Reverse.
- (c) Motor Stop.
- (d) Show Film.
- (e) Local/Remote Control.
- (f) Projector on/off.

Slide Projector
- (a) Lamp on/off.
- (b) Change slide.

These operations could be carried out from the respective projectors themselves and additionally, all except (e) and (f) could be carried out remotely at the control desk.

The sound output from each of the film projectors was fed to a mixing pad, the common output of which was passed directly to one of the high-level inputs of the sound control panel. An advantage of mixing the two outputs permanently was that projector sound was always available at the same input on the panel and there was no ambiguity as to which projector was in use. Each projector had facilities for reproducing either optical or magnetic sound tracks.

The 35 mm. slides were held vertically in the slide projector in clips in a twelve-inch diameter removable turret. Operation of the slide change mechanism would douse the projector lamp, move the turret round until the next slide was in the correct position for projection and then relight the lamp.

7.5. *Synchronizing Generator*

Two synchronizing generators with a synchronizing changeover panel were installed to feed the vision equipment. Pulses were fed to each of the units by coaxial tee connectors directly connected to the input sockets. The use of tee connectors was preferred to input and bridging output connectors, as with the former method a unit may be removed from service without interrupting pulse feeds to succeeding equipment.

Phantastron count-down circuits were used to derive the 60 c/s information from either a 31·5 kc/s crystal oscillator or from a 31·5 kc/s multivibrator controlled by an a.f.c. circuit locking to the mains frequency. The timing of the various pulses relative to one another was accomplished by triggering pulse generators from outputs at various points along a delay line.

Experience has shown that it is desirable to consider the two synchronizing generators as No. 1 and No. 2, used alternately on consecutive days, and not as "operating" and "reserve" generators. With the former mode of operation frequent use of both generators actually "on-the-air" is made, and constant check on their performance is provided. A synchronizing generator kept in "reserve," perhaps for many weeks, may fail to give satisfactory service when it is required.

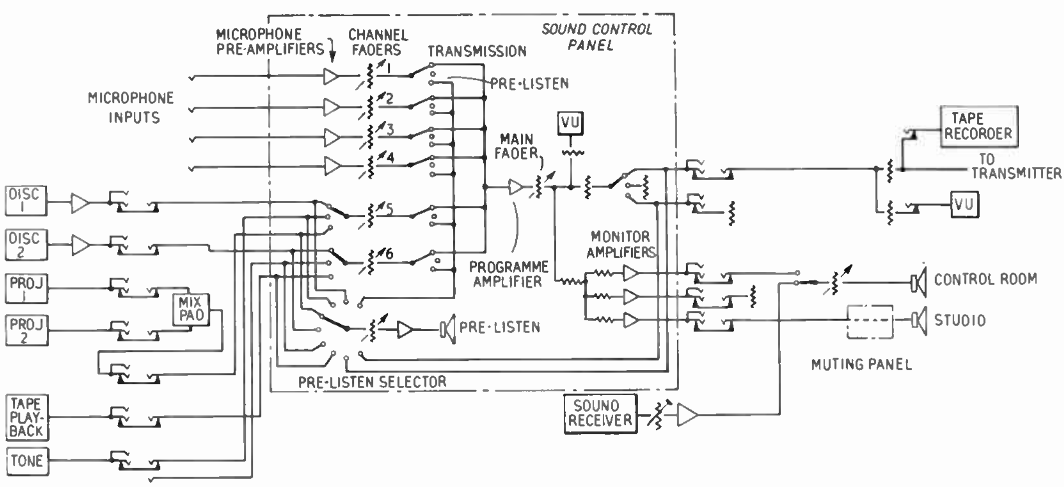


Fig. 8. Basic sound facilities diagram

8. Sound Facilities

The interconnections of the various items of sound equipment are detailed in Fig. 8. Sound inputs to the control panel were:—

(a) Two disc playback turntables.
(b) Film projector output (the combined output of the two 16 mm. projectors).
(c) A tape reproducer output.
(d) A variable frequency oscillator (used as a testing source and as line-up tone).
(e) Four microphone inputs.

The sound control panel had two high-level and four low-level input channels each controlled by a separate fader. Microphone pre-amplifiers were connected between the low-level inputs and their respective faders.

A three-position switch was fitted ahead of each high-level fader allowing for the choice of six high-level sources. The outputs of the channel faders could be switched to the main programme amplifier or to a pre-listen built-in loudspeaker monitor for cueing and level checking purposes. It was also possible to monitor of any of the high-level inputs and also the output of the programme amplifier on this pre-listen loudspeaker. Four stages of amplification were provided in the programme amplifier with negative feedback over the last three stages; to the output of the main fader were connected three bridging monitor amplifiers, a VU meter and an output pad. A three-position switch followed the pad allowing the output to be switched to either of two outgoing lines or "off" to a load resistor.

A microphone patch panel permitted the output from a microphone connected to any of the sixteen points in the studio to be patched to any of the four low-level inputs of the sound control panel.

The high-level inputs to the console were also passed through a patch panel facilitating isolation of faults, testing and also the connexion of alternative signals.

In order to avoid acoustic feedback from the studio monitor loudspeaker to the microphones, the loudspeakers in the studio area were automatically muted when the microphone channels were live. The relays for this purpose were so arranged that in their unoperated condition the speakers were muted. There was thus no possibility of the speakers remaining live should the power supply energising the relays have failed.

9. Talkback

A common talkback circuit using headsets was provided in the studio allowing the cameramen, floor staff and director to communicate with each other easily. The producer or vision mixer and sound control operator could speak over the studio talkback loudspeaker from separate microphones at the vision and sound operating positions respectively.

Figure 9 shows a diagram of the talkback arrangements (the components in the chained rectangle were added later when the announcer's studio was installed—see Section 17).

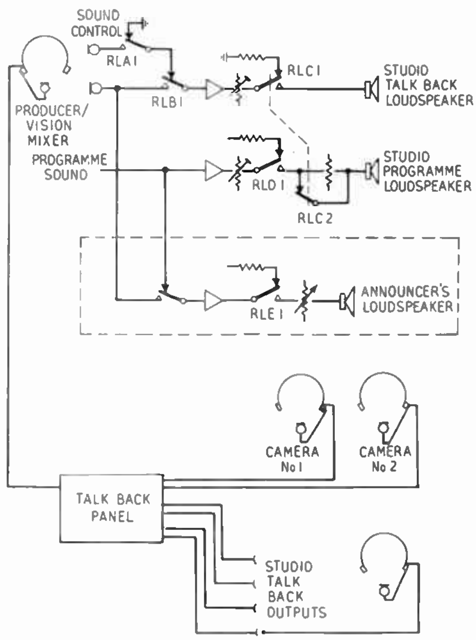


Fig. 9. Talkback diagram

The amplifiers and relays were rack mounted, the relays being operated by keys adjacent to their respective microphones. Apart from switching the studio talkback loudspeaker, relay RLC was also arranged to reduce the level of the studio programme loudspeaker, by switching in circuit a pad in series with this speaker.

10. Cue Lights

In addition to the usual camera "on-air" lights, lamps were provided at three points around the studio indicating the conditions—"Sound On" (green lamps) and "Vision On" (red lamps) for the benefit of the studio personnel. Red warning lamps were mounted outside and above each of the doors leading into the studio which were illuminated when the studio red or green lamps were on.

The control of the "Vision On" lamps was initiated automatically from the vision mixer on the depression of the pushbuttons switching either of the studio cameras on transmission. Similarly the sound control panel controlled the operation of the "Sound On" lamps.

11. Transmitting Equipment

11.1. *General*

The transmitters were housed in two steel cubicles bolted together to form one unit with a base measurement of 7 feet 6 inches long and 3 feet deep; the overall height was 6 feet 6 inches. Although the vision and sound transmitters shared a common 2000 volt high voltage supply, they were, apart from this feature, quite independent of one another.

11.2. *The Vision Transmitter*

Extreme simplicity was a feature of the design details of the vision transmitter, which thus required few operational adjustments and very little maintenance. Two air-cooled tetrode valves, type 4X250B, were used as output valves working in push-pull with near Class B linear operation, providing a peak rated output of 500 watts at the carrier frequency of 193·25 Mc/s. The drive was obtained from a crystal oscillator housed in a temperature-controlled oven. Three stages of frequency tripling, using two valves type 5763 and one 5894 multiplied the output frequency of the crystal oscillator to the carrier frequency. A further 5894 was used as an intermediate power amplifier to feed the final stage, which had an output impedance of 51 ohms.

The composite vision signal input of 1·4 volts d.a.p. was fed to a variable attenuator and then to the first vision amplifier valve, a 6AG7.

Three further 6AG7 valves operated in parallel provided the second stage of vision amplification. The output of this stage was resistance-capacitance coupled to three paralleled 6CD6G modulator valves, the grid circuit having d.c. restoration applied. There was direct coupling between the anodes of the modulator valves and the grids of the 4X250B output valves. As will be seen from the above description the vision modulator is of straightforward design, using only three stages of vision amplification. The use of direct anode-to-anode feedback, together with valves having a high figure of merit, made for elementary design, without the need for inductive correction circuits. Only one peaking coil was used in the entire transmitter, this was at the grids of the power output valves and was necessitated by high grid-to-earth capacitance of the valves and associated circuitry. The overall frequency response of the vision circuits was within 0·5 db up to 4·5 Mc/s, −2·0 db at 5 Mc/s and −6 db at 6 Mc/s (manufacturer's figures).

An r.f. envelope monitor was provided to enable modulation depth to be checked and adjusted; a single turn coupling loop was fitted near the output stage to feed a small amount of r.f. to the monitor.

11.3. *The Sound Transmitter*

A similar output stage to that in the vision transmitter was used for the f.m. sound transmitter, working at 197·75 Mc/s and nominally rated at 250 watts. The incoming sound signal was used to phase modulate a signal from a crystal oscillator; this signal was then multiplied 864 times in a series of eight stages to raise it to the carrier frequency.

