PART II

TELEGRAPHS

PART II.

TELEGRAPHS.

CHAPTER I.

TELEGRAPH AND CABLE SYSTEMS.

General statistics.—Prior to 1902 the only census at which statistics for telegraphs was reported was that of 1880, which covered the fiscal year ending nearest to June 1, 1880. But as the reports of that census contain no data relative to domestic ocean cable systems, the statistics are not strictly comparable with those for 1902. The comparison of the totals for the two censuses can be used, therefore, only as a general indication of the magnitude of the industry at the two periods.

The statistics concerning the telegraph and ocean cable systems relate to all operations of commercial land telegraph companies owned and operated within the United States, and of domestic ocean cable companies operating from the United States. The close relationship between the land and ocean telegraphs makes it impossible to present the statistics for the two classes separately.

As the majority of the telegraph systems are operated in a number of states, their business could not be segregated so as to show the capitalization, income, expenses, and equipment for the different states. Hence only the totals for the United States are given.

It should also be noted that in compiling the statistics for telegraphs the systems were divided into two general classes—the commercial land telegraph and the ocean cable systems, including all systems organized primarily for the transmission of messages for the general public; and the railway telegraphs, including all wires owned and operated in connection with a railway system, to subserve its business of a common carrier, or operated by a commercial telegraph company, through an arrangement with the railway company along the right of way on which the wires are strung, whereby messages relating to the railway business are given preference. The railway telegraph statistics are treated later in a separate table. The commercial telegraph systems are given in Table 1.

TABLE 1.—*Commercial systems—comparative summary: 1902 and 1880.*

	1902	1880
Number of systems	25	[1]77
Miles of wire	[2]1,318,350	291,213
Messages:		
Number	[3]91,655,287	[4]31,703,181
Receipts	[5]$29,118,089	[4]$13,512,116
Telegraph offices, number	27,377	12,510
Salaried officials, clerks, etc., number	829	337
Wage-earners, total number	26,798	14,591
Operators	13,093	9,661
Messengers	4,746	2,469
All others	8,959	2,461
Salaries and wages	$15,030,673	$4,886,128
Capital stock:[6]		
Authorized, par value	$123,233,075	$75,907,250
Outstanding, par value	$117,053,525	[7]$66,529,200
Total revenue	$40,930,038	$16,696,623
Gross receipts from telegraph traffic	$35,300,569	$13,512,116
From other sources	$5,629,469	$3,184,507
Total expenses	$37,204,727	$14,959,372
Salaries and wages	$15,030,673	$4,886,128
Operation and maintenance	$9,220,948	$3,846,039
Interest	$1,950,282	$564,341
Dividends	$6,256,603	$4,136,750
All other expenses	$4,737,131	[8]$1,526,114
Net surplus	$3,725,311	$1,737,251
Balance sheet:[6]		
Total assets	$195,503,775	$97,232,640
Construction and equipment	$156,911,448	$93,062,922
Real estate, stocks and bonds, machinery, etc.	$32,220,204	(9)
Bills and accounts receivable	$3,084,739	$3,081,922
Cash and deposits	$3,287,384	$1,087,796
Total liabilities	$195,503,775	$97,232,640
Capital stock	$117,053,525	$67,901,255
Bonds	$45,893,000	[10]$9,369,165
Cash investment of unincorporated companies, reserves, bills and accounts payable, dividends unpaid, and surplus	$32,557,250	[11]$19,962,220

1 Includes 6 operated by Western Union Telegraph Company.
2 Includes miles of wire operated by the Western Union Telegraph Company outside the United States, but does not include 16,677 nautical miles of cable operated by submarine cable systems.
3 Includes 820,498 cable messages.
4 Both number of messages and receipts were reported for 54 companies, while 17 others reported receipts only.
5 Includes $1,320,967, receipts for cable messages.
6 Reported by only 42 companies in 1880.
7 For cash.
8 Includes $40,000, sinking fund appropriation.
9 Not reported separately in 1880.
10 Includes funded and floating debt.
11 Reported as profit and loss.

It will be seen from Table 1 that the telegraph systems of the country owned and operated 1,318,350 miles of wire, to which should be added 16,677 nautical miles of submarine cable. They had 27,627 employees; an investment, or capitalization of stocks and bonds, of $162,946,525; a total revenue of $40,930,038; and total assets of $195,503,775. They paid $6,256,693 in dividends and $1,950,282 in interest on bonds. In all these respects, as well as in the number of messages, the telegraph was surpassed by its younger rival, the telephone, and, while the telegraph has intrinsically grown rapidly and has in itself the elements of steady increase, the statistics in this report give every warrant for the belief that each year must see a wider disparity between these two vital means of intercommunication.

Chief features of the data.—The striking decrease between 1880 and 1902 in the number of separate holdings, due to the numerous consolidations which have taken place of corporations previously competing or not before under one ownership, has been accompanied by a very great increase in the magnitude of equipment and business. In 1902 the telegraph business was practically controlled by two companies, yet, in spite of the tendency of consolidation to reduce the number of lines and offices, the mileage of wire in operation was more than four times and the number of messages nearly three times greater than in 1880.

The wire mileage in operation in 1902, exclusive of 16,677 nautical miles of cable, was 1,027,137 miles greater than in 1880.

The comparison of the number of messages sent during the two census years is affected by the fact that, in addition to the 820,498 cable messages included in the total for 1902, an unknown number of cable messages was reported by a company that did both a land and ocean business, and whose report could not be segregated. Moreover, in 1880, the number of messages was reported for only 54 companies; of the 23 other companies, 17 reported only "receipts from messages," 5 kept no records, and 1 had no message business.

The average rate per message in 1902, after deducting the number of cable messages and receipts therefrom, was 31 cents, as compared with 43 cents in 1880.

The number of telegraph offices in 1902 was 27,377, an increase of 14,867, or 118.8 per cent over 1880. Of the total number in 1902, 20,809 were in railway stations.

Between 1880 and 1902 the number of salaried officials, clerks, etc., increased from 337 to 829, or 146 per cent; the total number of wage-earners, from 14,591 to 26,798, or 83.7 per cent; the number of telegraph operators, from 9,661 to 13,093, or 35.5 per cent; and the amount paid in salaries and wages, from $4,886,128 to $15,039,673, or 207.8 per cent.

Comparison with the telephone.—It is an interesting and not altogether unprofitable speculation to attempt a determination of the effect of the telephone in reducing or checking the amount of telegraph business. This effect is produced in two ways—by substituting the long distance telephone call for the telegraph message between two widely separated points, and by obviating to a very large extent the necessity for using the telegraph within city limits. The effect of the telephone on the district messenger service is referred to later. As to long distance and toll line telephone talks or messages, the figures of telephone traffic give these as no fewer than 120,704,844, or nearly thirty millions more than the total number of telegraph messages. While a great deal of the telephone traffic has been new and self-originated, its competition has kept down the use of the telegraph. The rates of the two systems for medium distances do not differ greatly, and for very long distances they are overwhelmingly in favor of the telegraph, if the message be taken as the unit; but if the number of words exchanged be taken into account, as well as the time required for getting into communication, the telegraph is at a disadvantage in case of a large amount of traffic. Frequently the brief message will suffice, and the written telegraph serves as a record, but where a swift interchange is required, the telephone seems to have thoroughly established its superiority for social matters and for business. The public employs the telegraph at the rate of only a little more than once a year per capita, whereas the number of telephone messages is already 65 per capita.

Comparative data—earnings and expenses.—In the reports of the census of 1880 statistics of revenue and expenses were presented for 75 of the 77 systems or companies. The 2 other companies (one was not in regular operation, while the other did not have the necessary records) reported a combined mileage of only 301 miles. The 1880 statistics of assets and liabilities covered the operations of 42 companies. Of the 35 other companies—many of them of a petty character—18 were lines owned by railway companies which included the data for both railway and telegraph business in the same balance sheet, 7 failed to give a reason for not furnishing the data, 4 made reports that were too incomplete and unreliable to be included in the table, and 3 were private concerns. Of the 25 telegraph systems reported in 1902, 21 were operated by incorporated companies. The capitalization of these companies is shown in Table 2.

TABLE 2.—*Capitalization of incorporated companies: 1902.*

Number of incorporated companies	21
Capital stock and bonds authorized, par value	$173,126,075
Capital stock and bonds outstanding, par value	$162,946,525
Capital stock:	
Total authorized, par value	$123,233,075
Total outstanding, par value	$117,053,525
Dividends paid	$6,256,693
Common—	
Authorized, par value	$122,033,075
Outstanding, par value	$115,853,525
Dividends paid	$6,193,693
Preferred—	
Authorized, par value	$1,200,000
Outstanding, par value	$1,200,000
Dividends paid	$63,000
Bonds:	
Authorized, par value	$49,893,000
Outstanding, par value	$45,893,000
Interest paid	$1,949,150

Of the total authorized capitalization of commercial telegraph systems, capital stock constituted 71.2 per cent and bonds and funded debt 28.8 per cent. Of the total authorized capital stock, $117,053,525, or 95 per cent, had been issued and was outstanding at the end of the year covered by this report. Of this amount, 99 per cent was common, and 1 per cent preferred stock.

The dividends paid on the capital stock outstanding amounted to $6,256,693, the average rate being 5.3 per cent. Dividends amounting to $6,193,693 were paid by 10 companies on common stock, having a par value of $113,913,725, so that the average rate was 5.4 per cent. Only 1 company was authorized to issue preferred stock, and the entire amount, $1,200,000, was outstanding. This company paid on its preferred stock dividends amounting to $63,000, the rate being 5.3 per cent. Ten companies, having capital stock to the amount of $1,939,800, paid no dividends during the year covered by this report.

Bonds were outstanding to the amount of $45,893,000, and $1,949,150 was reported as paid in interest, the average rate being 4.2 per cent.

The total revenue and expenses of the 25 companies for the year covered by their reports are arranged in Table 3 in the form of an income account.

