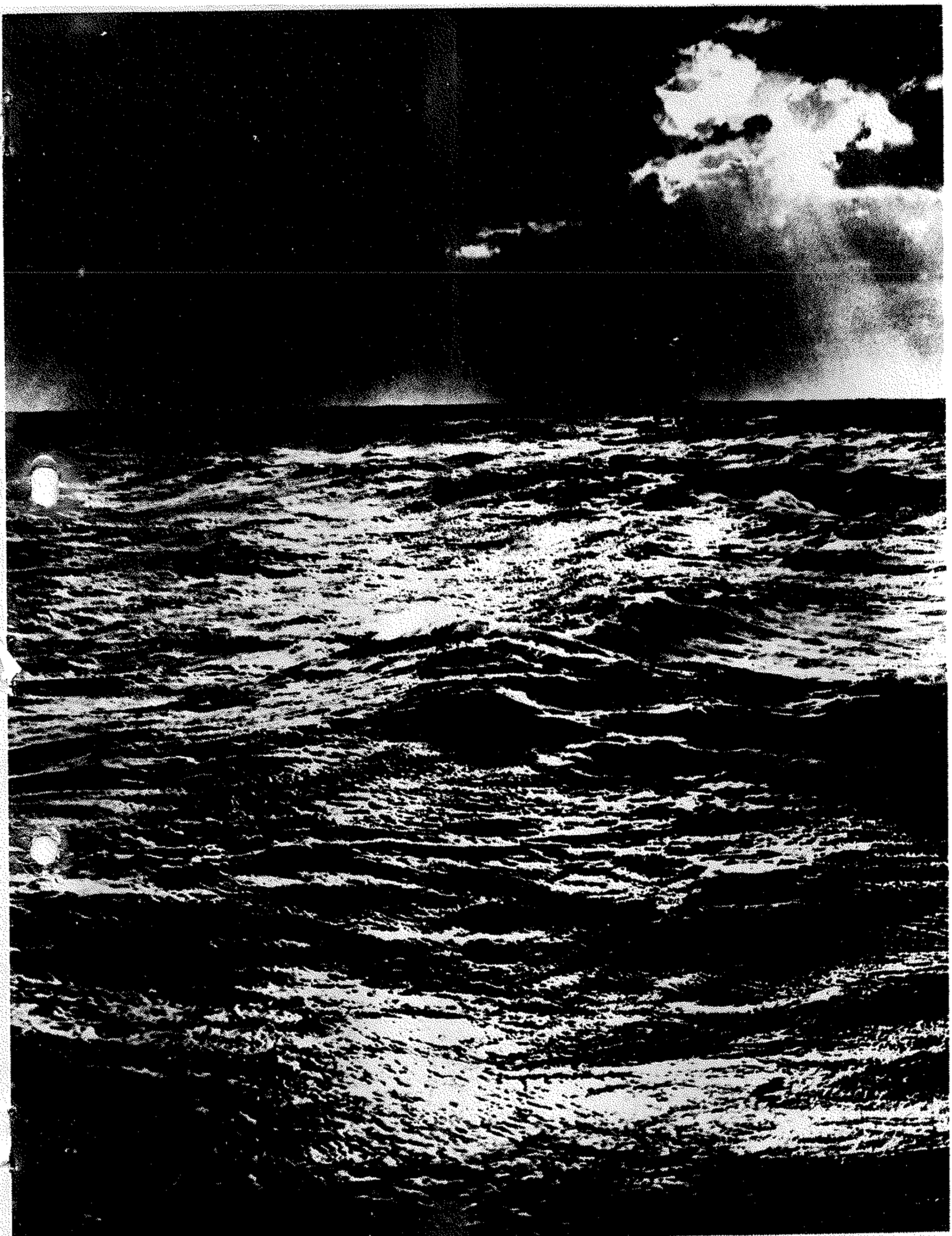
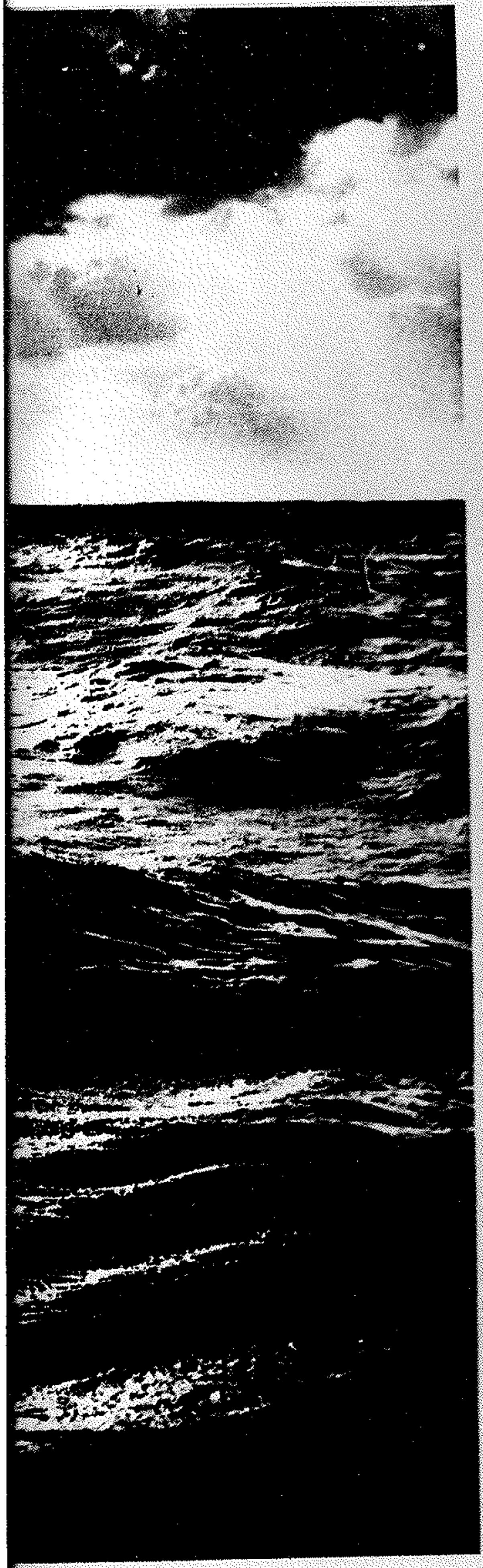
The Deep Sea Cables

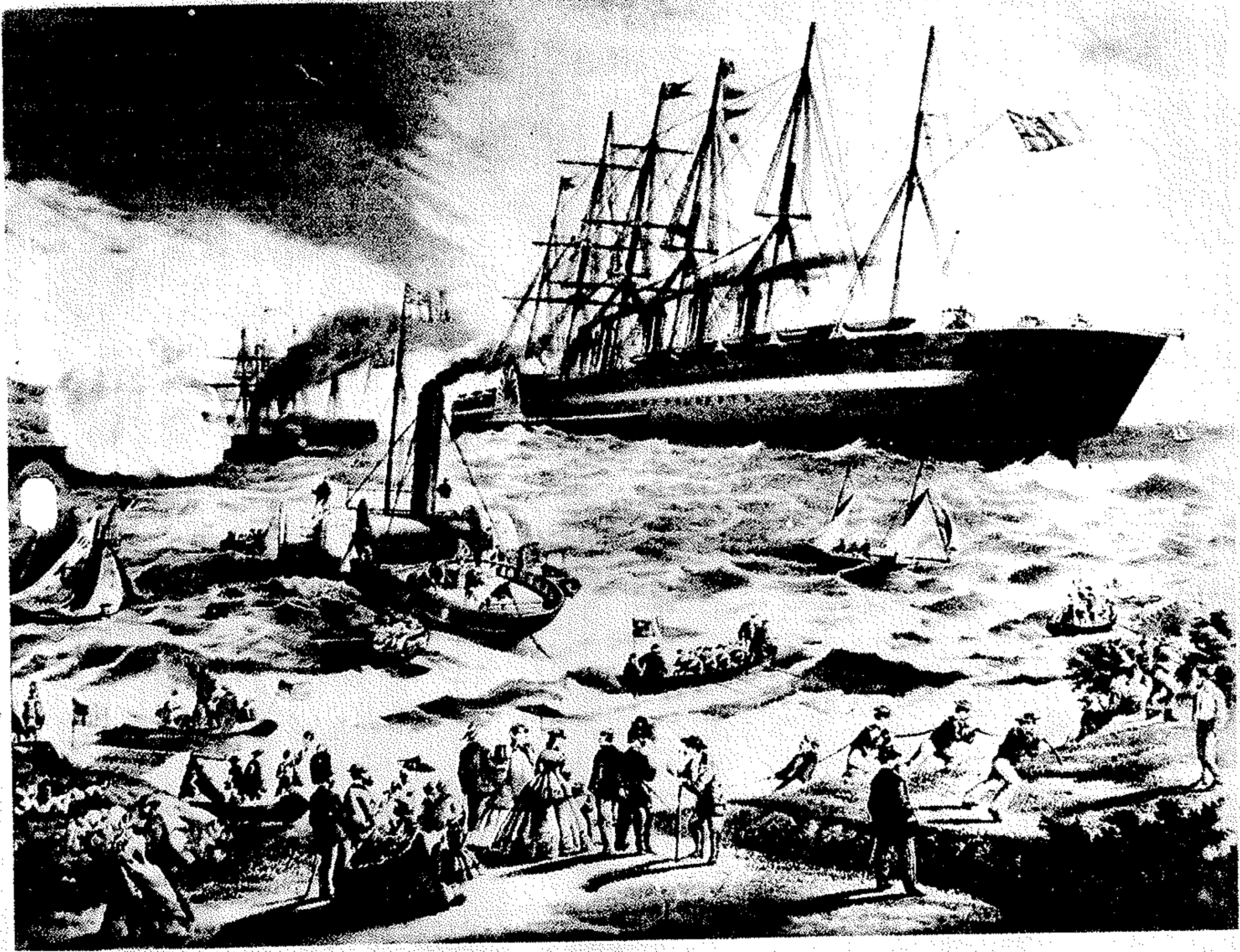




A Communications Challenge

The growth in world population and trade and the demand for faster, clearer overseas telephone service has created an international "communications explosion." To keep abreast of the pressing need for more overseas channels, the Bell System, since 1956, has been developing and laying ever more efficient trans-oceanic telephone cables.