11.4. *Metering*

As an aid to checking performance and detection of faults the following meters were fitted for the vision transmitter:

(a) R.F. Power Output.
(b) Voltage Standing Wave Ratio.
(c) Anode Current (Output Stage).
(d) Screen Grid Voltage (Output Stage); and
(e) Filament Voltage

and for the sound transmitter:

(a) R.F. Power Output.
(b) Voltage Standing Wave Ratio.
(c) Anode Current (Output Stage).
(d) Grid Current (Output Stage); and
(e) Filament Voltage.

Additional metering was provided to measure all anode voltages in the exciter units, the output voltages of the regulated power supplies, the high voltage power supply and the mains input voltage.

11.5. *Power Supplies*

Two main power switching circuits were provided on the transmitter, designated "low voltage" and "high voltage," respectively. The low voltage circuit breaker, controlled the +350 volt, +600 volt, and −400 volt regulated supplies for the vision transmitter, the +350 volt regulated power supply for the sound transmitter as well as the filament transformers for the high voltage power supply and the output stages and the supply to the air blowers. Filament supplies for the smaller valves were obtained from transformers fitted on the units requiring them. A variable output autotransformer between the circuit breaker and the low voltage power supplies allowed adjustment of the input voltages to these units. The low voltage power supplies employed circuits of the conventional series-regulated type.

The high voltage power supply was controlled additionally by a separate circuit breaker and variable output auto-transformer. Two 8008 mercury-vapour rectifiers were used in a double-diode arrangement in the supply, which was designed to provide up to 2000 volts for the output stages at a maximum current of 1000 mA. The output voltage could be raised and lowered by the adjustment of the "high-voltage" auto-transformer.

11.6. *Transmitter Cooling*

Air blowers were provided adjacent to the low voltage power supplies, directing currents of air over the valves. Extractor fans were fitted in the roof of each cubicle to draw the hot air out of the units which was then ducted away. Each pair of output valves was connected to a separate pressure chamber, supplied by individual centrifugal blowers. An air pressure of between 0·5 and 1 inch (water gauge) was maintained in these pressure chambers and air was then forced past the valves at high velocity, providing the necessary cooling.

11.7. *Protective Circuits*

In order to provide protection for the transmitter components the high voltage circuit breaker was tripped "off" under the following transient or steady fault conditions:

(a) Vision modulator overload.
(b) Vision excitation failure.
(c) Vision output stage overload.
(d) Sound excitation failure.
(e) Sound output stage overload.
(f) Air pressure low, vision output stage.
(g) Air pressure low, sound output stage.

Gate switches on the rear doors were wired so that the high voltage circuit breakers could not be operated unless both doors were closed.

A buzzer and a series of neon lamps were provided for use as aids to the indication and isolation of faults.

12. Aerials

The aerial tower erected on the roof of the building was designed as a self-supporting structure and was built of standard 2 inch scaffold pipe. The base dimension was 15 feet square tapering to 4 feet square at the 60 feet level. A parallel-sided section, 4 feet square, continued from this level up to the full height of 75 feet. It was on this upper section that the vision and sound transmitting aerials were mounted; the total height above sea level was approximately 135 feet.

Four corner type reflector aerials were fed from the vision feeder at the top of the tower; a similar group of aerials was mounted directly below the vision radiators and was connected to the sound feeder. The four aerials in each group were adjusted in azimuth in order to concentrate power along the major axis of the island group. It was estimated that the gain in the maximum power direction was about 1·8 times.

The vision and sound aerials were fed from the transmitters by separate 1$\frac{5}{8}$ inch diameter air-spaced coaxial transmission lines. The centre conductor of this type of line is spaced from the sheathing, which is made of corrugated steel tubing, by a polyethylene spiral strip. The sheathing is covered with bituminous weatherproofing material, plastic and impregnated tapes and then a vinyl outer covering. At a frequency of 200 Mc/s the attenuation of the cable is 0·35 db per 100 feet.

PART 3

13. General

Although the combined studio-transmitter centre provides a very compact television station the factors influencing the choice of the studio and transmitter sites are not necessarily compatible. In general, the studio will need to be located near to the largest mass of population, whereas the transmitter should be installed at the highest possible point overlooking this area. A compromise in the location is often such that the transmitter site may be far from ideal. In these circumstances it is necessary to separate the transmitter from the studio centre and locate it in a more suitable area.

It will be shown later that by arranging for remote control of the transmitting equipment it is possible to operate successfully both locations with no increase (and in this particular case a reduction) in staff, and at the same time provide a significant extension in coverage and gain useful accommodation area in the studio building.

The permanent site for the Bermuda transmitter was chosen to be at Prospect camp, a distance of 1·4 miles from the studio centre in Hamilton and the second highest point in the Islands. One of the reasons for not installing the transmitter at this site earlier was that at the time of commencement of the television service the area was occupied by the British Army Garrison. However, with the vacation of the camp a number of buildings became available and one was chosen as near as possible to the base of the tower, which was placed at a point 205 feet above sea level.

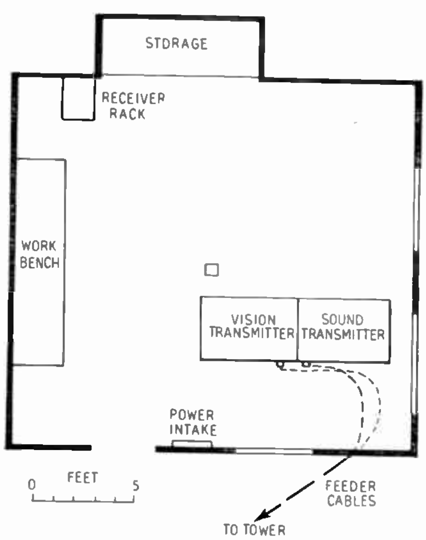


Fig. 10. Transmitter building: Prospect

The building housing the transmitter is 20 feet long by 18 feet wide with a ceiling sloping from 10 feet 6 inches to 9 feet. It is situated approximately 100 feet from the transmitting tower. A floor plan of the building is given in Fig. 10 showing the location of the transmitter and terminating equipment.

Very few minor faults and none of major magnitude had occurred whilst the transmitter was operating in Hamilton, and it was therefore decided that the installation at Prospect should be unattended and that the switching functions should be carried out remotely from the studio by land lines. The modifications required on the transmitter for this purpose were associated mainly with the power switching and protective circuits.

14. The Studio-Transmitter Link and Transmitter Remote Control

The vision signal is conveyed from the studio building in Hamilton to the transmitter site at Prospect by a one-tenth watt microwave link operating at 6962·5 Mc/s. The microwave transmitter head is mounted directly on the roof of the studio building and the receiver head is mounted 80 feet high on the transmitter aerial tower at Prospect. The approximate heights of the transmitting and receiving heads are respectively 60 feet and 285 feet above sea level. Both microwave heads are fitted with 2 feet parabolic reflectors. At the studio centre the vision signal is fed directly to the microwave transmitter unit in the studio equipment rack. A 100 feet cable connects this to the transmitter head on the roof.

At Prospect the receiver head is coupled to the microwave receiving equipment by 200 feet of cable. The demodulated vision signal at the output of the microwave receiver is passed to a line clamp amplifier where a processed signal is produced to feed the transmitter.

The sound signal is fed from the sound control panel at the studio control room to a centre-tapped 1:1 line-transformer, the secondary of which is coupled to No. 1 land line. (Fig. 11). At Prospect a similar transformer is used and the signal passes to a line amplifier and attenuator at the input of the sound transmitter. A total of four land lines connect the studio and transmitter; the length of each, routed through the telephone company's office is 15,470 feet (2·9 miles). One of these lines is

A short period fault on the transmitter, lightning discharge or similar transient effect would normally operate the overload circuit breaker trip on the transmitter. The reset coil of this is energized by the momentary action of relay RLA/1 *via* the phantom circuit on the programme line; no switching transient is heard on the sound transmission, due to the d.c. use of the line because, at the time of operation of the reset relay RLA/1, the transmitter would not be radiating.

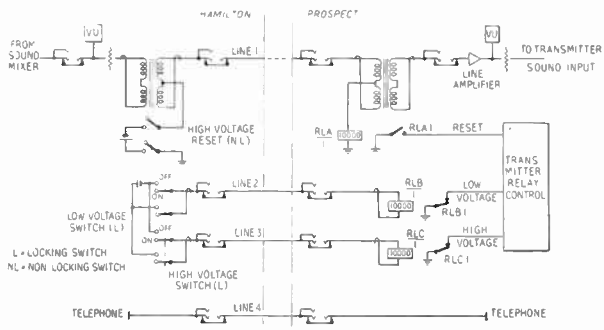


Fig. 11. Sound link and control lines: Hamilton — Prospect

used to carry the sound programme signal, one provides a telephone circuit between the two points and the remaining two lines, together with a phantom circuit on the programme line are used for remote control of the transmitter. Each of the lines is provided with monitoring and break-in jacks to enable a faulty line to be isolated and replaced with a serviceable one, if necessary. The control functions of the transmitter to be carried out remotely from the studio are (a) low voltage power supplies: on/off, (b) high voltage supply: on/off, and (c) overload circuit breaker: reset.

Separate lines are used to operate relays which control the low voltage and high voltage power supplies. These relays, designated RLB/1 and RLC/1 in Fig. 11, are de-energized when the transmitter is in the "on" condition; thus if either of these two lines become faulty or open during transmission time the transmitter would not be switched off. Under normal conditions these lines become serviceable spares during transmission time.

The operating time of the high voltage circuit breaker is sufficiently long so that by the time the transmitter is working again the programme line is once more balanced.

With the arrangement described it is possible to keep the transmitter operating satisfactorily with only one serviceable line.

