

GERRY SANDERSON joined the Authority from the Post Office in October, 1955, shortly after the first ITV station opened at Croydon. As a Lines Engineer he was partly responsible for the acceptance testing of nearly 90% of the Authority's vision and sound network installed by the Post Office, starting with the programme feeds to the Lichfield Station.



He was instrumental in starting the Authority's first laboratory and workshop, which was destined to blossom into the present Experimental and Development Department. He also carried out the first propagation tests for the Authority and so was surely the precursor of the present Service Area Planning Section.

As a member of the Network Planning Section he is now Project Engineer in charge of installing the link feeding 625-line colour signals to the new uhf transmitting station to be installed at Bressay on the Shetland Islands.

Synopsis

The extension of the television services to some of the remoter parts of the United Kingdom is beset, among other things, with the problems of getting suitable input signals to the appropriate relay transmitters. Because such areas may not be within reach of signals radiated from other transmitters, and because the established Post Office links are not available beyond the nearest principal towns or cities, special *ad hoc* provisions have to be made, usually by the broadcasting authorities themselves.

A case in point is the link to the new Shetland uhf transmitting station on the island of Bressay, near Lerwick, which is due to be brought into service towards the end of 1976. Signals from the Keelylang Hill transmitter on Orkney (IBA channel 43) will be taken off-air at Fair Isle, which fortuitously is most conveniently situated approximately mid-way between the two island groups of Orkney and

Bringing Colour to the Shetland Isles

by G L Sanderson

Shetland, and relayed to Bressay by means of a 7 GHz microwave link. Both the uhf and shf link terminals at Fair Isle and Bressay respectively make use of diversity reception techniques to minimise the effects of fading which can result due to the long oversea paths involved.

The equipment to be installed on Fair Isle will be housed in an ex-wartime radar station building, suitably converted, and since there is no commercial electricity supply available on the island, three 31 KVA 3-phase diesel generators will be provided in a separate specially-constructed building just over half a mile away. A major problem, however, is the supply and storage of an adequate quantity of fuel to enable services to be maintained throughout the long winter season when landing of the delivery vessel is likely not to be possible on account of severe weather conditions.

Introduction

From any of a number of the IBA's various publications, e.g. the ITV Handbook, the reader will probably know already that ITV programmes for

the northern areas of Scotland originate either directly or indirectly from the studios of Grampian Television in Aberdeen. It is from here that the

programme signals are fed via a Post Office link first to the IBA transmitter at Durriss for local transmission of the 625-line colour service on channel 25, and then northwards to the uhf relay station at Rosemarkie operating on channel 49. These signals from Rosemarkie are also picked up by high quality receivers, developed within the Authority for this purpose, at the IBA transmitting station at Rumster Forest near Lybster, Caithness, where they are re-broadcast on channel 24. From Rumster Forest they are received on the Orkney Islands at Keelylang Hill and are re-radiated on channel 43. The next link in the chain, from Keelylang Hill to the new uhf transmitter on the Isle of Bressay, just off Lerwick in the Shetland Islands, has proved to be the most difficult one to forge and were it not for the small island of Fair Isle, one of the Zetland group of islands standing alone in the Atlantic Ocean between Orkney and Shetland, it would have been even more difficult, see Fig. 1.

When investigations were first made into the method of feeding Bressay with television programmes it was realised that a direct path of over 100 miles between the two terminals was too long for either a re-broadcast link (RBL) or a super high frequency (shf) microwave link alone. It was then that the decision was taken to use a mixture of the two, with Fair Isle as the intermediate point. Transmitted signals from the Keelylang Hill transmitter would be received at Fair Isle, 66 miles away, by the same type of high quality receivers referred to above using diversity feed trough aerials combined with masthead amplifiers and, by means of a 7 GHz shf link, these would be extended to Bressay where a diversity system would again be used to overcome the possibility of fading on the overseas path during periods when propagation is bad. As, like all transmitting stations in the uhf network, Bressay is shared with the BBC it is logical that the method of feeding it should be similarly shared. In fact, it was the BBC who carried out the first propagation tests which proved the Fair Isle/Bressay path. However, the building and installation of the Fair Isle facilities, including the RBL and shf aerials, have been provided by the Authority in co-operation with the Post Office, though the BBC are responsible for installing their own electronic equipment.