TABLE 3.—*Commercial systems—income account: 1902.*

Gross receipts from operation		$35,300,569
Operating expenses		26,592,411
Net earnings from operation		8,708,158
Income from other sources:		
Dividends on stock of other companies	$1,159,058	
Lease of lines, wires, and conduits	4,185,709	
Rent from real estate	205,070	
Interest	6,719	
Miscellaneous	72,223	
		5,629,469
Gross income less operating expenses		14,337,627
Deductions from income:		
Taxes	588,726	
Interest—		
Floating debt	1,132	
Funded debt	1,949,150	
Paid for leased lines	1,816,615	
		4,355,623
Net income		9,982,004
Deductions from net income:		
Dividends on preferred stock	63,000	
Dividends on common stock	6,193,693	
		6,256,693
Net surplus for year		3,725,311

The total receipts of the commercial telegraph companies amounted to $40,930,038. Of this total, $35,300,569, or 86.2 per cent, represents the gross receipts from operation, including all receipts for messages sent over the lines of the telegraph systems in this country, whether originating in this country or forwarded for other systems under traffic agreement. The "income from other sources" amounted to $5,629,469, or 13.8 per cent of the gross revenue.

The operating expenses are presented in Table 4.

TABLE 4.—*Commercial systems—operating expenses: 1902.*

Total	$26,592,411
General operation and maintenance	24,260,621
Salaries of corporation officers	230,250
Salaries of general officers	255,740
Salaries of clerks	676,642
Wages	13,877,041
Operation and maintenance	9,220,948
Legal expenses	194,890
Rentals of offices and other real estate	875,213
Rentals of conduits and underground privileges	7,808
Telegraph traffic paid or due other companies	724,826
Miscellaneous	529,053

It is probable that the $26,592,411 shown for operating expenses includes all expenses that can be charged to the operation of the 1,318,350 miles of single wire and the 16,677 nautical miles of ocean cable.

Of all operating expenses, salaries and wages together amounted to $15,039,673, or 56.5 per cent; the other principal item, operation and maintenance, amounted to $9,220,948, or 34.7 per cent; and the remaining items of expense—legal expenses, rentals, telegraph traffic paid or due other companies, etc.—amounted to $2,331,790, or 8.8 per cent.

Fixed charges, which consist of taxes, interest, and payments for leased lines, amounted to $4,355,623. Deducting this from $14,337,627, shown as gross income less operating expenses, there remains a net income of $9,982,004. Deducting from the net income the $6,256,693 paid in dividends on the preferred and common stock, there remains a net surplus of $3,725,311.

In addition to the cost of repairs and renewals, included in the item operation and maintenance, an expenditure of $4,776,763 for new construction was reported by 7 of the 25 telegraph systems.

While different methods of bookkeeping were used by the several systems, and different items shown in their annual statements of assets and liabilities, it was found possible in every case to secure the amounts required to construct a balance sheet of the character shown in Table 5.

TABLE 5.—*Commercial systems—balance sheet: 1902.*

Total assets	$195,503,775
Construction and equipment	156,911,448
Real estate	4,768,131
Stocks and bonds of other companies	25,939,944
Machinery, tools, and supplies	945,795
Bills and accounts receivable	3,084,739
Cash and deposits	3,287,384
Sundry	566,334
Total liabilities	195,503,775
Capital stock	117,053,525
Bonds	45,893,000
Cash investment, unincorporated companies	7,310
Reserves	7,859,648
Bills and accounts payable	6,244,585
Dividends unpaid	366,666
Surplus	18,079,041

important cities and towns in the United States, exclusive of New York city. This company, which has a twenty-five-year contract with the Western Union Telegraph Company for the delivery and collection of messages, has an authorized capital stock of $10,000,000, of which $9,500,000 is outstanding. On this a dividend of 5 per cent was paid up to 1904, when the rate was reduced to 4 per cent. All message collection and delivery business of the Western Union Telegraph Company in New York city is handled by the local American District Messenger Company, which operates 85 offices in New York city, with 1,552 miles of circuit, 29,143 instruments, and 1,200 messengers. The authorized capital stock of this company is $4,000,000, of which $3,844,700 is outstanding. The dividends upon this in 1902 and 1903 were 2 per cent. The revenue from all sources was $567,676 and the operating expenses, inclusive of construction, $511,808. The net income was $65,868 and the dividends $76,888, leaving a deficit of $11,020. These figures are compiled from the last annual report of the company. It may be added that the Postal Telegraph Cable Company has organized a number of district messenger companies to render services analogous to the above, but in regard to these also no figures were collected.

The stock quotation service.—A part of the telegraph force of the country, more particularly in the large cities, is employed in handling stock quotations, a large number of the operators being in private employ. The quotations are not brought to separate account as messages, except perhaps in the figures of work done by the submarine cables; but it has been stated on good authority that there are on an average 1,000 Wall street cable messages per day, or about three hundred thousand per year; but this would by no means include all the cablegrams relative to prices of, or speculation in, stocks, wheat, pork, cotton, coffee, tobacco, etc.

The extent of the use of telegraphy in transmitting stock quotations is not perhaps fully appreciated, although the public is quite familiar with the stock ticker and the paper tape upon which the ticker prints its abbreviated record of sales and prices. The largest amount of this work is done in New York city, and under the direct supervision of the stock exchange, which treats the quotations made within its walls as the property of the exchange and its members. One stock quotation system, with about one thousand tickers in service, is owned and operated by the exchange. This system sent out over the tape nearly thirteen million separate impressions in 1901–2, and over seventy-five thousand on some days, while it required about fifty tons of paper to keep the tickers supplied with reels of narrow tape. In addition to this official service, there is another under exchange supervision, which furnishes tickers to about seven hundred and fifty customers in and around New York. Besides these nearly one thousand more tickers are employed on Manhattan Island in reporting produce, general news, sporting intelligence, etc. It will be seen that in the aggregate a vast amount of telegraphic service is thus furnished to the public. But this is not all, as outside of New York city twenty large cities have ticker services of their own, which in Chicago, Philadelphia, Boston, etc., represent a further patronage of this special form of telegraphy, now an indispensable part of daily life to the financial and commercial world. The ticker service is also supplemented by a news system, which consists of bulletins sent out by one or two enterprising agencies and depends in large measure upon telegraphic advices for its material. It is extremely difficult to bring such work to specific account, but an estimate was made a few years ago by one of the presidents of the Western Union Telegraph Company that 46 per cent of the messages transmitted were in reference to speculation of some kind.

Commercial telegraphs on steam railroads.—Along the right of way of steam railway companies the commercial telegraph systems had 181,921 miles of pole line, on which were strung 954,319 miles of single wire, or 72.4 per cent of the total wire mileage operated by all commercial telegraph systems, as shown in Table 1. Of this wire, 935,409 miles were copper and 18,910 were iron. In addition to this wire the railway companies owned and operated a large mileage in connection with the transportation business.

Railway telegraphs and telephones.—There were 684 railway companies that reported the operation of telegraph or telephone lines in connection with the transportation business. In their reports to the Interstate Commerce Commission the railway companies furnished considerable information concerning their telegraph and telephone systems. This information was supplemented by data obtained by the Bureau of the Census through correspondence with the companies. The results of the combined inquiries are summarized in Table 10.

TABLE 10.—*Railway telegraphs and telephones—summary: 1902.*

Number of companies reporting	684
Number of telegraph offices	31,278
Telegraph operators and dispatchers:	
Number	30,336
Wages	$20,040,730
Number of sets of instruments:	
Morse	85,140
Other	663
Number of cells of battery:	
Primary	278,293
Storage	11,914
Miles of single track	204,583
Total miles of wire	1,127,186
Owned	242,837
Not owned	884,349
Number of telephones in use	17,606
Number of telegraph messages sent during year:	
For railroad business only	201,743,756
Commercial	4,474,563

The railway companies for which data are included in Table 10 operated 204,503 miles of single track and had 1,127,186 miles of single wire along their right of way. Of this wire mileage, which includes both telegraph and telephone lines, no segregation being possible, only 242,837 miles, or 21.5 per cent, were owned by the railway companies.

A large proportion of the telegraph and telephone wire along the right of way of railway companies, and a considerable proportion of that operated by the railway companies is owned by commercial telegraph or telephone companies and is included in their reports. Hence an unknown portion of the wire mileage reported for railway telegraphs and telephones is a duplication of that shown in the report on commercial telegraph companies. Moreover, many of the commercial messages reported are included, also, among the messages reported by the commercial telegraph companies. Few railway companies, however, maintain telegraph lines for other than railway business, the commercial privileges, as a rule, being granted to commercial telegraph companies.

The railway companies reported 31,278 telegraph offices, but only 30,336 telegraph operators. It is probable that in a number of instances the railway companies reported as station masters, agents, etc., employees who also performed the duty of telegraph operator, and that these were not included with the operators.

CHAPTER II.

GOVERNMENTAL TELEGRAPH AND TELEPHONE SERVICE.[1]

Several branches of departments of the United States Government depend largely in their work upon the employment of the telegraph and telephone. Chief among these are the Signal Corps, the Weather Bureau, and the Life-Saving Service.