15. Tower and Aerials

The tower mounting the transmitting aerials is 270 feet high and is of triangular section, each side being 2 feet across. Five sets of guy-wires are attached to the tower at 50 feet intervals; the guy-wire anchors are approximately 200 feet from the base of the tower. The variations from this dimension and also the angular placement of the anchor points as shown in Fig. 12, are necessitated by the large number of existing structures in the area. The vision aerial is fitted at the top of the tower, 475 feet above sea level, and is a "ring-slot" radiator bolted directly to the northern face of the tower. The horizontal radiation pattern of

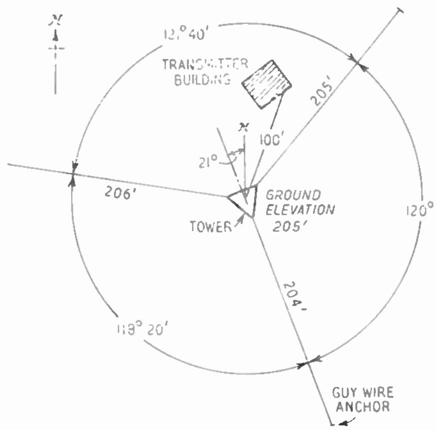


Fig. 12. Site plan: Prospect transmitter

a 725 Mc/s scale model of this aerial is shown in Fig. 13; the orientation of the tower is such that the maximum power is radiated approximately in an East-North-East—West-South-West direction, in conformity with the general outline of the islands.

The radiating slot is formed by two cylindrical vertical members, fixed to a cage formed by 38 flat-section split rings. Power is fed to the aerial at the centre of a 51 ohm air-spaced $1\frac{5}{8}$ inch transmission line. The r.m.s. gain of the aerial (at 193·25 Mc/s) is 4·0.

Mounted at 160 feet above the base of the tower is the sound transmitting aerial assembly, consisting of four corner type reflector aerials of the type used on the temporary tower in Hamilton as described in section 12. They are arranged in two pairs, vertically stacked, one pair facing East-North-East and the other West-South-West.

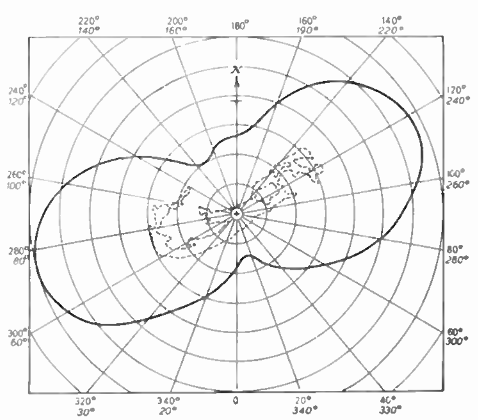


Fig. 13. Relative field: horizontal polar diagram

The transmission lines for the two transmitting aerials as well as the cable to the microwave unit and auxiliary cables for tower lighting and telephone, are carried between the base of the tower and the transmitter building by an enclosed 6 inches by 6 inches wooden duct supported about 2 feet from the ground.

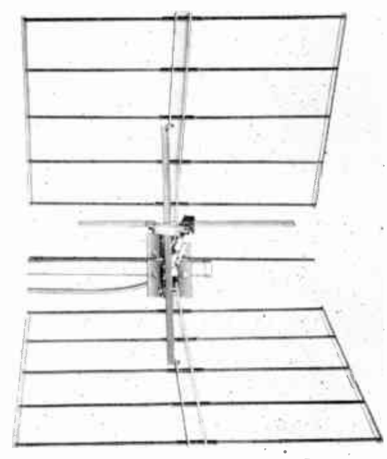
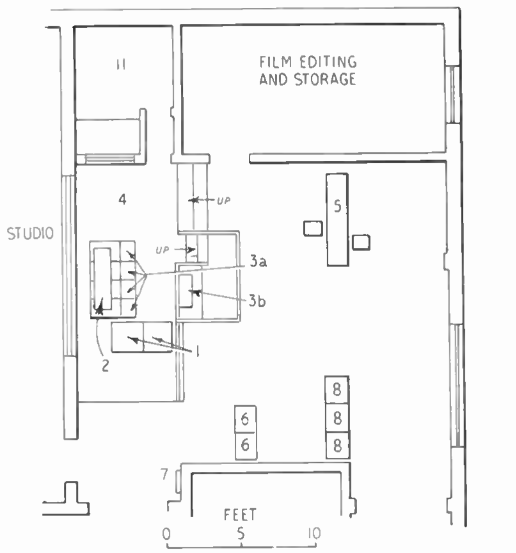


Fig. 14. A corner-type reflector aerial.

16. Control Room Modifications

With the removal of the transmitting equipment to the Prospect site, an additional 100 square feet of floor area became available in the control room. The opportunity was taken to relocate the telecine equipment, vision mixer control panel, sound control panel and disc playback equipment. In addition an announcer's studio approximately 6 ft. 6 in. by 8 ft. was built. Comparison of Fig. 15 with Fig. 5 will indicate the major changes.

An extension of the raised operating platform was constructed upon which was mounted the vision mixer remote control panel, projector remote control panel and talkback panel, providing two operating rows. This extension platform is a further 18 inches higher than the area where the vision consoles and sound control panel are mounted and is occupied by one operator performing the dual functions of programme director and vision mixer. A clear



1—Disc turntables
2—Sound control
3a–Vision control
3b–Vision mixer
4—Raised platform
5—Telecine
6—Sound racks
7—Power intake
8—Vision racks
11—Announcer's studio

Fig. 15. Floor plan: studio control room.

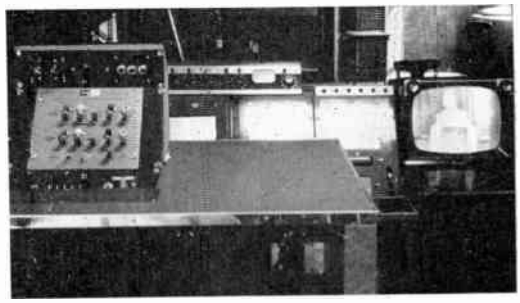


Fig. 16. The modified control positions. In the foreground are the vision mixer remote control panel, the projector remote control panel and the talkback switching panel. Behind these can be seen the camera control and transmission picture and waveform monitors, above which is mounted the sound control panel. At the extreme right hand side is the vision check receiver picture monitor.

view is obtained from this position of the camera and transmission picture and waveform monitors and also over this equipment into the studio through the dividing window.

Above the vision consoles on the lower section of the raised platform is mounted centrally the sound control panel playback; the disc turntables are placed to the left-hand side of the consoles. This arrangement enables a single operator to handle both the vision and sound control apparatus from one position.

17. The Announcer's Studio

The volume of the announcer's studio is approximately 420 cubic feet and is situated to the extreme right hand side of the lower operating platform. Celotex panels are used to cover the side walls and the back wall is heavily draped. A double-glazed window permits visual communication between the announcer and the vision/sound control operator and also the vision mixer/programme director. Directly in front of the window is a wooden table, felt-padded to reduce sound reflections, on which stands a picture monitor and the microphone (Fig. 17). A loudspeaker for programme monitoring and talkback is mounted above the window. A small control panel on the table contains a three-position key and a potentiometer for adjustment of the volume from the loudspeaker. The key (locking-on, off and non-locking on) controls the operation of a relay which (a) mutes the loudspeaker, (b) illuminates the local "microphone live" lamp and (c) connects the microphone through to the sound mixer. The announcer's microphone channel is normally left "faded-up" at the sound control panel, and the announcer has the responsibility of switching

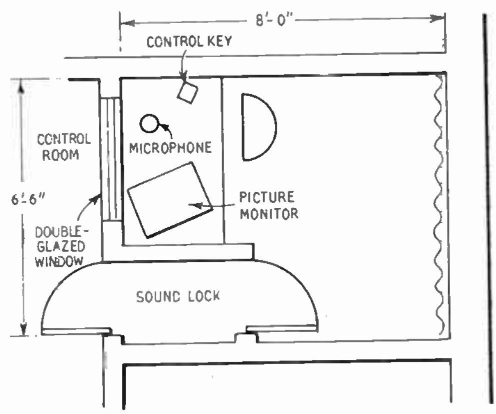
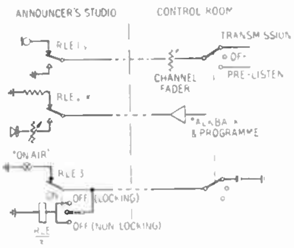


Fig. 17. Announcer's studio.

his microphone to transmission. Figure 18 outlines the basic facilities in the announcer's studio.



x = Relay contact operates before other contacts
y = Relay contact operates after other contacts

Fig. 18. Basic facilities: announcer's studio.

18. Conclusions

The above descriptions indicate that it is possible to provide perfectly adequate facilities for a commercial television service with a modest amount of equipment and a small number of staff. It is of interest to record that only three control room personnel are required to carry out all the functions necessary for the operation as described in Part 3, as compared to five with the previous arrangement; they are, namely

(a) the Vision Mixer/Programme Director (or Vision Mixer/Producer).

(b) the Vision and Sound Control Operator.

(c) the Telecine Operator/Film Editor.

During the first eight and a half months' operation the transmitter was in use for a total time of 2,133 hours (including testing periods). Out of this time seven hours and two minutes of programme were lost from all causes, representing a percentage of only 0·304.

19. Acknowledgments

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DISCUSSION

W. N. Anderson: Mr. Harris describes the transmitter at the Prospect transmitting station as being unattended. I wonder if he could tell us something about the reliability of the system and what maintenance arrangements are made. I am particularly interested in the extent of the reliability of the communication arrangements and the video circuit between the studio and the transmitter.