Fair Isle is a small island approximately three miles long by 1½ miles wide. It has a closely-knit community varying in number between 70 and 80 persons and consisting mainly of crofters but including members

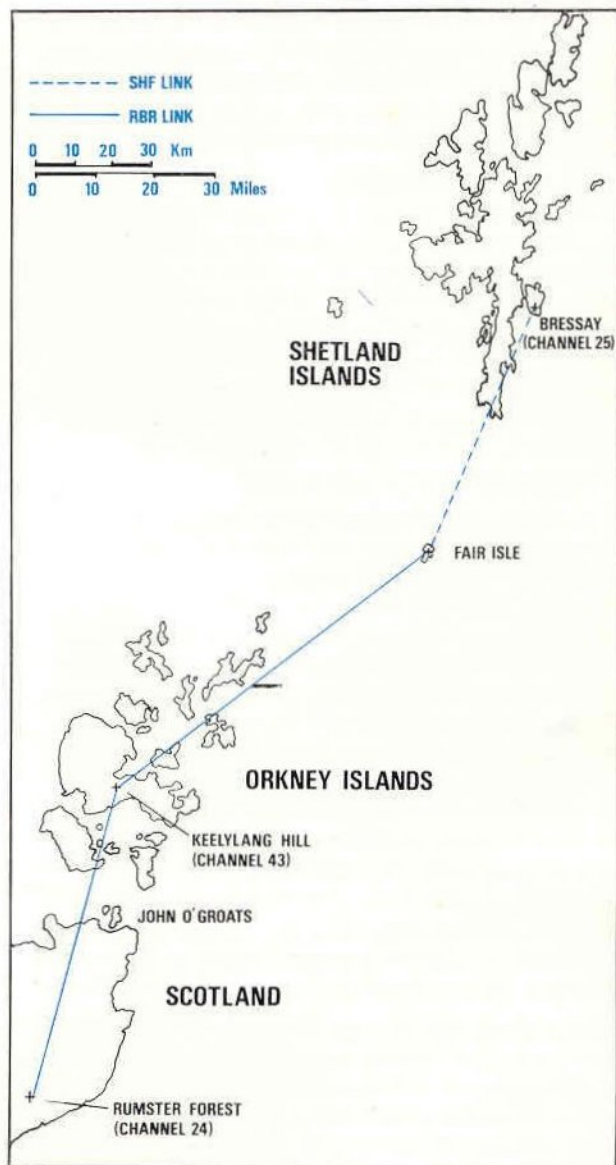


Fig. 1. The 100-mile link from Keelylang Hill to the new Shetland station at Bressay has to be installed in two sections. The radiated uhf signal from the transmitter at Keelylang Hill, serving the Orkney Islands, is received at Fair Isle and re-transmitted on a 7 GHz microwave link to Bressay.

of the Scottish Lighthouse Board staff, the Bird Observatory staff and the island nurse, all with their respective families. Access to the island is achieved from the Shetlands either by a chartered twin-engine 'Islander' aircraft or by the *Good Shepherd III*, a Brixham trawler converted for carrying passengers

and goods and which also serves as the main supply boat and mail carrier. The crofts are mainly situated at the south end of the island; the north end is mainly desolate and forms an important bird sanctuary for the study of northern and arctic bird life.

Being such a small community it would be uneconomic for the North of Scotland Hydro Board to install a power supply, so power on the island has to be locally generated. At the time of writing one generator serves every four or five crofts, but a larger installation suitable for supplying a small load to each croft on the south end of the island is under construction as a joint project between the islanders and the National Trust for Scotland. Distribution cables were laid during the summer of 1975 by volunteer student working groups.

