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ABSTRACT

After outlining the Federal Communications Commission's (FCC) responsibility for regulating interstate common carrier communication (non-broadcast communication whose carriers are required by law to furnish service at reasonable charges upon request), this information bulletin reviews the history, technological development, and current capabilities and prospects of telegraph, telephone (underseas cable), telephone (radio), satellite communications, the communications satellite corporation, telegraph (ocean cable), telegraph (radio), and telephone (wire). (RH)

Common Carrier Services

12-C 3/72

INFORMATION BULLETIN

PUBLIC INTEREST

The public has a vital stake in common carrier wire and radio communication. In 1969 it paid over 16 billion dollars for such service over facilities representing an investment of about 55 billion dollars.

EARLY FEDERAL REGULATION

Though several earlier acts of Congress related to specific telegraph matters, Federal regulation of interstate electrical communication may be said to date from passage of the Post Roads Act in 1866. This legislation was intended to foster the construction of telegraph lines by granting, among other things, rights-of-way over public lands.

Federal regulation of the rates and practices of interstate communication carriers was initiated by the Mann-Elkins Act of 1910. This extended certain provisions of the Interstate Commerce Act to cover common carrier services, both wire and radio.

COMMUNICATIONS ACT OF 1934

The Communications Act of 1934 coordinated in the Federal Communications Commission regulatory powers formerly exercised by various Federal agencies and broadened considerably the scope of such regulation. A major purpose of this statute is "to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges . . ."

COMMUNICATIONS SATELLITE ACT OF 1962

The Communications Satellite Act of 1962 provided for the establishment, in cooperation with other countries, of a commercial communications satellite system as part of an improved global communications network.

The United States' participation in this system is through the Communications Satellite Corporation (Comsat), a private corporate entity organized under this Act and subject to governmental regulation. Comsat's principal roles in this system are to act as manager of the conventional U.S. communications common carriers.

REGULATORY RESPONSIBILITIES OF FCC

The Federal Communications Commission regulates interstate and foreign communication such as telephone, telegraph, facsimile, telephoto and broadcast program transmission, whether by wire or radio, including cable and via satellites. Common carrier communication which is purely intrastate in character is not, in general, subject to Commission jurisdiction but comes under the authority of state utility commissions. Broadcast stations are not deemed "common carriers" by the Communications Act. In brief, a communications common carrier under the law is one whose services are open to public hire for handling interstate or foreign communications by electrical means.

The Communications Act recognized two types of such common carriers -- those fully subject to the Act, and those only partially so. The latter do not engage in interstate or foreign communication except through connection with the wire, cable or radio facilities of nonaffiliated carriers. They are exempt from certain provisions of the Act which apply to fully subject carriers.

The Act requires that every subject common carrier furnish service at reasonable charges upon reasonable request. No subject carrier may construct, acquire, or operate facilities for interstate or foreign communication without Commission approval. Likewise, it cannot discontinue or curtail such service without Commission approval. All charges, practices, classifications and regulations in connection with interstate and foreign communication service must be just and reasonable. The common carriers concerned file tariff schedules with the Commission, and those schedules are subject to review and regulation by the Commission.

The Commission has authority to prescribe the forms of records and accounts to be kept by the fully subject carriers. Under this authority, it has established uniform systems of accounts for them to follow, including the establishment and maintenance of original cost accounting, continuing property records, pension cost records and depreciation records. The Commission also requires the carriers to retain records for varying periods.

The Commission also prescribes the depreciation rates for the larger domestic telephone and telegraph carriers to be used in determining the depreciation charges to be included under operating expenses.

The larger fully-subject carriers file monthly and annual reports with the Commission giving specified financial and operating information.

The Commission regulates the interlocking of officers and directors of carriers fully subject to the Act, it being unlawful for any person to hold office in more than one such carrier unless authorized by the Commission.

Operating under licenses granted by the Commission, common carriers now use radio facilities over a substantial portion of their long-distance communication pathways. These as well as other radio facilities must be regulated to curb interference and avoid inefficient use of the limited frequency spectrum.

The common carrier radio license privilege is limited by the Act to citizens of the United States. It is denied to corporations in which any officer or director is an alien or of which more than one-fifth of the capital stock is owned by aliens or foreign interests.

After obtaining the approval of the Secretary of State, the Commission can issue and, after hearing, withhold or revoke licenses to land or operate submarine cables in the United States.

The Commission is charged with domestic administration of wire, cable and radio communication provisions of treaties and other international agreements to which the United States is a party.

The Communications Satellite Corporation is subject to the same regulatory controls by the Commission as are other communications common carriers, as well as to certain additional regulatory requirements. For example, the Commission must insure that there is effective competition in all procurement of equipment and services required for the satellite system by the Corporation or other common carriers and must insure that small business has an equitable opportunity to participate in such procurement. The Commission must also approve all financing by the Corporation, except for the initial issue of capital stock.

The Commission must also approve the technical characteristics of the system to be used by the Corporation and authorize the construction and operation of each terminal station either by the Corporation or by other carriers, or by both, as it determines will best serve the public interest, convenience and necessity.

TELEGRAPH

Invention

The concept of transmitting intelligence by electricity over a wire and the principle of electromagnetic telegraph was developed by Samuel F. B. Morse, an eminent portrait artist and professor at New York University. In 1835, Morse built the first telegraph instrument and tested it by stretching 1700 feet of wire around his room and sending signals from one end to the other.

As with many new inventions, immediate interest and acceptance was not forthcoming. Even after a demonstration before President Martin Van Buren in 1838, it took Congress five years before they agreed to appropriate $30,000 to build an experimental telegraph line from Washington to Baltimore.