A. Harris (*in reply*): The maintenance needed was done during the visit to the transmitter immediately after the morning test period. During the time I was at the station there was not a major fault of any kind. The transmitter did not break down due to equipment failure although there were faults on land lines caused by water leaking into the connectors. There were four telephone lines between studio and transmitter: one was used during the transmission for the sound signal and one for a telephone line. The other two were control lines and were only in use when the transmitter was not radiating. If the line being used for sound transmission developed a fault one of the control lines was cross-patched at the transmitter to take its place. For the first eight and a half months of programme time the transmitter was used for 2,133 hours which includes morning test transmissions, and out of this time seven hours and two minutes were lost which works out at round about 0·3 per cent.

G. Kay: I would like to ask Mr. Harris what ventilating problems he had in his small studios which, since they use vidicons, need a fair amount of light, and also how the ventilation was controlled.

I work in Birmingham where the sulphurous air causes havoc with the contacts on relays and switches. Can Mr. Harris give me any idea how sea air affects the reliability of switch contacts?

A. Harris (*in reply*) *:* We had two 1½-ton air conditioning units in the control room. The air conditioning units had only to deal with personnel and the vision and sound units since the hot air from the transmitter was ducted directly outside. The studio is of course a much bigger problem which was eased by its not being used continuously. There was one 3-ton air conditioning unit in the studio and a large exhaust fan. The air conditioner would be run during programme time as it was fairly silent. Few programmes exceeded, say, half an hour and the majority lasted 15 minutes, and so when the programme was finished the fan was switched on. This was not an ideal arrangement but it worked quite well.

On the question of contacts I think we were rather fortunate in using sealed-in relay contacts for the most part at the studio centre. In the mixer the switching was done by electronic means so we did not have any trouble on this item with switch contacts.

N. Hughes: When you say the transmitter was moved, was this done at night? Secondly, what method did you have of monitoring the various stages of the transmitter.

A. Harris (*in reply*) *:* The transmitter was moved overnight without losing any programme time. We closed down at 11.30 on Friday night, removed the control room windows (the control room was on the second floor) and lowered the transmitter in two halves to the street, and took it to the new site. It was on the air at 6 o'clock the next evening. We did not then have the sound aerial working as this could not be erected in time. We were associated with a local radio station operating two radio transmitters,one of which went off the air daily at 6 p.m. We put the television sound signal on to this radio channel by cross patching and asked viewers to tune to that for the sound accompaniment to the television programme.

The vision and sound signals were monitored by check receivers in the studio control room.

H. J. C. Gower: Mr. Harris mentions the number of staff employed; I assume that he refers to the control room area only as he has not included cameramen.

Secondly, I noticed that when he moved the transmitter he changed the mast from the self supporting to the stayed type; I wonder if he had any particular reason for that. Further, regarding the mast, did he have any windage problems as the island is within the hurricane area?

Finally, did the climate, which I believe is sub-tropical, have any other effect on the equipment?

A. Harris (*in reply*) *:* On the question of control room staff, although there were two cameras in use these were not always having to be moved about and one of the two cameramen could have an allotted job for occasions when only one camera was required to be moved.

The original mast which was mounted on top of the building was more or less self supporting because it was in the middle of the city and it was not possible to secure the guy wires round about it. On windage problems we did not have any particular problems ourselves, the mast being designed to take into account the prospective gales.

I think we were very fortunate in that we did not have a great deal of trouble of the kind one usually gets in 99 per cent. humidity and a temperature of 82°–85°F.

H. A. Philippart (*Associate Member*)*:* Could Mr. Harris tell us some of the factors governing the choice of equipment. For instance what factors led him to choose vidicons as a studio camera?

A. Harris (*in reply*) *:* The main reasons for using vidicon cameras are that they are of low initial cost, need little maintenance and are of course more easy to operate with semi-skilled staff.

Brit.I.R.E. BENEVOLENT FUND

NOTICE OF ANNUAL GENERAL MEETING OF SUBSCRIBERS

NOTICE IS HEREBY GIVEN that in accordance with the Rules the Annual General Meeting of Subscribers to the Institution's Benevolent Fund will be held on WEDNESDAY, 2nd DECEMBER, 1959, at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1. The meeting will commence at 6.45 p.m. (immediately after the close of the Annual General Meeting of the Institution).

AGENDA

1. To confirm the Minutes of the Annual General Meeting of Subscribers held on 26th November, 1958. (Reported on page 724, Volume 18 of the *Journal*, December, 1958.)

2. To receive the Annual Report of the Trustees. (Published on pages 723-5 of this *Journal*.)

3. To receive the Income and Expenditure Account and Balance Sheet of the Benevolent Fund for the year ended 31st March, 1959. (Published on page 724.)

4. To elect the Trustees for the year 1959-60.

   Rules 5 and 6 state :—

   5. The Trustees of the Fund shall consist of not more than five and not less than three members of the Institution who have been elected at an Annual General Meeting of Subscribers to the Benevolent Fund.

   6. The Trustees shall be elected at the Annual General Meeting by all members *who have subscribed to the Fund* during the preceding twelve months, ended March 31st in each year, and the Trustees shall hold office until their successors are appointed.

   The present Trustees, who offer themselves for re-election, are :—

   G. A. Marriott, B.A. (Immediate Past President).
   Rear Admiral Sir Philip Clarke, K.B.E., C.B., D.S.O. (Past President).
   A. A. Dyson, O.B.E. (Member).
   A. H. Whiteley, M.B.E. (Companion).
   G. A. Taylor (Member) (*Honorary Treasurer*).

5. To appoint Honorary Solicitors.

   The Trustees recommend the re-appointment of :—
   Mr. Charles Hill, 6 Gray's Inn Square, London, W.C.1.

6. To appoint the Honorary Accountant.

   The Trustees recommend the re-appointment of :—
   Mr. R. H. Jenkins, F.C.A., 42 Bedford Avenue, London, W.C.1.

7. Any other business.

By Order of the Trustees,

(*Signed*) G. D. CLIFFORD
(*Honorary Secretary*)

(The Rules governing the operation of the Benevolent Fund are published in the List of Members.)

BRIT.I.R.E. BENEVOLENT FUND

ANNUAL REPORT OF THE TRUSTEES FOR THE YEAR 1958-59

The Trustees of the Benevolent Fund have pleasure in reporting to subscribers on the working of the Fund for the twelve months ended 31st March 1959. The Accounts and Balance Sheet are appended to this Report.

The slight decrease in donations, as shown in the Revenue Account, does not reflect declining interest in the Benevolent Fund. In comparing the subscriptions and donations for 1958-59 with the figure for 1957-58, the Trustees point out that a special donation was received in 1957 which accounted for the high level of income in that year.

In 1958 over 200 more members supported the Fund, bringing the total number of member subscribers to 1,100 and the average donation was 9s. 6d. The Trustees have welcomed this additional support, but bearing in mind that the number represents only about 18 per cent. of the entire membership, there is still cause for disappointment in so few members supporting their own Benevolent Fund.

The Trustees would particularly like to see an increase in subscriptions through deeds of covenant. As the standard rate of income tax has been altered, it is felt worth while to include in this report an amended table giving examples of the way in which the Benevolent Fund can benefit from such covenants without in any way incurring the donor in any extra payment.

Amount covenanted annually for 7 years	Tax reclaimed annually by the Trustees	Estimated gross amount received by the Trustees
(Based on the Standard Rate of Income Tax at 7s. 9d. in the £)		
£ s. d.	£ s. d.	£ s. d.
1 1 0	13 4	10 0 4
2 2 0	1 6 8	24 0 8
5 5 0	3 6 5	59 19 11

It is hoped, therefore, that members will support the Fund in this way. Further details and a form of covenant can be obtained from the Honorary Secretary.

The Trustees again express grateful thanks for the continuing support of Electric and Musical Industries Ltd., and the Radio Industries Clubs of London and Manchester.

It is pleasing to record that in the past twelve months there have not been any new applications for assistance. It has therefore been possible to increase the amount of investment holding. This building up of capital resources is very necessary because, as the Institution grows older, assistance from the Fund will be in greater demand.

Grants.—The cases which are still receiving help mainly concern the welfare and education of children. This is typical of the type of help which it is believed the Fund will increasingly give in future years.

In the event of the death of a member—or serious illness—particularly among the younger members— a great deal of help can be given by relieving the remaining parent of some financial cares in the bringing up of children. The following case histories demonstrate this point.

Reference No. 441/10 is the case of longest standing, originating in 1948. It is expected, however, that within the next few months the Trustees' help will be limited to the education expenses of the youngest child who has been placed in the Royal Wolverhampton School. The eldest girl was educated to G.C.E. "O" level at Reed's School and the second girl left the Royal Wolverhampton School this year. Both are now making progress in their chosen careers.

Reference No. 122/15. The position of this family is materially the same; subscribers will recall that financial aid has been given since 1953. The member is still in ill health consequent upon a severe operation. The eldest son continues to make excellent progress at the Royal Wolverhampton School.

THE BRITISH INSTITUTION OF RADIO ENGINEERS
BENEVOLENT FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH, 1959

1958 £		£ s. d.
483	Grants	418 15 6
150	Purchase of Bursaries at Reed's School	100 0 0
7	Postage and Stationery	10 1 7
14	Sundry Expenses	33 15 6
781	Balance being surplus for the year carried to Reserve Account	747 13 2
£1,435		£1,310 5 9

1958 £		£ s. d.
1,126	Subscriptions and Donations	982 12 2
309	Interest Received (Gross)	327 13 7
£1,435		£1,310 5 9

BALANCE SHEET AS AT 31st MARCH, 1959

1958 £		£ s. d.	£ s. d.
	RESERVE ACCOUNT		
	Balance as at 1st April, 1958	7,854 1 5	
	Add Surplus for Year	747 13 2	
7,854			8,601 14 7
	CURRENT LIABILITIES		
—	Amount due to The British Institution of Radio Engineers		87 19 9
£7,854			£8,689 14 4

For Trustees:—

Signed
G. A. MARRIOTT (*Chairman*)
G. A. TAYLOR (*Honorary Treasurer*)
A. H. WHITELEY
G. D. CLIFFORD (*Honorary Secretary*)

1958 £		£ s. d.	£ s. d.
	FIXED ASSETS		
7,462	Investments at Cost ... ... (See Schedule on page 725)		8,497 8 2
	CURRENT ASSETS		
74	Income Tax Repayment Claim	110 0 10	
298	Cash at Bank	82 5 4	
20	The British Institution of Radio Engineers—Current Account	— — —	
			192 6 2
£7,854			£8,689 14 4

I have audited the above written Balance Sheet dated 31st March, 1959, in respect of the Benevolent Fund. I have received all the information and explanations I have required and in my opinion the Balance Sheet represents the true and accurate state of the Benevolent Fund.

