Television Links to the Channel Islands for the Independent Television Authority

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The distance of the Channel Islands from the English coast precludes the use of the usual methods of providing television links, and, because of the relatively small population served, the provision of a suitable submarine cable would be uneconomic. The islands are too close to the French coast to permit a tropospheric-scatter propagation link to be used, and the only practicable system is to relay signals radiated by broadcasting transmitters in England.

INTRODUCTION

The Channel Islands are situated some 16 miles from the coast of France and 60 miles from the south coast of England at the nearest points. They have a total population of about 100,000.

The Independent Television Authority (I.T.A.) operates a television transmitting station at Fremont Point on the island of Jersey, and a separate program contractor, Channel Television, has been appointed by the I.T.A. for the Channel Islands. The islands form the smallest of the I.T.A. areas, and have, for example, well under 1 per cent of the population of the Authority's London area. A unidirectional television link with the mainland is necessary in order to allow the program company access to the main Independent Television network, but, because only a small population is served, it is desirable that the cost of the link should be small.

Main inland television links are usually provided by means of line-of-sight microwave radio-relay systems. Links of this type can be provided economically and will give a good performance where the maximum spacing between stations does not exceed some 40 miles. The shortest distance to the Channel Islands is considerably greater than this, however, and extremely high aerials would be needed to give a line-of-sight path. The cost of the aerial-supporting structures alone would be sufficient to make a microwave link uneconomic in these circumstances. Other factors, including the high incidence of fading expected on long oversea paths, combine with the high cost to make a microwave link unacceptable.

Another possible means for the transmission of television signals over a 60-mile sea-path would be a suitable submarine cable, but again the cost would be prohibitively high in relation to the size of the population served. A radio link using tropospheric-scatter propagation would also be expensive, and, because the islands are close to the coast of France, it would not be possible to prevent an excessive proportion of the transmitted energy from reaching French territory, where it would be liable to cause interference.

The remaining possibility is the reception in the Channel Islands of television signals radiated by broadcasting transmitters in England, and this solution has been adopted. A receiving station has been set up on Alderney, the most northerly island of the group, and the nearest to the English coast, from where the signals are relayed to Jersey by means of a microwave radio-link. Fig. 1 shows a diagram of the complete system.

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CHARACTERISTICS OF CHOSEN LINKS

Transmitters

Three I.T.A. transmitters offer some possibility of reliable reception on Alderney: they are at Chillerton Down on the Isle of Wight, Stockland Hill near Axminster, Devon, and Caradon Hill near Launceston, Cornwall. Particulars of these transmitters are given in Table 1.

TABLE 1
I.T.A. Transmitters

Transmitter	Stockland Hill	Caradon Hill	Chillerton Down
Channel	9	12	11
Effective radiated power of vision transmitters in the direction of the Channel Islands (in kW)	20	20	2·7
Distance from Alderney (in miles)	88	119	77
Mean aerial height above sea level (in feet)	1,475	1,936	1,250
Polarization	Vertical	Vertical	Vertical
Program contractor	Westward Television	Westward Television	Southern Independent Television

All three transmitters are subject to a limitation of the effective radiated power (e.r.p.) in the direction of the Channel Islands, in order to reduce interference with French services. The e.r.p. of the Stockland Hill transmitter is 20 kW over a narrow angle in the direction of Alderney, specifically to provide an increased field strength in Alderney for the Channel Islands link. It was originally intended that the e.r.p. in this direction should be 50 kW, but this was reduced to 20 kW in order to avoid interference with transmissions from a French station at Bourges.

Received Signals

The measured median value of the field strength at the Alderney receiving site of the signal from Stockland Hill is +51 dB relative to 1 μV/m, and for 98 per cent of time the field strength lies in the range +12 dB to −5 dB relative to the median value. The measured median value of the field strength from the Chillerton Down transmitter is +49 dB relative to 1 μV/m, and for 98 per cent of time this signal lies in the range +16 dB to −8 dB relative to the median value. Thus, the signal from Chillerton Down has a somewhat lower median level than that from Stockland Hill, and is also subject to a greater fading range.

