Television Service to Belfast

T. KILVINGTON, B.Sc.(Eng.), M.I.E.E. †

U.D.C. 621.397.2 (416)

Vision signals for the B.B.C. temporary television transmitter at Belfast are picked up direct from Kirk o' Shotts on 56·75 Mc/s at a receiving site on Black Mountain and passed on a carrier of 6·12 Mc/s over about a mile of coaxial cable to the temporary transmitter site in Glencairn, whence they are re-broadcast on a carrier of 45 Mc/s.

Introduction

When the B.B.C. decided in the autumn of 1952 to set up, in time for the Coronation, a temporary television station to serve the Belfast area of Northern Ireland, the Post Office Engineering Department was faced with the problem of providing a link between some point on the existing television network and the new station. Time was short, about seven months—or rather less if transmissions were to start in time to allow a reasonable period for viewers and dealers to install and test receivers before the big event. The nearest point on the existing network was Kirk o' Shotts, but to provide a fully equipped cable or radio link between here and Belfast in the time available was out of the question. Consideration was therefore given to the possibility of picking up the signals, as radiated by the B.B.C. from Kirk o' Shotts, at some point on the Ayrshire coast, and relaying them across the Irish Sea by means of a 200 Mc/s link, equipment for which could be made available. However, from a consideration of the long sea path to be crossed and as a result of measurements of the Kirk o' Shotts field strength made both in Ayrshire and near Belfast, it appeared that this solution did not offer the prospect of any better service than if the signals were picked up in Northern Ireland direct from Kirk o' Shotts. The obvious simplicity of the latter scheme led to its adoption.

The site chosen by the B.B.C. for their permanent Northern Ireland television transmitter is between the summits of Black Mountain and Divis, some three miles west of the centre of Belfast. Access to this site is very difficult however, and the B.B.C. did not feel able to set up a station there until a road had been built, a process too lengthy to be carried out in the time available. It was therefore decided to set up the temporary transmitting station at a more accessible site alongside an existing road in Glencairn, about a mile north-east of the final site and about 600 feet lower in level.

Tests made by the Post Office in November 1952 at a point near the summit of Black Mountain, just above the 1200-ft. contour, indicated that, at that time of the year, there was an adequate field strength available from Kirk o' Shotts to provide a good noise-free signal. In fact it was estimated that with an aerial array having a gain of some 15 or 16 db. relative to a half-wave dipole, there should be a margin of about 25 db. against fading before the signal became unusable. Approach to this site was, of course, just as bad as in the case of the B.B.C. permanent site, but in view of the lighter equipment to be transported, it was felt that, although it might be very difficult, it was not wholly impracticable to set up a receiving station on Black Mountain.

For the connection between the receiving site and Glencairn it was decided to use coaxial cable. There were two main grounds for this choice. First it would be possible to transmit power over the coaxial tubes, thereby feeding the Black Mountain station without the need for a separate expensive power cable; and secondly, suitable translation equipment of proved reliability, as used on the London-Birmingham television cable system, was immediately available.

† Senior Executive Engineer, Radio Experimental and Development Branch, E.-in-C.'s Office.

Building Sites and Cable Route

Black Mountain.

As already mentioned, the Black Mountain site is near to the summit at about 1,200 ft. There is an infinite variety of approaches to the site—all bad! The only practicable route for wheeled vehicles, however, is from Good's Farm by a circuitous route of about three miles across a trackless waste with many boggy patches. When the project was mooted in November, local opinion was that the hilltop would be inaccessible for a considerable proportion of the winter and steps were taken to get as much material as possible on site before the weather became too bad. However, thanks to a winter of unprecedented mildness a tractor was able to make the journey on most days, though not without getting bogged down on a number of occasions. Later, a Land Rover was also used with considerable success to transport goods and personnel over the route.

The task of setting up the aerial array and the timber buildings was no mean one. The bulky building sections, the cement and ballast for the foundations, the poles for the aerials and a variety of other materials all had to be conveyed to the site by tractor-drawn trailer. Even the water for mixing the concrete had to be carted, for the plentiful bog water at hand was not considered suitable for the purpose.