42, Bedford Avenue, London, W.C.1.
18th August, 1959.

R. H. JENKINS, *Chartered Accountant,*
Honorary Auditor.

Reference No. 929/26. The widow and children—a girl and two boys—continue to receive assistance. In this connection the Trustees wish to mention the help which is being given by the R.A.F. Benevolent Fund, which has undertaken responsibility for the two boys until 1960 when they reach the age and standard for admission to Reed's School. From then until they achieve G.C.E. at "O" level the children will be the responsibility of the Institution's Benevolent Fund.

Other grants made were of a small nature to assist in temporary difficulties.

Schools.—In view of the objects of the Fund, the Trustees continue to recommend support of such schools able to provide suitable facilities for the education of fatherless children.

For nearly 20 years there has been active Institution association with Reed's School; boy and girl nominees of the Trustees have been educated at Reed's School and it was a matter of great regret that, a few years ago, lack of financial support resulted in the Girls' School having to close. The boys' school at Cobham is, however, flourishing and indeed, a new wing has recently been completed in order to accommodate additional intake. As already stated, it is anticipated that two sons of a deceased member will be admitted to Reed's School during the next 12 months and these children will enjoy the benefit of the Bursaries which the Trustees have purchased by regular annual payments to the School.

As a direct result of these contributions, the Institution at present enjoys three Bursaries, named in honour of Past Presidents who have given a great deal of help in establishing the Institution's Benevolent Fund. They are The William E. Miller, The Rear Admiral Sir Philip Clarke, and The George A. Marriott Bursaries.

The Trustees also continue to support the Royal Wanstead School which is one of the very few schools of this type providing primary as well as secondary modern/grammar education with boarding facilities. During the period of the 11-plus examination it has been especially difficult to place children who failed the examination into a recognized grammar school; the Royal Wanstead School has been of particular help during this difficult period and has also planned the curriculum so as to enable the child who may be called a "late developer" to enter the school stream leading to the G.C.E. examinations.

The Royal Wolverhampton School, which at present has two children nominated by the Trustees, also has facilities for children under 11 years of age. The main stream of this school, however, is directed towards a grammar school education.

The Trustees are grateful to the Governors and staff of these three schools and feel sure that subscribers will endorse the support which the Trustees have given by grants.

Acknowledgments.—The report of the Trustees would not be complete without recording thanks to Mr. Charles Hill and Mr. R. H. Jenkins, who act as Solicitor and Auditor respectively, in an honorary capacity.

The Trustees are also grateful to the members who have drawn their attention to Benevolent Fund cases. Often the most deserving cases are the most reluctant to ask for assistance and any member who knows of a case eligible and deserving of assistance from this Fund is asked to contact the Honorary Secretary.

Schedule of Investments at Cost

	£	s.	d.
£200 3% Savings Bonds 1960/70 ...	191	3	6
£200 3% Savings Bonds 1965/75 ...	182	15	9
£1,500 3½% War Loan	1,157	15	9
£200 British Electricity 3% Guaranteed Stock 1968/73	155	19	6
£2,000 British Transport 4% Guaranteed Stock 1972/77	1,863	14	10
£4,000 4% Consolidated Stock	3,526	16	0
Jays & Campbells (Holdings) Limited —500 5½% Cum. Pref. Shares of £1 each	354	2	0
Associated Newspapers Limited—200 Deferred Shares of 5s. each	166	4	6
£100 6% L.C.C. Loan 1975/78	99	4	4
£200 6½% Liverpool Corporation Mortgage	200	0	0
£200 5½% Exchequer Bonds	201	2	0
£300 Middlesbrough Corporation Mortgage Loan	300	0	0
£100 Associated Electrical Industries 6% Debenture Stock 1978/83	98	10	0
(Market Value as at 31st March, 1959 £7,737 0s. 0d.)	£8,497	8	2

AN EXPERIMENTAL ELECTRONIC TELEPHONE EXCHANGE

An experimental electronic telephone exchange is now undergoing exhaustive tests at the Post Office Research Station at Dollis Hill, London. When these tests have been completed, equipment for about 1,000 lines will probably be installed within two years for the public exchange at Highgate Wood, in North London. Although this experimental model is not built as a public exchange, it does provide facilities for telephone calls within the Research Station and also into the London public telephone system. It will be used to prove the principles involved in designing electronic exchange systems.

The introduction of electronics to telephone exchange design is expected ultimately to reduce initial cost, provide smaller and less equipment which will need less space in buildings, and give greater reliability because of the virtual absence of moving parts. The use of electronics in GRACE—the equipment used in connection with Subscriber Trunk Dialling*—for instance, and the Magnetic Drum Director, introduced some time ago at Lee Green Telephone Exchange, are considered by the Post Office to have established the advantages of electronic systems.

Basically the exchange employs the principle of time division multiplex and switched highways for the ultimate connection, where each highway can carry up to 100 simultaneous conversations and sufficient highways are provided depending on the traffic of the exchange. The exchange lines are arranged in groups and each line in a group is connected by electronic gate circuits employing germanium diodes to the highway for that group. Each highway in turn can be connected to any other, again by electronic gate circuits. These highways transmit speech and other signals to and from the lines in the form of amplitude modulated pulses of 1 microsecond duration. The number of lines in a group connected to a highway is several times the possible number of simultaneous conversations, depending on the class of traffic originated by the lines.

* "Subscriber trunk dialling in the British Post Office," *J. Brit.I.R.E.*, **19**, pp. 45-6. January 1959.

Each connection on a highway uses a pulse channel transmitting one of a series of interleaved cyclically recurring pulse trains, typically of 10 kc/s repetition frequency. Lines are connected to channels by applying suitably timed pulses to the gate circuits. Magneto-strictive delay lines are used as temporary memories or registers for storing the pulses which have been allocated to the subscribers' gates for connection to the highway, and also for controlling the gates inter-connecting the highways. The delay lines receive information dialled by subscribers, count and store the dialled pulses, obtain any translations which are necessary to route calls to other exchanges and transmit digit pulses when outgoing routes are established. Delay-lines also control the supervision of connections after they have been established. They connect tones to the calling lines and ringing to the called lines at appropriate times, detect answering and clearing and arrange for the metering of successful calls.

A magnetic drum is used as a semi-permanent memory. This drum carries all the information relative to all subscribers' lines and junctions and acts in this respect as the exchange library. Another portion of the drum is linked to the register equipment to provide translation facilities for routing the call either to a local subscriber or to subscribers on other exchanges. Positions on the drum particular to each subscriber are used to record the accumulated total of unit fee registration debited against the subscriber and as such replace the individual electromechanical message registers provided in existing systems.

Speaking at the Research Station recently, the Postmaster-General emphasized that this experimental installation does not imply an immediate and wholesale changeover of the public telephone system to electronic switching. There are still problems to be solved with the time division system and investigation into the technical and economic merits of alternative electronic systems have yet to be completed. The decision, however, of the Post Office and the manufacturers who are co-operating in the project, to plan a public installation of the system indicates their confidence in the progress so far made.

Some Aspects of Television Reception on Band V †

by

H. N. GANT, ASSOCIATE MEMBER‡

A paper read on 2nd July, 1959 during the Institution's Convention in Cambridge.

Summary : The problems facing the designer of a television receiver for use on Band V are considered. Choice of aerial, signal/noise ratio and oscillator stability are discussed in some detail in respect of performance and complexity, and suitable valves for signal frequency amplifiers and oscillators are reviewed. Various possible arrangements for the front end of such a receiver are assessed. Some experimental results achieved with an experimental tuner using normal mass production techniques and components are discussed and the construction of this unit described.

1. Introduction

In considering the possibilities and requirements for a receiver for television reception on Band V, two matters are of paramount importance, namely, performance and cost. Unless the ordinary user can obtain a programme on this Band comparable with those of Bands I and III, and without a large increase in the cost of the receiver, the additional facility may not find general acceptance by the public. It may, however, become an interesting novelty and set problems for designers and production engineers if salesmen create a demand for it. This happened in the case of the short-wave ranges provided in domestic sound receivers which were never used except for a few days after installation of the receiver. If, however, it is planned to give not just another programme, but some new service such as increased definition or colour television requiring a larger bandwidth for the transmitted information, then it becomes inevitable that Band V should be brought into use, since there is no frequency space available elsewhere.

The major problems for the receiver designer are therefore to provide adequate sensitivity and oscillator stability at the higher frequencies in a manner which will permit relatively cheap components and mass production techniques to be used, while ensuring that the apparatus is likely to retain something approaching the designed performance for long periods without skilled attention.

2. Sensitivity

2.1. *Signal Strength at the Receiver*

Increased attenuation and the more marked effects of screening make it more difficult for the transmitter engineer to provide large areas of high field strength in Band V than at lower frequencies. Also, the power picked up by a simple dipole receiving aerial is proportional to the square of the wavelength, but on the other hand the smaller physical dimensions of the dipole permit the use of more complex arrays.

Estimates based on field measurements show that at about 650 Mc/s the field strength from a 200 kW transmitter using a typical aerial array some 700 ft above ground level is about 1 mV/m at a receiving aerial 30 ft high 45 miles away in a fairly well populated area but not overshadowed by high buildings. Near the fringe of the range it was found that the rate of fall with distance is just under 1 db per mile. At the upper end of the band the field strength would of course be less. These figures are the median of the measurements at a number of sites in the locality, so half would be worse.