In April of 1844, members of Congress witnessed the sending and receiving of messages over the partially completed line. The Whig party held its national convention in Baltimore where Henry Clay was nominated on May 1, 1844. This news was hurried to Annapolis Junction (between Washington and Baltimore) where Morse's partner, Alfred Vail, wired it over the completed portion of the line to the capital. This was the first news dispatch carried by electric telegraph.

The official opening on the completed line was held on May 24, 1844, when Morse sent his famous first message "What hath God wrought?" from the Old Supreme Court chamber in Washington to his partner in Baltimore.

Three days later the Democratic national convention in Baltimore nominated James K. Polk, Since Van Buren seemed the likely choice, skeptics refused to believe the report telegraphed to Washington until persons arriving by train from Baltimore confirmed the story. The telegraph then became an accepted, valuable tool in communications.

Development

Morse and his associates obtained private funds to extend their line to Philadelphia and New York. Other firms entered the field and small telegraph companies began springing up in the East, South and Midwest.

Wire telegraph played an important part in the Nation's development. It speeded communication at the time the West was being opened. It aided the extension and operation of railroads. The dispatching of trains by telegraph began in 1851 and side by side, the iron rail and iron wire pushed over plain and through wilderness to make new settlements possible and to bring regions into closer contact. This association of telegraph and railroad built communities and opened markets.

On April 1, 1851, a group of Rochester, New York, businessmen organized The New York and Mississippi Valley Printing Telegraph Company, which started operation with 550 miles of wire and the license to use a telegraph printer invented by Royal E. House.

This device, resembling a small piano, was the first telegraph instrument to print Roman letters, numerals and punctuation marks instead of Morse code. While it had only limited use then, the House printer established the basis for development of today's high-speed, automatic printing telegraph machines.

When the new company began operation there were fifty other small telegraph companies. There was no interconnection of lines, messages were transferred physically from one company to another, and rates were as high as $20 for a single telegram. The New York and Mississippi Valley Printing Telegraph Company set out to establish a unified, efficient service on a nationwide basis.

During its first five years, the company acquired eleven other lines operating in the five states north of the Ohio River. On April 4, 1856, the name of the company was changed to The Western Union Telegraph Company, signifying the union of "western" lines into one system.

At the outbreak of the Civil War, fast communication with the far west became essential. The only rapid communication with the west at that time was by Pony Express, which required as many as ten days to carry telegrams and mail from the western telegraph terminal at St. Joseph, Missouri, to Sacramento, California. A telegraph line was needed to bridge the gap, but the task of stringing a 2,000-mile pole line across plains filled with hostile Indians and over the rugged Rockies, was a formidable one. Engineering experts predicted that the project would require ten years to complete.

A young and resourceful Western Union general agent surveyed several different routes for the transcontinental system and finally followed the Pony Express route. Next, he organized two teams of builders, one to work from the west and the other from the east.

The strands of wire, uniting the Nation in rapid communication for the first time, were joined at Salt Lake City on October 24, 1861--exactly three months and twenty days after the project was started; the experts were amazed.

Competition

Until 1877, all rapid long-distance communication depended upon the telegraph. However, the advent of the telephone in that year brought rivalry. Patent litigation between Western Union and the infant telephone interests was terminated in 1879 by an agreement which largely separated the two services.

In 1881, the Postal Telegraph Company, a competitive system, entered the field. For economic reasons, Postal was merged with Western Union in 1943. The result is that today only one company -- Western Union -- offers a nationwide public message telegraph service. There are some other telegraph companies, but they are small and mostly serve railroads or particular industries in limited areas.

Progress

The last half century saw major improvements in Western Union's nationwide communications network. Nonrusting, low resistance copper wire was substituted for the iron wire used initially. Overhead telegraph wires in congested areas were replaced by underground cables which are constantly being improved and enlarged to handle the growing volume of record communications.

The company's coast-to-coast microwave beam system was completed in 1961, exactly 100 years after the completion of the first transcontinental telegraph line. This system is designed to handle forms of communication including data, voice and video, at high speeds and in large volume. Western Union is continually in the process of expanding and improving this network. Plans are underway to overbuild (add to the existing facilities) with digital equipment to handle the growing demand for data communications and provide even faster service.

The original Morse telegraph involved code printing and reproduction on tape, and in most countries this mechanical feature was retained. In the United States, however, the industry for many years depended upon the operator's ear as well as his "fist." In those days a good Morse code operator could send 40 to 50 words a minute.

Teleprinter, or teletypewriter machines started to come into general use about 1925. The message is typed on a typewriter-like keyboard and reproduced on a like instrument at another point. In addition to their use by telegraph companies, these machines are a particular aid to press services and other business, as well as government entities. Modern equipment can transmit up to 150 words per minute through the use of automatic tape drives.

Western Union developed the "multiplex" system which made possible the transmission of eight messages simultaneously over a single wire (four in each direction) on a time-sharing basis. The first multiplex circuit was installed between New York and Boston in 1913. Many messages can be sent simultaneously over a single pair of wires by utilizing separate electrical frequencies. The latter is known as the "carrier current" system, and is now extensively used for telegraph transmission. The ease by which circuits may be derived through carrier current methods has resulted in a departure from multiplex and other time-sharing systems toward individual channels for operator sending and receiving.

Installation of mechanical message switching equipment commenced in 1937. It has been extended by Western Union into a system of automatic and semi-automatic reperforator switching centers in key cities. This has eliminated the manual retransmission of messages at relay offices and has resulted in speedier service. Several computer centers which automatically relay message traffic have already replaced some of the reperforator centers. Gradually, others will be installed and by the end of 1972 all message switching and routing will be handled electronically by computers rather than mechanically.