For 1 per cent of time the received-signal level is below the lower limit quoted, and for a smaller proportion of time the level is low enough for the noise level to be obtrusive, or even so severe as to render the signal unusable. During the remaining 1 per cent of time abnormally-high signal levels are received. High signal levels are not normally a cause of unsatisfactory signals, but occasionally they are accompanied by multi-path propagation, the effects of which may, in severe cases, render a signal unusable. A picture marred by multi-path propagation may show several images, possibly of similar brightness, laterally displaced from one another.

The median field strength of the signal from the Caradon Hill transmitter is considerably lower than that from the other transmitters, and the received signal is unusable for most of the time. However, when the conditions of propagation are such that extremely high-level signals, marred by multi-path propagation, are received from Stockland Hill, it sometimes happens that an acceptable signal is provided by the Caradon Hill transmitter.

Interference

Because the level of the signals received at Alderney is rather low the link is more than usually susceptible to the effects of interference. Two types of interfering signal are most common: "ignition-type" interference, caused mainly by petrol-engine ignition systems, and co-channel interference from other television transmitters.

Considerable ignition-type interference was experienced when the receivers on Alderney were first put into operation, since about 200 of the 400 motor vehicles on the island were unsuppressed. These, together with some 50 other engines, including 23 on various types of boat, were fitted with suppressors, and interference due to this cause ceased almost completely. Occasional outbreaks still occur, but these are usually caused by the engines of boats visiting the island.

Interference of an impulsive kind also arises occasionally from an 11 kV overhead power-distribution line which passes in front of the receiving aerials at a distance of about 200 yards. The line is exposed on the seaward side, and salt deposits accumulate on the insulators so that under certain weather conditions flashovers occur. The deposits can be removed by washing, but in some types of weather they can return in a few hours.

