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Transatlantic Communications— An Historical Resume

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The papers that follow describe the design, manufacture and installation of the first transatlantic telephone cable system with all its component parts, including the connecting microwave radio-relay system in Nova Scotia. The purpose of this introduction is to set the scene in which this project was undertaken, and to discuss the technical contribution it has made to the development of world communications.

Electrical communication between the two sides of the North Atlantic started in 1866. In that year the laying of a telegraph cable between the British Isles and Newfoundland was successfully completed. Three previous attempts to establish transatlantic telegraph communication by submarine cable had failed. These failures are today seen to be the result of insufficient appreciation of the relation between the mechanical design of the cable and the stresses to which it is subjected as it is laid in the deep waters of the Atlantic. The making and laying of deep sea cables was a new art and designers had few experiments to guide them.

During the succeeding ninety years, submarine telegraph communication cables have been laid all over the world. Cable design has evolved from the simple structure of the first transatlantic telegraph cable — a

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stranded copper conductor, insulated with gutta-percha and finished off with servings of jute yarn and soft armoring wires — to the relatively complex structure of the modern coaxial cable, strengthened by high tensile steel armoring for deep sea operation. The coaxial structure of the conducting path is necessary for the transmission of the wide frequency band width required for many telephone channels of communication. The optimum mechanical design of the structure for this first transoceanic telephone cable has been determined by many experiments in the laboratory and at sea. As a result, the cable engineer is confident that the risk of damage is exceedingly small even when the cable has to be laid and recovered under conditions which impose tensile loads approaching the breaking strength of the structure.

The great difference between the transatlantic telephone cable and all earlier transoceanic telegraph cables is, however, the inclusion of submerged repeaters as an integral part of the cable at equally spaced intervals and the use of two separate cables in the long intercontinental section to provide a separate transmission path for each direction. The repeaters make possible a very large increase in the frequency band width that can be transmitted. There are fifty-one of these submerged repeaters in each of the two cables connecting Clarenville in Newfoundland with Oban in Scotland. Each repeater provides 65 db of amplification at 164 kc, the highest transmitted frequency. The working frequency range of 144 kc will provide thirty-five telephone channels in each cable and one channel to be used for telegraph traffic between the United Kingdom and Canada. Each cable is a one-way traffic lane, all the "go" channels being in one cable and all the "return" in the other.

The design of the repeaters used in the North Atlantic is based on the use of electron tubes and other components, initially constructed or selected for reliability in service, supported by many years of research at Bell Telephone Laboratories. Nevertheless, the use of so many repeaters in one cable at the bottom of the ocean has been a bold step forward, well beyond anything that has been attempted hitherto. There are some 300 electron tubes and 6,000 other components in the submerged repeaters of the system. Many of the repeaters are at depths exceeding 2,000 fathoms ($2\frac{1}{4}$ miles) and recovery of the cable and replacement of a faulty repeater might well be a protracted and expensive operation. This has provided the incentive for a design that provides a new order of reliability and long life.

On the North Atlantic section of the route, the repeater elements are housed in flexible containers that can pass around the normal cable laying gear without requiring the ship to be stopped each time a repeater is laid. The advantages of this flexible housing have been apparent during the laying operations of 1955 and 1956. They have made it possible to continue laying cable and repeaters under weather conditions which would have made it extremely difficult to handle rigid repeater housings with the methods at present available.

A single connecting cable has been used across Cabot Strait between Newfoundland and Nova Scotia. The sixteen repeaters in this section have been arranged electronically to give both-way amplification and the single cable provides "go" and "return" channels for sixty circuits. "Go" and "return" channels are disposed in separate frequency bands. The design is based closely on that used by the British Post Office in the North Sea. Use of a single cable for both-way transmission has many attractions, including that of flexibility in providing repeatered cable systems, but no means has yet been perfected of laying as part of a continuous operation the rigid repeater housings that are required because of the additional circuit elements. This is unimportant in relatively shallow water, but any operation that necessitates stopping the ship adds appreciably to the hazards of cable laying in very deep water.

The electron tubes used in the repeaters between Newfoundland and Scotland are relatively inefficient judged by present day standards. They have a mutual conductance of 1,000 micromhos. Proven reliability, lower mechanical failure probability and long life were the criteria that determined their choice. Electron tubes of much higher performance with a mutual conductance of 6,000 micromhos are used in the Newfoundland-Nova Scotia cable, and it is to be expected that long repeatered cable systems of the future will use electron tubes of similar performance. This will increase the amplification and enable a wider frequency band to be transmitted; thus assisting provision of a greater number of circuits. If every advantage is to be taken of the higher performance tubes, it will be necessary to duplicate (or parallel) the amplifier elements of each repeater, in the manner described in a later paper, in order to assure adquately long trouble-free performance. This has the disadvantage of requiring the use of a larger repeater housing.

During the three years that have elapsed since the announcement in December, 1953 by the American Telephone and Telegraph Company, the British Post Office, and the Canadian Overseas Telecommunication Corporation, of their intention to construct the first transatlantic telephone cable system, considerable progress has been made in the development and use of transistors. The low power drain and operating voltage required will make practicable a cable with many more submerged repeaters than at present. This will make possible a further widening of the transmission band which could provide for more telephone circuits with accompanying decrease in cost per speech channel or the widened band could be utilized for television transmission. Much work, however, is yet to be done to mature the transistor art to the level of that of the thermionic electron tube and thus insure the constancy of characteristics and long trouble-free life that this transatlantic service demands.

The present transatlantic telephone cable whose technical properties are presented in the accompanying papers, however, gives promise of large reduction in costs of transoceanic communications on routes where the traffic justifies the provision of large traffic capacity repeatered cables. The thirty-six, four-kilocycle channels which each cable of the two-way system provides, are the equivalent of at least 864 telegraph channels. A modern telegraph cable of the same length without repeaters would provide only one channel of the same speed. The first transatlantic telegraph cable operated at a much slower speed, and transmitted only three words per minute. The greater capacity of future cables will reduce still further the cost of each communication circuit provided in them. Such considerations point to the economic attractiveness, where traffic potentials justify it, of providing broad band repeatered cables for all telephone, telegraph and teletypewriter service across ocean barriers.

The new transatlantic telephone cable supplements the service now provided by radio telephone between the European and North American Continents. It adds greatly to the present traffic handling capacity of this service. The first of these radio circuits was brought into operation between London and New York in 1927. As demands for service have grown, the number of circuits has been increased. We are, however, fast approaching a limit on further additions, as almost all possible frequency space has now been occupied. The submarine telephone cable has come therefore at an opportune time; further growth in traffic is not limited by traffic capacity.

Technical developments over the years by the British Post Office and Bell Telephone Laboratories have brought continuing improvement in the quality, continuity and reliability of the radio circuits. The use of high frequency transmission on a single side band with suppressed carrier and steerable receiving antenna are typical of these developments. Even so, the route, because of its location on the earth's surface, is particularly susceptible to ionospheric disturbances which produce quality deterioration and at times interrupt the service completely.

Cable transmission will be free of all such quality and continuity limitations. In fact, service of the quality and reliability of the long distance service in America and Western Europe is possible. This quality and continuity improvement may well accelerate the growth in transatlantic traffic.

The British Post Office and Bell Telephone Laboratories are continuing vigorous programs of research and development on submarine cable systems. Continuing technical advance can be anticipated. Broader transmission bands, lower cost systems and greater insurance of continuous, reliable and high quality services surely follow.