Timber buildings of types that are now standardised in the Post Office were erected: a B1 building with an internal partition added to make two rooms, one for equipment and the other for staff welfare facilities; and an A-type building to house the supplementary diesel-driven power supply generator. The larger building is shown in Fig. **1**. Stout

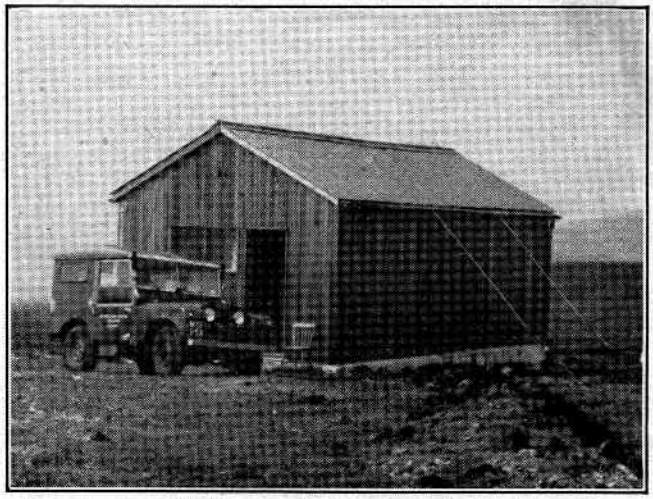

Fig. 1.—The B1 Timber Building on Black Mountain.

wire stays over the roof are fitted to prevent the buildings from being carried away in the high winds that may be expected.

Glencairn.

The Post Office building at Glencairn, also of timber, was a considerably easier problem as there was good access from a road. The building is situated on the B.B.C. site, close to the building housing the transmitter.

Cable.

The inter-site cable is a standard two-tube $\frac{3}{8}$-in. coaxial cable with 16 interstice pairs, some of which are used for supervisory and control purposes, and with armouring added. It is laid directly in the ground along a route of about one mile which is almost a straight line joining the two sites. Although this route is short, it is very steep, with gradients of more than 1 in 2 in parts, and the laying of the cable appeared to be a very formidable task. However, thanks to the enterprise and ingenuity of the Northern Ireland staff, it went surprisingly smoothly. Most of the drums of cable were hauled to the mountain top by means of the tractor towing a specially constructed drum trolley.* The cable was then taken off the drums and man-handled into position down the hillside.

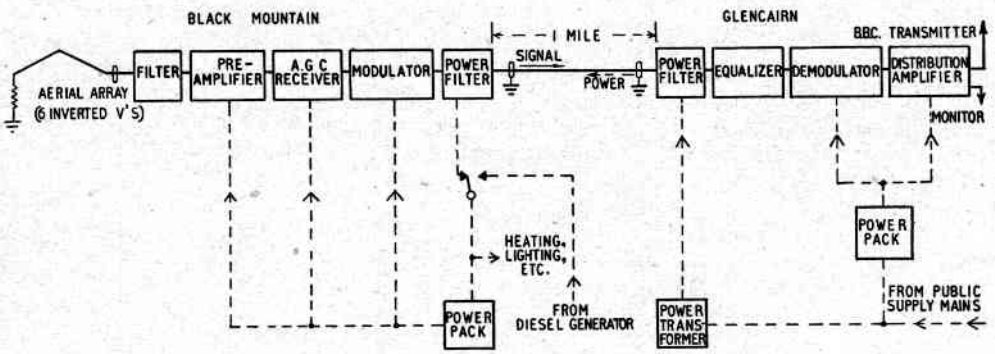

FIG. 2.—BLOCK SCHEMATIC DIAGRAM OF EQUIPMENT.

EQUIPMENT

Fig. **2** is a schematic diagram of the equipment. The two stations are intended for unattended operation and in order to avoid the need for automatic changeover equipment two continuously running, completely independent signal channels are provided, the B.B.C. engineers effecting a manual changeover at the output when necessary. Figs. **3** and **4** are photographs of the equipment at Black Mountain and Glencairn respectively.

