A Cable Laying Facility

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In order fully to utilize new broadband submarine cable systems it has been necessary to consider new techniques for placing the system on the ocean bottom. This article describes the general development plan that resulted in a new cable ship capable of efficiently handling any new system. The article thus serves as an introduction to the remaining articles of this special issue.

I. INTRODUCTION

The need for new and more complex submarine cable systems to handle a growing transoceanic communications business produced many new features in the design of cable and repeaters and auxiliary electronic equipment.[1,2,3] It also made necessary new solutions to the problem of placing the cable system on the ocean floor. This task appeared formidable to the early telegraph cable engineers, and many failures preceded the final development of a satisfactory mode of operation. In terms of modern systems their task was simple, since they were interested only in a single-conductor circuit that would remain a low-resistance path well insulated from the sea.

Modern broadband cable systems present a large number of new problems. The cable is now a complex transmission line whose characteristics up to high frequencies must be predictable and stable after the laying process. Repeaters and equalizers requiring large rigid containers are now inserted in the cable at frequent intervals. Both cable and repeaters are expensive and must not be wasted by the lack of precise payout control.

When development of a repeatered telephone system[4] was initiated by the Bell System, it was recognized that the laying of such a system in deep water was a sizable problem. Consequently, effort was concentrated on a flexible repeater that could be handled like cable with only minor modifications to existing cable ships.

At the same time it was realized that this restriction would unduly constrain future developments of broadband systems, and a program was started in 1953 to develop more versatile and more precise techniques and machinery for cable laying that could be integrated into a working cable ship. The objective was a modern cable laying facility that would permit the efficient installation of any type of cable system that might be developed in succeeding years. The many parts of the facility are described in companion articles.[5,6,7] These were developed as an integrated system under a common development plan described below.

As a first step, analytical and simple model work was started on the fundamental mechanics of cable laying and recovery. Some of the questions to be answered were:

(1) What is the configuration of a cable on its way to the sea bottom or during recovery? What are the forces involved?

(2) What is the nature of the ocean bottom environment?

(3) How must the cable be controlled for proper distribution on the bottom?

(4) What are the effects of wind, currents, and wave motion on the laying process?

Many of these questions have not yet been completely answered and are the subject of continuing exploration and study. However, a sufficient background of fundamental knowledge was assembled to guide the development of cable laying techniques and equipment. Some of this work has been reported.[8] Additional information will be published as studies of general interest are completed.

II. OBJECTIVES AND REQUIREMENTS

The objectives of a perfect cable laying technique can be stated quite simply:

1. The cable should just follow the bottom contour — laying wasteful excess cable must be avoided without increasing the chance of failure during or after laying. Cables suspended above the bottom in areas of varying depth are subject to damage by chafe, abrasion, and man-made hazards.

2. In the trip from shipboard to its place on the bottom no part of the cable or repeaters should be subjected to excessive mechanical deformation or shock. This will insure that the reliability and transmission stability of the system are not affected by the laying process.

With these objectives in mind, analytical work continued. Basic ideas were studied with table-top models and $\frac{1}{4}$-scale working models. Finally the better ideas were converted to full-scale models. At the same time naval architects were brought in as consultants to consider the proposals in the terms of a marine environment and to incorporate them in preliminary arrangements of a new cable ship. Other persons engaged in cable laying were briefed on the new ideas and their comments solicited to take advantage of prior experience.

From these studies came four fundamental requirements to guide the final development:

(1) The cable laying process should be continuous at speeds of 4–8 knots to avoid unpredictable transients and ship control difficulties.

(2) The cable, when under high tension, should be in a straight line and should be handled by machinery that would treat it as gently as possible to eliminate transmission variations and possible damage.

(3) Personnel requirements should be kept to a minimum so that long systems with close-spaced repeaters would not require oversized, highly trained ship crews.

(4) Methods should be safe and simple, avoiding the need for close timing or coordination, since a ship at sea can be a very unstable platform.

III. NEW DEVELOPMENTS

The exploratory work suggested that the cable ship be considered in terms of two independent functions: (1) high-speed continuous laying of rigid repeater systems, and (2) repair of cable systems of any type or slow-speed laying of a few repeaters. The first function was assigned to the stern of the ship and the second function to the bow.

For stern laying three new developments were needed:

(1) a new cable engine which would hold cable without damage and simultaneously accommodate rigid repeaters without change in speed,

(2) a method to control the cable and repeater during overboarding, and

(3) a system for handling and stowing cable and repeaters in the ship that would permit continuous and essentially unattended payout.

For the functions at the bow, conventional cable engines using large-diameter drums were adaptable. Many new features were desirable, but of most importance was controlled movement of the cable line in the horizontal plane to permit repeaters to be handled without overriding cable on the drum.