Within 30 miles of the London transmitters live 10½ million people, and within 40 miles there are 11½ million, a figure that increases by about 100,000 per mile increase in radius. At provincial centres, although the figures are smaller, the increase of population per mile increase in radius at the fringe is about double that for the London area. The importance of achieving the maximum coverage is therefore obvious.

2.2. *Sensitivity ideally required*

For satisfactory television reception the required signal/noise ratio (on peak white signal,

† Manuscript first received 12th March 1959 and in final form on 19th May 1959. (Paper No. 528.)

‡ E.M.I. Electronics Ltd., Hayes, Middlesex.

U.D.C. No. 621.397.029.63

full modulation) is generally taken as 30 db for at least 90 per cent. of the time. With a bandwidth of 3 Mc/s the noise power in a resistor $4kTB = 4{\cdot}94 \times 10^{-14}$ watts, or -133 dbw. The signal energy picked up in a dipole in a field of 1 mV/m at 650 Mc/s is $3{\cdot}1 \times 10^{-10}$ watts or -95 dbw. In practice of course an aerial giving gain would be used. The amount of gain available from this would depend upon whether it would be required to receive only one or a number of stations of different frequencies or even lying in different directions .

Many different types of aerial are suitable for such an application. Most of them fall into four categories, the main properties of which may be summarized as under—

(a) Broadband dipole. A dipole having a very thick or conical outline for the elements gives a wide bandwidth, wide enough to cover the whole of Band V, with a figure-of-eight polar diagram.

(b) Dipole with reflector. A reflector may be used to suppress half the figure-of-eight polar diagram of a dipole and give a unidirectional response without unduly affecting the bandwidth.

(c) Long wire aerials. With a long wire which is not resonant a wide bandwidth can be achieved. The polar diagram has a narrow main lobe, but appreciable response in other directions. It could be made to operate fairly well on Bands I and III also.

(d) Yagi arrays. These give the highest gain but are of narrow bandwidth and, unlike the types mentioned above, such an array could not be made to work satisfactorily over more than a few adjacent channels in the band. Most of the energy is concentrated in a rather narrow beam.

The performance which may be expected with various typical systems is set out in Table 1.

A factor influencing the choice of aerial at these high frequencies is the greater likelihood of ghost images by reflections of the transmitted wave arriving by different paths with an appreciable time delay. Suitable orientation of an aerial system of narrow beam width can often overcome this.

On the assumption that a broad-band aerial will be necessary but that alternative stations lie in a common direction a corner reflector and dipole would be a typical choice, from which a gain of 7 db at 650 Mc/s could be expected. The smaller signal picked up by a dipole at higher frequencies will be roughly offset by the greater aerial gain. Attenuation in the aerial feeder cable will not be negligible at these frequencies, but it should be possible to keep this down to about 3 db in a typical domestic installation without excessive cost by choice of a suitable cable. High impedance cables have less attenuation than those of lower impedance at comparable cost, but open wire types are more liable to the effects of weather and interference, and are more affected by adjacent conductors.

The power level at the receiver end of the feeder would thus be -91 dbw. This is only 42 db greater than the noise in a resistor, so to achieve a signal/noise ratio of 30 db the noise factor of the receiver must be not worse than 12 db or the coverage will be less than the postulated 45 miles radius. This allows nothing for fading, for which American field surveys suggest that a margin of some 3 db should be allowed. Nor does this figure take account of the fact that the assumed field strength is the median level of all sites at that range ; half can be expected to be worse.

It has been found that very small changes in the position of a receiving aerial can give significant changes in the received power. Considerable experimentation may be necessary on installation to find the best position in fringe areas. Field experiments carried out at rather short range over flat country by D.S.I.R. suggest that to give the required signal/noise ratio at 90 per cent. of sites would require an increase in the mean field strength for the area of 1 db, or to cover 98 per cent. of sites, 2 db at 650 Mc/s, the figures being 1½ db and 3 db at 900 Mc/s. American experience over moderately hilly country at greater range however suggest that very much greater increases are required. It is probable that under the conditions likely to hold in the London area, for example, to increase the coverage from 50 per cent. to 90 per cent. of sites will require an increase in the mean field strength by about

7 db. To give such coverage up to 45 miles radius would thus require a receiver having a noise factor not worse than 2 db for 3 Mc/s bandwidth, which obviously cannot be achieved at present.

2.3. *Design of the U.H.F. Section*

2.3.1. No signal frequency amplification

In the U.S.A. where this frequency band is already in use many receivers incorporate a "u.h.f. insert" in the turret tuner. This consists of a crystal mixer with the necessary tuned circuits and either a separate valve oscillator, or harmonics of the existing v.h.f. oscillator are used. Typical noise factors for production models of such receivers are 15 – 18 db at 650 – 900 Mc/s, or 1 db better for models using a separate u.h.f. oscillator valve. The performance of such receivers would permit coverage only up to 30 miles radius. It can therefore be expected that considerable design effort would be devoted to improving the sensitivity if this Band is to be fully exploited.

Since the crystal mixer is inherently noisy owing to its low conversion efficiency, it is not easy with such a simple system to effect much

Table 1

Performance of some typical aerial arrays

Type	Detail	Gain at		Half Power Beam Width		Dimensions		
		650 Mc/s db	900 Mc/s db	Hor.	Vert.	Width ft.	Height ft.	Depth ft.
Broad band dipole	One	0	4	60°	60°	1½	1	—
	Two, vertical stack	3	7	figure of 8	50°		2	
	Four, vertical	6	10		40°		4	
Dipole with plane reflector	One	3	7	60°	60°	2	1	½
	Two, vertical	6	10		50°		2	
	Four, vertical	9	12		40°		4	
Dipole with corner reflector	One	7	11	50°	50°	2	2	1
Long wire	Two vees vertical stack	6	10	30/40°	30/40°	4	1	4
Yagi	5-element	8	8	50°	50°	1		½
	2 × 5 element vertical stack	11	11	50°	35°	1	2	1½
	10-element	10	10	35°	35°	1		3

improvement over the figures quoted above. By considerable increase in engineering complexity, such as the use of very low loss coaxial tuned circuits, selected mixer crystals and a cascode first intermediate frequency amplifier stage an improvement of some four decibels could be expected, but considerable ingenuity and development would be necessary to achieve this at reasonable cost on a production basis.

As an example of this, an American tuner has been described using variable capacitor tuning within a container which itself constitutes the inductance. Two such tuned circuits are coupled together and used between the aerial and the mixer crystal, for which a silicon diode type 1N82 is used. The oscillator was a modified Colpitts type using a 6AF4 valve. The noise factors achieved with this tuner were 10·5 to 13 db at the ends of Band V.

With ordinary (i.e. not specially selected) crystals it is likely that in production there would be a spread of at least 2 db in the noise factors achieved, as well as the conversion loss of about 10 db.

2.3.2. Signal frequency amplification—special valve types.

It thus seems that some amplification at signal frequency would be advantageous, but few available valve types are suitable for this. Disc-seal triodes will give satisfactory amplification up to well above the required 900 Mc/s, but have several disadvantages. They are expensive to make and use heavy anode currents, thus dissipating relatively large anode powers. This necessitates the use of large masses of metal for cooling, so that they are best used in coaxial circuits, which do not easily lend themselves to variable tuning over a wide frequency band nor to cheap mass production. The use of such valves could give receivers having noise factors of 8 – 11 db over the band, their gain being ample to cause the mixer and i.f. amplifier noise to have negligible effect on the overall noise factor.

Newer triodes requiring smaller anode powers while still giving a useful measure of amplification over the required frequency range are now available. Among these may be mentioned the American micro-miniature metal-ceramic types, for which performance comparable with that from disc-seal triodes is claimed, with anode currents of about 5 mA. The published figures for the valve show that the equivalent noise resistance is rather high but that the input conductance is low and that the power gain is higher than from disc-seal triodes up to 900 Mc/s. Early samples of the type 6BY4 available in this country did not however come up to expectations. Used as a signal-frequency amplifier using lumped constant circuits at 650 Mc/s with 13 Mc/s bandwidth, followed by a silicon diode mixer and cascode first i.f. stage, the measured noise factor for the whole receiver was 12 – 13 db, which is 3 – 4 db worse than calculations based on published data. Changing from lumped constants to coaxial tuned circuits gave no significant improvement. There was actually no advantage in using the signal frequency amplifier, since without it the same circuit gave a measured noise factor of 13 db. It is understood that this valve type has now been superseded, but its successors have not been tried.

2.3.3. Use of pin based valves

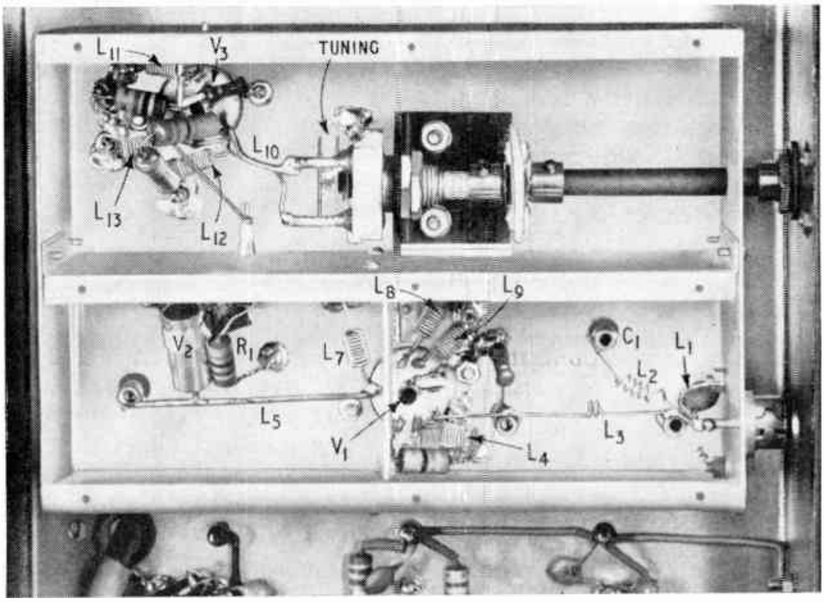
Recently introduced valves of more conventional construction, such as types PC86, 6AN4 and A2521, are also attractive for this application. Used as a signal frequency amplifier with silicon diode mixer and low noise first i.f. amplifier a noise factor for the receiver of 10 – 11 db at 650 Mc/s should be obtained which is about 3 db worse than for disc seal triodes. Typical of these valves is the British A2521,

By courtesy of *Wireless World*

Fig. 1. The Band V convertor assembled as a self-contained, screened unit, including power supply.

which is in large scale production with a closely controlled specification, particularly of the noise figure. The claimed figures for this type in Band V are 13 db gain at 650 Mc/s with 10 Mc/s bandwidth and 10 db noise figure.