Other improvements of telegraphic service now under way include the restructuring of the public office network to be more responsive to customer preference and usage. Prominent among these programs is the establishment of several large centralized telephone bureaus for accepting telegrams. The first of these centers, in Moorestown, New Jersey, was placed in service late in 1971.

When this program is completed early in 1973, customers anywhere in the country wishing to send a Western Union message may do so by dialing a toll-free number to reach an operator promptly, at any time of day or night.

These telephone bureaus will be supplemented by a combination of large company-owned public offices and a nationwide network of Western Union agencies established with reputable business entities in the communities being served.

In addition, Western Union is continually studying and instituting new services to make communications more accessible to the public. In most places customers may charge all telegraphic service--messages, money orders, and gifts--on bank credit cards.

Western Union also provides the landline handling of international and ship-shore messages originating and terminating in the continental United States outside of the so-called "Gateway" cities. Gateway cities are those in which the terminals of international carriers are located.

Extensive private wire systems, in which the telegraph company leases circuits and equipment for operation by customers, are provided by Western Union to business firms, Government agencies and military services. Certain of these systems employ equipment and methods similar to those used in the telegraph company's own mechanized switching centers, and incorporate computer and data transmission techniques permitting communication by high-speed printers, punched card and magnetic tape devices, facsimile, high-speed data and voice.

Facsimile has been employed by Western Union since 1939 to connect customers directly with telegraph offices, and to provide certain business customers with local private line intercommunication systems. The telegraph company also provides a public facsimile service between certain of the larger cities.

In 1959, Western Union placed in operation a customer-to-customer teleprinter exchange service called "Telex," which permits users to dial other subscribers directly for two-way telegraph communication. It links various cities in the United States, Canada, and Mexico. Western Union also provides Telex service, through the facilities of the international carriers, to subscribers in Hawaii and some 135 countries abroad. Telex patronage has continued to grow rapidly and subscribers in the United States now number approximately 33,000.

During the 1960s additional services were added to the Telex offering to provide more sophisticated time and money saving services. Four computer centers are now in operation in New York, Chicago, San Francisco, and Atlanta providing users with Telex Computer Communications Services (TCCS). TCCS became nationwide in 1970 and enables users to dial directly into the computer centers for various purposes including: multiple address messages (as many as 100 messages, the same or different, to 100 different addresses with only one connection), interconnection with the TWX network, store-and-forward if the receiving line should be busy, and connection with the public message network to file telegrams.

On July 28, 1970, the Federal Communications Commission gave its approval for the company to purchase the TWX network from the Bell System. TWX, a direct-dial teleprinter exchange service similar to Telex, currently has 40,000 subscriber terminals around the country. Western Union assumed full operation of TWX on April 1, 1971. Within a few years, the Telex and TWX networks will be joined together to make a single nationwide, computer-operated teleprinter exchange service providing written communications for over 75,000 customers.

Broadband Exchange Service, inaugurated by Western Union in 1964, and now serving more than 457 domestic subscriber stations in 48 cities, enables subscribers to use pushbutton instruments to select transmission channels of various bandwidths to meet voice, facsimile or high speed data or punched tape, drums or teleprinters.

Hot/Line service now provides a subscriber with an inter-city private line business telephone service in which a permanent connection between stations is activated and rings the distant telephone, without dialing, immediately upon lifting the handset at either terminal.

The decade of the 60s was one of technological advancement for Western Union. This advancement has led to the introduction of many new communications offerings which are described briefly in the next few paragraphs.

Two shared-use, computer-operated communications services are now in use. Information Communications (INFO-COM) is specially designed to serve the needs of general business. The Securities Industries Communications Network (SICOM) is now serving special requirements of users of the Securities Network. Both were designed to provide advanced private wire record communications services at a substantial reduction in cost to the user through the shared use of the electronic data communications equipment necessary to operate them.

A unique experiment taken on in 1969 by Western Union in conjunction with the U. S. postal department has proved extremely successful in tests over the last two years. The service, called MAILGRAM, combines the technological know-how and facilities of Western Union with the Post Office's nationwide delivery force. MAILGRAM provides fast, next-day delivery of messages at a cost more than an airmail letter, yet less than telegram. Since January of 1970 the service has been available to Telex and INFO-COM customers in a number of cities. Using already-in-place equipment, customers file their messages to a computer which routes them by zip code to a receiving post office nearest the destination city. In certain cities MAILGRAMS may be filed by the general public by telephone or at Western Union Offices. A postal employee takes the message off the teleprinter, stuffs it in a specially-designed window envelope and hands it to a postman for first class delivery.

Customer acceptance of MAILGRAM has been so great that volume has grown from about 400 per week during the first month of testing in 1969 to 25,000 per day at the end of 1971.

In December of 1970, a new computer center was added to the basic Western Union network specifically to expand MAILGRAM service. Presently, the number of Telex subscriber terminals to which MAILGRAM will be available during the remainder of the experimental period is being increased. In addition, the company has begun working with several high volume users to establish procedures for accepting multiple-addressed MAILGRAMS directly from computer-generated magnetic tapes for intercity transmission to local post offices.

DATACOM service was introduced in 1970, in response to the evident need of large data-communications users for low cost transmission facilities. It provides for private use of a data channel between 45 major cities along the route of Western Union's transcontinental microwave system. Through new methods of channel subdivision that increase the information-carrying capacity of a given bandwidth, DATACOM is said to save bulk users as much as 80 percent of their transmission costs.

Coaxial cable is designed to carry radio and TV programs as well as telephone and telegraph traffic. Its ability to transmit currents on an extremely wide range of frequencies permits the handling of a much larger number of communication channels over a single pair of conductors than was previously possible.