This is the story of how the Bell System is meeting the trans-oceanic cable challenge, and of Western Electric's vital part in this all-important program, designed to provide the people of the United States with clearer, speedier, more reliable international telephone service.



Submarine Cable History

Benjamin Franklin, who lived not 200 years ago, had scarcely any swifter means of overseas communication than Julius Caesar, who lived 2,000 years ago. Messages abroad from both depended upon wind-driven sailing ships.

In today's electronic age, it is hard for us to realize that even into the last century scientists knew little about the electrical communication of intelligence. With the discovery in 1820, however, that electric current produces a magnetic field, the era of rapid communication was born. Two generations later, the electromagnetic telegraph blanketed much of the earth.

But across-the-ocean telegraphy was still in the future.

Then on July 13, 1866, the American,

First transatlantic telegraph cable is pulled ashore in Newfoundland in 1866. Old Kummel & Forster lithograph shows GREAT EASTERN in background.

Cyrus W. Field, sailed aboard the *Great Eastern* from Valentia Bay, Ireland, toward immortality in communications history. Fourteen days later, the ship anchored at Heart's Content, Newfoundland, trailing behind her a 2,000-mile cable that bound the old world to the new.

Field's gift to humanity was the first permanent transatlantic telegraph cable. His accomplishment came after 11 years of frustration—of inadequate knowledge of the topography of the ocean floor, of cables broken and lost in North Atlantic storms, of difficulties in raising capital for new ventures; of completing a link in 1858, only to have it fall silent in a month.

In 1876, only 10 years after the Atlantic cable was laid, Alexander Graham Bell invented the telephone. But it was to be 80 years before the Atlantic Ocean was spanned by a telephone cable—though AT&T established a cable link with Cuba as early as 1921.

There are two reasons for this interval. Transmitting the human voice by cable across an ocean is much more complex than sending a Morse Code signal overseas. Furthermore, in the 1930's when science had progressed to the point where an Atlantic telephone cable was considered feasible, the depression inhibited its development, although research was continued.

Improvements in radio and a better understanding of the ionosphere, the electrical layer above our atmosphere that reflects radio waves back to earth, fortunately provided us with a built-in method of overseas communication. All we had to do was bounce radio waves off the ionosphere and they came ricocheting down across the ocean.

In 1927, AT&T President Walter S. Gifford inaugurated the first commercial radio-telephone service between New York and London. From that date until completion of the first undersea telephone cable in 1956, radio was the only means of sending instantaneous speech to Europe.

Though it is still being used today, radiotelephone is not always reliable. Atmospheric conditions affect transmission and reception. All too often reception fades out or is accompanied by a sound like sizzling bacon, which not only is annoying but sometimes obliterates the signal altogether.

To establish a virtually foolproof international telephone service between Europe and the U.S., AT&T, in 1953, entered into an agreement with the British Post Office and the Canadian Overseas Telecommunications Corporation to lay a transatlantic telephone cable. Such a cable had been theoretically possible for some time as a result of the Bell Laboratories development beginning in the 1930's of deep-sea repeaters, or amplifiers, which boost the human voice at intervals over long distances. After World War II, these repeaters were put to the test in a cable between Florida and Cuba. This system works today as well as the day it was inaugurated.

Moreover, telephone technology had been improved to the point where our long-distance carrier equipment could step up and "stack" a number of conversations, one on top the other in a high-frequency range, and filter them back down to an audio frequency at the other end. These factors made the transatlantic program economical.

Thus, in 1956, the first transatlantic telephone cable was completed linking Oban, Scotland, with Clarenville, Newfoundland. It was one of the most important milestones in communications history.

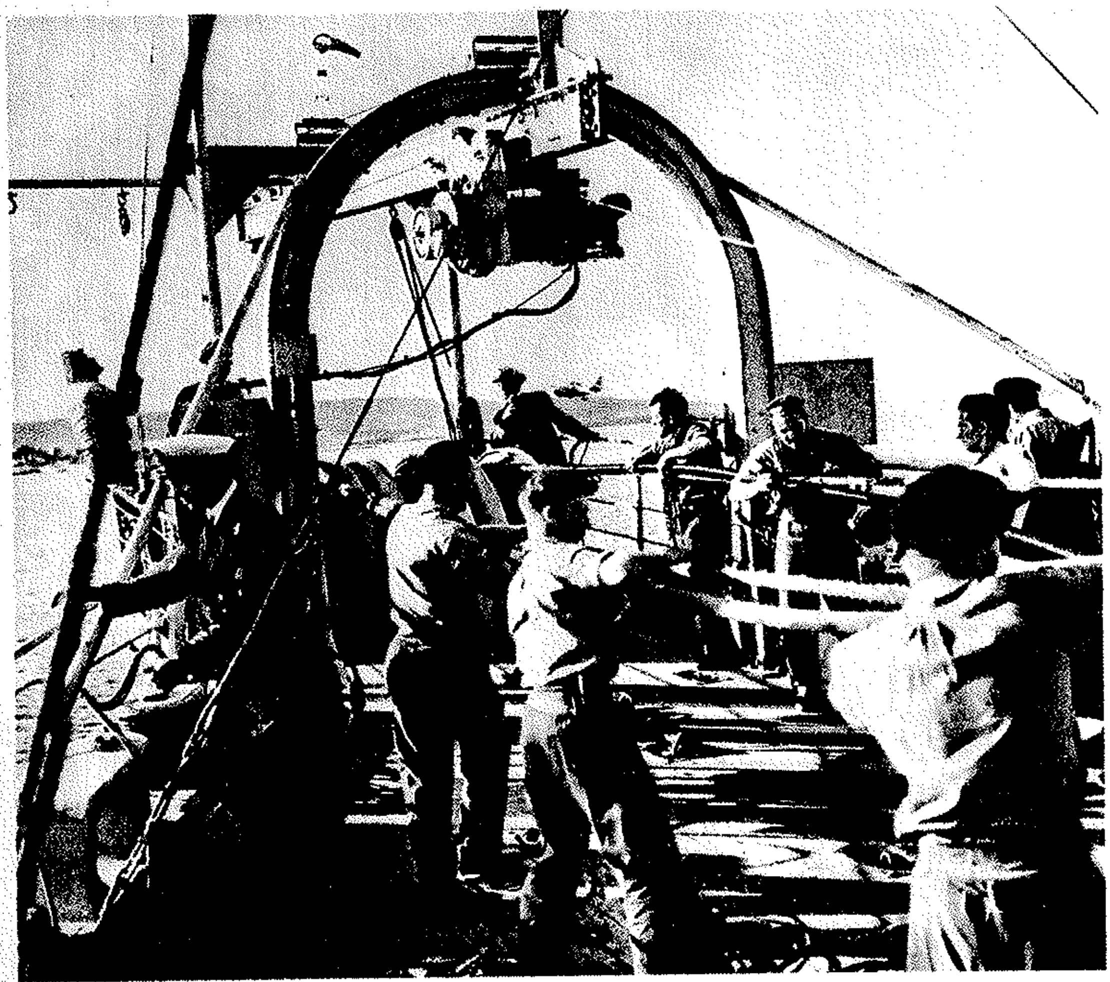
Since then, AT&T's Long Lines Depart-

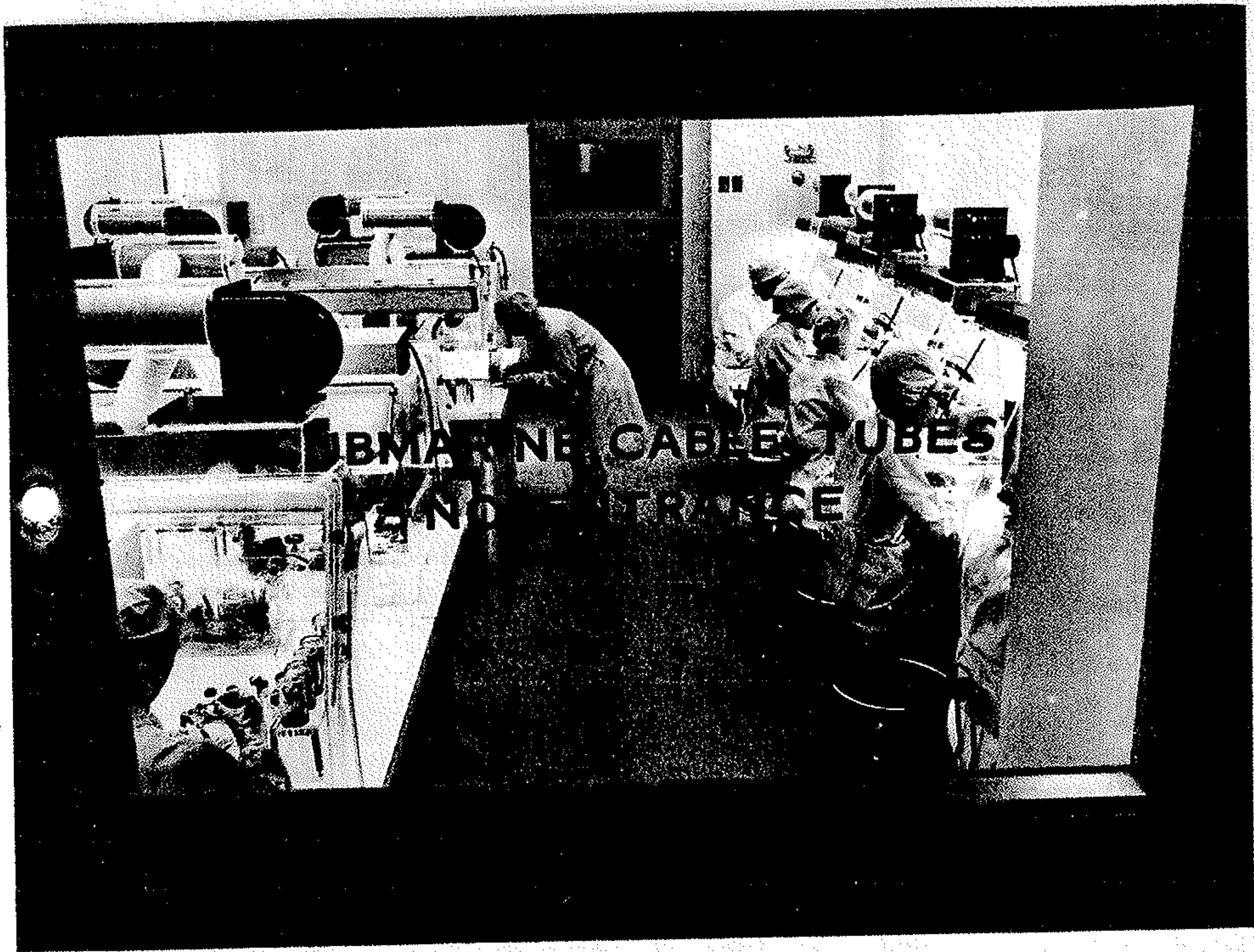
At Clarenville, Newfoundland, in 1956, cable end is floated on drums and hauled ashore, completing first telephone link with Oban, Scotland.