United States Signal Corps.—One of the earliest demonstrations of the value of telegraphy in warfare was that given in the United States during the Civil War, when for several years a large body of operators on both sides was employed in the maintenance of communication between the forces scattered over the immense area embraced in the field of conflict. On the Federal side no fewer than 1,200 operators were thus employed in the field, sharing all the perils and vicissitudes of the war. Out of the conditions thus developed sprang the present telegraphic system operated by the Signal Corps of the United States Army under the Chief Signal Officer. According to the report made for 1903–4 by Gen. A. W. Greely, Chief Signal Officer, this corps has by law an authorized strength of 1 brigadier-general, 1 colonel, 2 lieutenant-colonels, 6 majors, 18 captains, 18 first lieutenants, 36 master signal electricians, 132 first-class sergeants, 144 sergeants, 156 corporals, 552 first-class privates, 168 privates, and 24 cooks—a total of 46 officers and 1,212 enlisted men. At headquarters in Washington a staff consisting of 1 chief clerk, 1 chief of disbursing division, 26 clerks, 3 messengers, and 1 laborer is also necessary for the prompt and satisfactory transaction of public business passing through the office. At the Signal Corps post at Fort Myer, Va., the Corps has an important school of instruction, although work of a more extensive character is now being done at Omaha, Nebr., in the instruction of enlisted men in signaling, telegraphing, telephoning, ballooning, etc. During the year military telegraph lines, with an aggregate length of 507.5 miles, were in operation at ten different posts, and handled 41,805 messages, while at four different posts, lines aggregating 254 miles were transferred or abandoned. The sum of $2,213.07 was collected for the transmission of commercial telegrams over the military lines, and the sum of $3,450.65 was collected and transferred to commercial companies, the latter amount covering tariffs for messages transmitted by such companies over their land lines.

The Signal Corps in the Philippines.—These statistics, however, are far from doing justice to the work of the Signal Corps, particularly in Alaska and in the new American possessions in the Philippines. At the end of the fiscal year 1903–4 no less than 42 per cent of the enlisted force of the Signal Corps was still serving in the islands, and fully 50 per cent of the entire Corps has been required by military necessities to serve there for periods ranging from two to four years. The work of the United States Signal Corps in the Philippine archipelago marks in reality a distinct advance in the application of electricity to the art of war. In extent of mileage of circuit, rapidity of development, and number of military messages transmitted its operations have surpassed those of any previous military system of communication. The submarine cables laid and land lines built had an aggregate length of 10,450 miles, of which 7,000 miles were operated at one time. General Greely states that the official messages have run into the millions, and that in Manila alone over 100,000 words were handled by the Corps in a single day. For the first four and one-half years the entire expenditure for material and instruments, submarine cables, and other expenses out of the Signal Corps appropriation aggregated $1,381,614. In connection with this work the disbursements of other bureaus of the Army, etc., have been estimated at $1,100,000, making the total cost, direct and indirect, for the entire plant and its operation and maintenance almost $2,500,000. During the year of active operations the cost of sending words over land lines was about five mills per word, and over submarine cables three cents per word. This includes the cost of plant, operation, maintenance, and all other expenses, but does not take into account the value of lines and material on hand or transferred to the civil government. In this connection it is interesting to note that the estimated cost of telegrams over the British military telegraph system in South Africa was fixed at about seven mills per word. The average for the Philippines covered, however, only the operation of land lines, whose original installation is less costly than submarine cable, while in the South African figures credit is taken for the full value of all stores and other material used in the construction of the lines transferred to the civil administration after the Boer War.

[1] Many of the statements in this chapter are derived from the Annual Report of the Chief Signal Officer, U. S. A., for the year ending June 30, 1904, and from the Report of the Chief of the Weather Bureau for 1902–3.

Up to June 30, 1904, there had been transferred by the Signal Corps to the civil government of the Philippines 2,965 miles of land lines and submarine cables. Yet, as a matter of fact, the United States Army in 1898 had found the islands practically destitute of telegraphic facilities, the insurgents having destroyed the few Visayan lines of the Eastern Extension, Australasia, and China Telegraph Company (Limited). By the fortune of war there came into the possession of the Signal Corps about 400 miles of dilapidated and antiquated line in northern Luzon, but the system as it stands at the time of this report is virtually a new creation throughout.

The tariff value of the messages sent by the Signal Corps under disturbed conditions in the Philippines can not be satisfactorily determined, according to General Greely. It may be stated, however, that the Eastern Extension Telegraph Company (the only commercial system operating in the islands) at a minimum commercial tariff of 5 cents a word for official business would have received for this work $7,758,750. As will be noted, the cost to the United States, through the operations of the Signal Corps, was less than one-third of this amount. There should be added also in these estimates the charges for more than 2,000,000 telephone messages, amounting, at 10 cents per message, to at least $200,000. There should also be credited to the Signal Corps the tariffs, amounting to $82,996.12, collected for commercial messages and dispatches and paid into the insular treasury. Gratifying as this exhibition is, the service rendered has obviously been too valuable to be measured by tariff rates. On this point Gen. Arthur MacArthur may be quoted as follows:

> The wire service of the Signal Corps is simply indispensable. It is not too much to say that in the absence of this efficient service it would be impossible to hold this archipelago with less than 150,000 men, which is now well and efficiently performed by 60,000. We need wires, instruments, and operators everywhere—the more the better. It simplifies everything, makes unity of action possible, insures concentration of troops on threatened points, and, altogether, is of such importance that it is impossible to say too much in behalf of its indefinite extension to the limit of possible usefulness. . . . The purpose of the present writing is to impress the War Department with the view that successful operations in these islands absolutely depend upon the Signal Corps, in consequence of which provisions therefor should be made upon a scale commensurate with the importance of the interests involved.

As a further illustration of the aid rendered national officials engaged in civilian work, the following is quoted from a letter written by Gen. J. P. Sanger, U. S. A., Director of the Philippine Census:

> Since January 1, 1903, almost the entire correspondence of the Bureau has been by telegraph, and during this period I have sent and received nearly 10,000 telegrams and cable messages, many of them at great length and a large proportion of them in the Spanish language.
>
> With the exception of a few errors—due, no doubt, to idiomatic and obscure phrases, requiring occasional repetition—the work has been carried on with such skill and dispatch as to merit special commendation; and, before leaving Manila, I wish to express to the members of the Signal Corps performing the duties of telegraph operators my high appreciation of their efforts and of the excellent organization and administration of the telegraph service.

With regard to the facilities afforded to trade and commerce in the Philippines, it may be noted that in June, 1901, the Chief Signal Officer made arrangements which increased largely the telegraphic facilities available to merchants and others. Every office in the archipelago was opened for insular commercial communication, while 60 of the larger offices were accorded facilities for handling foreign cable messages. The tariff fixed was very low, being 2 cents per word for points on the island of origin and 4 cents per word for points outside. The receipts from all such commercial messages were deposited in the insular treasury. To sum up the conditions of operation in the Philippines, there were on July 1, 1903, 4,577 miles of wire, of which 3,105 were land lines and 1,472 submarine cables. Part of this system during the year was transferred to the civil government and part abandoned, so that on June 30, 1904, the Signal Corps was operating 2,052 miles of land line and 1,468 miles of cable, connecting in its general system 84 telegraph offices and 13 telephone offices, exclusive of the telephone exchanges in Manila and at military posts. In the operation and maintenance of this system there were on duty at the end of the year 9 officers, 1 detailed officer from the line of the Army, and 356 enlisted men of the Signal Corps, as well as 158 civilians, of whom 147 were natives of the Philippines. In the city of Manila the telegraphic and telephonic systems, on a single conductor basis of estimate, aggregated 174 miles of circuit, of which 123.4 was telephonic. The military telephone system embraced 211 telephones connected with one main central with a 100-drop switchboard in operation night and day, and two subcentrals operated 10 hours daily. The number of calls during the year was 291,997. Outside of Manila local telephone systems for military purposes had been established at 28 army posts and stations and had an aggregate of 38 miles of circuit and 229 telephones. In addition it is understood that the constabulary lines of the Philippines aggregated 4,203 miles, of which 172 were cable, 1,861 telegraphic land lines, and 2,170 telephone lines. In connection with these, 66 telegraph offices and 197 telephone offices and stations were maintained.

Alaskan telegraphs.—In Alaska, as well as in the Philippines, the United States Signal Corps has had an arduous and serious task to perform in establishing and maintaining telegraphic communication. To realize the extent of the territory covered in that region by the network it would be necessary to plot it on a map of the United States as stretching from Wyoming to the Bahamas. The cables used would stretch from Newfoundland to the coast of Ireland, and the land lines would extend from Washington to Texas. The entire construction included 3,625 miles, embracing 2,079 miles of cable, 1,439 miles of land line, and a wireless system of 107 miles. These operations include, moreover, a most extensive utilization of American material, apparatus, and skill in the field of submarine work. The seamless rubber cable of American manufacture laid by the Corps between Sitka and Seattle is 1,070 miles in length, laid at an average depth of 1,000 fathoms and at an extreme depth of 1,700 fathoms, and it is said to have a transmitting power greater by 25 per cent than the amount of capacity arrived at in accordance with a mathematical calculation on the basis of the transatlantic gutta-percha cables, while in its original cost the former was less expensive than the latter. The cable in Alaska has been thrown open to public use and operated most successfully. The other extensive portion of the Alaska cable system—the Sitka-Valdez section—is 640 miles in length. These cables are operated by Signal Service operators, employing the latest Cuttriss syphon recording instruments. The following sections, aggregating 2,128 miles, are now installed and in operation in Alaskan waters:

	Miles.
Skagway to Fort William H. Seward	21
Fort William H. Seward to Juneau	102
Junéau to Sitka	291
Seattle to Sitka	1,070
Sitka to Valdez	640
Valdez to Fort Liscum	4

If the Norton sound cable, which has been abandoned, be included, a total of 2,260 miles of submarine cable has been laid in the waters about Alaska. The land line system of Alaskan telegraphs, nearly 1,500 miles in length, was scarcely completed when in June, 1903, extensive forest fires in the valley of the Tanana destroyed various portions of the circuits, aggregating 100 miles in length. The line was rebuilt, however, and thrown open to the general public for commercial service before winter began. It has since been operated with unusual success, although the difficulties are serious and exceptional, as a result of high gales, inaccessibility, the rigors of winter, etc. No fewer than 206 breaks, due mostly to blizzards, forest fires, high winds, and sleet storms, have had to be made good.