One pair of coaxial units can carry as many as 9,000 telephone conversations simultaneously. Alternatively, each of these voice pathways can be equipped to provide up to 18 telegraph circuits. The most modern coaxial cable comprises 22 tubes; 20 (10 pairs) are used for regular service and two tubes are kept in reserve. Thus, at normal capacity, a coaxial cable system can handle as many as 90,000 conversations simultaneously. TV signals may also be carried on these coaxial facilities.

CATV Service

Community antenna television (CATV) service over coaxial cables was initiated in 1949. It first developed in communities situated in valleys and other locations where unfavorable terrain prevented television reception by way of conventional rooftop antennas. Modern CATV systems transmit off-the-air broadcasting, locally originated programing and FM broadcasting direct to CATV subscriber homes via a network of coaxial cable. As many as 20 channels can be transmitted over a single system.

Dial Telephone

Development of the telephone is revealed in the evolution of its instruments. For example, it is a far cry from the streamlined dial handsets of today to the cumbersome wall hand-rung models of a generation ago.

It is an oddity that the dial telephone was invented by an undertaker--Almon B. Strowger of Kansas City. He devised it about 1889. The first dial exchange was installed at La Porte, Indiana, in 1892. By 1921, dial telephones came into general use. Today, about 98 percent of all telephones are dial-operated. In addition to local dialing, almost all subscribers can dial distant telephones.

Switchboards

Telephones were first leased in pairs. The subscriber had to put up his own line to connect with another listener.

The first switchboard was set up in Boston in 1877. New Haven saw the first regular telephone exchange in 1878. Early switchboards were manned by boys.

Development of the switchboard permitted interconnections to be made with fewer lines. For example, to join six subscribers with one another by private lines would require 15 separate circuits. One switchboard can handle many times that number of lines. Thus, a switchboard serving 10,500 telephones is a substitute for 55,119,750 separate wire connections. In busy areas, "multiple" switchboards duplicate subscribers' line terminals for speed and convenience in making connections.

Another important telephone development was the vacuum tube repeater amplifier. Under the voice frequency system, telephone repeaters are placed at 35- to 150-mile intervals while under the cable carrier system repeaters are only about 8 to 17 miles apart. Coaxial cables require repeaters at about 1- to 8-mile intervals. It staggers the imagination to realize how the energy of one's voice has to be stepped up for a coast-to-coast telephone call. About the easiest way to indicate this is to say that this "boost" is figured at 10 followed by 100 ciphers!

Transistor

The transistor was developed by the Bell Telephone Laboratories in 1948. It consisted of a metal tube about the size of a shoelace tip containing two hair-thin wires touching a pinhead-size piece of a solid semi-conductive material soldered to a metal base. It used about one-tenth of the power required to operate an ordinary flashlight bulb and amplified about 100 times.

Transistor development has progressed rapidly. Today thousands of different types are available to meet specific needs ranging from amplification to high-speed switching. Because of their small size, low-power requirements and reliability, transistors have supplanted vacuum tubes for many communication uses. Transistors made smaller radio receivers possible.

They opened the way to direct distance dialing and have an important part in TASI and the pulse code modulation system used on land cables. They work in many telephone transmission and switching systems as well as in missiles, satellites, computers and all types of data processing equipment. They also have application in hearing aids, artificial larynxes and other devices.

Carrier Systems

Carrier technique permits large numbers of telephone conversations to be transmitted, without interfering with each other, over a single pair of conductors, a coaxial cable or a radio system. This is done at the sending end by translating the speech currents of different conversations from their ordinary voice frequency range to higher frequency bands. At the receiving end, the signals are again translated downward to their original audio frequencies.

On Bell System open wire lines, as many as 16 different conversations are carried simultaneously over a single pair of conductors. In cables, two pairs of wires often carry 24 conversations at the same time, or as many as 216 duplex telegraph circuits. In the case of coaxial cables and microwave radio systems, this same technique enables transmission of thousands of simultaneous conversations. The method of using current of different frequencies to "carry" several conversations is also applied to the transmission of telegraph messages, data and facsimile.

One of the most recent developments, designed to increase the capacity of underground cables in urban areas, is pulse code modulation (PCM). PCM takes the sound of the human voice and translates it into a mathematical code of high speed electrical pulses (64,000 per second per voice channel). Using this technique, 24 conversations, so coded, can take place over two pairs of wires simultaneously without interference. At the receiving end, these codes are translated by PCM terminals into the voice you hear on the telephone.

A PCM system is presently under development that will encode up to 96 voice channels for transmission over two pairs of cable conductors.

TASI

Time Assignment Speech Interpolation (TASI) is a system employed to increase the capacity and reliablity of overseas telephone circuits. The system detects pauses in normal conversation and transmits other active conversations during these pauses. TASI A normally carries 74 circuits on 37 channels. A new system, designated TASI B, can serve up to 235 telephone circuits on 100 overseas channels.

Due to the relatively high terminal costs of the TASI system it is not economically feasible to apply to land line (domestic) voice circuits operating over cable or radio multiplexed systems. Also, it is not economical to convert a TASI A system to a TASI B system.

Connections

The first Bell Telephone company started in 1878. It developed into the American Telephone and Telegraph Company (AT&T), incorporated in 1885. AT&T and its 23 associated telephone companies comprise the "Bell System," which provides a great variety of communication services.

Many independent telephone companies provide service, largely in the rural areas. Practically all of them interconnect with the Bell System, thereby permitting a telephone subscriber to call almost any other telephone subscriber in the world.

In the early days of the telephone, many cities and towns had rival telephone systems. Philadelphia, the last major area to give up dual service, did so in 1943.

TELEPHONE (UNDERSEAS CABLES)

The basic difference between underseas telephone cables and underseas telegraph cables is that underseas telephone cables have amplifiers spaced about twenty miles apart. The use of amplifiers provide a much higher capacity, and, in addition to telephone conversations, these cables can also handle non-voice or record communications such as data, teletype, slow-scan video, and facsimile.