ment has established telephone cable links with Alaska, Hawaii, France, Puerto Rico and Bermuda. Early in 1963, service began to Jamaica and the Canal Zone through a new cable. The third transatlantic cable is being completed this fall between the U.S. and England, and the timetable calls for completion in the summer of 1964 of a link from Hawaii to Japan, via Midway, Wake and Guam.

With Telstar, the Bell System opened up vast worldwide communications possibilities. To bridge the gap between the present and future systems, and indeed to supplement satellite systems when they come, the Bell System is continuing with its underseas cable program—bringing to the people of the U.S. an across-the-oceans telephone service as clear and reliable as a call across the street.

Final splice in the cable is made off Clarenville aboard British cableship, MONARCH. Project was a joint effort between U.S., Canada and Great Britain.





Western Electric's Role

The Bell System's underseas telephone cable program is the result of research and development by Bell Laboratories and operation by AT&T's Long Lines Department. Western Electric manufactures the basic ingredients—submarine repeaters; power, test and carrier equipment and part of the cable.

The most important element of underseas voice transmission is the repeater. In 1953, W.E. set up a plant in Hillside, N.J., to manufacture the repeaters that are presently in operation approximately every 40 miles along most of our submarine cables.

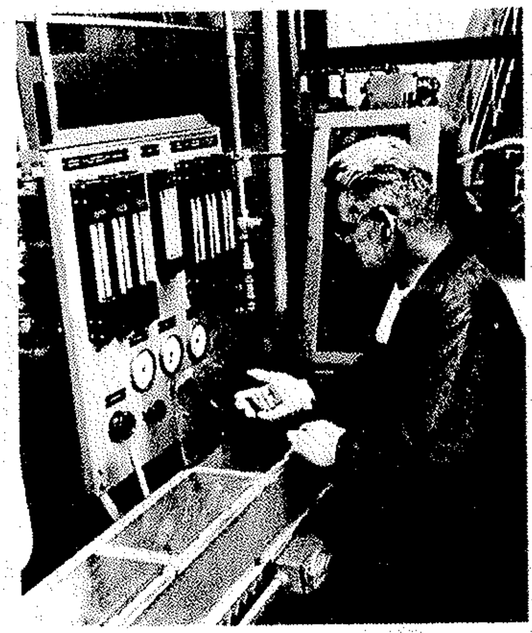
Looking like a flexible series of copper cans about eight feet long, they are only a little wider than the cable. They amplify voice signals in one direction, thereby requiring a two-cable system between two points—one incoming, one outgoing.

Hospital-like conditions are required in Allentown assembly of ocean cable tubes. One dust speck in tube could cause the malfunction of a repeater.

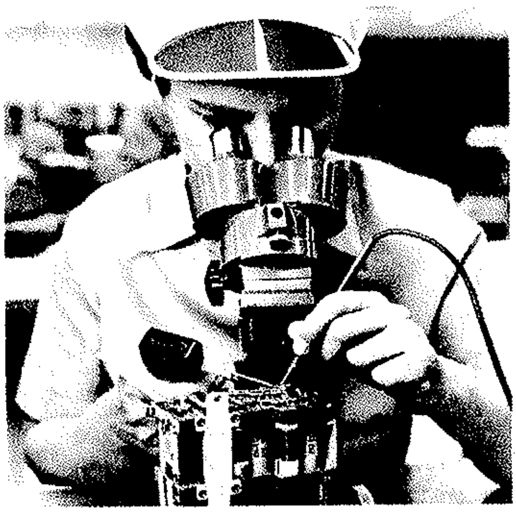
Our newest repeaters provide for two-way transmission. Since 1960, Western Electric's Clark Shops in New Jersey have been assembling a new two-way, rigid repeater to be used with a cable of advanced design made at the Baltimore Works. Repeater manufacture is a team effort involving several Western Electric locations. Included are electron tubes of almost unbelievable reliability, produced at the Allentown Works, and thin, spiraled resistance wire from the Buffalo Plant. Hawthorne produces ferrites—easily magnetized chemical compounds—for the transformer cores, and super-purity nickel for electron tube cathodes.

Besides high-precision quartz crystal units for the new repeaters, Merrimack Valley Works makes all the terminal carrier equipment for the cable systems. In addition, they manufacture Time Assignment Speech Interpolation (TASI) equipment which increases the number of conversations that may be carried through a cable over a fixed number of channels.

The two-way armorless, coaxial cable produced at Baltimore is radically different from that now lying in the Atlantic and Pacific depths. Designed specifically for use with our new repeaters, it is currently in operation between Florida and the Canal Zone.



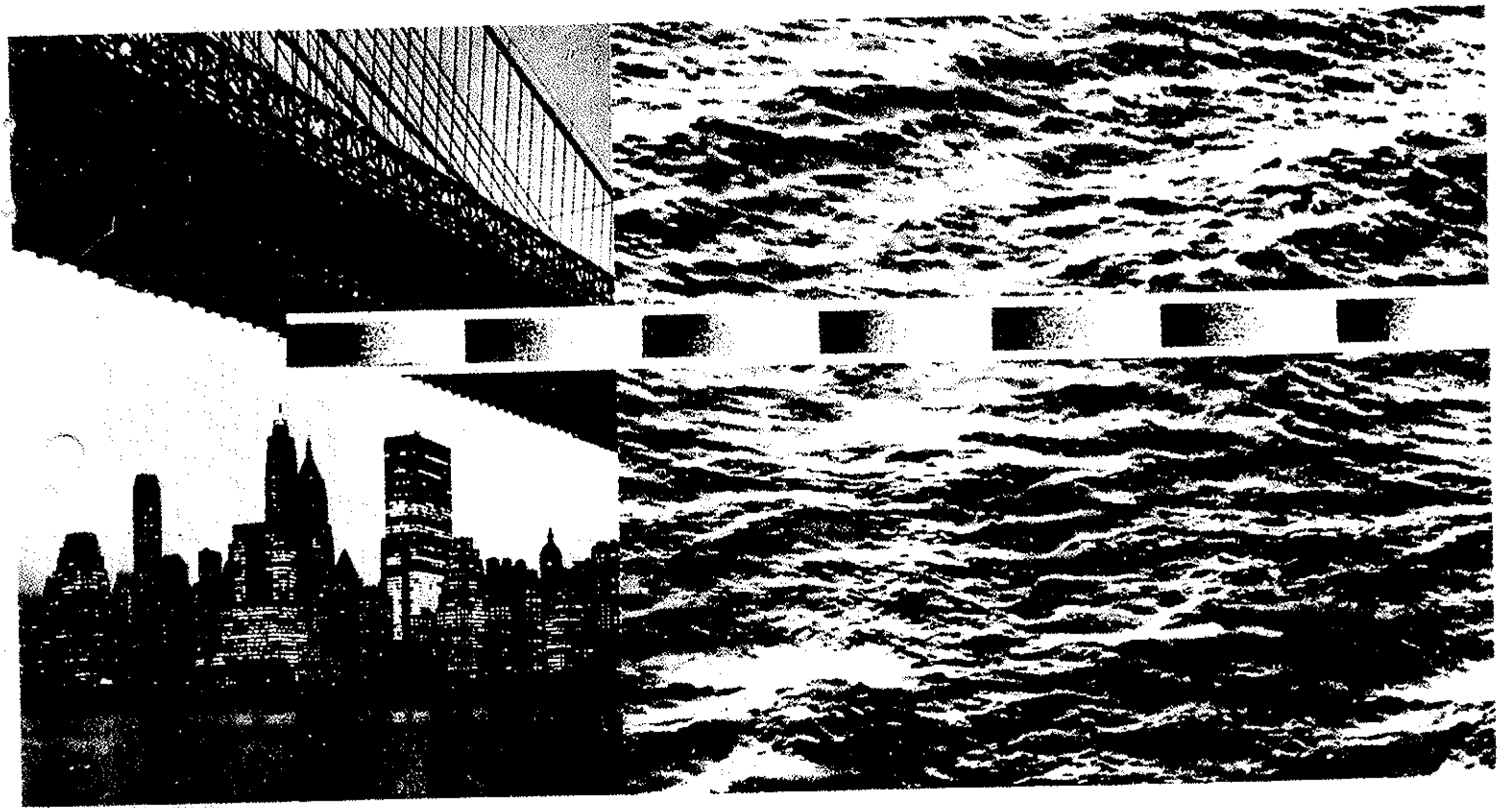
Ferrites are removed from an automatic furnace by tender at Hawthorne Works. Furnace fires them at temperatures exceeding 2,200 degrees Fahrenheit. **Repeater networks** are made, below, in Clark Shops to rigid specifications. Here, a technician uses a microscope in soldering leads.