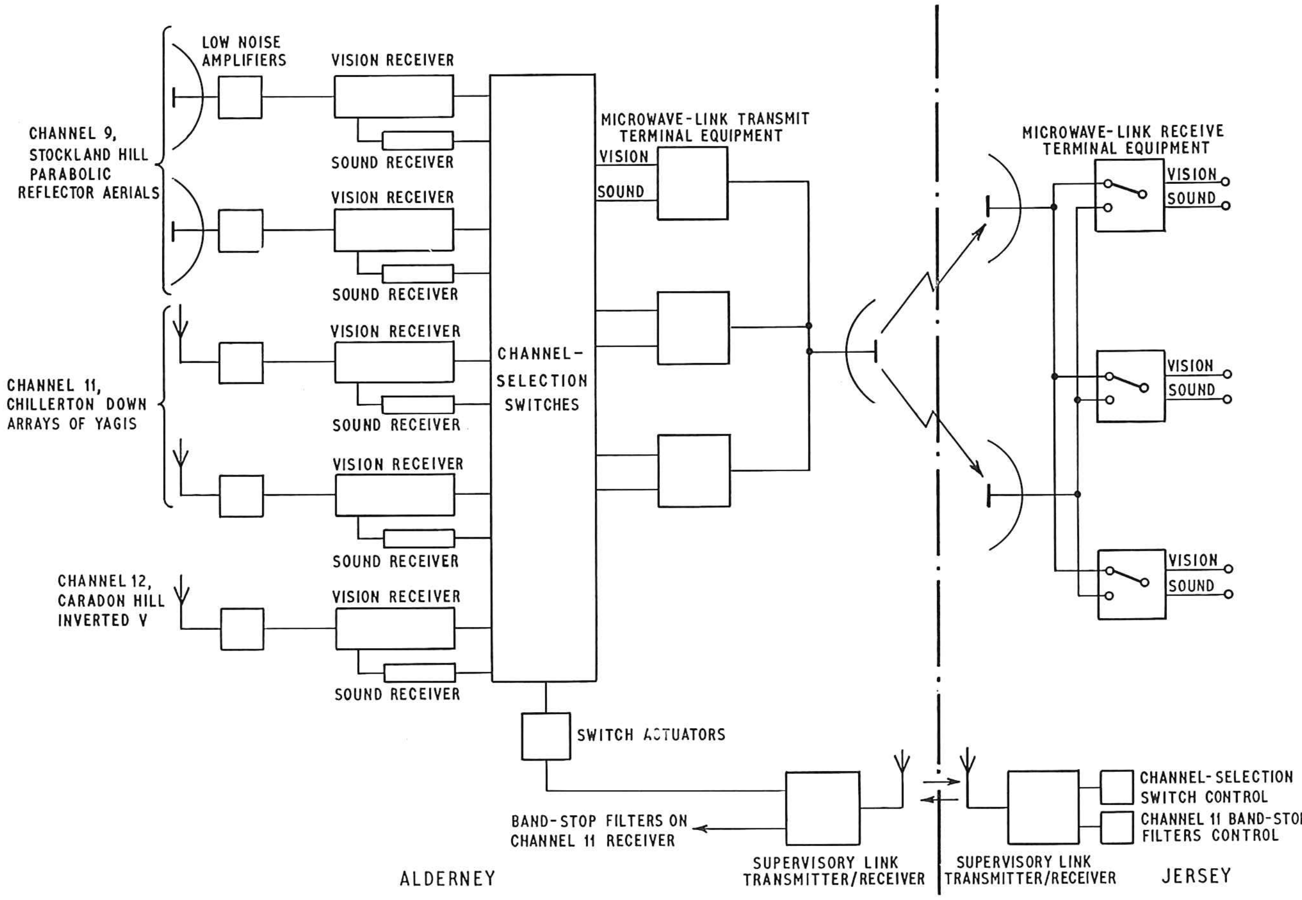


FIG. 1—Television links to the Channel Islands

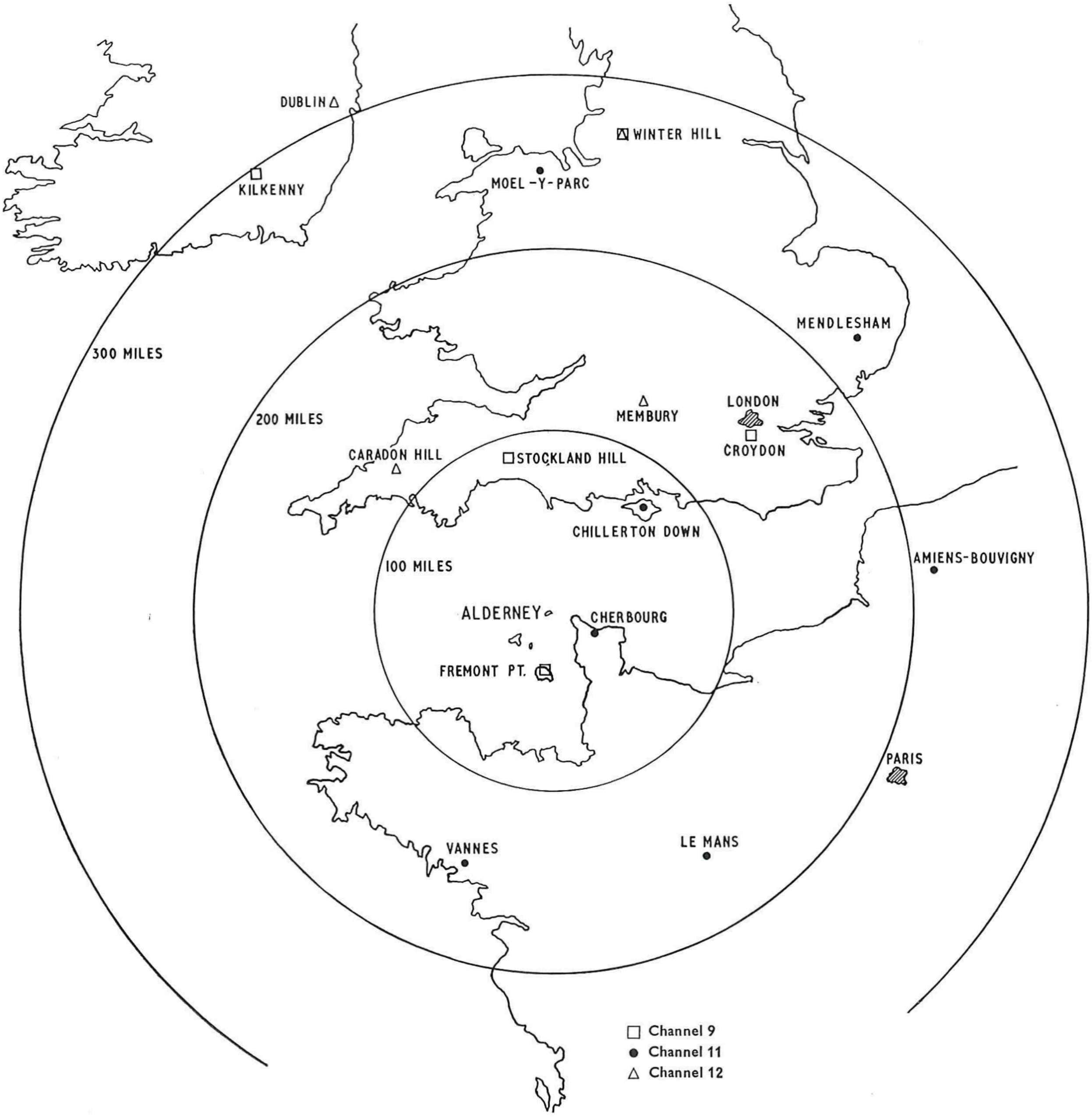
Co-channel interference may be caused by any of a large number of television transmitters in France, the United Kingdom and Eire, especially when radio-propagation conditions favour the long-distance transmission of v.h.f. signals. The map (Fig. 2) shows the locations of the wanted stations and of some of the potential sources of interference. Particulars of the stations shown on the map are given in Table 2. The "protection ratio" referred to in this table is the separation required between the levels of the wanted and unwanted signals in order that the picture may be of acceptable quality.

The transmitter at Fremont Point, Jersey, is potentially the most important source of interference affecting the signals received on Channel 9 from Stockland Hill. In order to reduce the level of the interference, the e.r.p. of the Fremont Point transmitter in the direction of Alderney has been reduced to the lowest practicable figure. Unfortunately, this has placed the island outside the service area of the transmitter, and has left it without a reliable source of television signals. In spite of the reduction of e.r.p., however, the field produced in Alderney is still large enough to produce an objectionable amount of interference, but this has been reduced to a completely acceptable level by the use of aerials giving considerable rejection in the direction of the unwanted signal. In addition, these aerials are sited on the north-facing slope of a hill, below the crest, in order to take advantage of the screening provided by the hill.

The other potential sources of co-channel interference with the Stockland Hill signal are effective only infrequently, when conditions favouring long-distance propagation exist over the path concerned. Identification of the source of co-channel interference of a transitory kind is seldom possible, but there have been a few occasions when the test card of the Winter Hill transmitter has been clearly seen at Alderney.

Most of the co-channel interference that is experienced on the signal from Chillerton Down arises from French stations operating on the French Channels F11 and F12. The vision carrier frequency of Channel F11 lies within the bandwidth of the British Channel 11 at a frequency corresponding to a modulating frequency of 1·3 MHz. Easily-noticed interference patterns may be produced by signals of this frequency, so that, as Table 2 shows, a high protection ratio is required. Interference with the British Channel 11 from the French Channel F12 arises from the upper part of the vision sideband, where the energy level is normally low, and possibly also from the sound carrier, the frequency of which lies just outside the pass-band of a Channel 11 vision receiver. Only a relatively-low protection ratio is required in this case.