The IBA's involvement with the Post Office came about in the following way. In the spring of 1973 when the Authority approached the National Trust for Scotland, the trustees of Fair Isle, for permission to build a link station on the island, they were informed that the Department of the Environment was also looking for a similar site there for the Post Office who were to provide extra communication channels for the North Sea Oil Project. It was further suggested to them that an attempt be made for both parties to work together, to share facilities and thus prevent a proliferation of masts on such a small island. A meeting was, therefore, arranged with representatives of the IBA, the BBC and the Post Office during June 1973 which was to result in a very successful working partnership between IBA engineers and those of the Post Office.

The original plan for Fair Isle, as far as the Authority was concerned, was for a small building to house the link equipment, and a relatively lightweight 150 ft mast. However, after holding discussions with the Post Office and hearing their plans it was realised that a larger building would be required, and a much larger tower.

Propagation Planning

Having chosen a route, the next part of the exercise was to investigate, with the aid of Ordnance Survey maps and profile charts, whether or not it was possible to obtain a workable path between Keelylang Hill and Fair Isle, and between Fair Isle and Bressay.

Keelylang Hill has a mean aerial height of approximately 880 ft above ordnance datum with a clear path out to sea towards Fair Isle in which

direction the aerial pattern has been designed to give its maximum erp of 100 kW. The signal then passes over a 66-mile path to Fair Isle, 61½ miles of which is over the sea.

As already mentioned, it is because of this very long sea path that it was decided to install a diversity system at Fair Isle with aerials at 25 ft and 150 ft and, to improve the signal-to-noise ratio, a mast-head amplifier is to be fitted to each. To further enhance the signals over this very long sea path automatic video correctors will be fitted which will make use of test line signals inserted on lines 19, 20, 332 and 333 of the video signal to correct most of the distortions likely to be present on the incoming signal particularly overall signal level, bar tilt, 2T pulse amplitude, 2T pulse shape, and luminance/chrominance gain and delay inequalities.

At the time of the initial planning the Keelylang Hill transmitter had not entered service. It was, therefore, impossible to carry out any long term reception tests as is usually done when planning the more difficult paths. Decisions had, therefore, to be made purely on theoretical considerations. It is a well known fact that in the field of propagation theoretical decisions cannot always be relied upon to hold in practice. It was for this reason that when assessing the wind-loading for the tower on Fair Isle allowance was made for the erection of a further two 10 ft diameter shf aerials on the south face to enable the possible provision of a diversity system via Sanday or North Ronaldsay at some time in the future should the RBL prove to be totally unsatisfactory.

The Fair Isle/Bressay path, which is 44½ miles long, is virtually a line of sight path as Ward of Cairn, on which the Bressay transmitting station stands, is visible from the Fair Isle site on a clear day. But here again, 31 miles of the path is over sea and hence a diversity system, this time at shf, is being installed using two 8 ft diameter aerials at 15 ft and 80 ft above ground level, i.e. 736 ft and 801 ft above ordnance datum respectively. A further help is the existence of Ward Hill, just north of Sumburgh Airport, Shetland, which tends to shield the receiving aerials from the indirect reflected signals off the surface of the water. These would otherwise be likely to arrive at the aerials out of phase with respect to the direct, wanted signal and thus cause fading.

The Link Building

The first visit to Fair Isle was made in July 1973

by a party consisting of representatives of the Post Office, the Department of the Environment and the Authority, and an inspection was made of a number of ex-wartime buildings which had formed part of a naval radar station. One building, a disused generator station, stood out as being most suitable with regard to both layout and position for a clear path to Bressay. This building, standing at a height of 525 ft aod, consisted of the generator housing, a room 25 ft \times 18 ft 6 in \times 13 ft high, with a 10 ft 6 in blast wall enclosing two sides, Fig. 2.