In a Typical Call to London

You speak into your telephone and the sound waves are converted into electrical waves of the same frequency. These electrical waves travel to your telephone exchange and are routed to White Plains, N.Y. Here they are boosted by carrier equipment into a high-frequency range, as is the case with most long-distance calls. They travel through a land cable to Portland, Maine. At this point they are launched into the ether on a microwave system, leaping from tower to tower across New Brunswick to Sydney Mines, Nova Scotia. After being stepped down to a more modest carrier frequency, the waves now go through a shallow-water cable and through the bogs of Newfoundland, terminating at Clarenville. At Clarenville, they enter the transatlantic cable, descending to depths of 2½ miles, fading away with distance and being amplified at intervals by 51 repeaters, before coming out in Oban, Scotland. From here, the carrier waves travel 550 miles down to London where they are suppressed and filtered down to audio-frequency oscillations. These are converted back to sound waves in the telephone of the listener.

All this has happened in less than 1/10th of a second!



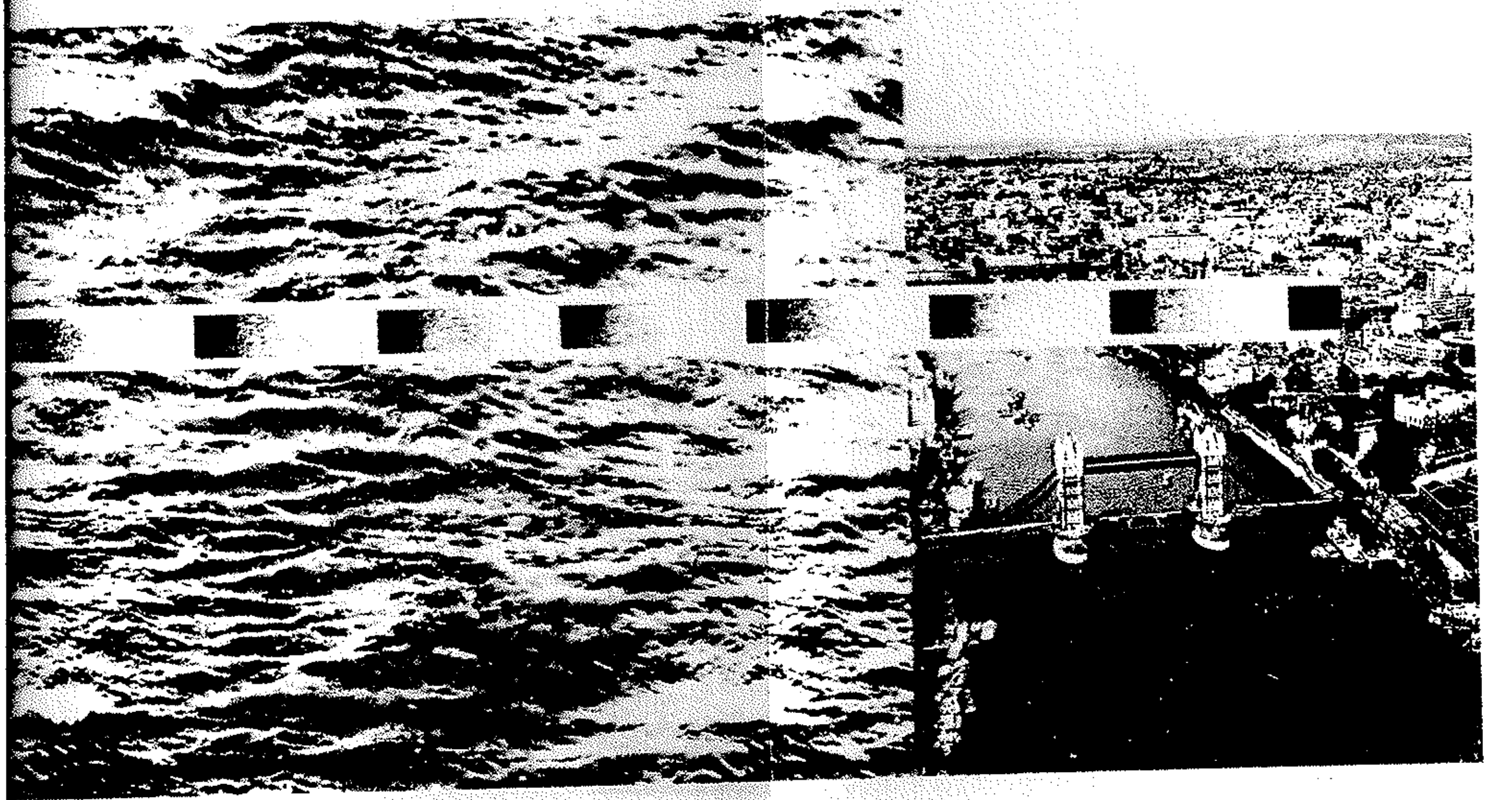
TASI

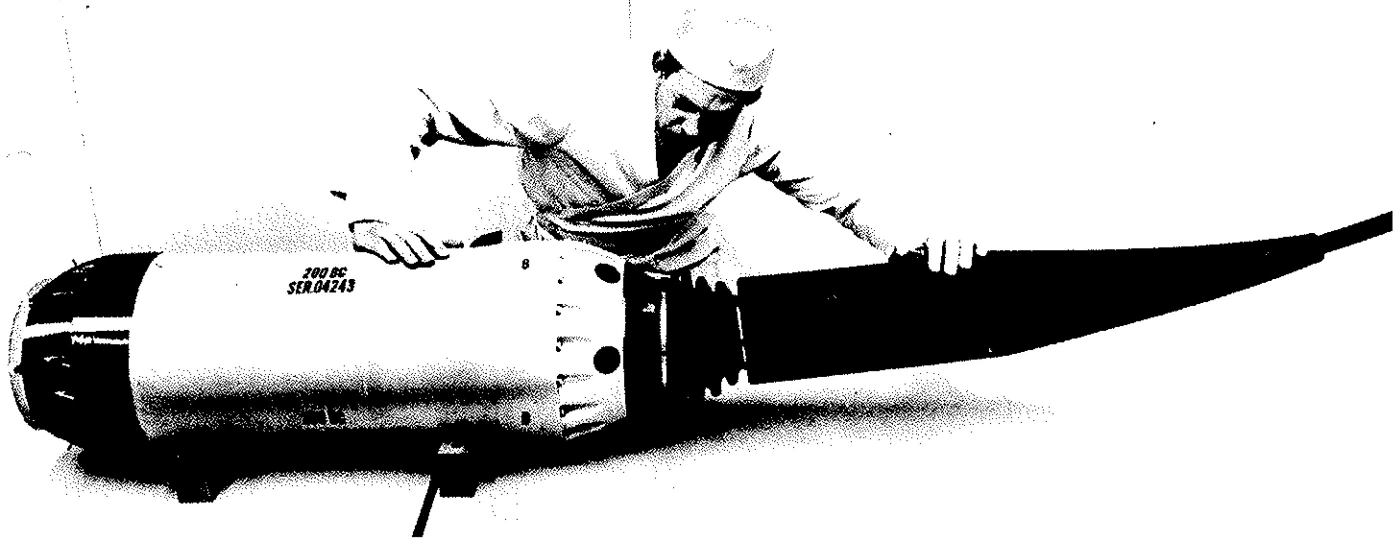
The Time Saver

When you are talking on the telephone and your friend is listening, he is not using his talking channel. Even when you are talking, you have to stop for breath now and then. To the scientists at Bell Laboratories this is a waste of facilities. And when those facilities are costly underseas cables, the waste is intolerable. Our answer to this situation is TASI—developed by Bell Laboratories and made by Western Electric.

TASI takes advantage of idle time by interweaving additional speech signals—from entirely different speakers—into a two-way conversation. This system, now in use at many of our cable terminal stations, is doubling the number of conversations that can be handled simultaneously.

To insure that a momentarily disconnected party will have an open channel when he speaks again, TASI samples each channel 8,000 times a second to select an idle one and reconnects the original speaker just as fast. In this way, although a single channel carries many voices one after the other in rapid succession, TASI sorts out the bits of conversation and sends them to their proper listeners—who, like the speakers, remain unaware of the whole process.





The Repeater

Take 5,000 precision components, put them into a three-foot long, 13-inch diameter beryllium copper cylinder, and drop it to the ocean floor where pressures are thousands of pounds per square inch—and expect it to function perfectly for at least 20 years!

This is WE's challenge with the new 128-channel repeaters.

The minimum 20-year working life-span is desired for two reasons; one, because a repeater's failure could disrupt vital international communication, and two, because of the high cost of raising a repeater.

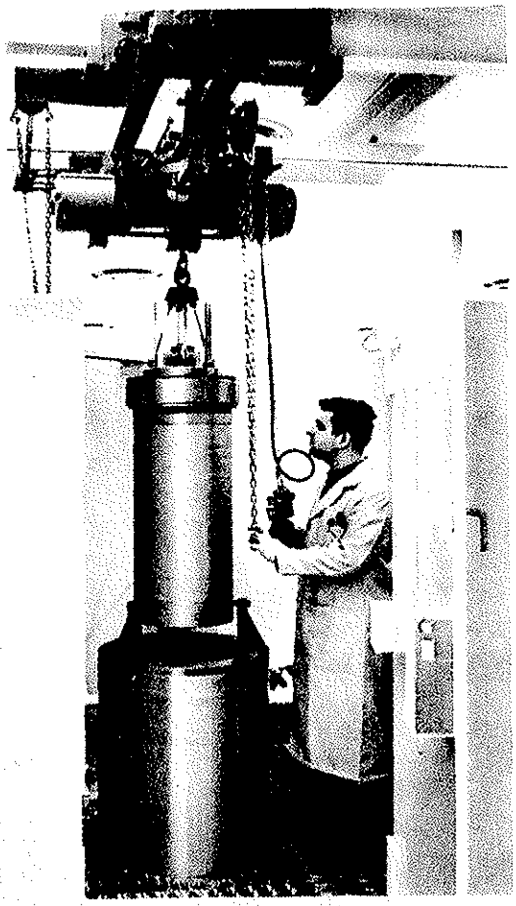
The standards of operation expected of a repeater demand a radical departure from normal manufacturing specifications. To attain them, the Clark Shops and electron tube manufacturing areas at Allentown are constantly warring against the tiniest particle of dust, one speck of which could upset a repeater's critical balance and cause malfunction. A sampling of the carefully controlled air at Clark will reveal a dust-count only 1/50th of that found in the average home.