The first transatlantic telephone cable was placed in service between Newfoundland and England in 1956, and between Newfoundland and France in 1959. By 1970, six additional cables had been laid connecting North America and Europe.

The latest one, TAT-5, connects Rhode Island and Spain and service is extended from Spain throughout Europe and the Mediterranean by microwave relay and a new Mediterranean cable.

In 1964, the first telephone cable to Japan was placed in service, linking Hawaii, Midway, Guam, and Japan. On Guam, connection is made with a cable to the Philippines and with a British Commonwealth cable to Australia, New Guinea, Hong Kong, North Borneo, and Singapore. At Hawaii, the cable is interconnected with two U.S.-Hawaii cables and with a British cable from Vancouver, Canada, to Fiji, New Zealand, and Australia.

Several cables interconnect the islands in the Caribbean. Cables have been laid from Florida to Puerto Rico, to St. Thomas, and to Jamaica. From Jamaica, the cable is extended to the Canal Zone and St. Thomas is connected with Venezuela by cable. In addition, a cable was laid in 1962 from New Jersey to Bermuda and extended to Tortola. Other islands in the Caribbean are interconnected by satellite, over-the-horizon and high frequency radio and microwave relay.

The first few of these underseas telephone cables consisted of two cables (one for each direction) enclosed by a layer of steel wire for strength and protection. The amplifiers used vacuum tubes and were spaced about 40 miles apart. These cables could handle about 48 telephone conversations over a maximum cable length of 2200 nautical miles. In contrast, the latest cable laid across the Atlantic can handle over 700 two-way telephone conversations over a maximum cable length of 4000 miles on a single cable. This type of cable is coaxial with an inner stranded steel wire for strength. This stranded wire is copper plated and acts as the inner conductor of the coaxial cable.

Around this is an insulating layer of polyethylene an inch and a half in diameter covered by a layer of copper that serves as an outer conductor. The entire cable is surrounded by a waterproof layer of polyethylene. The amplifiers are transistorized and spaced about ten miles apart. Near the shore ends, the cable is protected with a layer of external armor and buried for additional protection from damage by trawling and dredging operations.

TELEPHONE (RADIO)

Development

The ingenuity of many individuals made radiotelephony possible. Besides enabling most of the world's telephones to be interconnected, radio is supplementing or augmenting wire lines in the United States and is extending the telephone network to isolated places, moving automobiles, trains, airplanes, and vessels.

Dr. Lee De Forest used radio in 1907 to telephone from ship to shore the results of a yacht race on Lake Erie. In 1915, speech was successfully transmitted from Arlington, Virginia, to the Eiffel Tower in Paris. Shortwave transatlantic communication with high-frequency radio signals generated by tube transmitters began in 1924. Commercial radiotelephone was opened between New York and London in 1927, and to South America three years later.

In 1935 the first telephone call was made around the world, using a combination of wire and radio circuits.

Overseas Telephony

Before the first underseas telephone cable was laid in 1956, the only method available to place a telephone call overseas was by means of high frequency radio. Since then, the underseas cable and the communications satellite have supplanted high frequency radio for overseas calls. High frequency radio is used today primarily to reach points not served by either cable or satellite and as a backup to these newer facilities.

Whether cable, satellite, or radio facilities are used, the basic procedure in making an overseas call is the same. The caller initiates a call from any telephone in the domestic telephone system and the long-distance operator switches the call to the appropriate overseas operating office.

If an overseas circuit is available, the overseas operator completes the call immediately. Otherwise, the overseas operator asks the caller to hang up and that she will call him back when a circuit is available. Although English is used by the overseas operators in this country and at the foreign terminals, parties to an overseas telephone conversation may use any language.

From the overseas operating office, the call is routed by landline to the appropriate underseas cable terminal, earth station, or radio transmitter, depending on whether a cable, satellite, or high frequency radio circuit is used. At the receiving terminal of the circuit, the call is routed to the operating office at the overseas location and then through the local telephone network there to the person for whom the call is intended.

Recently, direct distance dialing has been established between New York City and a large part of Europe. Within the next decade, it is anticipated that distance dialing will be expanded to include most of the world.

Privacy of overseas point-to-point high frequency radiotelephone conversations is assured by "scrambling" the speech. This is done by a device at the transmitting point which jumbles the words so that they sound like gibberish to anyone who might listen in, but at the receiving end the electric currents which produce the sound waves are restored to their original form. The scrambling is not always possible on high seas ship-to-shore circuits.

Alaskan Radiotelephone

In Alaska the nature of the terrain and distribution of the population makes radio essential for speedy long-distance communication. Accordingly, virtually all the coastal and point-to-point radio services there furnish public telephone or telegraph service. Independent radiotelephone stations throughout Alaska are interconnected in a network operated, until recently, by the Alaska Communication System (ACS), an agency of the Department of the Air Force. As a result of Alaska's achieving statehood, there has been an expansion in the State of non-Government operated radiotelephone facilities.

In January 1971, the Alaska Communication System was sold to RCA Alaska Communications, Inc. (RCA Alascom), a new subsidiary of RCA Global Communications.

SATELLITE COMMUNICATIONS

Early Experiments

The use of satellites to relay communications over long distances was proposed as early as 1945 by the British scientist and science fiction writer, Arthur C. Clarke. The first of a series of experimental satellites to test the feasibility of satellite communications was launched in 1960, and within five years the technological foundation was laid for the establishment of a global system of communication satellites.

One of the first of these experimental satellites was Echo I, which was launched August 1960. Echo was an inflated sphere of aluminized mylar, approximately a hundred feet in diameter. Two earth stations, which could both see the Echo satellite, could communicate with each other by bouncing radio signals off the satellite's reflecting surface. Although communications were successfully accomplished, it was not deemed practical to use passive satellites, such as Echo, for regular communications because of the extremely high transmitting power required and the resulting small capacity provided.