It was decided that the best way to modify the building was to roof over the area between the blast wall and the side of the main building. This would form a smaller apparatus room which would conveniently house the IBA/BBC equipment, and the remainder of the area would be fitted out as an amenity area with four bunks, toilet and cooking

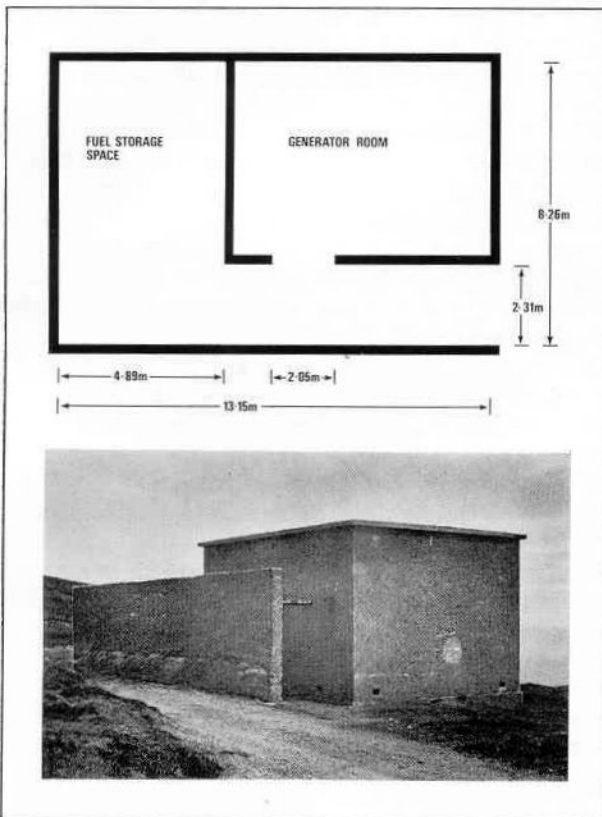


Fig. 2. The link equipment on Fair Isle is housed in a converted ex-wartime radar building. The illustration shows an outline plan and a photograph of the building as it was prior to reconstruction.

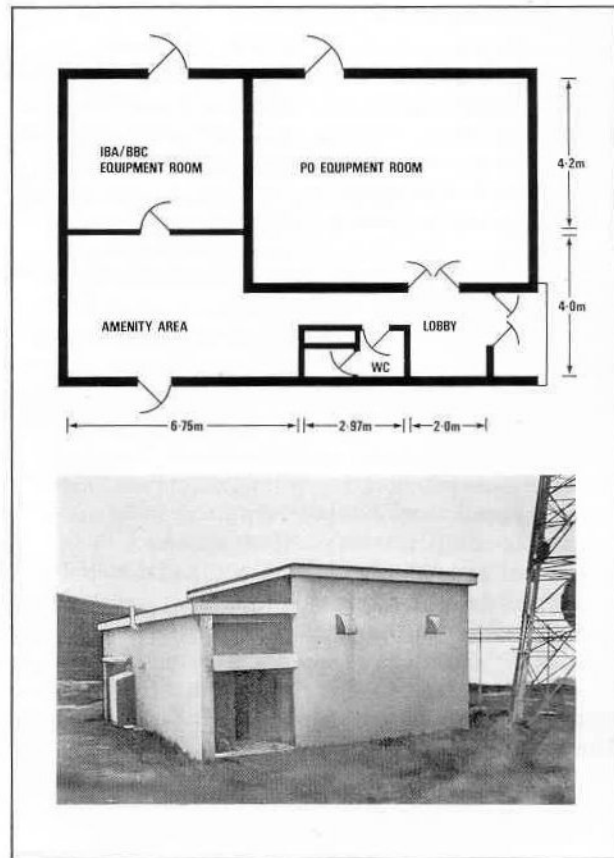


Fig. 3. As part of the conversion, the area between the blast wall and the main building has been roofed over to form an apparatus room for IBA/BBC equipment, and an amenity area for common use. The original generator room has been allocated to the Post Office. The photograph shows the building shortly before the work was completed.

facilities for the use of visiting engineers when detained by bad weather, or when the meagre accommodation facilities on the island are full of visitors as often happens during the bird migration seasons, see Fig. 3. The building operations have now been completed and what was originally an eyesore has been turned into a respectable looking building by use of a suitable cement rendering over the existing roughcast walls. All building work for the project was carried out under the control of the Authority.