A number of tuners incorporating such an r.f. stage followed by a silicon diode (CV 2154) and another A2521 as oscillator and a cascode first i.f. amplifier were recently manufactured for use in field trials of Band V television reception by the B.B.C. and B.R.E.M.A. (Fig. 1). The measured noise factor of these at 650 Mc/s lay between 10·3 and 11 db for the entire batch with no selection of valves or mixer crystals, showing that production tolerances on performance for this valve type are very close. These units have been fully described elsewhere.† Orthodox mass production components and techniques were used throughout except that the inductors of the series tuned cathode and anode circuits of the signal frequency amplifier were straight heavy conductor instead of coils (Fig. 2). Also the cathode circuit tuning and aerial coupling were adjusted for minimum noise factor rather than for maximum power transfer. Since these units were required to tune over a very limited range of frequencies, the r.f. stage was not provided with variable tuning, but had a bandwidth of 13 Mc/s. The mixer diode was tapped on to the anode inductance in a position chosen to load the circuit to give the required bandwidth. Image rejection was aided by the use of a series resonant circuit across the aerial input socket.



By courtesy of *Wireless World*

Fig. 2. R.f., mixer and oscillator section of the convertor.

Such a circuit should be quite capable of further development to cover the whole of Band V in switched steps, the noise factor getting worse with increase in frequency; it should, however, be possible to keep it down to 13 db overall up to 900 Mc/s. The power gain of this r.f. amplifier is sufficient to reduce greatly the effect of the crystal noise, but there was a degradation of 2 db when the silicon diode was replaced by a v.h.f. germanium type. The cascode first i.f. amplifier was not really necessary, since it was found that changing to pentode degraded the noise factor by less than 1 db. Similarly, the use of two stages of r.f. amplification, or a valve mixer was considered unlikely to improve the performance by more than

† H. N. Gant, "Television reception on band V," *Wireless World*, **64**, pp. 244-6, May 1958.

I db, and hardly warranted the increase in cost and complexity, and the stability problems likely to arise.

Using such a receiver the service range for 90 per cent. of sites would be about 35 miles, which would fall short of the full 45 mile coverage by about 1 million potential viewers in the London area, or more elsewhere.

2.3.4. Other possible arrangements

Other arrangements are possible. One is to use a double triode valve, half as a mixer and the other triode as an oscillator, but currently available valves will not function satisfactorily above about 700 Mc/s. Progress in valve design could probably extend this, but it would be very difficult to prevent serious radiation by the aerial from the local oscillator.

A similar valve could be used as a self oscillating mixer preceded by a grounded grid r.f. amplifier, as is done in many commercial Band II sound receivers. This would reduce the local oscillator radiation and give a better noise factor than the previous method, but the design would be very difficult, and no valve is yet available to cover up to 900 Mc/s.

Again, if a suitable double triode and oscillator/mixer were developed, the Band V front end could closely resemble that at present used for Band III, i.e., a cascode r.f. amplifier, followed by a mixer pentode with an oscillator triode in the same envelope. It could in fact use the same valves on all Bands, which, given suitable valves, would be cheaper than any other arrangement discussed yet giving a performance equal to the best.

3. Oscillator Stability

Using amplitude modulation for the sound with a 4·5 Mc/s separation as in the British system requires that the oscillator drift be not more than some 100 kc/s ; otherwise there will be noticeable degradation of performance, i.e., sound on vision or vice versa, or diminution of sound output. At 900 Mc/s this implies a very high order of stability for a tunable oscillator—0·01 per cent. or 100 parts in 10^6. This is equal to that achieved until recently, by simple crystal-controlled oscillators. In the experimental tuner using A2521 valves no great efforts were directed at the problem of stability since the units were used only for field trials by skilled operators. After an initial 10 minute warm-up period the drift was 500 – 700 kc/s in half an hour's running from a stabilized power supply.

The oscillator of the American experimental tuner using tuned circuits consisting of a variable capacitor in a metal container which formed the inductance had a negative temperature coefficient trimmer capacitor added. The initial large drift on switching on was completed in 3 minutes. In the case of a domestic television receiver the effect of ambient room temperature changes is not important, but large changes inside the cabinet may be expected, typically about 20° C. The drift from this cause in this American tuner was between 100 and 200 kc/s at different frequencies within Band V. The heater and h.t. supplies in a domestic television receiver are taken directly from the mains, and in many districts the supply voltage may vary by 5 per cent. or more. The measured change in frequency for a 5 per cent. change in h.t. voltage was 75 kc/s at the highest frequency. With a similar change in heater voltage it was only 35 kc/s in the American tuner. The effect of temperature is thus the most important factor.

In an American production convertor for a single preset channel in either Band IV or V the oscillator settles down quickly after switching on for the lower frequencies, but at the top of the band it takes 20-25 minutes to reach within 100 kc/s of the final frequency. This unit uses an oscillator inductance consisting of a few turns of unsupported stiff wire and partial temperature compensation by the use of coupling capacitors having a negative temperature coefficient. It therefore appears that considerable effort will have to be put in to develop oscillator circuits of sufficient stability.

4. Interference

Cosmic noise at these frequencies is too small to have any effect on performance. Owing to the low efficiencies of conductors carrying impulses as radiators at such high frequencies, to the marked effects of screening, and to the highly directive aerials used, impulsive interference is unlikely to constitute a serious problem. It may be expected that the interference limiters normally included in television receivers will be found adequate, in conjunction with judicious choice of the aerial site and the use of a screened down-lead. Adjacent channel interference would be the same as that experienced in other bands since it is a function solely of the i.f. amplifier design. Spurious responses of the receiver on Band V may however be important. These may be due to images, harmonics of the local oscillator, production of sub-harmonics of the i.f. in the mixer, direct i.f. breakthrough, cross-modulation or intermodulation. All these are functions of the design of the front end. Using a coupled pair of coaxial or other high Q tuned circuits in experimental tuners, it has been found that the image is the worst interference, and it can be kept 40 db below the wanted signal, with other spurious responses much less. A similar result was achieved in the tuner using A2521 valves, without the use of high-Q tuned circuits, but in this case there was a preset absorbtion circuit, which might be difficult to use in a receiver tuneable over the whole band. The American production convertor mentioned earlier which used a coupled pair of tuned circuits having printed inductors, achieved only 30 db image rejection, and in this case the signal frequency tuned circuits of the receiver itself on a channel in Band I were used to give a double superheterodyne having a first i.f. of 60 Mc/s or just under. It is apparent that further work will be required to achieve a satisfactory design to ensure freedom from interference of this nature, and that considerable care will be required in the planning and allocation of transmitting frequencies.

5. Conclusions

Before a television service on Band V can come into use, considerable development work on suitable receivers will be required. This will apply particularly to finding economically acceptable ways of achieving adequate image rejection and oscillator stability. A range to give 90 per cent. coverage up to some 30 miles could be achieved using receivers with no signal frequency amplification, merely a crystal mixer and suitable oscillator. To increase this by the addition of a r.f. amplifier valve stage would only increase the service range by about 5 miles with valves at present available, so would probably not be commercially acceptable. If the valve manufacturers could develop improved versions of the double triodes and triode pentodes at present used for Band III which extended their range to still higher frequencies, it is likely that this arrangement could be the cheapest and the most satisfactory design for a receiver to cover Band V.

News from the Sections . . .

South Wales Section

The first meeting of the new session was held on September 30th at the Glamorgan College of Technology, Treforest, when Mr. H. Henderson, B.Sc., of the B.B.C. Engineering Training Department, Wood Norton, Evesham, gave a most instructive and entertaining paper on "The Use of Demonstration Equipment in Basic Radio Theory," in which he described some of the special problems encountered in B.B.C. radio training work.

Mr. Henderson's main demonstration consisted of a wave synthesis machine which was able by electro-mechanical means to produce a fundamental frequency and up to ten harmonics of it; each or all of the components could be varied in amplitude and phase, combined, and displayed on a large-screen oscilloscope. He was able readily to show the composition of waveforms containing odd and even harmonics, square waves, and modulated carriers.

C. T. L.

South Midlands Section

There was a large attendance on October 2, at the North Gloucestershire Technical College, Cheltenham, to hear a paper on "Loudspeakers" by Mr. F. H. Brittain.

Mr. Brittain began by giving a survey of early loudspeakers and then discussed the Rice-Kellogg moving coil which he said was still the basis of most modern loudspeakers. Referring to the full range electrostatic speaker Mr. Brittain was of the opinion that development to date had not shown that it would replace the moving coil type.

Passing then to the main subject of the paper —the moving coil loudspeaker—he pointed out that although theory predicted that the cone would act as a rigid piston it was in fact, neither rigid or a piston. Metal cones could be used to give a fair degree of rigidity and dents could be moulded in to prevent cone resonance. Dual systems were essential using small, light loudspeakers to handle the higher frequencies; since these speakers were very small, approximating to point sources, a more uniform distribution of the higher frequencies was obtained. To give adequate power and improve the performance two h.f. units were preferable. Mr. Brittain then discussed cabinets and said that vented enclosures were normally used as they were economical in space. Damping of column resonance in the cabinet was mentioned. His demonstrations ranged from an early horn speaker to a modern sterephonic system.