FIG. 3.—EQUIPMENT AT BLACK MOUNTAIN.

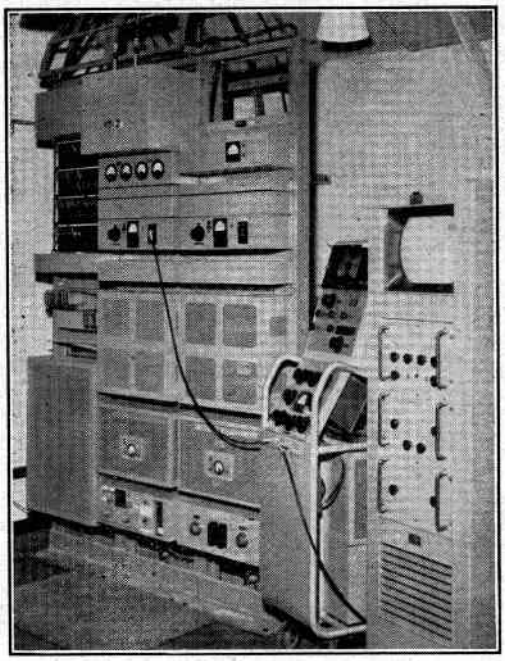

FIG. 4.—EQUIPMENT AT GLENCAIRN.

Aerial Arrays.

Twelve inverted-V aerial elements supported at the apexes by a triatic suspended from three 45-ft. poles and at the ends by individual short poles, are combined in two groups of six in such a way as to provide two independent arrays each with a theoretical gain of 16·5 db. relative to a half-wave dipole and a beam width of 10 degrees to the half-power points. In practice the gain of each array was found to be 15 db. The outputs from the two arrays are matched to 75-ohm coaxial cable for leading in to the equipment. Fig. **5** shows the construction of the aerials.

This type of aerial, besides having a high gain, also has a very broad bandwidth and will pick up signals even down to the medium frequency band. Precautions had to be taken, therefore, to avoid intermodulation troubles that might be caused in the receiver by the presence of strong unwanted signals. There are two possible sources of such signals—local medium-wave broadcasting stations and the local B.B.C. television station itself, the latter being the more important. The normal field strength of the Kirk o' Shotts transmitter at Black Mountain is about 100 microvolts per metre on 56·75 Mc/s whereas it was estimated that the field from the local vision and sound transmitters might be as much as 2 volts per metre at 45 and 41·5 Mc/s respectively. To avoid blocking of the first stage of the pre-amplifier, a high-pass filter is included in circuit having a loss of 28 db. at 45 Mc/s and 40 db. at 41·5 Mc/s but passing the wanted signal without appreciable attenuation. This filter, together with rejection circuits in the pre-amplifier following it, gives a substantial measure of protection against interference from the local transmitters, but there are three other factors that also help in this respect. One is the fact that the direction of the local transmitter is depressed substantially below the horizontal and the aerial picks up signals from this direction less efficiently; secondly, the path between the local transmitting and the receiving array is non-optical, a shoulder of land intervening; and finally the local transmission is

*See p. 152.

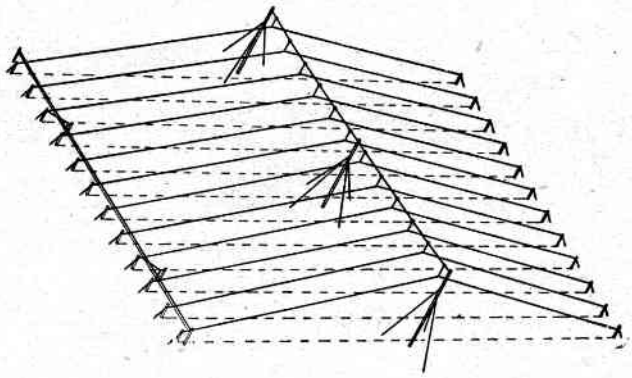

FIG. 5.—AERIAL ARRAY AT BLACK MOUNTAIN.

horizontally polarised whereas the receiving array is designed for the reception of vertically polarised signals. In the latter respect it is perhaps fortunate that the line of shoot from the receiving array to Kirk o' Shotts passes almost directly over the local transmitter, for in other directions the array of V's would offer less discrimination against horizontally polarised signals.