The Generator Station

In the introduction it was pointed out that because of the small population of Fair Isle it was not economical to provide power facilities on the island

as a commercial venture. Therefore, the next problem, and in many ways the most difficult, was to obtain a source of power suitable for the calculated maximum load. During the early days, before the Post Office joined the project, much thought had been given to various forms of power supply ranging from the more obvious wind-driven generators to thermo-electric and photo-electric systems. After due consideration windpower was rejected, not on the grounds that there would not be enough wind on Fair Isle, but that at times during the winter the gusts would be so strong that even if the wind vanes were to be fitted with automatic feathering the chance of self destruction would be very high. In fact, this did happen on Shetland when another public authority was carrying out similar tests. The cost of providing batteries to maintain the supplies during the albeit infrequent calm spells and of their upkeep was a further factor against the use of windpower. Thermo-electric supplies were discounted due to the cost of fuel and the difficulty of supplying and storing it. Solar cells were turned down mainly on account of the cost of the units and supporting batteries, together with the lack of strong sunlight in this area.

However, with the inclusion of the BBC and the Post Office in the scheme such supplies were considered inadequate for the load required, and a decision was therefore made in favour of diesel electric generators. Calculations of maximum power requirements, including heating and ventilation in both the technical areas and the amenity area, were carried out by all three parties and resulted in a maximum total requirement of just under 25 kW (31 kVA).

At one of the early planning meetings it was decided that the IBA should be responsible for all the building work on the island, together with the tower, and that the Post Office should be responsible for the provision and distribution of power supplies, including the import and delivery of fuel. Division of the cost of providing the power, after having split the capital costs, would then be on a metered demand principle.

Based on the calculations mentioned above, the Post Office agreed to install three 31 kVA 3-phase generators thus permitting one to be used as duty generator, one as stand-by and one as a maintenance spare so there should always be one reserve generator readily available even during a major overhaul. Together with these generators would be the

associated control gear for automatic or manual change-over as required.

Meanwhile the Authority's architect went ahead with the design of a suitable building to house the generators and the main fuel storage tanks capable of holding 14,000 gallons of diesel fuel, just over twelve months supply at normal running. The specification for the design of the generator building stipulated that the noise level, with one generator running, should not exceed 55 dB when measured at the edge of the site, nominally 10 ft from the building. In the event it was decided that the generator building should be situated in a disused open-ended quarry about a third of the distance between North Haven, where the oil would arrive, and the link building some half-mile further on at the top of the hill. Not only would this reduce any noise reaching the Bird Observatory hostel at South Haven but it would also prevent the building becoming an eyesore in an as yet unspoiled part of the island. It is the personal opinion of the author that both of these objectives have been achieved even though a suggestion made by the architect that the roof of the building should be covered with soil and then seeded with grass had to be turned down on several counts, one being the risk of injury to the crofters' sheep should they jump down on to the roof to get to the lush pasture thereon!

The generator building is shown in Fig. 4. It consists of three major sections, the engine room, the messroom and toilet, and the fuel storage room. The three 31 kVA alternators are each driven by a 4-cylinder Lister diesel engine. The exhaust outlets of these are fed into a long noise-suppression chamber running the length of one side of the engine room which thus provides a very high degree of 'silencing'. It is not expected to fully load this system for several years to come as the planning requirements have taken account of long term Post Office plans. Distribution of the power to the link station is accomplished by means of two parallel four-core cables forming a ring main to protect continuity of supply. Naturally, steps have been taken to balance the loads on each phase as accurately as possible.