Most of the interference experienced from the French Channel F11 is believed to originate from the transmitter at Amiens. The receiving aerials for the signal from Chillerton Down are adjusted to have minimum gain in the direction of Amiens, but it is also necessary to introduce a band-stop filter into one of the receivers in order to provide additional suppression at the unwanted carrier frequency on occasions when the level of the interfering signal is abnormally high.



The stations shown transmit on, or co-channel with, the channels indicated by the key symbols

FIG. 2—Locations of wanted stations and potential interference sources

The waveform response of the receiver is considerably degraded by the introduction of the filter, but the effect on picture quality is considered to be less objectionable than that of the interfering signal.

TABLE 2
Principal Sources of Co-Channel Interference

Station	E.R.P. in in Direction of Alderney (kW)	Distance from Alderney (miles)	Polarization	Protection Ratio Required (dB)
Stations Affecting Channel 9				
Fremont Point . .	0·1	32	Horizontal	35
Croydon . .	50	150	Vertical	35
Winter Hill . .	100	265	Vertical	35
Kilkenny . .	50	293	Vertical	22
Stations Affecting Channel 11				
Cherbourg . .	4	27	Horizontal	12
Vannes	10	146	Horizontal	12
Le Mans . .	50	160	Vertical	22
Amiens-Bouvigny	100	214	Vertical	39
Mendlesham . .	40	228	Horizontal	25
Moel-y-Parc . .	25	244	Vertical	35
Stations Affecting Channel 12				
Membury . .	0·5	128	Horizontal	25
Winter Hill . .	2·5	265	Vertical	35
Dublin	50	305	Horizontal	15

The chief source of co-channel interference from Channel F12 is the transmitter at Cherbourg, the field strength of which is considerably greater than that of any of the wanted signals. Interference from this source is also controlled by appropriate shaping of the aerial response.

The remaining French stations shown on the map are situated to the rear of the Channel 11 aerials, and the interference from these sources is adequately suppressed by a screen behind the aerials.

In spite of the very low signal level received from Caradon Hill, no case of co-channel interference with this signal has so far been recorded.

LINK EQUIPMENT

Five independent receivers and aerial systems are provided, giving duplicate facilities on the two main signal-sources of Stockland Hill and Chillerton Down, and a single receiver for the Caradon Hill signal. Three independent unidirectional microwave channels are provided between Alderney and Jersey, and the interconnexions between the five receiver outputs and the inputs to the three microwave channels are made by means of remotely-controlled coaxial switches.

Aerials

Each of the two aerials used on Channel 9 consists of a parabolic reflector, 30 ft in diameter, with a 4-element yagi array as the source. The aerials are sited on the slope of a hill, and one is placed 40ft above the other in order that the benefits of height deversity may be obtained. A photograph of one of the aerials is shown in Fig. 3. The gain of these aerials is 20 dB relative to a half-wave dipole, and the front-to-back ratio, i.e. the ratio of the gains of the aerial in the two directions of the major axis, is 27 dB. The upper aerial is at a height of 260 ft above mean sea-level.

Each of the two aerials used for reception of Channel 11 signals consists of an array of eight yagi aerials, each yagi comprising eight elements. The spacing of the yagis is arranged to give minimum response at angles of 73° and 45° from the axis, and the array is backed by a screen which shields the aerial from signals arriving from the rear. Each array has a gain of 18 dB relative to a half-wave dipole. The gain in the directions 45° and 73° from the axis is 38 dB less than the maximum gain, while in directions to the rear of the aerial the gain is at least 50 dB less than the maximum. A photograph of one of the aerials is shown in Fig. 4.

An inverted-V aerial is used for the reception of Channel 12 signals. It is made up of 12 parallel wires, and has a gain of 20 dB relative to a half-wave dipole. This type of aerial was chosen in order to relieve the tower of the additional loading which would have been imposed by a further array of yagi aerials.