Radio Equipment.

Each radio receiving channel comprises a low-noise pre-amplifier followed by a receiver fitted with automatic gain control. The average, R.M.S. and peak levels of a television modulated carrier are not constant but change according to the brightness of the picture transmitted. They cannot, therefore, be used for automatic gain control and a more complicated arrangement has to be resorted to. In the television signal, following each synchronising pulse, a short period of black level is transmitted. This is known as the post-synch. suppression or "back porch" and since it always represents black level, the carrier amplitude during this period does give a measure of the signal strength. In the receiver, therefore, arrangements are made to pick out this particular portion of the signal, measure its level, and use a D.C. voltage derived therefrom for gain control in such a way as to maintain the black at a substantially constant level. The receiver delivers a video signal in the band 0-3 Mc/s of amplitude one volt, peak to peak, which is then passed to the cable transmission equipment.

Cable Transmission Equipment.

For transmission over the coaxial cable to Glencairn the video signal is put on to a carrier of 6·12 Mc/s as used on the London-Birmingham television cable.* In this case, however, owing to the short length of the cable, no line amplifiers are required, the output from a modulating unit being fed directly to the cable at Black Mountain and the signal from the cable being fed, after equalisation by passive networks, directly to a demodulating unit at Glencairn. The separate video signals from the two channels are fed to the B.B.C. transmitter building via short coaxial cable leads.

The power filters that enable power to be fed into the coaxial tubes at Glencairn at the same time that the signal is being taken from them (and vice versa at Black Mountain) are similar to those used with C.E.L. 3 equipment except that they are modified to take $\frac{3}{8}$-in. coaxial cable sealing ends and to handle a little more power current than normal. Transformers are used at Glencairn to feed power from the public supply mains into the coaxial tubes, but at Black Mountain power from the tubes is fed directly without transformers from the power filters to the equipment. As with the rest of the equipment, two completely independent power feeds are provided, each tube carrying power for the equipment associated with it on the mountain. Up to 10 amps. can be passed over each tube, enough to supply not only the equipment but also a certain amount of power for lighting, heating and test apparatus. Additional power at Black Mountain for heating, cooking or extra test gear is provided by a 5-kW diesel set which can also be used for running the equipment in the event of cable faults requiring the cable to be isolated from the mains supply.

Picture monitoring facilities are provided both on Black Mountain and at Glencairn, and at the latter place a trolley monitor is provided of the type specially designed for use with London-Birmingham translation equipment. The link will not normally give an output unless Kirk o' Shotts is transmitting, so in order to test the serviceability of the equipment at other times, a rudimentary form of transmitter is provided at Glencairn. This transmitter can be switched on if Kirk o' Shotts is not radiating and a signal from it received at Black Mountain and arriving back at Glencairn by way of the cable indicates that all is well with the equipment.

To assist the maintenance staff, the Kirk o' Shotts sound transmission is also received on Black Mountain and passed at audio frequencies down an interstice pair to Glencairn, to enable them to hear any announcements that may be made. The sound feed for the B.B.C. transmitter, however, is by cable over a normal music circuit.

THE LINK IN OPERATION

The preliminary period of observation of signal strength using equipment hurriedly assembled in a small battery hut on Black Mountain occupied about a week in November 1952. During this time a steady signal was received, the deepest fade being of the order of 10 db. Observations with the final aerial array and with the station approaching a state of completion were begun early in March 1953. As might be expected, there was rather more fading at this time of the year and on two occasions the signal strength fell to an unusable level for periods of 5 and 3 minutes. At other times the signal was usable and was held at a substantially constant output level by the receiver automatic gain control, although occasionally during the deeper fades the background noise was higher than would normally be acceptable from a point-to-point television link.