The Norton sound section of Alaska has been the scene of the development by the Signal Corps of a wireless system necessitated by the apparent inability to maintain permanent cable connections between Cape Nome and St. Michael. In the late summer of 1903 the wireless bases for Norton sound were established at Safety harbor and St. Michael, where portable houses were built, in which were installed engines, batteries, and wireless apparatus, supplemented at each station by two masts 210 feet high, between which were suspended fan-shaped antennae, consisting of 125 copper wires one foot apart. The generating plant comprises a 5-horsepower gasoline engine, a 3-kilowatt motor dynamo, a 60-cycle alternator, and step-up transformers. The transmitting and receiving apparatus operates successfully across a distance of 107 miles, and with it, in one afternoon alone, 5,000 words were exchanged between Safety harbor and St. Michael. Up to the present time this wireless system has sent over 1,000,000 words. It has been so successful that General Greely has recommended its extension to Dutch harbor or some other point in Unalaska, pointing out that the Signal Corps wireless station at Safety harbor could work to Nunivak Island to the south over the 250 miles of sea intervening, and that the Navy Department could, by stations of suitable power on Nunivak and Unalaska Islands, perfect communication over the balance of the distance, which is less than 400 miles. Similarly the signal station at Safety harbor could communicate readily with a wireless station at a suitable point on the Asiatic shore of Bering strait, thus completing the circuit around the world by that route, as was attempted and abandoned at the time when it was first proved that cable could be made operative across the Atlantic ocean.

During the year $56,935.89 was spent for Alaskan telegrams handled by the Signal Corps alone. Of this amount, there was collected on account of Alaskan line tariffs $12,208.93, which was deposited in the Treasury of the United States, as required by law. There was also collected and turned over to other lines the sum of $17,539.81. The balance, $27,187.15, was collected by other lines for tariffs on messages sent into and out of Alaska. Of the entire volume of business, amounting to 55,559 messages, there were 31,020 commercial and 26,539 official messages, the latter being chiefly telegrams connected with the transaction of Government business within the territory. With the recent additions to the facilities above described there has been a rapid increase of traffic.

United States cable ships.—It was found necessary that the Signal Corps should have a cable ship of its own for its submarine cable operations. With the cooperation of the Quartermaster-General of the Army, the transport *Burnside* has been utilized as a transport and as a cable ship in the Philippines and in Alaska. The efficiency of this transport was demonstrated during 1904 in picking up and laying cables in ocean depths ranging from one to two miles.

For several years past the repairing of Signal Corps cables along the Atlantic coast has depended upon the employment of commercial companies' cable boats, with the result that, despite every effort, cables connected with some of the most important defenses of the United States have been interrupted for long periods because of the inability to secure promptly a suitable boat by charter. During 1904 the Quartermaster-General of the Army purchased a boat, which has been named the *Cyrus W. Field*, and which is used by the Signal Corps for such work. The *Field* is fitted up with such cable apparatus as makes it an efficient and satisfactory boat for cable maintenance and repair.

Other telegraphic work of the Signal Corps.—Other work of a telegraphic character under the management of the Signal Corps comprises the operation of the telegraph and cipher bureau of the White House, which places the Commander-in-Chief of the Army and Navy in quick and direct communication with the military and naval forces of the United States.

A further development of the work of the Corps has been found in the organization of the Signal Corps of the National Guard. There exist, as shown by the 1904 report of the Chief Signal Officer, distinct organizations of this character, with commissioned officers and enlisted men, in California, Colorado, Connecticut, Illinois, Indiana, Iowa, Louisiana, Maine, Massachusetts, Nebraska, New Jersey, New York, Rhode Island, Texas, Utah, Washington, West Virginia, the District of Columbia, and the territory of Oklahoma; while detachments under noncommissioned officers have been organized in Maryland, New Hampshire, Rhode Island, and the territory of Arizona. These organizations are drilled in telegraphic technique and practice, are generally equipped with apparatus, and have shown themselves able to transact a considerable volume of telegraphic business during maneuvers and special operations of the National Guard.

Telegraphy in the Weather Bureau.—An important development of the official telegraphs of the United States has been that carried on by the Weather Bureau of the United States Department of Agriculture, with headquarters in Washington. An idea of the extensive nature of this work may be formed from the fact that on July 1, 1903, no fewer than 2,015 places in the United States were receiving daily forecasts, 926 were in receipt of special warnings, and 7,096 were in receipt of emergency warnings, all this work being done at Government expense. By means of the telephone 28,251 stations were in receipt of daily forecasts and 7,602 of special warnings, while in addition 3,087 points were reached daily by means of railway telegraphs, these being supplemented daily by an allied service by railway trains at 2,423 points, by mail at 78,164 points, and by rural free delivery service at 97,648 points. The data for this distribution were received in part through the cooperation of the principal telegraph companies, while the Weather Bureau had, at the date of its report in 1903, 421 miles of telegraph and telephone lines. The office operates also systems of submarine cable, as, for example, 9 miles from Key West, Fla., to the storm warning and vessel reporting station on Sand Key Island, Fla.; 23½ miles of submarine cable from Point Reyes Light, Cal., to Southeast Farallone Island, Cal.; and 8 miles of cable from Glenhaven, Mich., to connect with the storm warning display station on South Manitou Island, Lake Michigan. These are typical examples of the cable operations necessitated by the work of the Weather Bureau. The most notable extension to the work of the Bureau was made by means of the telephone, in regard to which Dr. Willis L. Moore, Chief of the Weather Bureau, in his report dated August 11, 1903, says:

> A marked increase (nearly 20,000) is shown in the number of places receiving forecasts by telephone without expense to the United States, and with the rapid extension of "farmers' telephone lines" (so called) opportunity is afforded for placing weather information directly in the homes of the more progressive agriculturists, as well as in the telephone exchanges of rural centers of population, where it is posted for the benefit of the general public. The managers of these local telephone lines seem to be very much interested in this matter, and, with very few exceptions, have given their hearty support in making the distribution as successful as possible. It is not difficult to secure the cooperation of these officials, as a statement of the fact that forecasts can be had gratis adds to the inducements which they can offer to prospective subscribers. The great advantages of this plan of dissemination are apparent when we consider the very early hour at which the production reaches the subscriber and the slight amount of labor involved in furnishing him with the information.

The weather map published by the Bureau summarizes daily in graphic form the telegraphic work done, being a photograph, so to speak, of weather conditions prevalent over the entire country. The record is taken daily at 8 a. m. and 8 p. m. at each of the 200 stations distributed over the 3,000,000 square miles, and embodies barometric and thermometric data, as well as observations relating to wind, rain, etc. At 8.30 p. m. these reports are dispatched to Washington, with the right of way over all other telegraphic business, and from them the map and the forecasts are developed each day at headquarters in Washington. The national capital is thus the central station from which the principal forecasts are sent out. Local forecasts are also issued at Chicago, Boston, New Orleans, Denver, San Francisco, and Portland, Oreg. The forecasts made for thirty-six or forty-eight hours are sent to the morning and afternoon papers and are published in 2,500 daily newspapers, in addition to the distribution given them as already noted. The promptness and value of the service may be inferred from the fact that in the middle Western states, from Ohio to Nebraska, 600,000 farmers obtain the morning weather forecasts by telephone thirty minutes after they are issued.

The total cost of the Weather Bureau is about $1,400,000 a year, and the careful investigation of an American insurance company has shown that the annual saving to the people of the United States by this telegraph and telephone weather service is $30,000,000. It is stated that during the cold wave of 1898 fruits valued at not less than $3,400,000 were saved by the telegraphic forecasts. With regard to shipping, also, the warning service has been of great utility, for forty-five minutes after the determination of a storm warning at Washington it is brought to the notice, or placed in the hands, of every sea captain in every lake and ocean port of the United States. It is stated that whereas formerly 75 per cent of the loss of the shipping on the Great Lakes was due to storms, now less than 25 per cent can be attributed to this cause on account of the efficiency of the storm warnings.

United States Life-Saving Service.—An important and valuable branch of telegraphic and telephonic work done by the National Government is that constituting the operations of the United States Life-Saving Service, conducted under the administration of the Treasury Department. This service does not now maintain, and never has maintained, any telegraph lines. The telephone is used exclusively between the life-saving stations in preference to the telegraph; for it is more convenient, its use is more easily learned, special operators are not required, and its maintenance is easier. As is well known, the stations of the Life-Saving Service extend along the coast of the United States at intervals of but a few miles, so that the whole seaboard is under patrol, and news of a shipping disaster or similar occurrence at one point can be immediately communicated to contiguous stations and the necessary aid obtained. The first lines of the Service were established in 1879, and the system has been gradually extended along the various coasts until, according to the statement of Mr. S. I. Kimball (for many years General Superintendent), there are now more than a thousand miles of line connecting stations with each other where they are contiguous and geographically related, and connecting isolated stations with the nearest local telephone exchange. The termini of all the lines running along the coast are either connected with or in the immediate neighborhood of the general telegraph systems of the country, so that messages can be promptly transferred from the telephone lines to the telegraph lines and sent to any part of the country. The utility of this service is frequently tested, not only in the communication of news to the press, but also in case of shipwreck, in enabling anxious friends and relatives to get in touch with each other with a minimum of agonizing doubt and delay.

Upon the plan above outlined, the country, or coast, is divided into 13 districts. The region of the Great Lakes is an exception to the plan, there being no system of continental lines connecting station with station, except in a few cases where such an arrangement can be advantageously effected. Most of the stations, however, are connected with telephone exchanges, giving long distance facilities in addition to local service.