Another type of experimental satellite that was launched contained active repeaters. These satellites (Score, Courier, Telstar and Relay) received the signals transmitted from the earth stations, amplified them, and retransmitted them back to earth at a different frequency. In addition, several of these satellites caused recorders to store messages received from an earth station for retransmission at a later time. This allowed earth stations to communicate with each other even though the satellite was not visible to both earth stations at the same time. Of course, telephone messages could not be handled by this scheme.

All these satellites were placed in relatively low altitude inclined orbits. As a result, the satellites could be seen simultaneously by two earth stations for only about 15 minutes at a time. This problem was solved by the launch of the Syncom satellites into geostationary orbits. These satellites are placed in orbit at an altitude of 22,300 miles with zero inclination. The period of a satellite at this altitude is 24 hours so that the satellite appears to be stationary with respect to the earth's surface, hence the name geostationary satellite. All earth stations that can see the satellite can communicate with each other for 24 hours a day. At this altitude, the range of service covers roughly a third of the earth's surface. Since Syncom, all the communications satellites that have been launched for regular service have been placed in geostationary orbits.

The Global Communication Satellite System

As a result of the success of these early experimental satellites, the U.S. decided to make this technology available to the world by the establishment of a global communications satellite system on a commercial basis. In 1962 Congress passed the Communications Satellite Act of 1962, which created the Communications Satellite Corporation (Comsat) and charged it with the responsibility of establishing the system on a commercial basis. Two years later, on August 20, 1964, the International Telecommunications Satellite Consortium (INTELSAT) was established under the Agreements Establishing Interim Arrangements for a Global Commercial Communications Satellite System. From the original fourteen signatories, INTELSAT has grown to a consortium of 77 member nations at the end of 1970.

The first of the commercial communications satellites, Early Bird, was placed over the Atlantic in 1965 and had a capacity of 240 two-way voice circuits, or a single one-way TV channel. This satellite was an 85-pound cylinder 23 inches high and 28 inches in diameter and could be used by only two earth stations at a time. By January 1971, nine additional satellites had been placed in orbit.

In contrast to the first of these satellites, the fourth generation INTELSAT IV satellite is a 1500-pound cylinder 94 inches in diameter, with an overall height (including antennas) of over 17 feet. This satellite can handle up to 9000 two-way telephone conversations, or 12 TV channels, and may be used by any number of earth stations at the same time.

Similarly, the number of earth stations for use with this system has grown from five in 1965 to an estimated 70 earth stations in over fifty countries by the end of 1972. U.S. earth stations are located at Andover, Maine, Etam, West Virginia, Jamesburg, California, Brewster Flats, Washington, Talkeetna, Alaska, Paumalu, Hawaii, Cayey, Puerto Rico, and Guam.

THE COMMUNICATIONS SATELLITE CORPORATION

The Communications Satellite Corporation (Comsat), established under the Communications Satellite Act of 1962, is a unique entity in the number of roles it plays. Comsat is a private corporation regulated by the Commission that furnishes satellite circuits to other U.S. communications carriers. It was financed by an initial offering of 10 million shares at $20 a share. Half of these shares were purchased by U. S. carriers authorized by the Commission to own stock in Comsat and the other half by the general public. The corporation is governed by a board of 15 directors, three of whom are appointed by the President of the United States and the other 12 elected by the carriers and the public stockholders. The number of directors selected by each group changes from time to time as stock is purchased and sold.

Comsat is also the official representative of the United States in the International Telecommunications Satellite Consortium (INTELSAT) and casts the U.S. block of votes in INTELSAT in accordance with U. S. policy as directed by the Department of State, the Commission, and the Office of Telecommunications Policy of the Executive Office of the President.

In addition, Comsat currently serves as manager of the global satellite system with the basic responsibility for the planning and managing of the system under the direction of the Interim Communication Satellite Committee, which represents the entire membership of INTELSAT.

Domestic Satellite Communications

To date, satellites have been used for communications primarily across intercontinental distances. In 1965, the American Broadcasting Companies, Inc. requested an authorization for a satellite system to distribute TV programs to its affiliates throughout the U.S. Because of the difficult technical and legal issues involved with a domestic satellite system, an extensive five-year inquiry was conducted by the Commission. This inquiry resulted in a basic policy decision that domestic satellite systems should be authorized to any qualified entity and several formal applications have already been accepted. It is anticipated that communications satellites will be used within the next few years to relay telephone, data, and television traffic throughout the U.S., Hawaii, Alaska, and Puerto Rico.

TELEGRAPH (OCEAN CABLE)

Invention

In fathering the telegraph, Samuel F. B. Morse also pioneered in submarine telegraphy. Ocean telegraph cable is, in effect, a seagoing extension of the land telegraph system to link islands and continents.

In 1842, over an insulated copper wire submerged in New York harbor, Morse demonstrated that electrical impulses could be sent under water. It remained for the perseverance of Cyrus W. Field to make the submarine cable practical. Transoceanic cable service was accomplished after many disappointments.

With capital obtained from private subscriptions in New York and London and, in part, appropriated by the British and United States governments, an attempt was made in 1857 to lay a cable under the Atlantic Ocean.

The cable broke after 335 miles of it had been paid out by a ship operating from Ireland. In June the following year, another attempt failed. Not daunted, these pioneers succeeded in laying the cable the following month. But it soon became inoperative. Another cable-laying effort, in 1865, proved futile.