The installation of the link was completed by the target date, 1st April, 1953, and the B.B.C. first started to radiate the signals for test purposes on 11th April. A week later regular test transmissions were commenced and the full programme service began on 1st May. For the first month of service and until after the Coronation, Post Office staff were in daily attendance at Glencairn, but since this date the stations have been operating on an unattended basis. A pen recorder has been used to keep a continuous record of the receiver A.G.C. voltage and hence of signal strength. An analysis of the record shows that over a period of four weeks in June the signal strength fell below the usable level for about 0·44 per cent. of the total time during which Kirk o' Shotts was transmitting. This is believed to be the worst part of the year for fading and it is expected that the record over a whole year will show a substantial improvement. There is some evidence to show that the worst fading conditions are associated with periods of warm, stable weather and that the deepest fades occur an hour or two after sunset, although this is not at all conclusive. As with all radio engineering projects, the design is a compromise between cost and speed of provision on the one hand, and reliability on the other. In this particular case the emphasis

* The system is fully described by Kilvington, Laver and Stanesby, *Proc.I.E.E.*, 1952, Vol. 99, Part I, p. 44.

was entirely on speed of provision with some inevitable sacrifice of reliability on account of propagation uncertainties. Nevertheless, the periods of loss of signal so far recorded represent only a very small percentage of the total time and, if this performance is maintained, the grade of service must be considered very satisfactory in the circumstances.

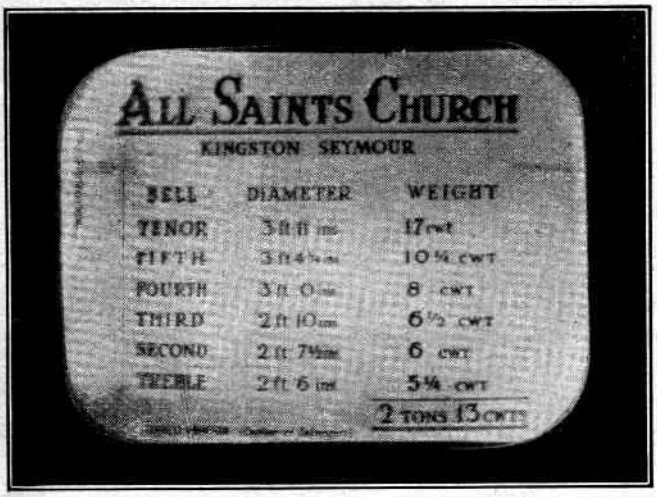

FIG. 6.—PICTURE RECORDED AT BROADCASTING HOUSE, BELFAST.

Fig. **6** shows a television picture recorded by kind permission of the B.B.C. at Broadcasting House, Belfast. The illustration is of particular interest because of the number of links in tandem over which it had passed. Originating at an outside broadcast from Kingston Seymour in Somerset, it was passed to Wenvoe by B.B.C. microwave link, thence by Post Office $\frac{3}{8}$-in. cable to London, 1-in. cable from London to Birmingham, $\frac{3}{8}$-in. cable from Birmingham to Manchester, and microwave relay from Manchester to Kirk o' Shotts. From Kirk o' Shotts it was radiated by the B.B.C. transmitter, and picked up by the Post Office receiver on Black Mountain; thence by cable to Glencairn whence it was re-radiated by the B.B.C. transmitter, finally being picked up on a receiver at Broadcasting House, Belfast. Eight different video-to-video links were therefore involved in the transmission over a distance of about 770 miles.

CONCLUSION

The author would like to pay tribute to all those who helped in setting up the stations and in particular to the staff of the Northern Ireland Region who carried out their work on Black Mountain under very arduous conditions, and to the staff of Construction Branch who assisted with the cable jointing. To them must go the main credit for the fact that the "ready for service" target date of 1st April was met.