Development of methods and equipment to meet these specific needs was undertaken in early 1957. These did not by themselves make a cable handling facility, but had to be integrated into the design of the cable ship. In general, they required large spaces and involved heavy

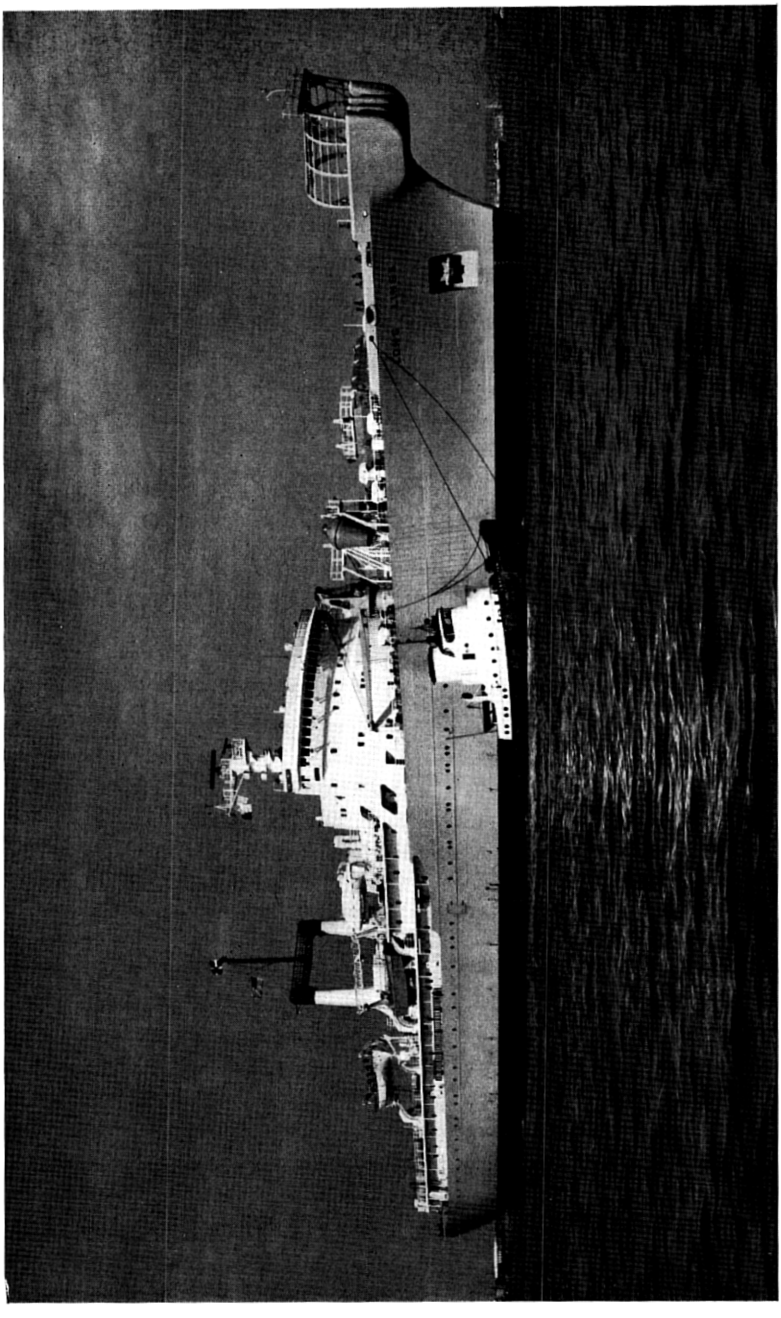

Fig. 1 — C. S. *Long Lines*.

machinery, so provision had to be made in the basic structure and in the spatial arrangements of the ship. It proved to be essential that the development of the laying system and the design of the ship be coordinated under an integrated system concept.

Then the ship with its cable gear had to be put to work in a dynamic sense. This involved operation of the cable gear and the ship by personnel in accordance with requirements dictated by the cable system. To accomplish this most effectively, it was necessary to consider navigation and ship control, control of the laying process, transmission testing and adjustment, cable splicing and loading, communications and many other factors to insure that the cable and repeaters could be placed safely and precisely along the desired route.

IV. CABLE SHIP *LONG LINES*

The new Bell System cable ship, *Long Lines*, shown in Fig. 1, represents the first example of cable ship design following the basic philosophy of an integrated system design. It was not sufficient that the ship be able to lay the newest system, but was necessary also that its equipment be flexible enough to lay other systems which might follow in the natural evolution of undersea transmission systems. The papers that follow in this special issue describe some of the more important developments and present the story of this new ship. Throughout the descriptions the need for coordination of all the parts should become apparent.

This new cable handling facility has proved, in its first important test of laying a new transatlantic cable, that the thorough development program was successful. Cable and repeaters were payed out continuously at 8 knots with a ship's complement about 25 per cent less than that used on other cable laying ships of comparable size. A facility is available that can be adapted to handle any transoceanic system that might be considered in the next decade. The basic design is such that new features can be added as our knowledge increases and new techniques are developed.

Many organizations and individuals were responsible for the success of this undertaking. During the development the following organizations outside the Bell System were important members of the development team:

Bergen Research and Engineering Company assisted in much of the quarter-scale model design, construction and testing.

Western Gear Corporation was responsible for final design and manufacture of the cable engines.

Gibbs & Cox, Inc. provided the necessary marine background and contributed to many of the design concepts.

The final design and construction of the cable ship was the responsibility of the Long Lines Department of the American Telephone and Telegraph Company. Gibbs & Cox, Inc. acted as its design agent in this undertaking. A contract for construction of the ship was signed with Schlieker Werft, Hamburg, Germany on October 27, 1960. The launching occurred on September 24, 1961, and the ship arrived in the United States on April 13, 1963. It sailed for its first cable laying job on July 23, 1963.

The ship is owned by Transoceanic Cable Ship Company, a wholly owned subsidiary of A.T.&T. Co. It is operated by Isthmian Lines, who handle the cable laying and repair work with the technical assistance of Bell System personnel.

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