A lively discussion followed, questions on dual cone speakers, diffusion of high frequencies, and electrical analogues being raised.

G. W. M.

North Western Section

The North Western Section held the first meeting of its 1959-60 session at the Reynold's Hall, College of Science and Technology, Manchester on Thursday, October 1. Mr. L. E. Jansson gave an interesting and useful paper on "Transistor High Frequency Amplifiers".

After a brief resumé of recent advances in the transistor field, the paper described how the available information on transistor characteristics was converted for the first stage in amplifier design. The maximum theoretical and maximum usable gain was then assessed for either single or multi-stage amplifiers. The importance of stability conditions was stressed since the usable gain was generally limited by these factors.

After explaining in considerable detail the circuitry, associated parameters and initial choice of the operating conditions which determined the performance that can be obtained in tuned and R-C coupled amplifiers, a technical film was shown. This very effectively recapitulated many of the points made.

Following the reading of Mr. Jansson's paper the Annual General Meeting of the Section was held. Reports were given on the activities during the 1958-59 session by the retiring officers. The reports were evidently to the complete satisfaction of the membership of the Section who re-elected Mr. J. W. Harrop, B.Sc. (*Associate Member*) as Chairman and Mr. W. H. Cooke (*Associate Member*) as Honorary Secretary. Other members re-elected were Messrs. C. W. Miller, D.Sc. (*Member*), J. Andrew, F. J. G. Porter, B.E.M., and S. Whittam, M.A. (*Associate Members*), F. A. Mitchell (*Associate*), P. E. D. Smith (*Graduate*) and P. A. Bennett (*Student*). Mr. D. L. Leete, B.Sc. (*Associate Member*)—see page 624 of the October *Journal*—was also elected to the Committee. F.J.C.P.

Radio Engineering Overseas . . .

The following abstracts are taken from Europe and Commonwealth journals received in the Library of the Institution. Members who wish to borrow any of these journals should apply to the Librarian, stating full bibliographical details, i.e. title, author, journal and date, of the paper required. All papers are in the language of the country of origin of the Journal unless otherwise stated. The Institution regrets that translations cannot be supplied.

MEASUREMENTS ON SEMI-CONDUCTORS

A recent Czech paper contains a description of a contactless method of measuring semi-conductor conductivity. The relations derived serve for calculating the conductivity of small semi-conductor samples in a cavity resonator. In addition the quality factor (the electrical losses within the sample as a function of the conductivity) is analysed. The region of this dependence for ascertaining the electrical conductivity irrespective of sample form is determined by a simple formula. The results of verifying the method experimentally, its accuracy and applications are stated.

"The measurement of semi-conductor conductivity in the microwave range." B. Kvasil and V. Husa. *Slaboproudy Obzor (Prague)*, **20**, pp. 667-671, November 1959.

MULTIVIBRATOR DESIGN

Stability in cases of tube, voltage, and certain component changes may be gained by proper design of the circuit, or by applying non-linearity. A practical example with the results of experiments has been presented by a Czech engineer in which stability in cases of a changing time-constant of the R.C.-network may be achieved by introducing negative time feedback. Designs described in literature as well as a new circuit developed by the author are presented; the last is especially suitable for continuously working voltage dividers. The results of experiments with the new circuit are stated.

"A contribution to stabilizing the pulse duration in monostable multivibrators." T. Hornak. *Slaboproudy Obzor (Prague)*, **20**, pp. 700-703, November 1959.

SURFACE-WAVE TRANSMISSION LINES

The G-line proposed by Goubau in 1950 as a surface wave transmission line is very useful because of its simple construction, but it has defects such as large conductor loss, small concentration efficiency of the wave and so on. Two Japanese engineers have proposed lines composed of dielectric membranes for the more advanced surface wave transmission lines. Two examples with this construction have been described, called O-guide and X-guide respectively. They are designed according to the principle that a dielectric membrane placed parallel to the electric field has more effective concentrating action than one located perpendicularly. It is claimed that the lines have two merits: absence of conductor loss and high efficiency of concentration. Better results can be realized by shielding the lines using metal to eliminate interference from the external field. The results of the analysis on transverse electric fundamental mode in the O-guide are described, and the theoretical characteristics of the transmission line are discussed. It is concluded that the lines will be especially suitable for u.h.f. as they have lower attenuation constants than coaxial lines, G-lines and rectangular wave guides.

"Surface wave transmission line composed of dielectric membrane." Masao Sugi and Tsuneo Nakahara. *The Journal of the Institute of Electrical Communication Engineers of Japan*, **42**, pp. 731-37, August 1959.

PARAMETRIC AMPLIFICATION

It is shown in a Dutch paper that the energy relations pertaining to parametric amplifying devices, as derived by various authors, are a direct consequence of the invariance of the total-energy function of the parametric system under certain transformations. The theory is generalized so as to comprise arbitrary parametric systems. Some general properties of parametric systems, which can be deduced immediately from the energy relations, are discussed. A small number of typical examples are briefly treated to illustrate some fundamental principles following from the general theory.

"General energy relations for parametric amplifying devices." S. Duinker. *Tijdschrift van het Nederlands Radiogenootschap*, **24**, pp. 287-309, No. 5, 1959. (In English.)

HORN-PARABOLA AERIALS

The design of horn-parabola aerials has been discussed at length by a Czech engineer. After general considerations on antenna geometry the formulae for height, depth and breadth respectively are derived and also for the dimensions and area of the supposed aperture. The curves are treated by limiting the sector of a rotary paraboloid and the walls of a pyramid horn. All dimensions and curve parameters (ellipses in general) are expressed as functions of the illuminating angle of a rotary paraboloid and the aperture angle of the pyramid horn. To enable a quick survey of the variations of antenna dimensions to be gained, some graphs of the most important antenna dimensions in relation to its height are presented. Finally the paper contains tables with formulae for antenna design.

"The dimensions of a horn parabola antenna." F. Stranak. *Slaboproudy Obzor (Prague)*, **20**, pp. 691-699, November 1959.

END-FIRE AERIALS

An investigation by a German engineer has revealed that electro-magnetic waves emerging from weakly directional concentrating primary radiators can be concentrated in an axial direction with the aid of travelling wave systems installed in front of these radiators. When a suitable shape and coupling factor is chosen, the gain of the primary radiator increases with the length of the system and for all the various radiators the concentration of the main lobe is mainly determined by the radiation coupled system. Guidance of the waves can be achieved with rows of directing discs or directing dipoles as well as with directing rings having a diameter of approximately one quarter wavelength. Radiation coupled circular and flat wire helices, a wire bent periodically in the direction of propagation, or a toothed strip of sheet metal are suitable, depending on the type of polarization.

"Systems for guiding waves on end-firing radiators." G. Trentini. *Nachrichtentechnische Zeitschrift*, **12**, pp. 501-508, October 1959.

RADAR AERIAL TECHNIQUES

The aerials of search radar equipment rotate at a constant velocity on which is superimposed relatively small fluctuations mainly caused by wind. These fluctuations have to be transmitted to where the rotating movement is reproduced in a display. The information content of the fluctuations has been calculated by a German engineer on the basis of many measurements. The minimum channel capacity required for the transmission has been determined and compared with the channel capacity required for the transmission of the rotating movement without prior removal of the part not containing information. In conclusion a possible method of translating this rotating movement is described.

"Long distance transmission of the angular informations from a shaft rotating with an average uniform speed." K. Dinter. *Nachrichtentechnische Zeitschrift*, **12**, pp. 491-496, October 1959.

EARTHING TECHNIQUES

A proposed method of replacing the radial earthing network of equipment in telecommunication installations by a large area earthing mesh in which all earth points are inter-connected by a mesh of wires has been put forward in a recent German paper. Line screens are included in this mesh and cable sheaths are also used as earth leads, resulting in a very low earthing impedance. These means reduce interference in carrier-frequency systems due to high-frequency fields, the earthing of telecommunication systems becomes uniform, and an insulated installation of such equipment is unnecessary.

"Large area earthing in telecommunication installations." O. Warmers and A. Ziegler. *Nachrichtentechnische Zeitschrift*, **12**, pp. 497-500, October 1959.

PROPAGATION AT V.L.F.

Measurements of field strength of the transmitters GBR (16 kc/s), GBZ (19·6 kc/s) and GIY 20 (51·95 kc/s), made in the Heinrich Hertz Institute in Berlin-Charlottenburg during periods of solar flares, show positive and negative field anomalies, dependent on frequency, time of day, and year. These are explained in a recent paper as interferences between ground wave and rays reflected from the ionosphere. It is assumed that the height of reflection decreases during a solar flare. The median height of reflection is between 69 and 76 km for 16 kc/s, and decreases down to 12 km during a solar flare. The same model can explain the change of the frequency spectrum of atmospherics during a solar flare.

"The frequency dependence of the effect of solar flares on long wave coverage." H. Volland. *Archiv der Elektrischen Ubertragung*, **13**, pp. 443-448, October 1959.

PROPAGATION AT V.H.F.

At the Kiruna Geophysical Observatory in Kiruna, Sweden, radio signals from Central European v.h.f. transmitters, e.g. Langenburg, which is 2,000 km distant, could be received within the period February 1958 to August 1959. These unusual conditions for frequencies of 90 Mc/s occurred only five times—during the summer months. A quite specific sporadic E-layer, evaluated in collaboration with Ionospheric Observatories at Uppsala, Sweden, and Kjeller, Norway, gives the best explanation for these unusual receiving conditions.

"Unusual propagation conditions for ultra short waves." J. Ortner and A. Egeland. *Archiv der Elektrischen Ubertragung*, **13**, pp. 420-428, October 1959.