Low-Noise Amplifiers

In every instance the aerial feeders are long enough to introduce appreciable loss of signal. To prevent the deterioration of noise performance, which would otherwise occur due to the feeder loss, a low-noise amplifier having more than sufficient gain to offset the loss is fitted close to the aerial terminals. Because the cable connecting the aerial to the amplifier is short the input circuit of the amplifier may be adjusted to give optimum noise performance, with little regard to any mistermination that may result, since the short-delay echoes so generated have a negligible effect on the waveform performance. The output impedance, on the other hand, must be matched to the feeder-cable impedance in order to suppress reflections which would otherwise give rise to long-delayed echoes. The amplifiers have a gain of 20 dB and an effective noise factor of 3 to 4 dB. Each amplifier makes use of two low-noise transistors, for which the d.c. power is fed along the coaxial cable carrying the radio-frequency signals.

The extremes of temperature to which equipment mounted on masts is subject are reduced by enclosing each amplifier in a thermally-insulated container having a thermal time-constant that is long enough to show an appreciable reduction in the diurnal temperature variation of the amplifier. As the

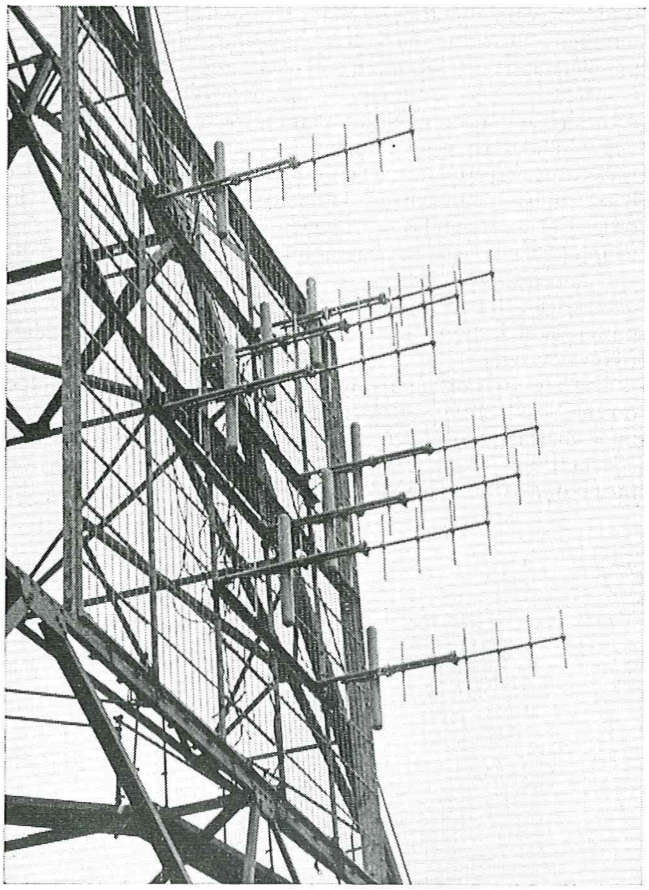
FIG. 3—One of the Channel 9 aerials

power dissipation of each amplifier is only a few milliwatts, a small thermostatically-controlled heater is fitted inside the container so that low temperatures, which might lead to condensation of moisture, are avoided.

Receivers

The receivers used are modified versions of the standard vision receiver for direct pick-up links (Radio Receiver, No. 25A[1]).

On the standard receiver the automatic gain control (a.g.c.) system is effective over a range of input signal-levels of 40 dB. This range is insufficient for the conditions encountered on Alderney, and it has been extended to 60 dB by the use of delayed a.g.c. on early stages of the receiver that were previously not controlled. By this means the overload point of the receiver is increased by some 20 dB, and distortion of the very high-level signals occasionally received at Alderney is largely prevented.



The photograph shows the aerial temporarily mounted for test purposes

FIG. 4—One of the Channel 11 aerial arrays

On inland links where direct pick-up receivers have been used to provide vision signals the accompanying sound signal has usually been transmitted over a conventional program circuit. This method is rather costly for the Channel Islands link, and the cheaper alternative of receiving the broadcast sound-signals has been adopted. The standard vision-receiver is modified to allow the extraction at intermediate frequency of a signal which is fed to a separate sound-receiver. The sound receiver has its own independent a.g.c. system, with an effective range of 60 dB.

