THE BELL SYSTEM

TECHNICAL JOURNAL

DEVOTED TO THE SCIENTIFIC AND ENGINEERING

ASPECTS OF ELECTRICAL COMMUNICATION

Volume 49 | May–June 1970 | Number 5

SF Submarine Cable System

Foreword

I. HISTORICAL BACKGROUND

Prior to the mid-1950s, transatlantic voice communication was entirely by high frequency radio. Because the transmission quality and reliability did not come up to standards for domestic circuits, the use of the service was limited.

Completion of the first transatlantic telephone cable system[1] in 1956 brought consistently high-quality overseas transmission to the public for the first time. The telephone user responded to this improvement with a great increase in transoceanic calls.

II. TRAFFIC GROWTH

Figure 1 shows the growth in total bandwidth across the Atlantic from the United States which was provided to meet this increased use. This curve is an exponential whose increase averages $27\frac{1}{2}$ percent per year. A plot of message traffic for the same route would show a similar exponential increasing at 23 percent per year. The $27\frac{1}{2}$ percent figure includes channels to provide private wire and data service. In recent years these services have been growing even faster than the message load. The 23 percent annual growth of message service is approximately double the growth rate for domestic long-haul traffic within the United States.

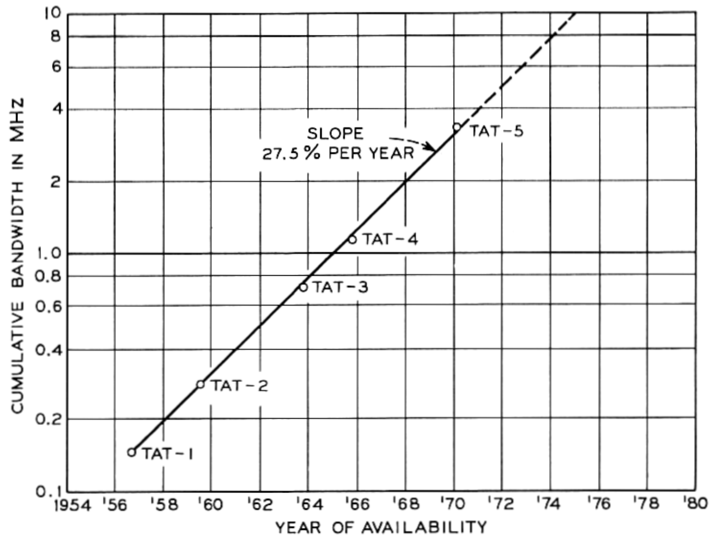

Fig. 1—Growth of transatlantic one-way bandwidth.

To date, there have been no indications of a saturation effect which would cause traffic growth to depart from this increasing exponential. In fact, reduced tariffs made possible by wider band systems will contribute to continuing growth in the future.

Today, overseas traffic goes by both cables and satellites with a small fraction by point-to-point radio. It is interesting to note what happens to the curve of Fig. 1 if one assumes an equal division between cables and satellites. So long as growth is exponential, sharing the load between these two media merely has the effect of shifting the cable bandwidth curve to the right by about three years, after which the growth curve is exactly as before.

III. BACKGROUND OF THE SF SYSTEM

In the latter half of the 1950s, Bell Telephone Laboratories carried on a limited exploratory program to see what could be done with devices and amplifier circuits for a new wideband system. This exploratory effort pioneered transistor characterization which later contributed significantly to the SF System. In the late 1950s, however, device technology was not yet ready for the extremely high reliability demands of submarine cables. Therefore, we decided to complete the development of a second-generation electron tube system called SD.[2] This system carried 128 two-way channels on a single one-inch armorless cable.

The first SD System connected Florida and Panama Canal Zone via Jamaica in 1963. The TAT-3 System linked the U. S. and Britain later that year. A network of Pacific SD Systems joined Japan, the Philippines, and the United States in 1964. The TAT-4 System extended from the U. S. to France in 1965.

While the SD System was being designed, Bell Laboratories was developing semiconductor technology which could meet the reliability needs of undersea cables. Thus, in 1963 we were able to schedule detailed development of the SF System.

In the early stages of development, we aimed for 660 high quality 3-kHz channels. This was later revised to a goal of 720 channels. With the experience of installing and equalizing two SF Systems behind us, we now know that the system is capable of meeting objectives for over 800 channels.

Thus, it has been possible to install new capacity to keep pace with the rapidly mounting need.

IV. DESIGN CHALLENGES AND FIRST TRANSATLANTIC USE OF SF

The challenge of developing a new cable system is multidimensional. Diverse specialties must be organized and mobilized so that the final product is an economical system which will provide the maximum number of high quality, reliable channels permitted by current technologies. The range of disciplines and problems involved is great. It spans oceanography, complex mechanism design, sophisticated circuit design, and advanced semiconductor and component design. Because of the unusual environment, mechanical design of undersea units assumes an important role and must be closely interwoven with electrical design.

Throughout the design and manufacture, control and reliability are watchwords. Close control of cable and repeater characteristics is essential to equalize precisely a system which must provide successive stages of electronic amplification to make up for some 16,000 dB of signal attenuation at the top frequency. Reliability targets are set at one failure in 10^{10} hours for passive components and five failures in 10^9 hours for transistors. It simply is not feasible to test items and prove in advance that these levels of reliability have indeed been achieved. Therefore, we design and test system elements meticulously, pre-age and screen devices and components carefully, and manufacture and inspect the final product with extreme care.

This common thread of reliability runs through the various articles of this issue. It is an implicit part of all of the articles having to do with design of various components and subsystems. It is the dominant theme of the article on manufacture of repeaters and equalizers.

In March 1970, the TAT-5 SF System established a direct link between the United States and Spain. Installation and system alignment proceeded smoothly; performance has exceeded design expectations. These results are concrete testimony to the many people who so painstakingly performed the multitude of steps essential to the development, manufacture and installation of the SF System.

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REFERENCES

1. Special Transatlantic Cable Issue, B.S.T.J., *36*, No. 1 (January 1957), pp. 1–348.
2. Special SD Submarine Cable System Issue, B.S.T.J., *43*, No. 4 (July 1964), pp. 1155–1479.