On July 27, 1866, the steamship "Great Eastern" completed the laying of a new cable from Valentia, Ireland, to Heart's Content, Newfoundland, for the Anglo-American Telegraph Company. Returning to mid-Atlantic, the ship located and raised the cable used in the 1865 attempt, spliced it, and extended it to Newfoundland, where it was landed on September 8. Thus, America and Europe were linked by two cables.

Telegraph cable communication did for these two continents what the land telegraph accomplished domestically. International commerce was stimulated, and the exchange of news became a matter of minutes instead of weeks.

Other transatlantic cables were laid by the American Telegraph and Cable Company in 1881 and 1882. Western Union entered the cable business by leasing these two cables in 1882. In 1884, the Commercial Cable Company put into operation two more Atlantic cables. Cable contact with Central and South America was established in 1882 by Central and South America Cables, the predecessor of All America Cables and Radio, Inc. The first transpacific cable from the United States, completed by the Commercial Pacific Company in the early 1900s, connected with Asia but was discontinued in 1951.

With the advent of radiotelephone, underseas telephone cables, and satellite facilities, as well as new modulation techniques, the underseas telegraph cables have been phased out and no longer play a significant role in overseas communications. The major reason for this has been the greatly expanded capacity of the new facilities. Since a telephone circuit can be subdivided into more than 20 telegraph channels, three voice circuits in an underseas telephone cable have the same capacity as an entire underseas telegraph cable.

This is to be considered in the light that a modern underseas telephone cable provides over 700 telephone circuits and satellite capacity is measured in thousands of circuits.

Construction

An ocean cable is not suspended from shore to shore. It is too heavy for that, so it rests on the bottom of the sea, miles deep, hugging submarine depressions and climbing and descending undersea mountains just as if laid on exposed terrain.

There is an erroneous idea that ocean cable is of the same thickness throughout. Most of it--the deep-sea section--is less than an inch in diameter, but toward shore it may reach a thickness of four inches. This is to protect it from being chafed by rocks or fouled by anchors or fishing gear.

Whenever there is a break in a cable or disruption of cable service, engineering tests are made at the shore terminals and then special ships can locate the point of trouble, grapple for the cable, no matter at what depth, and hoist it aboard ship for necessary splicing or other repair.

For nearly 60 years after the first cables were completed there was no material change in cable design. In 1924 a Western Union cable to the Azores featured certain improvements. Of the continuous loaded type, it featured a copper conductor and a separately wound metallic tape made of "permalloy" developed by the Bell Telephone Laboratories. The capacity of this compares with less than 300 letters a minute obtained with the original transatlantic cable. However, permalloy cables laid by Western Union in 1926 and 1928 have a capacity of approximately 2,400 letters (400 words) a minute.

Operation

The physical operation of an ocean telegraph cable is like that of a land line. As in the case of telegrams, cablegrams are sent automatically by printers or tape. Pictures can be cabled by facsimile.

Transatlantic cables were first operated by manually repeating the messages at points along the route.

In 1921, regenerators were developed which permitted direct transmission between terminals. This had the effect of speeding service as well as reducing expense.

Some telegraph cable carriers provide direct customer-to-customer cable service. This enables the businessman in New York who has a teleprinter in his office to cable a businessman in London whose office is similarly equipped. International Telex service is now available between the United States and most of the other countries in the world.

TELEGRAPH (RADIO)

Development

Guglielmo Marconi, an Italian inventor, began experimenting with wireless telegraph in 1890. Six years later he obtained an English patent, and in 1897, a British company was formed to exploit the idea.

In 1899, Marconi sent a radiotelegraph signal across the English Channel. This led to installation of wireless equipment on a number of ships. However, transmission range was then extremely limited. In 1901, radio was for the first time employed to bring help to a ship--the "Medora"--which experienced difficulty in the English Channel.

Shortly thereafter (also in 1901), Marconi received the letter "S" sent from England to Newfoundland. This was the first successful transoceanic radio transmission.

The first transoceanic radiotelegraph service was established by the Federal Telegraph Company, a predecessor of ITT World Communications Inc. (formerly Mackay Radio and Telegraph Company, Inc.), in 1912, linking San Francisco with Honolulu.

Overseas radiotelegraph service developed very slowly, primarily due to the initial use of spark and arc sets which were unstable in operation and caused much interference. The Alexanderson high-frequency alternator and the De Forest tube were answers to some of these early technical problems.

The United States Government took over all radio facilities in this country when it declared war on Germany in 1917, and throughout that emergency our radiocommunication services were operated by the Navy. On March 1, 1920, the day after the relinquishment of Federal wartime control, the Radio Corporation of America transmitted its first commercial transatlantic radiotelegraph message, opening a direct circuit between this country and England.

Operation

Telegraphy by radio is similar to that by wire, except that radio waves are used to carry the signals over water and other expanse. Many of the mechanics described under "Telegraph," also apply to radiotelegraph communication.

Overseas Circuits

Today five American companies operate point-to-point radiotelegraph circuits between the continental United States and overseas and foreign points. Through their facilities it is possible for anyone almost anywhere in the United States to send a radiotelegram to almost any place in the world. They are: RCA Global Communications, Inc., which was organized in 1929 as a subsidiary of the Radio Corporation of America to take over the latter's radiotelegraph operations; ITT World Communications Inc., which superseded Mackay Radio and Telegraph Company, Inc. and Globe Wireless Ltd., (owned by the American Cable & Radio Corporation, a subsidiary of the International Telephone and Telegraph Corporation); Press Wireless, Inc., organized in 1929 to furnish, primarily, press services, and acquired in 1965 by ITT World Communications Inc.; Tropical Radio Telegraph Co., organized in 1913 to take over the radiotelegraph activities of the United Fruit Co.; and United States-Liberia Radio Corp., organized in 1928 to handle the radiotelegraph business of the Firestone Plantations Co.