The fuel storage room contains a Braithwaite tank of approximately 16 ft × 13 ft × 10 ft which has been divided into three sections to prevent total loss of oil should a leak occur. All seams have been both welded and secured with nuts and bolts; also the floor of the

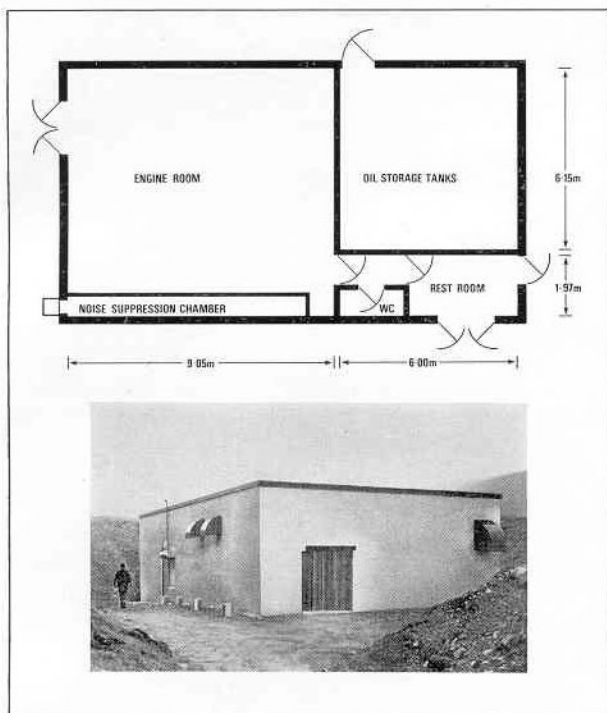


Fig. 4. Photograph and outline plan of the purpose-built generator building in which the Post Office has installed three 31 kVA diesel generators to provide power for the project, including full stand-by facilities. Connection to the apparatus building is by means of a ring main cable system. The main fuel storage tanks are fed by pipeline direct from a 7000 gallon reservoir tank near the loading jetty at North Haven. A high degree of 'silencing' is provided by arranging for the exhaust outlets to pass through a noise-suppression chamber which runs the length of one side of the engine room, and, in consideration of the noise problem and other environmental factors, the building has been sited in a disused quarry.

room is sunk below ground level and is proofed inside to form a bund or sump large enough to contain the contents of all three sections without spillage in the event of an accident. The tanks are filled by means of a pipeline from North Haven details of which are given below.

Fuel Supply

One of the biggest problems connected with this project has been to establish the means by which fuel can be efficiently and economically imported on to the island in sufficient quantities to enable services to continue over fairly long periods when, due to weather or other reasons, deliveries could not be made. The normal method used by the islanders is to ship the fuel in 40-gallon drums on the *Good Shepherd III*,

but this would not be practical when dealing with quantities such as twelve to fourteen thousand gallons per year. The Post Office, whose responsibility it was to solve this problem, did a great deal of research before finally deciding that the only way to ship the fuel was in 600-gallon tanks on the *Islander*, a small coaster working out of Kirkwall, Orkney, which is available for charter for journeys to Fair Isle.

One of the main problems with shipping to Fair Isle is that the only landing place is in North Haven where a small jetty 200 ft long has been built, but this has a maximum depth of water at high tide of only $1\frac{1}{2}$ fathoms. Consequently, any ship larger than a trawler has to get in, tie up, unload and get out again within a period of four hours, otherwise it is stuck until the next high tide. All the tankers available in the area have too large a draft for them even to enter safely – hence the proposal to use ten 600-gallon tanks loaded on to a coaster. To make matters even more difficult there is a large rock almost in the middle of the entrance which implies that even the small coaster has to wait for ideal weather conditions before attempting an enter. This, of course, precludes any guarantee that deliveries will take place at all between the end of October and the beginning of May.