All the telephone lines of the Service are constructed and maintained by a superintendent of telephone lines, with the aid of a corps of seven linemen, distributed over the various coasts of the country as the necessities may require. These linemen, however, are assisted in their duties by the life-saving crews, when such assistance can be rendered without interfering with their regular duties. It is difficult, if not impossible, to give an adequate idea by figures of the amount of work performed by the telephone corps attached to this service. These men, it may be said, are incessantly on duty, ready to meet the emergencies brought about by the shifting of beaches along the coast, the cutting through of gullies and inlets by severe storms, the strokes of lightning, and other troubles that tend to the interruption of constant communication over the circuits. As an illustration of the importance of the system, the following passage may be quoted from the official pamphlet entitled "Organization and Methods of the United States Life-Saving Service," published in 1894:[1]

> The telephone lines which now extend along nearly all those portions of the coast on which contiguous stations are located make it easy to quickly concentrate the crews of two or more stations at any point where additional force is required, as in the case when several wrecks occur at the same time in the same neighborhood, and the double equipment at each station expedites this concentration by permitting the reinforcing crew to come unencumbered. A notable illustration of the benefit of such a combination of crews was the work achieved near Cape Henlopen in the great storm of September 10, 11, and 12 last, one of the most destructive that has ever visited our coast, when the crews of three stations, under the leadership of Captain Clampitt, of the Lewes Station, rescued the crews of 22 stranded vessels—194 persons—by the use of every form of rescuing appliance, 23 being landed with the surfboats, 16 with the self-righting lifeboat, 135 with the breeches buoy, and 20 with the life car—not a life being lost.
>
> The telegraph and railroad systems of the country are also used to secure the services of the crews at scenes of rescue far remote from their stations. On two occasions the Cleveland crew has been called to Cincinnati, Ohio, and Newport, Ky., a distance of 240 miles, to render aid to the sufferers from inundations in the Ohio valley. On the first occasion, 1,200 persons were succored; on the second, over 800. The crew of the Sturgeon Bay Ship Canal Station, Lake Superior, was once called at night to Chocolay Beach, near Marquette, Mich., a distance of 110 miles. Proceeding by special train running at the highest attainable speed, and taking with them their beach apparatus and boat, they reached the beach at midnight, and, through a blinding snowstorm and in spite of bitter cold, were able to board two stranded vessels and rescue 24 persons after every effort of the citizens had failed. Shorter journeys of from 15 to 30 miles by rail are frequently undertaken, especially where the railway skirts the shore, as it does on many parts of the coast.

[1] By Sumner I. Kimball, General Superintendent of the Service. Read before the committee on life-saving systems and devices, International Marine Conference, November 22, 1889; pages 28 and 29.

CHAPTER III.

HISTORY AND DEVELOPMENT OF TELEGRAPHY.

Pioneers of telegraphy.—From the earliest dawn of civilization there has been an insistent effort to develop and perfect means of communication for the exchange of intelligence. The fundamental idea of society is that of intercourse, and it might be said that the place of any people in the scale of civilization may be determined by the extent to which it has cultivated and perfected its facilities for intercommunication. Among some of the most barbaric and primitive races, however, ingenious methods for signaling have long been known, and in the earliest historical records of the leading nations of antiquity are to be found frequent notes of the speed with which dispatches could be sent, signals exchanged, and warnings given over great expanses of country by various noises, columns of smoke by day, bonfires on mountain peaks by night, and other devices, some of which to-day remain as obscure in their nature as they appear to have been certain in their results. Many instances are noted in which the news of a great event has apparently been circulated hundreds of miles away simultaneously with its occurrence. From the scientific standpoint it seems certain that in the strict sense of the term no telegraphic agency intervened and that in each case the rumors were nothing more than the expression of natural foreboding or instinctive prophecy. Dismissing telepathy from consideration, it would seem that the earliest systematic telegraphic work was that done by means of signaling semaphores, which to this day remain extensively in use on railroads and frequently under electrical control.

With regard to the use of electricity or magnetism, Galileo, in 1632, referred to an occult art by means of which sympathetic magnetic needles, though widely separated, could be made to exchange signals for purposes of communicating intelligence, but this was merely the echo of a tradition or superstition that had come down from the ancients.

The discovery of an electrostatic discharge from a body electrified by friction was eagerly seized upon as a means of signaling, and as early as 1727 Stephen Gray made an electric discharge from an excited glass tube situated at one end of the line, to pass over a circuit some seven hundred feet in length, suspended in the air by silk threads, and thus effect the motion of a pith ball electroscope located at the other end. It was obvious that the delicate movements of the electroscope could be made to constitute a system of signals. Twenty years later Professor Watson constructed a telegraph line that extended from the rooms of the Royal Society of London over the house tops and used the earth as the return circuit. He employed the discharge of a Leyden jar or condenser as the current for operating the crude signals. A year later Benjamin Franklin sent crude signals across the Schuylkill river at Philadelphia. Cumulative results from these experiments set many minds working upon the problem of an electric telegraph, and in 1753 a practical suggestion of this nature was made by an unknown correspondent of the Scot's Magazine, who advanced the idea of having parallel wires corresponding to the letters of the alphabet extended between two given places. In 1774 an actual working telegraphic line of this kind was established at Geneva, Switzerland, by Le Sage, who had 24 wires, insulated in glass tubes, buried in the earth, and employed an ordinary frictional machine to deliver a charge to the wires. Such work remained, however, purely experimental and fruitless until the discovery of the primary voltaic battery by Volta enabled investigators to dispense with the use of frictional machines and placed in the hands of inventors and physicists a readily available source of current.

From this new point of departure successful advances were soon made. In 1812 Professor Soemering, of Munich, brought out an electro-chemical telegraph which was highly ingenious. Employing the discovery of the power of a current from a battery to decompose water, he caused the passage of the current over the circuit to evolve gas in the appropriate tube at the other end of the line, thus indicating any one of the 35 numerals and letters. About the same time similar work was done independently by Doctor Coxe, of Philadelphia, the signals being distinguished at the far end of the line through the decomposition of water or of a metallic salt. Ingenious as these methods were, it is obvious that a telegraph system comprising between 30 and 40 circuits and depending for its signals upon the evolution of a tiny bubble of gas could never be very practical. Another German, Schweigger, reduced this ponderous system of 35 wires to 2, the letters being indicated not simply by the bubbles, but by the time elapsing between their appearance. A remarkable step forward was made in 1816 by Ronalds, of England, who invented a telegraph system in which he used clocks, one at each end of an underground wire. In front of each clock was suspended, from an insulated wire, a pith ball electrometer. These balls were discharged as a brass plate or hand capable of being moved along the signal disk was made to touch a given letter, so that a series of signals could thus be transmitted equivalent to letters or numerals. Ronalds worked a line not less than 8 miles in length, but the transmission was slow. Upon the communication of his plan to the British Admiralty, he was informed that "telegraphs of any kind are now wholly unnecessary" and that "no other than the one now in use would be adopted." The English Government at this time was using semaphoric telegraphs, which had been improved by an Englishman named Murray from the telegraphs of like character employed by the French.

A significant advance was made in 1819, when the physicist Romagnesi discovered the deflecting influence of a galvanic current on a free magnetic needle, causing it to take a position at right angles to the flow or direction of the current; the direction of the current being reversed the deflection of the needle was also reversed. This and the great discovery by Oersted of the production of magnetism by electricity served as the basis of the needle telegraph system, as well as the groundwork of all modern telegraphy.

In 1820 Ampère, in a memoir to the Royal Academy of Sciences of Paris, disclosed the plan of an electric telegraph which depended on the deflection of a magnetic needle surrounded by coils of wire through which the currents were passed. He remarked significantly that the communication between the battery and the different coils was to be opened and closed by means of keys, but he still based his apparatus upon the employment of as many wires and magnetic needles as there were letters. In 1820 Schweigger made the interesting discovery that the deflection of the needle might be increased by coiling an insulated wire as a helix and thus conducting the current around the needle from end to end; while in 1821 Arago noted that a piece of soft iron thus surrounded by a helix of wire, when a current of electricity was passed through it, became a temporary magnet. In 1825 Sturgeon, of London, found that by loosely coiling copper wire around a varnished piece of insulated soft iron bent into the form of a horseshoe, the successive coils being insulated from each other, he could at will, upon passing a current through these coils, convert the soft iron into an electro-magnet and could as quickly demagnetize it. This provided means for reciprocal motion and for so controlling the movements of an armature in front of the electro-magnet that it acted in response to current impulse from a distant point, thus giving signals that might be taken by either the eye or the ear, or even be impressed upon paper. It will be seen that, while no practical telegraph had yet been brought out, successive experimental steps had developed the sources of current, effective circuits, and electro-mechanical and electro-chemical means, so that, by forces liberated or utilized at one end of the circuit, signals could be received and recorded at the other end many miles away.

The year 1837 was a notable one in the history of telegraphy, for the reason that Wheatstone and Cooke, in England, utilizing the work of Oersted and his contemporaries, devised an operative needle telegraph with right and left deflection, and put it into actual service in 1838 on the line of the London and Blackwall Railway, one of the first of England's steam railroads. They employed two conductors and two needles. At almost exactly the same time Steinheil, in Germany, discovered that a good electric connection could be made with the ground at each end of a single line, so that the return circuit or wire was no longer needed, while the resistance of the line was greatly reduced.

Simultaneously Morse, in America, was doing his great work, and in 1837 was able to make a public exhibition of apparatus whose conception dated back to 1835. Prof. S. F. B. Morse was a man of typical American versatility, one of the fathers of American art, as well as one of the founders and the first president of the National Academy of Design. His fame rests, however, upon his electro-magnetic telegraph, and, while his share in this and even his originality has been bitterly contested and the essentials of the art have been claimed for his distinguished associates, Professors Henry and Alfred Vail, it is impossible to deny that from Morse sprang the original conception and that by him much of the original work was done. Through struggle and privation his persistent and persevering efforts carried the invention to the point where it became a practical and invaluable art. The status of Morse in regard to the telegraph has been admirably set forth as follows by the late James D. Reid:[1]

> Morse's entrance into the circle of inventors was sudden and unexpected. . . . He was a painter, educated indeed in general electric science to the extent attainable by collegiate instruction and intimacy with professional teachers, but having never pursued its study with reference to practical results. He entered now not so much to discover, although even in this he has earned a permanent fame, as to invent and combine. He brought into use the painter's art . . . the blending, the combining of things known. He took familiar elements, and, with a dexterity which looks like inspiration, put them together. He then invented a language by which they could find expression. Up to his time it is well known that there had been practically no telegraphic language. Morse gave the alphabet of that language, and it is to-day acknowledged and employed by all nations as the telegraph idiom of the world. There was also, as all know, up to Morse's time no recording telegraph. Morse also gave that, and it is in preferential use by every nation on the earth.