The intermediate-frequency amplifiers of the vision receivers are fitted with two sound-channel-rejection filters, one tuned to suppress the co-channel sound signal, and the other the adjacent-channel sound signal. The intermediate-frequency amplifier in one of the Channel 11 receivers is provided with a further narrow-band rejection filter to suppress the vision-carrier of the French Channel F11, but this filter is brought into use, by means of a remotely-controlled switch, only when severe interference is experienced.

Microwave Link

The microwave radio-relay link connecting Alderney to Jersey operates in the 2 GHz band and provides three unidirectional broadband channels. The path length is 35 miles and is almost entirely over water. Height diversity is provided at the receive terminal to reduce the effects of surface reflections. The two receiving aerials are mounted on the I.T.A.'s mast at Fremont Point, at heights of 90 ft and 180 ft, and in each receiver a switch automatically selects the aerial providing the better signal.

The baseband bandwidth available on each broadband channels extends to about 8 MHz. The lower 3 MHz of this bandwidth is occupied by the 405-line television signal, and at a frequency of 7·5 MHz a sub-carrier is inserted which is frequency modulated by the accompanying sound-signal.

Supervisory Link

A bothway u.h.f. radio link operates over the same path as the microwave link. It provides a speaker circuit, a signalling channel by means of which an alarm may be extended from Alderney to Jersey, and control facilities which extend to Jersey the control of the channel-selection switch and control of the band-stop filter in one of the Channel 11 receivers.

SYSTEM PERFORMANCE

The signal received at Alderney is subject to fading and interference for a small proportion of time, but the degradation due to these effects may not always be severe enough to render the signal completely unusable for re-broadcasting purposes. For this reason the description "program marred" has been introduced to cover those occasions when the signal, though usable, is below the standard normally regarded as acceptable for rebroadcasting. Program-marred time typically amounts to less than 2 per cent of time, taken over a period of several months. The time for which the signal is unavailable, or is unusable for any reason, is much less, and is under 0·1 per cent of time.

The waveform performance of the link depends on the adjustment of the broadcasting transmitter as well as that of the receiver, and some variation from time to time is to be expected. Typically, however, using a pulse-and-bar test waveform[2] an overall K-rating of 3 per cent is obtained, though in making the measurement the increased half-amplitude duration of the sine-squared pulse which results from the vestigal-sideband mode of transmission is disregarded. The line-time non-linearity of the links is measured using a saw-tooth test waveform and is typically 7 per cent.

The signal-to-noise ratio at the receive terminal varies considerable, according to propagation conditions. Measurements of the noise level cannot readily be made during program hours, and the available information is derived from a single daily observation and the incidence of the program-marred condition. The daily measurements indicate that on the Stockland Hill link a typical ratio for the unweighted wideband r.m.s. noise and peak-to-peak signal levels is 38 dB. On the Chillerton Down link the ratio is some 6 dB to 8 dB lower, but in this instance the noise level is raised by interfering co-channel signals. The program-married classification is applied when the signal-to-unweighted r.m.s. noise ratio

[1] ELKINS, N. A., MILLS, D. E., and FENSOME, L. D. W. A Receiver for Direct Pick-Up Television Links. *P.O.E.E.J.*, Vol. 53, p. 239, Jan. 1961.

[2] MACDIARMID, I. F. Waveform Distortion in Television Links. *P.O.E.E.J.*, Vol. 52, pp. 108 and 188, July and Oct. 1959.

falls to 26 dB or less, but marred time arises also from causes other than noise so that a ratio of 26 dB is exceeded for rather more than 98 per cent of time.

On the Stockland Hill sound receivers noise levels of −35 dB to −40 dB relative to the signal level, corresponding to 40 per cent modulation of the broadcasting transmitter, are typical, while on the Chillerton Down receivers the relative noise levels are usually some 5 dB higher. In both cases the total harmonic distortion of the sound signal, when the transmitter is modulated to a depth of 80 per cent at a frequency of 1 kHz, is normally 30 dB below the level of the fundamental.