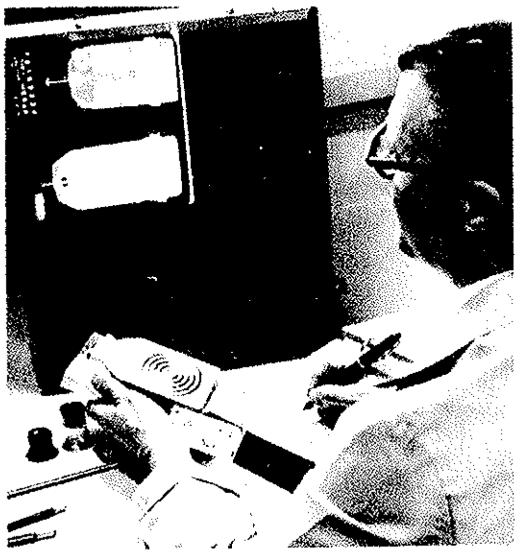
Protective cover and connecting boot of new, 128-channel, rigid repeater are inspected by engineer. This is type used on new transatlantic link.

Floors, walls and ceilings are kept spotless, and each work bench is scrubbed every morning. Employees wear lint-free uniforms, caps and smocks, and like surgeons they must scrub their hands before starting to work. Women wear a minimum of makeup. In the unceasing drive to eliminate any imperfection from the repeaters, even shoes are vacuum-cleaned before employees enter a work area.

This exacting manufacturing effort is carried over into Clark's Purchasing activity. The most careful attention is given to selection of materials. For example, paper capacitors—components that store electricity—must be made from the best paper obtainable. Often it takes months to find the right kind; some of it is only 3/1000ths of an inch thick and must meet stringent electrical, mechanical and chemical requirements. More time is consumed subjecting the chosen capacitors to a number of severe tests after which they are life-tested for six months before they are finally passed. Less than 65 per cent make the grade.

A stringent program of tests is undergone by all individual parts, including among thousands of others, 58 capacitors, 48 inductors, six electron tubes, three gas tubes, six transformers and a crystal unit.





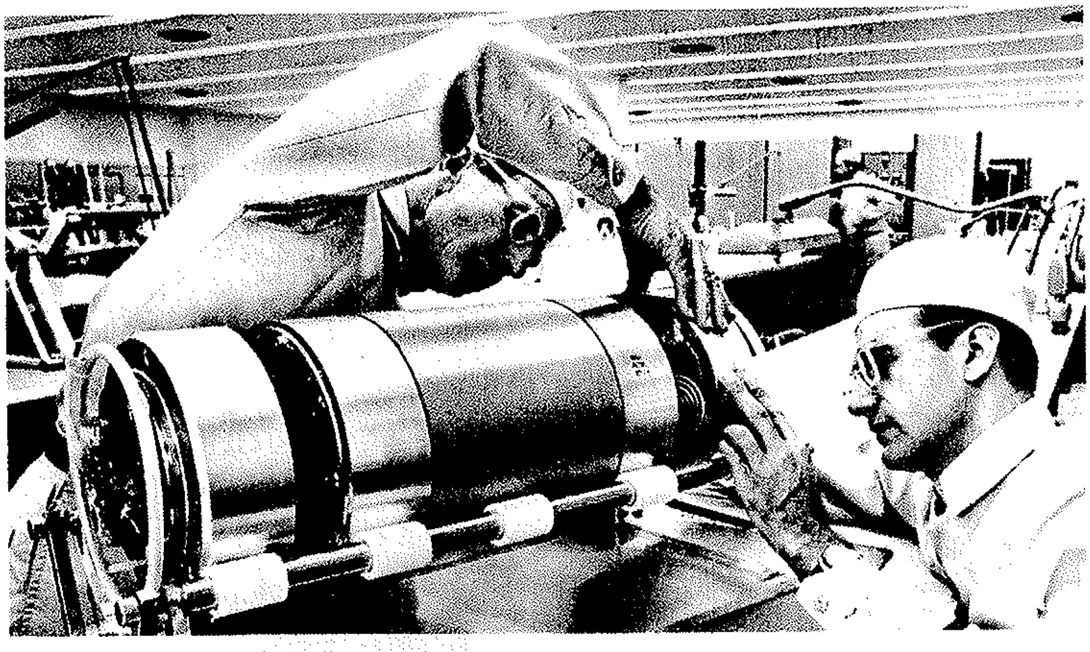
An X-ray is used to check the soldering and assembly at Clark Shops of gold-covered capacitor can. These components are integral parts of submarine repeaters. Leak test, at left, subjects repeater unit to helium pressure of 12,000 psi. This is more than repeaters need withstand on ocean floor.

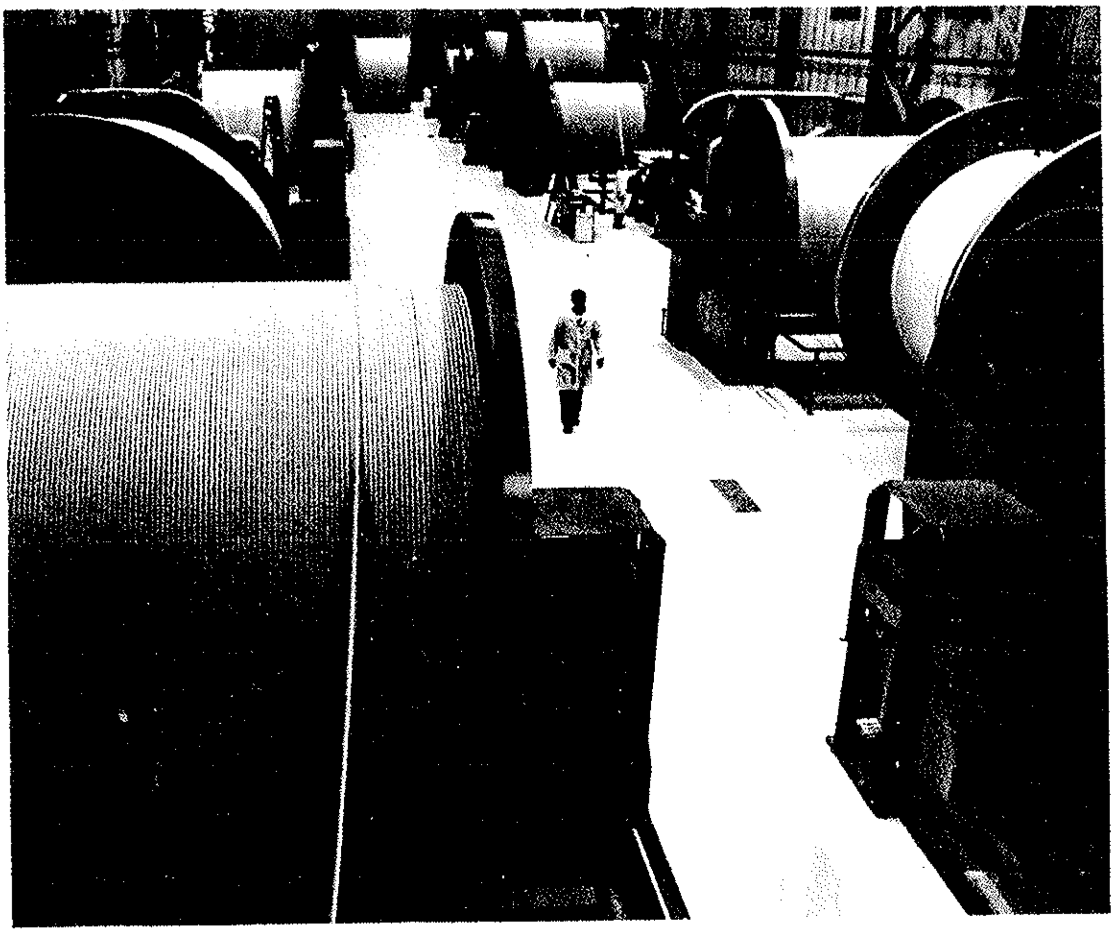
Each month 1,500 industrial X-ray photos of individual components are taken at Clark to spot flaws in moldings, metals and soldered joints that are beyond human detection.

The parts are assembled with watchmaker precision, under the microscope where necessary. Completed repeaters undergo an additional total of 1,700 testing procedures. One of the most important is the pressure test in which the repeaters are surrounded by helium under a pressure greater than they would encounter on the ocean floor. Helium is used because its atoms are much smaller than water molecules and will pass through cracks and pores far more rapidly than moisture. A detector, known as a mass spectrometer, is used to determine if there are leaks. The mass spectrometer is so sensitive it can detect a leak that over a period of 26 years would let through only a thimbleful of gas.

One repeater takes 63 weeks to make. And nothing of the manufacturing or testing activity is left to faulty human memory. Clark has an elaborate data processing system which records every assembly operation and every test. A computer analyzes test data at each step along the way. Not until the computer gives its O.K. is the part or assembly passed on to the next station.

Painstaking care in assembly is apparent as technicians slide power separation filter into position on one of the five sectional repeater assemblies.