[1] The Telegraph in America, page 77.

A MAIN OPERATING TELEGRAPH ROOM.

AUTOMATIC REPEATER EQUIPMENT IN TELEGRAPH OPERATING ROOM.

With regard to another important step, the relay, Reid[1] has also the following:

> Morse made his discovery with the relay in 1836. It was the discovery of a means by which the current which through distance from its source had become feeble could be reinforced or renewed by its own action. It made transmission from one point on a main line, through indefinitely great distances and through an indefinite number of branch lines, and to an indefinite number of stations and registration at them all, by the manipulation of a single operator at a single station, both possible and practicable.

It was not until 1837 that two of his instruments were put in operation at the ends of a short line. In the earlier stages of his work Morse had thought it necessary to embody the signs to be recorded or printed in a kind of type which would regulate the opening and closing of the circuit, in order to mark or imprint corresponding points or signs upon a card or strip of paper at the desired intervals of time. For this purpose he made a quantity of type, some few pieces of which are still preserved, but in his more perfected apparatus this plan was abandoned.

In 1837 Morse filed his caveat in the United States Patent Office and six months later applied for a patent, which he obtained in 1840. His first completed instrument for recording was tested in 1835, and a model of the relay was shown to a few persons in that year and in 1836. The apparatus shown to Alfred Vail in 1837 was already in such promising and operative condition that the offer of pecuniary and mechanical assistance was immediately made to Morse by the Messrs. Vail, for which assistance Morse assigned to Vail one-fourth interest in the patents. A Morse instrument made at the Speedwell iron works of the Vail family at Morristown, N. J., was put in experimental operation over three wires of copper circuit carried around a room, and on January 24, 1838, this apparatus was shown in operation at the University of New York in Washington Square. A few weeks later it was inspected by the Committee of Science and Arts of Franklin Institute, whose report may be taken as authoritative of the stage of development and as evidence of the fact that telegraphy had reached a practical stage. The report says:

> The instrument was exhibited to them in the hall of the institute, and every opportunity given by Mr. Morse and his associate, Mr. Alfred Vail, to examine it carefully and to judge of its operation. The instrument may be briefly described as follows: (1) There is a galvanic battery of sixty pairs of plates, set in action by a solution of sulphate of copper. (2) The poles of this battery can be connected at pleasure with a circuit of copper wire, which in the experiments we witnessed was 10 miles in length. The greater part of the wire was wound round two cylinders, and the coils insulated from one another by being covered with cotton thread. (3) In the middle of this circuit of wire—that is, at what was considered virtually a distance of 5 miles from the battery—was the register. In this there is an electro-magnet made of a bar of soft iron bent into the form of a horseshoe, and surrounded by coils of the wire which forms the circuit. The keeper of this magnet is at the short end of a bent lever, at the end of the longer arm of which is a fountain pen. When the keeper is drawn against the magnet, the pen comes in contact with a roll of paper wound round a cylinder, and makes a mark with ink upon this paper. While the telegraph is in operation, the cylinder which carries the paper is made to revolve slowly upon its axis by an apparatus like a kitchen jack, and is, at the same time, moved forward, so that the pen, if constantly in contact with the paper, would describe a spiral or helix upon its surface. (4) Near the battery, at one of the stations, there is an interruption in the circuit, the ends of the separated wire entering into two cups, near to each other, containing mercury. Now, if a small piece of bent wire be introduced, with an end in each cup, the circuit will be completed, the electro-magnet at the other station will be set in action, the keeper will be drawn against it, and the pen will make a mark upon the revolving paper. On the other hand, when the bent wire is removed from the cups, the circuit will be interrupted, the electro-magnet will instantly cease to act, the keeper will, by its weight, recede a small distance from the magnet, the other end of the lever will rise and lift the pen from the paper, and the marking will cease. (5) The successive connections and interruptions of the circuit are executed by means of an ingenious contrivance for depressing the arch of copper wire into the cups of mercury, and raising it out of them. This apparatus could not be described intelligibly without a figure, but its action was simple and very satisfactory. (6) Two systems of signals were exhibited, one representing numbers, the other letters. The numbers consist of nothing more than dots made on the paper, with suitable spaces intervening. Thus . . .   . would represent 325, and may either indicate this number itself, or a word in a dictionary, prepared for the purpose, to which the number is attached. The alphabetical signals are made up of combinations of dots and of lines of different lengths. There are several subsidiary parts of this telegraph which the committee have not thought it necessary to mention particularly. Among these is the use of a second electro-magnet at the register, to give warning by the ringing of a bell, and to set in motion the apparatus for turning the cylinder. The operation of the telegraph, as exhibited to us, was very satisfactory. The power given to the magnet at the register, through a length of wire of 10 miles, was abundantly sufficient for the movements required to mark the signals. The communication of this power was instantaneous. The time required to make the signals was as short, at least, as that necessary in the ordinary telegraphs. It appears to the committee, therefore, that the possibility of using telegraphs upon this plan in actual practice is not to be doubted, though difficulties may be anticipated which could not be tested by the trials made with the model. One of these relates to the insulation and protection of the wires, which are to pass over many miles of distance to form the circuits between the stations.

In 1837 Morse had made a report to the Secretary of the Treasury of the United States with regard to his telegraph system, and in the following year it was exhibited before the President of the United States and his Cabinet. Morse now attempted to secure aid from Congress for the construction of a line about 40 miles in length between Washington and Baltimore, and finally a bill was passed by a small majority appropriating $30,000 for this purpose. This line was duly constructed, and on May 24, 1844, Miss Ellsworth, daughter of the United States Commissioner of Patents, sent over it the memorable message, "What hath God wrought!" A short while afterwards the National Democratic Convention, sitting in Baltimore, nominated Polk for President, and the immediate transmission of the news by telegraph to Washington not only caused a sensation, but helped the young

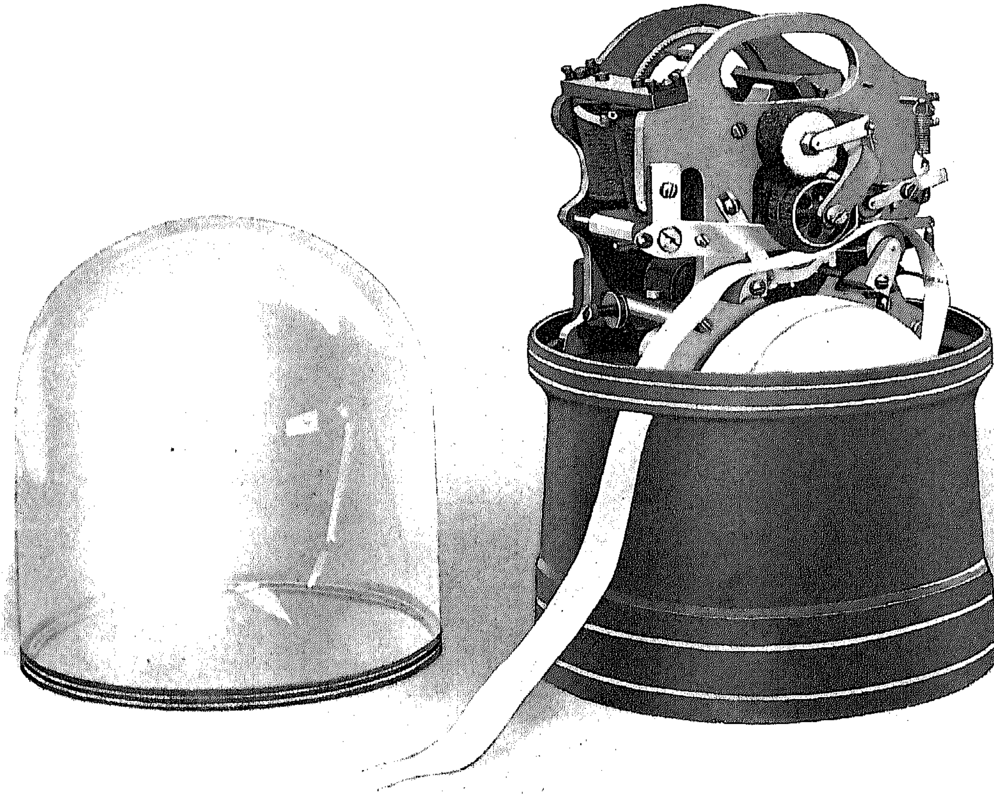
[1] The Telegraph in America, page 78.

invention in many other ways. During the session of 1844–45 Congress made an appropriation of about $8,000 to keep the system in operation during the year, and placed it under the supervision of the Postmaster-General. A tariff of one cent for every four characters was instituted, and Messrs. Alfred Vail and J. H. Rogers were appointed operators under Professor Morse as superintendent. The Government declined, however, to go any further in its assistance, and also refused to purchase the Morse telegraph for $100,000, the price at which it was offered by the inventor and his associates. Thus, contrary to the practice prevailing in Europe, the telegraphs reverted to private hands and have so remained up to the present time.