The method of delivery is for the ship to unload the ten complete tanks one at a time on to the jetty using its own derricks. They will then be emptied and reloaded on to the ship. It was realised during the planning that by using a mobile pump of reasonable size it would not be possible to pump 6,000 gallons of fuel directly to the generator station 170 ft up the hill and a quarter of a mile away in the time available. To overcome this a 7,000 gallon reservoir tank has been housed in a small building on the shore at North Haven into which the oil is pumped from the tanks on the jetty at a high rate via a fairly level underground pipeline. When the delivery vessel has departed with the empty tanks, the mobile pump is moved from the delivery point on the jetty to the reservoir tank building where it is connected into a different part of the system to pump the fuel, at a slower rate, up the pipeline to the main storage tanks in the generator station. Further, following a request on behalf of the islanders by the National Trust for Scotland, provision has also been made for a short extension to be added to the pipeline from the jetty to North Haven which will allow the islanders to use the jetty terminal for filling a tank of their own, which

they will install later, enabling them to buy their diesel oil in bulk at cheaper rates. The mobile pump will also be available to assist them in this enterprise.

The Tower

As was mentioned earlier, when the Post Office joined the Fair Isle consortium, the proposed specification for the tower had to be drastically altered. From a relatively light 150 ft stayed mast for carrying the receiving trough aerials and the Yagi aerials for the radiotelephone, and having the shf aerial mounted on a short separate structure or on the roof of the building, it became a 150 ft tower capable of supporting up to fifteen 12 ft and two 10 ft parabolic reflectors, two trough aerials and three 12-element Yagis, see Fig. 5. Only five 12 ft reflectors are being mounted in the first instance; one for the IBA/BBC and four for the Post Office who plan to erect the other ten as required over a period of the next forty years. The possible provision of the two 10 ft reflectors by the IBA/BBC will depend on whether the operation of the RBL proves satisfactory as explained earlier.

The tower complies with the normal basic type of construction used elsewhere by the Authority and the Corporation, but at the request of the Post Office a central feeder-supporting spine has been added and provision has been made for walkways and platforms to be constructed behind each dish position, although, for economical reasons, at the time of writing these have only been fitted to the aerials so far installed.

It is well known that Fair Isle experiences some of the highest surface wind speeds in the United Kingdom. Because of this the mast has had to be designed with a fully loaded windspeed factor of 158 miles per hour for a three second gust, and hence it is a very sturdy looking structure weighing over 32 tons without the aerials or feeders.

Bressay

The Fair Isle end of the link installation, having produced the more interesting problems concerning the building, transport, power, accommodation, etc., has been fully described in the foregoing, but a brief description should, however, be made of the Bressay installation.

At Bressay there already exists a BBC vhf station which is fed by shf link with signals picked up at the