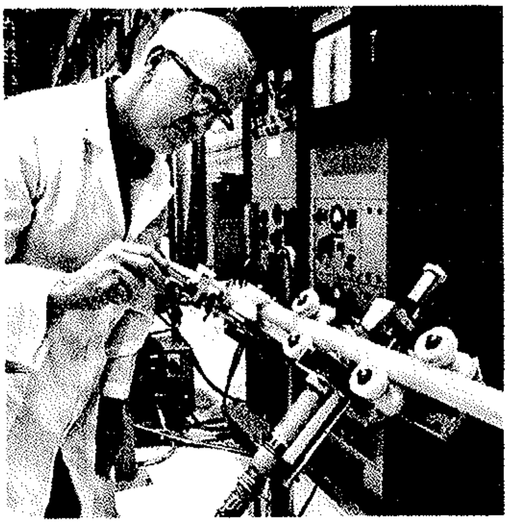


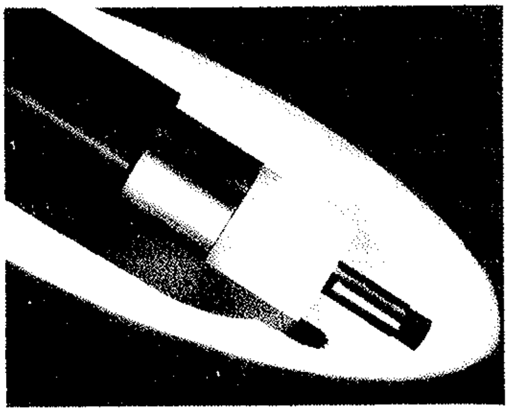
The Cable

While supplies at Clark may be measured in millimeters and milligrams, those in the Baltimore Works' Ocean Cable Building are measured in miles and tons. Here where our new armorless submarine cable is made, engineers work with tons of steel wire, carloads of polyethylene plastic, and miles of finished product.

Everything about the operation is big. The Cable Building itself is the size of two football fields. Inside, the cable-making machinery is Paul Bunyan-sized as well, and includes some of the world's largest spools—giant reels that hold 20-nautical-mile lengths of cable and weigh more than 50 tons when loaded.

Although it is only 1¼ inches in diameter, the new cable could be classified as "big" considering the job it does. Because of the improved repeaters and an enlarged coaxial conductor system, the cable provides 128 two-way circuits—more than any other ocean cable in use today. The band width—a million cycles—is about six times that provided by earlier cables. In addition to telephone channels, the cable permits





Armorless ocean cable, above, measures only 1¼ inches in diameter. Polyethylene is pared to an exact thickness of one inch on the cable production line at left, insuring an even spacing between the inner, and the outer conductors.

transmission of data, telephotographs, and other specialized communications services.

Engineers were faced with a novel task in the cable's design. The earlier cable, because of its spiral armoring, had a tendency to twist when dropping to great depths in the sea. This action constituted no problem with our flexible repeaters. However, it was found that the bulky, rigid design of the new 500-pound repeaters retarded this movement, damaging the cable.

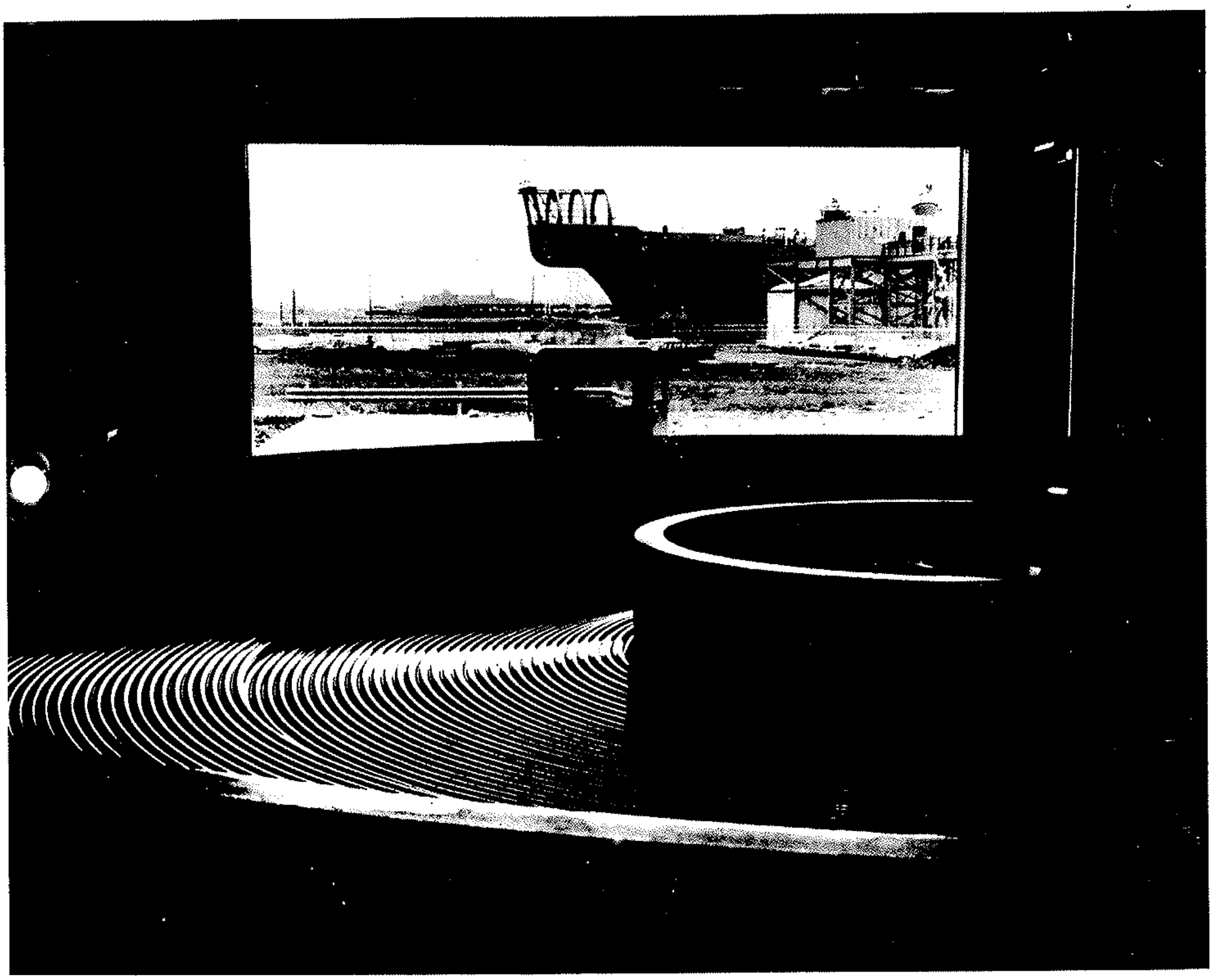
The twisting problem was overcome by doing away with the spiral armoring on the outside of the cable and providing the necessary strength through an inner core of stranded steel. The result is a relatively lightweight, easily handled cable that does not twist or kink in its deep-water descent.

Manufacture is carried on in processing lines moving at the rate of about 22 feet per minute. Initially, steel wire and copper are fed through a 300-foot core strander and inner conductor forming line. Next comes a thick coat of polyethylene plastic, formed around the inner conductor at temperatures of up to 460 degrees. The cable then passes through a 1,200-foot stainless steel "bathtub" to cool.

After cooling, the polyethylene is concentrically pared down so that the cable has a near-perfect diameter of one inch. Only 0.001 of an inch tolerance is allowed. This is to insure an even spacing between the inner and outer conductors so as to provide the best possible transmission.

Finally, the outer copper conductor and a tough, black plastic jacket are added. The finished cable is coiled inside king-sized steel pans and submerged once more for electrical tests in another water trough—this one resembling a double-sized swimming pool. After this, the pans are stacked four high in the building's storage area to await the arrival of the cableship. More than 3,000 miles of cable can be stored at one time.

Ready for loading, a tank of ocean cable is towed from the manufacturing building at Baltimore Works to plant dock where C. S. LONG LINES is moored.



Laying the New Cable

As the Bell System's new cableship, the *C.S. Long Lines*, completes the third transatlantic telephone cable this fall between New Jersey and Cornwall, England, it marks a new era in cableship planning and operation. All previous repeatered telephone cable systems have been designed around existing cableships. The Bell System has reversed this practice and designed the 511-foot *C.S Long Lines* for our new repeaters and cable.

A team composed of representatives from Bell Laboratories and the Long Lines Department under the guidance of AT&T's subsidiary, the Transoceanic Cable Ship Co., owners of the ship, worked with naval architects and engineers for many months, studying the design relationship of cable,

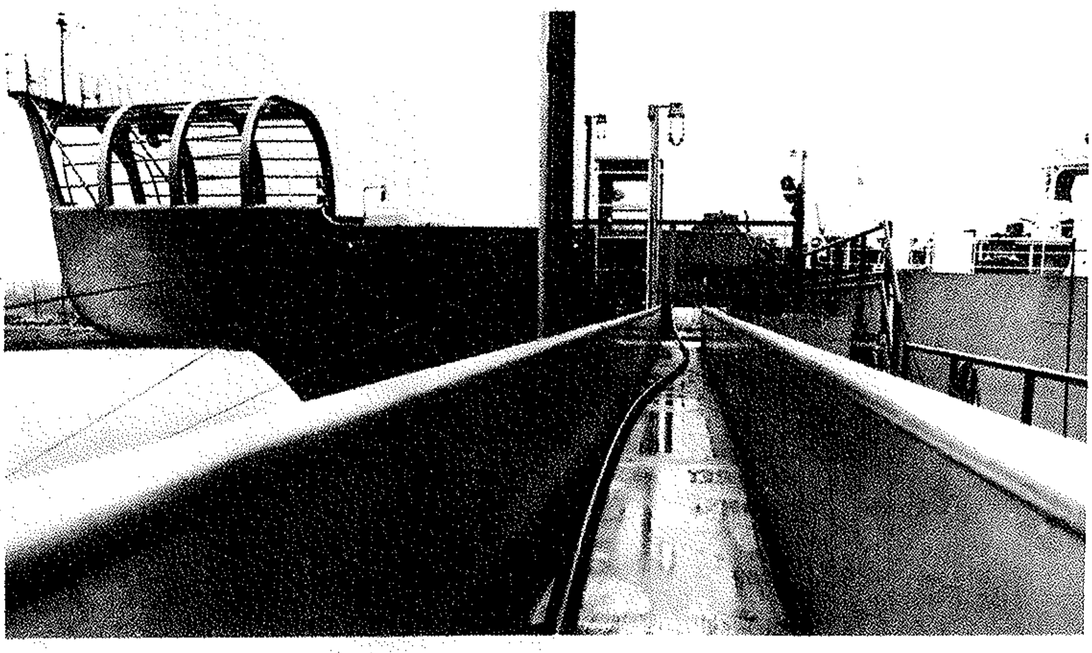
Outward bound, C. S. LONG LINES steams out of New York Harbor. Completed this year, it is most modern telephone cableship afloat.

repeaters, cable-laying machinery and ship construction. The *C.S. Long Lines* has new machinery from the tanks amidships, which hold about 2,000 miles of cable, to the linear cable engine that controls the passage of the cable and repeaters from the tanks to the sea. This machinery is located near the stern. Repeaters are stacked in a series of cradles just above the cable tanks in a position which allows them to be taken away in proper sequence.