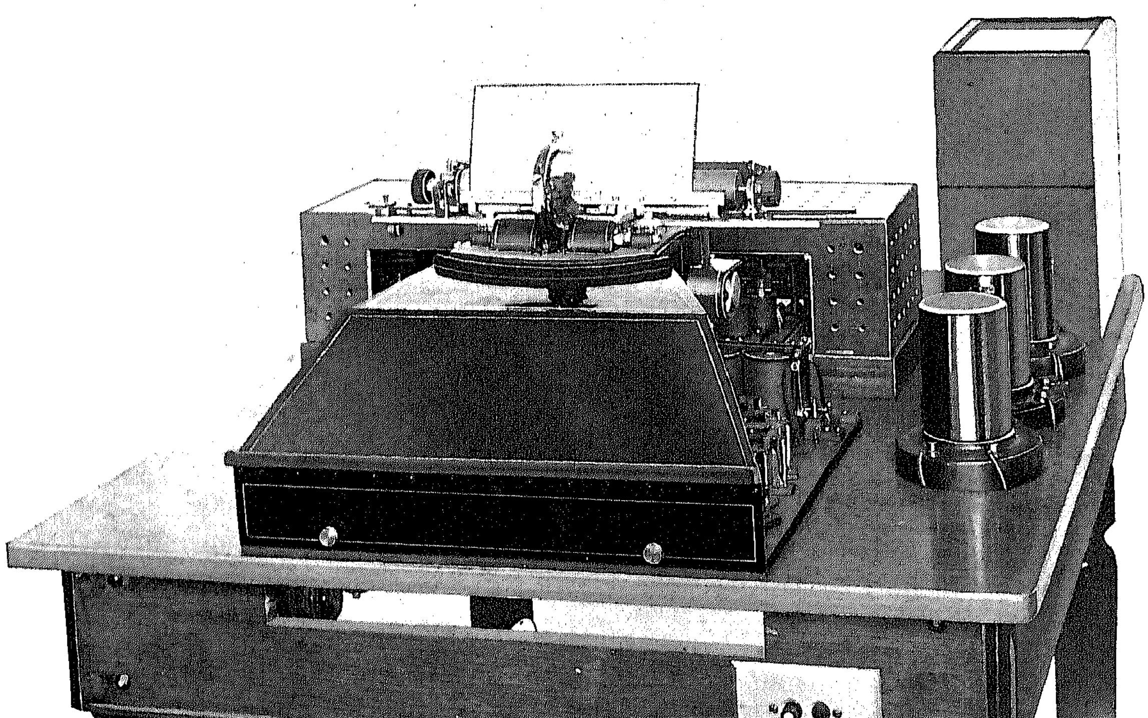
Commercial developments.—The early days of telegraphy as an industry in the United States witnessed the usual difficulties and disasters that every new art encounters. The growth of business was naturally attended also by a great many rivalries and competitions. The first chapter of the American commercial telegraphic development, summing up all the pioneer work of whatever character, may be said to have closed with the formation of the Western Union Telegraph Company, which in 1856 consolidated a large part of the telegraphic systems of the country. No sooner had Morse shown his system to be operative and succeeded in enlisting capital than other inventions and devices also found their supporters, and it took several years before the chaos of conflicting claims and methods could be reduced to system and the best types of apparatus could establish their superiority. The Morse system has always been based essentially upon the operation of a lever key, the depression and raising of which, opening and closing the circuit, causes a series of longer and shorter electrical impulses to pass over the wire, thus making corresponding clicks with the sounder or imprinting themselves on tape as dots and dashes, the nature and sequence of which translate themselves into letters and numerals.

But from the very first other principles competed with this simple manual plan, and some of them remain operative to the present day, though, strange as it may seem, after three-quarters of a century of tremendous electrical development the whole great telegraphic system of the world is still based primarily and essentially upon the skill of the human hand—i. e., upon manual operation as distinguished from mechanical transmission. In other words, telegraphy remains a handicraft. Machine telegraphy was, however, like chemical telegraphy, given a very early trial, and some of the companies competing with the Morse system based their claims to public support upon the employment of printing apparatus, such as the Hughes and Phelps, and, perhaps more notably the House, upon which patents were granted in 1846 and in 1852. Some idea of the ability of the House mechanism may be formed from the fact that its capacity has been rated at from 1,800 to 2,600 words an hour; indeed, a press report containing 3,000 words, more or less abbreviated, has been sent by it in the same time. Two men were required for the reception or transmission of such a message, one known as the "grinder," to give the machinery motion by turning a crank, and the other to act as the operator. Some of these operators became so expert and highly trained that, even when the type wheel was performing at the rate of 6,000 revolutions per hour, they could calculate the variation of time between strokes, and read messages on the House printer from the sounds these made.

Such automatic or machine printing systems have attracted attention from time to time, and several are now before the public as competitors for favor. None of them, however, has been able to secure the enthusiastic approval of telegraphic authorities in America, although elaborate and continued experiments have been made over long circuits, and the only one in general employment outside of the Morse system is the more or less antiquated Wheatstone, in which messages are prepared by perforating tape by hand punches, the tape being afterwards run through machines permitting signals to be transmitted, which, upon being taken off at the other end of the long circuit, give a record in dots and dashes in ink on a strip of stiff paper. A speed of 400 words a minute is attainable with the perforated tape run through a Wheatstone automatic transmitter at high speed, the receiver at the distant end giving a clear and distinct impression of the signals. This speed is, however, only attainable on circuits of moderate length, say 200 miles of overhead line. As compared with such rapid work the average rate by hand of from 25 to 50 words a minute seems very slow. This slowness is offset, of course, by the time spent by the Wheatstone operator in preparatory punching; but an enormously increased amount of telegraph business can be transmitted by the machine method over the same wire, and great economy is thus obtained in the time during which the circuit is occupied for the transmittal of a message. The assertion is made by the advocates of automatic and high speed telegraphy that, given favorable conditions, such systems would enable a large proportion of the mail matter now sent by trains to be put on the wires with enormously increased expedition. Thus the written contents of a whole mail bag from New York to Chicago, if handled by automatic or machine telegraph, could be sent over the circuit between the two cities in one or two hours, so that a letter written at the seaboard in the morning could be delivered to a merchant on the banks of Lake Michigan before his lunch hour. Automatic high speed telegraph systems, in which speeds of 1,500 to 2,000 words per minute are attained, have usually employed at the receiving end chemically prepared paper, upon which the current by its decomposing effect traces the



NEW FAST STOCK TICKER.



TYPEWRITING TELEGRAPH SYSTEM.

dots and dashes of the Morse alphabet. One of the chemical solutions used for this paper is iodide of potassium, the current setting free the iodine, which appears as brownish characters upon the paper strip.

The inventors of automatic systems maintain that all this is feasible and should have been carried out long ago; while, on the other hand, the managers of large telegraph systems, although permitting their wires to be used for such experimental work, assert that the practical difficulties are too serious to be overcome, and that the key and the sounder associated with the Morse alphabet remain to-day the necessary foundation of the commercial telegraphic art. With one of the modern machine telegraphs, the ingenious Buckingham system, over one and a half million messages have been transmitted, and a record has been made of 2,429 words between New York and Chicago in slightly less than twenty-four minutes. In this system the messages are actually received in type-written form on message blanks and are thus ready for instant delivery.

One striking improvement has been the invention of duplex, quadruplex, and multiplex telegraphy. In duplex telegraphy two distinct messages are simultaneously transmitted in opposite directions over a single wire. In diplex, two messages are transmitted over one wire at the same time in the same direction. The next step made was due largely to the work of Edison, and was that of enabling one wire to carry two messages at the same time from each end of the line. A number of working circuits in America are thus quadruplexed, and the "phantom circuits" thus created effect an enormous saving in line construction. It has, indeed, been asserted that such saving amounts to as much as fifteen or twenty millions of dollars in the United States alone.

A number of multiplex telegraph systems have been brought out, although very few are apparently operative or in practical use. Among the most notable are those with which the names of Gray and Delany have been associated. Some depend upon musical tones, which serve as the vehicle of an equal number of separate telegraphic messages. These tones are sent over the line in the form of rapid interruptions of current obtained by means of tuning forks, vibrated automatically by electro-magnets. Such harmonic systems, although admirable as beautiful inventions, have no prominent place in the art.

A more practical development which has been carried out on both sides of the Atlantic consists of the synchronous system in multiplex telegraphy, such as that of Delany, in which trailing fingers or arms passing over the face of disks at each end of the line are maintained in synchronous relationship. The single line wire between the two disks is led to the different portions of each disk in such a manner that as the two arms travel around they can distribute electrical impulses successively to each section. Through this division or dissection of the line, say into as many as thirty-six separate parts, it is feasible to transmit with virtual simultaneity 36 separate messages. This ingenious system has never been pushed to quite such an extent, but it has been found possible to send several messages simultaneously in both directions. Obviously either the arm may travel or the disk upon which it makes contact may revolve, the result in each case being the placing simultaneously in contact of corresponding parts of the disk, so as to give the sectors and the operators working them momentary use of the wire in swift succession.

Aside from methods of sending dispatches, a great deal of experiment was devoted in the early days to the insulation of circuits. The idea of burying wires underground was taken up at the very outset, but the practice was soon adopted of raising the wires attached to insulated arms, brackets, or knobs on poles. In this exposed position, especially in wet and foggy weather, the current leakage from the line rendered the effective transmission of signals very difficult. Both copper and iron wire was used in the first circuits, but copper was soon abandoned on account of undue elongation and lack of tensile strength, and iron wire came into common use. On many circuits the iron wire was fastened to the bare poles with iron staples, such poor insulation resulting that the cutting down of every second pole was actually carried out in order to render the line operative. Some of the circuits were insulated with tar; in one or two cases they were coated with beeswax. In a short time insulators fastened to the cross arms by wooden pins were developed. As early as 1848 one of the contracts for circuits in Maryland, to be built at a cost of $300 a mile for a single wire line, specified that there should be 20 poles to the mile; that the wire should be three-ply, No. 14 iron wire, painted when put up, insulated with square glass globes set in the end of the poles, with a glass cover and with a wooden one 10 inches square, the poles themselves to be of white oak, chestnut, or cedar. The number of poles was soon raised to 35, but this appears in other respects to have been fairly standard construction. At a very early stage, before 1850, neat iron poles were adopted at Louisville. A very early form of insulation was a small iron hat, into which an iron stem with a hook was inserted and was held until hot brimstone in the hat had cooled and solidified around it. About 1849 No. 9 galvanized iron wire was adopted for some of the circuits in New England, associated with cylindrical glass globes for insulators. These globes were secured by an iron stem and hook to a wedge of wood insulated with gum shellac. Some of the earliest circuits consisted of several strands of No. 16 iron wire, twisted into a cord, the idea being to increase both strength and conductivity; but it was soon found that this form retained moisture, which caused oxidation and disastrous weakness. Other early attempts at insulation and the construction of durable circuits comprise the adoption of vulcanized rubber as insulating material in place of glass, and short poles of only 10 or 12 feet, so as to avoid high winds and atmospheric electricity. It was soon found, however, that vulcanite exposed to the atmosphere became foul and fragile, and that the shorter poles, half the length of the ordinary, were exposed to the dangers of spring freshets, while the wires could not be carried clear of buildings, etc., which would not constitute an obstacle to circuits at the ordinary height.