A Resin-Encapsulated Termination for Coaxial-Pair Cables

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U.D.C. 621.315.212.2:621.315.687.3

The point of entry of a coaxial cable which terminates in a buried-repeater case must be sealed. The coaxial pairs are terminated on sealing-ends, which must be capable of withstanding the pneumatic pressure within the cable. The control pairs of the cable are brought out on a flexible cable-tail, terminated on a multi-socket connector. The cable termination is then encapsulated in a suitable resin. This article describes the method by which such a resin-encapsulated termination is formed.

INTRODUCTION

A coaxial cable which terminates in a buried-repeater case must be sealed at its point of entry. The seal is incorporated in the cable termination; it takes the form of a brass gland which is soldered to the lead cable-sheath and sealed to the repeater case by an O-ring seal.

The cable termination has to support the coaxial pairs so that they can be terminated on sealing-ends, which form the electrical connexions between the coaxial pairs and the flexible connecting leads from the amplifier equipment. The sealing-ends must be capable of withstanding the pneumatic pressures contained in the cable, the termination acting as an air block between the cable and the amplifier equipment so that the pressure in the cable is isolated from the equipment and does not fall when the lid of the repeater case is opened. Fig. 1 shows two resin-encapsulated terminations fitted in a buried-repeater case.* One termination is longer than the other to allow the connexions on the lower termination to be more readily accessible.

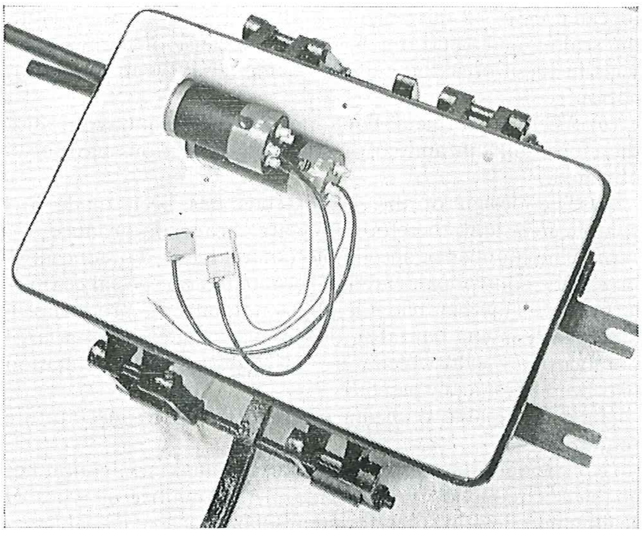

FIG. 1—Two resin-encapsulated terminations in a buried-repeater case

TERMINATING METHOD

The cable gland is fitted by passing it for a distance of approximately 10 in. along the cable (see Fig. 2) and then soldering it to the lead sheath after removal of the polythene outer sheath. The cable end extends beyond the gland for approximately 6 in., and from this section the lead sheath is removed to expose the coaxial pairs and the paper-insulated 10 lb/mile control pairs. A flange on the gland has an O-ring seated into it so that, when the termination is fitted into the case and a circular nut is tightened, the O-ring seal completely envelopes the cable-entry hole and securely seals the termination into the case. The other side of the flange is grooved to form a firm key to a resin block, which will be cast over the cable core after terminating operations have been completed.

Each sealing-end consists of a centre pin, which is supported centrally within an outer cylindrical metal casing by two small annular blocks made of polytetrafluorethylene (PTFE), a heat-resistant plastic. Two rubber washers of approximately the same diameter as the PTFE blocks are sandwiched between the blocks, and, when the sealing-end is assembled, the blocks are compressed, expanding the rubber washers radially so that they grip the centre pin and the inner wall of the metal

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* CLINCH, C. E. E., and STENSON, D. W. Housing of Repeater Equipment Underground. *P.O.E.E.J.*, Vol. 56, p. 158, Oct. 1963.