Heart of the new system is the linear cable engine. The machine has tractor-like grips above and below the cable that pull the cable, smoothly and gently, from the tanks at a speed of about eight knots in a manner that distributes the strain on the cable. The grips of the machine widen and close around one of the repeaters, letting the repeater pass without delay and still not allowing the cable to slip. Prior to proceeding to a cable-laying assignment, the repeaters are spliced into the cable at 20-nautical-mile intervals.

The 11,200 gross ton *C.S. Long Lines* is capable of continuous cable and repeater payout at an average speed of up to eight knots. The ship will be used to lay about 16,000 miles of cable over the next two years, and also to maintain the nearly 20,000 miles of Bell System ocean cable now in use.

Serpentine length of cable moves along loading trough toward LONG LINES.

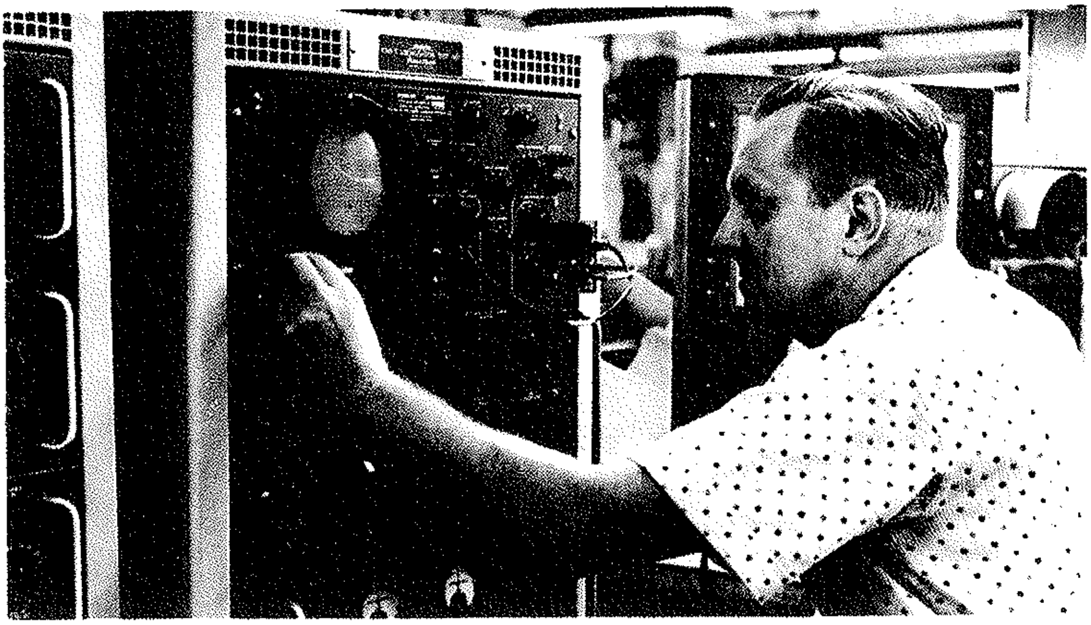


Underseas Trouble Shooter

Gone are the days of hit-or-miss methods of locating the rare faults that may develop in our submarine cables. To speed repairs, WE's Kearny Works manufactures a device called the Fault Localization Test Set that pinpoints any difficulty. Sets are in operation at each end of all of our cables.

The test sets are, in essence, electrical models of the actual cable systems in that they consist of simulated repeaters and cable sections having the same electrical characteristics as the actual cable. If a fault occurs, an operator sends a signal over the actual cable as well as over the model cable in the test set. He then explores each 20-mile section on the test set by inserting a section containing a simulated fault. When he reaches the cable section in the test set corresponding to the faulty section in the actual cable, an oscilloscope tells the operator he is on target. Even the nature of the actual fault—a leak, short circuit, a complete break—can be determined by the test set because the simulated fault can be adjusted to coincide with the actual fault.

If trouble comes, this Fault Localization Test Set, being checked out at Kearny Works, will locate faults on the ocean floor.



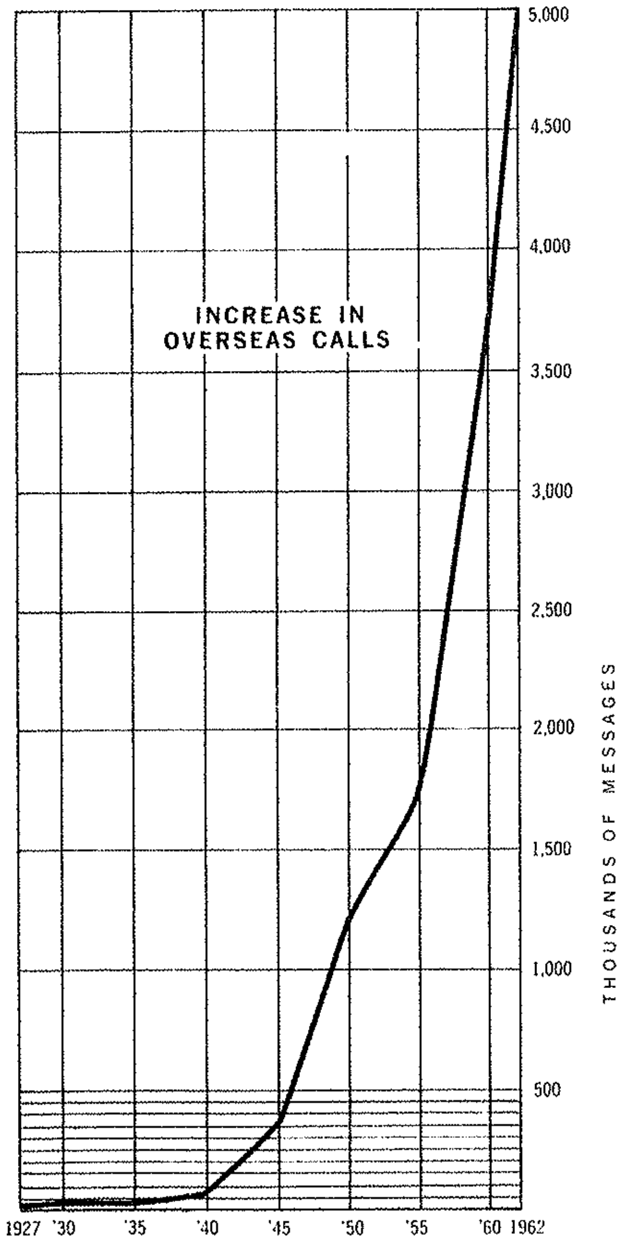
The Future

There is no such thing as finality in the communications field. What is new and good today will be followed by something newer and better tomorrow. The Bell System's Telstar program is an example.

The question might be asked: "Why continue to develop and lay cable systems for international communications when there is every reason to believe satellites might be the communications medium of the future? Couldn't a satellite system do more than an ocean-full of cable?"

Frederick R. Kappel, AT&T board chairman, has said: "In a few years' time, the capabilities of ocean cables for handling all kinds of communications, including television, will surely equal those of satellites. And looking to the long future, which is very long indeed, the world's need will surely require the best we can accomplish in building voice highways across the reaches of space *and* along the ocean floor."

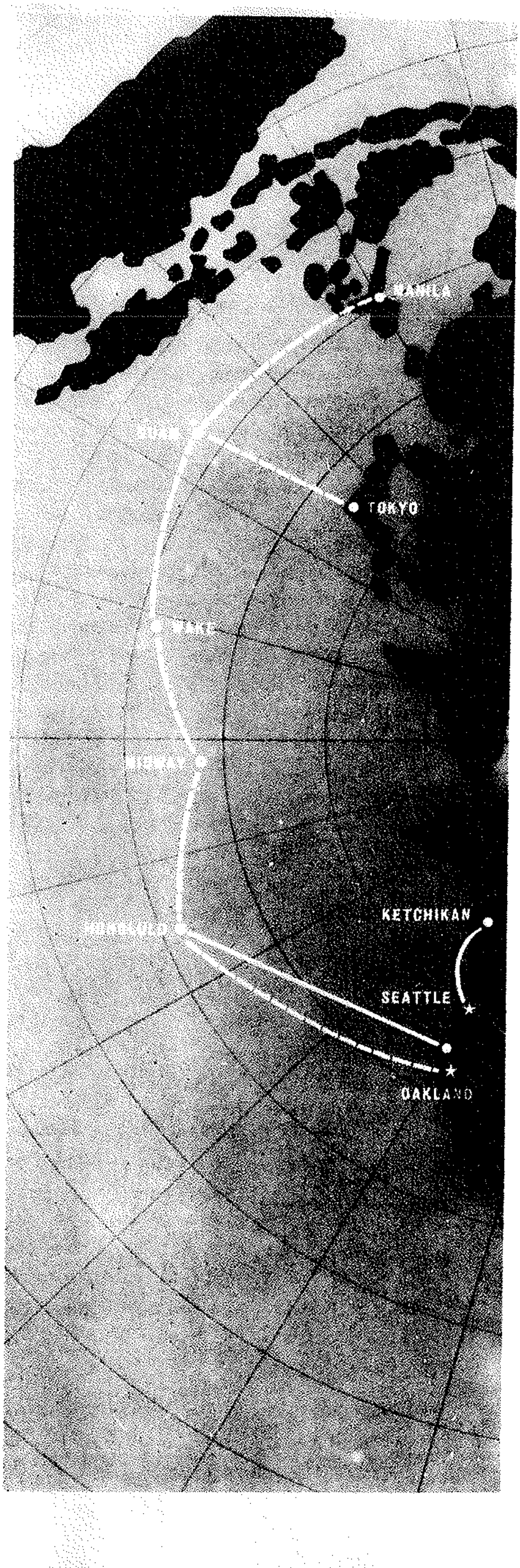
The Bell System is and will continue to be a world leader in communications satellite research. But it is difficult to say with certainty when mankind will be able to loft enough satellites in precisely the proper location, or traveling at precisely the proper speed, to help handle the world's communications. And even when such a system is realized, the growth in overseas needs means that cables and satellites, as well as overseas radio circuits, are needed to assure diversity and flexibility and to provide the number of circuits that will be required.