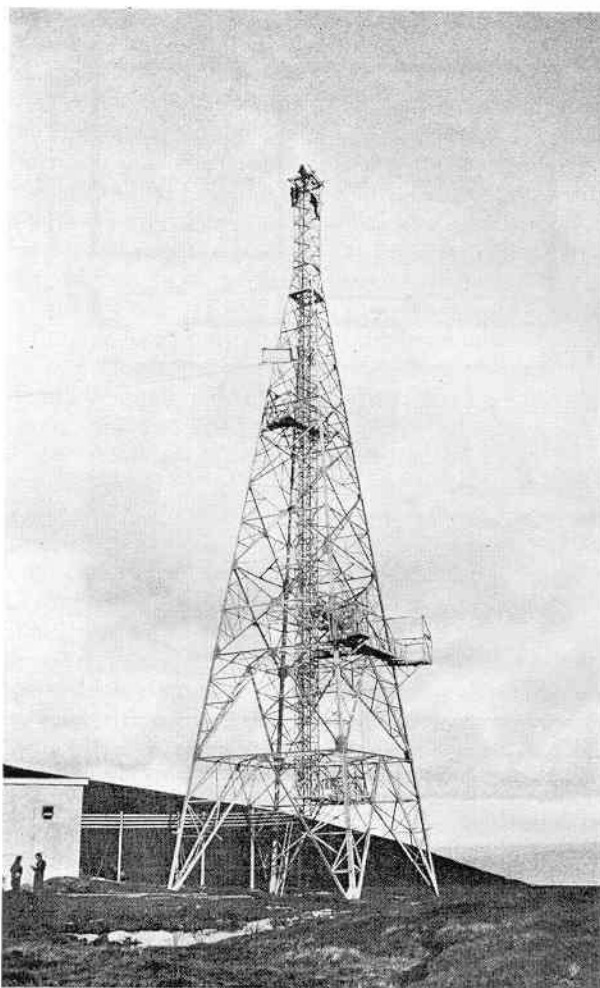


Fig. 5. The aerial tower on Fair Isle has been designed to accept a maximum loading of fifteen 12 ft and two 10 ft parabolic aerials with a fully loaded windspeed factor of 158 mph during a three second gust. The photograph shows the tower just after completion, before erection of the first batch of aerials.

southern end of Shetland direct from the Orkney vhf transmitter at Fitful Head.

To provide for the new IBA/BBC uhf transmitters the BBC is constructing a new building and erecting a new 257 ft tower to support two 8 ft diameter shf aerials respectively at 15 ft and 80 ft levels. Each of these aerials is cross-polarised, as is the one on Fair Isle, in such a way that vertical polarisation will be used for BBC1 and BBC2 and horizontal polarisation for ITV and, hopefully, Programme 4. Flexible waveguide type 14 is used at both ends of the link except inside the building at Bressay where rigid

waveguide is preferred on account of the large bending radius required for the flexible type.

Power supplies for Bressay are obtained from the Scottish Hydro-electric Board's generator station at Lerwick.

Telemetry

IBA remote control and supervisory telemetry signals for Bressay, Fair Isle and Keelylang Hill are being carried by a radiotelephone link working in the private users band around 465 MHz and terminates at the IBA transmitting station at Rumster Forest. From here the signals are carried, along with those from Rumster Forest itself, to the control station at Durris by means of a Post Office private wire. Speech signals are carried on this circuit as well, the telemetry signals being separated by filters, but signalling is only available between the control station and any one of the stations *en route*, or vice versa. Signalling between intermediate stations is not available except by audio monitoring.

GENERAL DATA

	FAIR ISLE	BRESSAY
Map Reference	HZ 213 732	HU 503 387
Site Heights (aod)	525 ft	743 ft
Mast Heights (agl)	150 ft	257 ft
RBR Aerial Heights (agl)	25 ft and 150 ft	—
SHF Aerial Heights (agl)	20 ft	15 ft and 80 ft
Reflector Diameters (Focal Plane)	12 ft	2 × 8 ft
Path Lengths	Keelylang Hill to Fair Isle – 66 miles (uhf)	
	Fair Isle to Bressay – 44.5 miles (shf)	
SHF Polarisation	Cross-polarised (BBC vertical IBA horizontal)	
Fibre glass radomes fitted to all dishes to reduce wind loading.		
IBA (shf) transmitter output power: 0.5 watt (nominal)		
Receiver noise figure 7.5 dB.		
Bressay transmitter frequencies IBA 7477 MHz		
BBC1 7452.5 MHz BBC2 7501.2 MHz		

Conclusion

An attempt has been made in the foregoing to briefly survey the problems which can arise in an otherwise straightforward exercise of supplying a programme feed to a uhf television transmitter in the IBA/BBC chain of stations bringing the 625-line colour service to remote parts of the British Isles. Although the system is not due to become operational until the latter part of 1976, the Authority's engineering staff are confident of its ultimate success.