In addition to regular telegraph classifications, some international carriers handle other types of traffic, including broadcast program material, multiple-address press messages, facsimile and radiophotos. Overseas transmission of pictures began in 1924.

As is the case with underseas telegraph cables, the new higher capacity cable and satellite facilities have supplanted radiotelegraph for the most part. The radiotelegraph facilities in service today are used mainly to connect points not served by cable or satellite and as a backup to the newer facilities.

Domestic Circuits

In 1964, Western Union inaugurated its 7,500-mile transcontinental microwave system extending from Boston, New York and Washington to San Francisco and Los Angeles. The system incorporates modern techniques and is designed to carry all types of communications at high speed and in large volume. It will permit the telegraph company's expansion into newer and broader areas of telecommunications, including the offering of management information services.

Ship-to-Shore Service

A major portion of radiotelegraph correspondence between ships and shore is handled in the continental United States and Hawaii by RCA Global Communications, Inc., ITT World Communications Inc., and Tropical Radio Telegraph Co.

Service to Land Vehicles

Telegrams can also be sent to and from moving land vehicles which are equipped with radiotelephone, such as automobiles, trains, buses, and trucks. The driver or passenger simply asks for telephone connection with Western Union and sends his message collect or charges it to the mobile unit telephone number.

TELEPHONE (WIRE)

Invention

> "If I can get a mechanism which will make a current of electricity vary in its intensity, as the air varies in density when a sound is passing through it, I can telegraph any sound, even the sound of speech."

So declared Alexander Graham Bell in 1879 while experimenting with his "harmonic telegraph." On June 2 of that same year, by fashioning a makeshift diaphragm, this teacher of deaf mutes discovered that he could hear over a wire the sound of a twanging clock spring.

Bell then knew that it was possible to do what he had hoped--send vocal vibrations over a telegraph wire so that they could be transformed into sound for a listener at the other end.

Nine months later, on March 10, 1876, Bell transmitted the first complete sentence heard over a wire. What he said was, "Mr. Watson, come here, I want you!" It was received by his associate, Thomas A. Watson, in an adjoining room of their tiny Boston laboratory.

Development

United States Patent No. 174,465, issued to Bell in 1876, became known as the "most valuable patent." Yet early efforts to popularize the telephone met with disappointment. Though people paid to hear Bell lecture on "the miracle discovery of the age," for a time they seemed unaware of its possiblities.

However, the year 1877 witnessed erection of the first regular telephone line--from Boston to Somerville, Massachusetts. At the close of 1880, there were 47,900 telephones in the entire United States. The following year brought telephone service between Boston and Providence. New York and Boston were connected in 1884. Service between New York and Chicago started in 1892, but not until 1915 was trancontinental service inaugurated.

Operation

The telephone is an electrical device which picks up a spoken word and speeds it invisibly and inaudibly by wire, cable or radio to another point. In this process the telephone instrument performs two functions--it converts the sound waves of the human voice into electrical waves for transmission and, at the receiving end, it transforms this electrical energy back into sound waves that can be recognized by the human ear.

The telephone system provides the highways which carry this electrical speech. Strands of copper wire link rural subscribers; more populous places use cable. In big cities, the cables are placed in underground conduits or buried directly in the ground. City-to-city transmission is over cables or microwave radio.

When a telephone user dials a call from one city to another, the call goes first to the local central office. There it is connected to its destination either through manual switchboards or dial equipment. If it is handled on the latter basis, the dial switching equipment finds the most direct route to the distant city. If all circuits on that route are busy and an alternate route is available, the equipment will automatically select the other circuit path in a matter of seconds. At intervals along the way, repeater amplifiers maintain the strength of the transmission. At the terminal end, equipment in another central office accepts the incoming call and routes it to the desired telephone. Most of this same equipment is used in a similar manner when a long-distance call is placed with the operator. Much of the nationwide telephone network has been arranged to permit completion of intercity calls by direct distance (customer) dialing.

Over 110 million telephones in the United States can be interconnected by more than 18,000 central offices. These connections are made manually or automatically. On the manually-operated switchboards this is accomplished by means of "cords" (wired plugs) and "jacks" (sockets representing subscriber or other lines). A system of small electric signal lights aids the operators in handling calls. In dial telephone operation, connections are made by complex automatic switching equipment.

Cable

Toward the close of the 19th Century, the myriad of overhead telephone wires in large cities became such an obstacle to effective fire fighting and were so subject to storm damage that it was necessary to develop overhead cables. Success in enclosing many wires in a single cable eliminated need for many cross-arms on telephone poles. In 1888 it was possible to squeeze 100 wires into a large cable; today more than 5,000 strands can be encompassed in a cable about the size of a man's wrist. Some cables are maintained under inert gas pressure to keep out moisture which may cause short circuits. The gas also helps detect leaks in the cable sheath. Today, many of these cables are located underground.

Experiments with underground telephone cable date back to 1882 but it was not until 1902 that the first long-distance buried cable was placed in operation--between New York and Newark, New Jersey. In 1913, Washington and Boston were so linked. The original transcontinental telephone line was of open wire. The first cross-continent cable line was opened in 1942.

Coaxial cable was a development of multi-channel experimentation. It had its first practical test between New York and Philadelphia in 1936. Commercial service was inaugurated between Stevens Point, Wisconsin, and Minneapolis in 1941. It proved so successful that the American Telephone and Telegraph Company has constructed many coaxial links in its national cable microwave system.

REFERENCE MATERIAL

Those interested in greater detail about wire and radio communication services may obtain various printed publications of the Federal Communications Commission. These are not distributed by the Commission but are sold by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. A list of FCC publications currently available from that source may be obtained on request to the Public Information Officer, Federal Communications Commission, Washington, D.C. 20554.

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