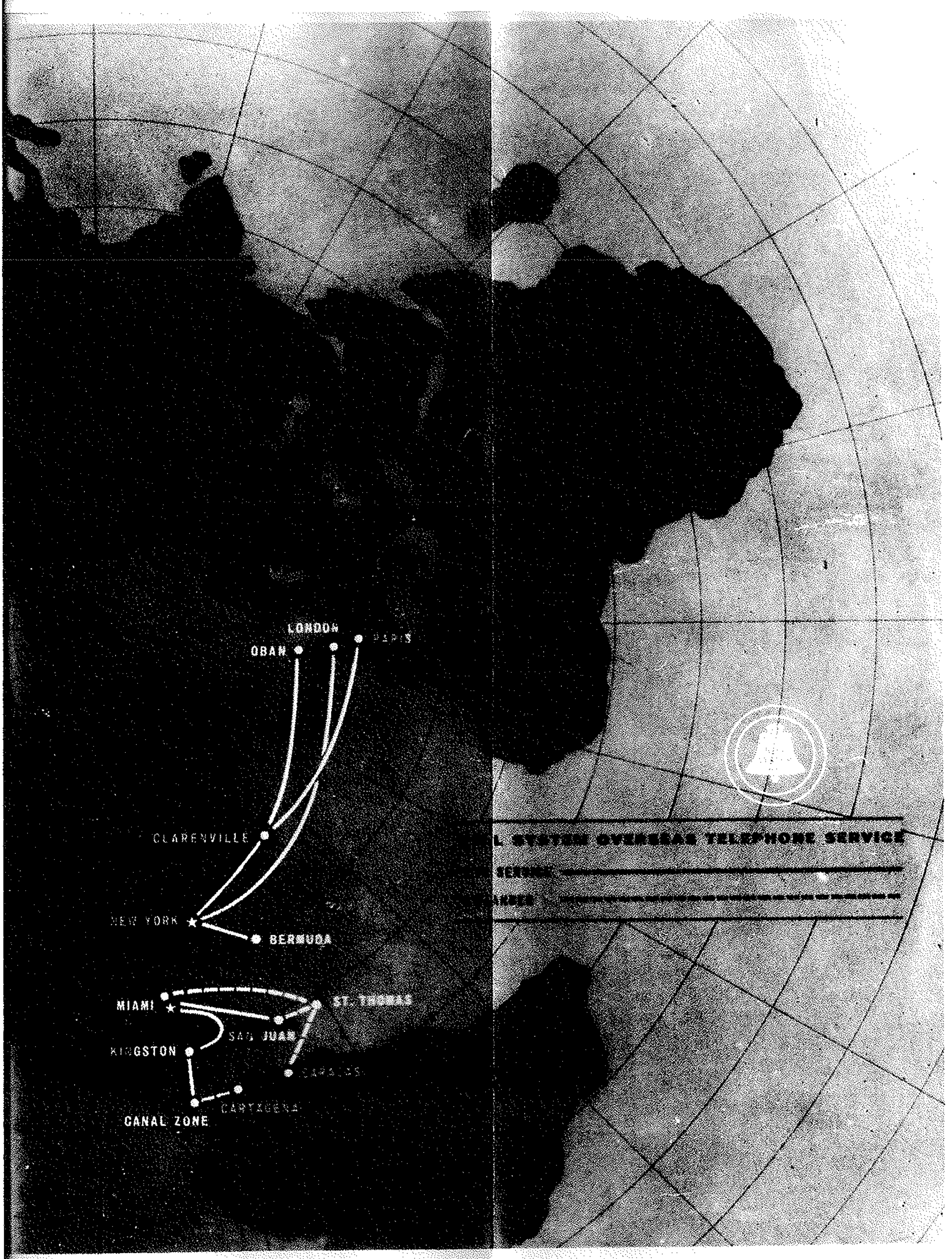


The Future (continued)

Today there are approximately 700 U.S. overseas circuits, lumping radio-telephone and cable circuits together. In the late Sixties, AT&T plans to have ready for use a transistorized cable that will carry 720 voice circuits. But the volume of overseas messages is increasing at a rate of 15 per cent every year. AT&T forecasts that by 1980 we shall need 10,000 circuits for telephone calls alone if this rate of increase is maintained. This figure will have to be augmented by 2,000 circuits for data and defense communications and still more for television.

Meanwhile, Bell System communications technology is providing the world's telephone users with ever newer, ever better overseas service. Direct operator dialing between Europe and the U.S. recently went into effect. In cooperation with Great Britain, it is expected that direct operator dialing will be introduced between the U.S. and Australia in 1963. The same service with Japan will follow in 1964 upon completion of the cable between Hawaii and Japan.

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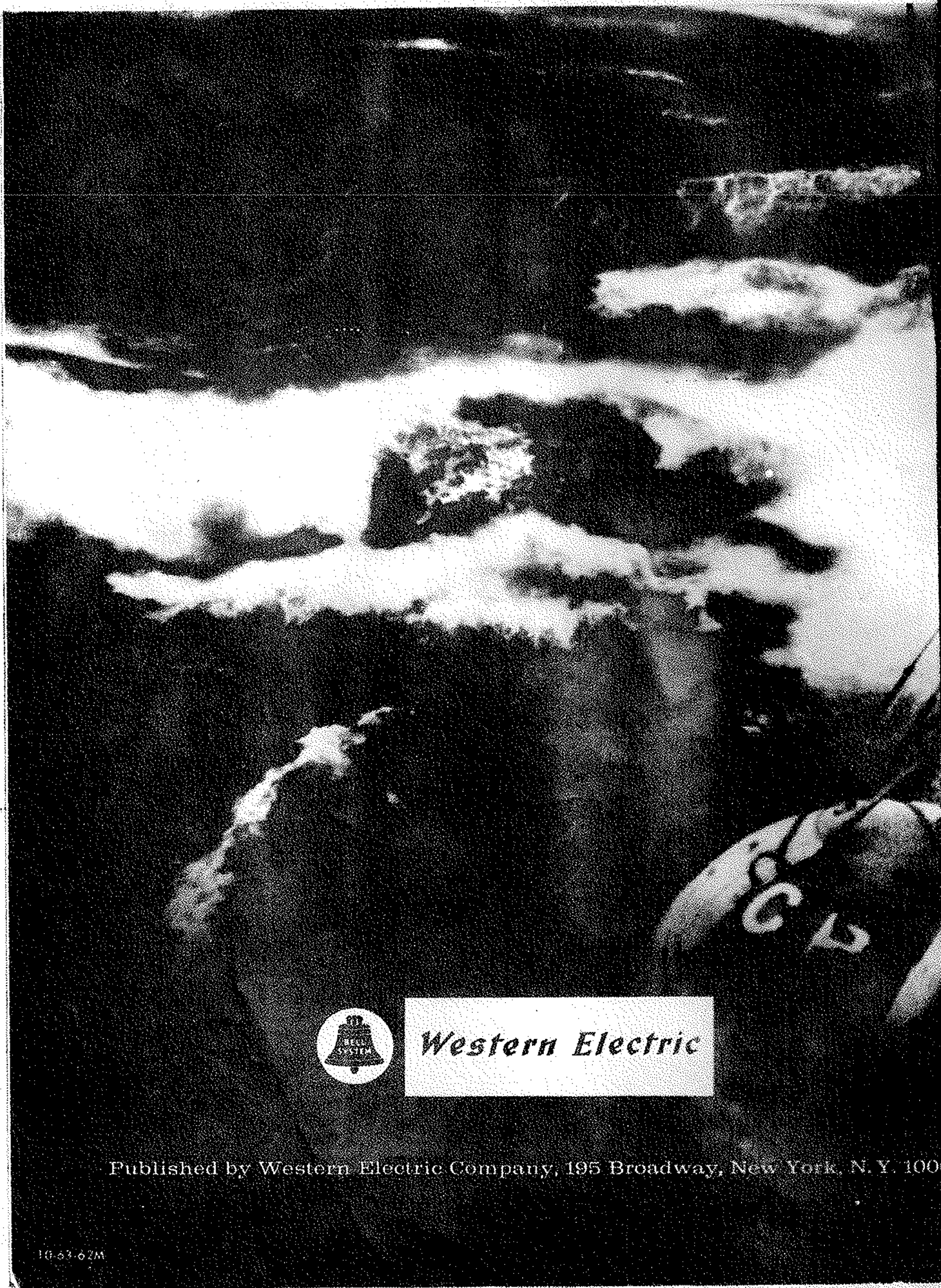

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