Submarine telegraphs.—The attempts to transmit signals commercially through wires laid under water date back as far as 1839. In the summer of 1842 Morse laid an insulated wire in New York harbor between Castle Garden, at the southern extremity of Manhattan Island, and Governors Island, the United States military headquarters at the junction of the East and North rivers. He employed a wire wrapped in hempen thread, well soaked with pitch and tar, and surrounded by rubber. A few signals were exchanged over this circuit, but the cable was torn up, as a great many of its successors have been, by the anchor of a boat and part of it was carried off by the sailors. This experiment was repeated at Washington in the following December and both experiments are described in a letter of Mr. Morse to the Secretary of the Treasury, dated December 23, 1844. Numerous other experiments were made in the next few years in the United States. The first submarine wire insulated with gutta-percha in this country was laid across Hudson river in 1849 from New York city to the New Jersey shore. This wire or cable having no protection other than the gutta-percha the circuit soon broke down and was abandoned. The first submarine cable of any length antedated this a year, having been laid in 1847 across the strait from Dover, England, to Calais, France, the cable consisting of a copper conductor, surrounded merely by an insulating layer of gutta-percha.

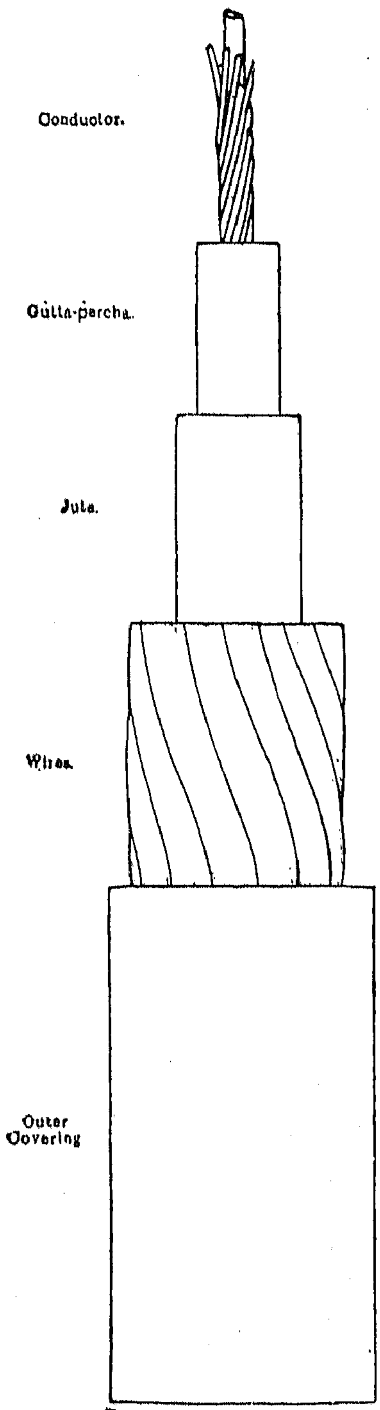
Although the early failures were somewhat discouraging, the more sanguine inventors and scientists were convinced that such work could be indefinitely extended. Morse said with regard to data obtained from his own trials, "The practical experience from this law is that telegraphic communication on the electro-magnetic plan may certainly be established across the Atlantic ocean. Startling as this may now seem, I am confident the time will come when the project will be realized." The same idea appealed to many minds, but it was not until numerous shorter lengths of cable had been laid in different parts of the world, particularly those connecting England with the continent of Europe, that the larger project was pushed forward. The successful carrying out of the idea was in great measure due to the courage and indomitable perseverance of a young New York merchant, Cyrus W. Field, who associated with himself such well-known Americans as Peter Cooper, Moses Taylor, and Marshall O. Roberts. Capital was pledged, Government support was enlisted, on both sides of the Atlantic surveys were made, and in 1858 the first Atlantic cable was laid between Ireland and Newfoundland. Congratulatory messages were exchanged between Queen Victoria and the President of the United States, and the public enthusiasm on both sides of the Atlantic was intense.

Very little was known, however, about the conditions governing the construction of cables to be lowered to and raised from such extreme depths as 2,000 fathoms, and this first cable linking the New World with the Old lasted but a few weeks. Its sudden lapse into silence caused many people to be skeptical as to whether messages had actually been exchanged. As a matter of fact, exactly 400 messages had been transmitted between August 5, the day it was connected on both sides of the ocean, and September 1, the time of its interruption. Such a failure, following a long series of other ruptures and interruptions, was enough to paralyze all further effort, but the courage of Mr. Field and his associates rose superior to every obstacle, and the work was renewed in 1865, when another cable was laid across the Atlantic, only to break again in deep water before completion. A final effort was made in 1866, when a third cable was successfully and permanently laid on the bed of the ocean, while the cable laid the previous year was recovered and repaired in deep water, so as to become available for business. By this time about $12,000,000 had been invested, all of which would have been totally lost had the attempt failed, so that one need hardly grudge the handsome rewards which were enjoyed by most of the parties in the enterprise when at last their efforts brought fruition.

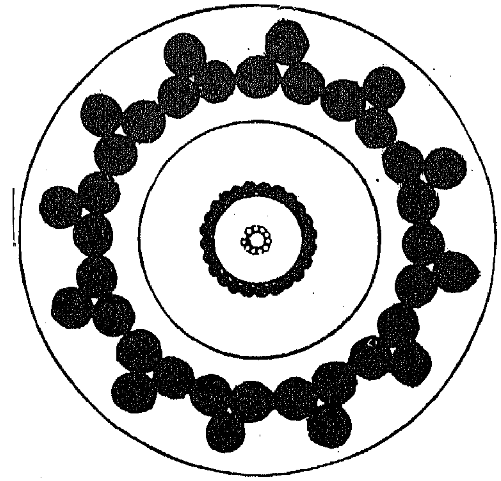
Since 1866 the history of submarine telegraphy has been one of continuous advance, until all the oceans have been occupied by these circuits. The last definite figures with regard to cables give the number as 1,750, with an aggregate length of nearly 200,000 miles, their cost being estimated at $275,000,000 and the number of messages transmitted annually over them at more than 6,000,000. The fleet maintained for laying and repairing these cables in all quarters of the globe would constitute a fair-sized navy, and several large factories in the leading countries of the world are devoted exclusively to the production of submarine cable.

Submarine cables.—Considerable progress has been made in the production of submarine cable, although of late years the chief changes have been in the direction of increasing the weight.

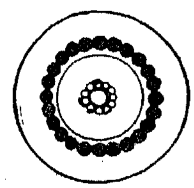
At the present time such cable, as shown in illustration on page 117, consists broadly of a central core or conductor of stranded copper wire, over which is a



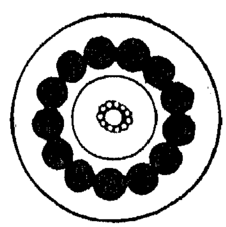
Submarine Telegraph Cable, with various layers stripped.



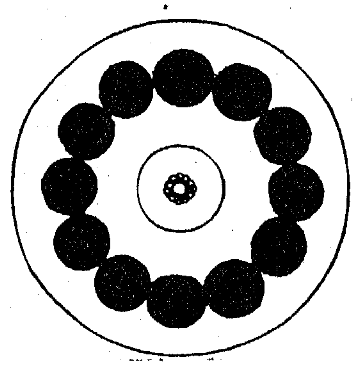
Shore-end Cable.



Deep-sea Cable (for greatest depth).



Deep-sea Cable (for lesser depth).



Intermediate Cable.

TYPES OF SUBMARINE CABLES.

18407—06——9

layer of insulation consisting usually of gutta-percha or a gutta-percha compound. These constitute the cable proper, but are protected by a wrapping of jute or hemp, around which is placed an external sheathing of stranded iron or steel wires covered with tape and compound. The core of the cable varies in size and weight of copper according to the length of cable and the speed at which it is proposed to send signals through it. A small core permits only a slow rate of transmission, while a large one allows a high rate of speed to be obtained over the longest cable. The copper core in a modern cable will weigh as much as 650 pounds per nautical mile, with an electrical resistance of nearly $1\frac{3}{4}$ ohms the mile. In the earlier cables the gutta-percha insulation weighed about as much as the copper—that is, 400 pounds to the mile—which is now about the standard weight for the gutta-percha.

Such a cable can be worked over a distance of 1,850 nautical miles, or 2,130 statute miles, at a speed of 40 words, or about 200 letters, per minute, but lighter cables do not permit of such a high efficiency. When worked duplex, the carrying capacity of the cable is approximately 80 words, or 400 letters, per minute. The shore end or shallow water portion of such cables weighs about fifteen tons to the mile and receives especially heavy armor on account of exposure to abrasion by rocks, ice, etc.; but the deep sea portion weighs only one ton to the nautical mile in water, with a breaking stress of six tons, so that it would support at least six miles of its own weight when immersed. The cable to be laid is carried to sea in lengths of several hundred miles, coiled up in large tanks, from which the cable is paid out by means of a special, highly ingenious gear and sheaves which permit the operation to be checked at any minute. Should the work of laying the cable be interrupted—as, for example, by fog or storm, or on the approach to shore—the end is buoyed so that it can be picked up. Cable can be paid out at a speed of four to eight miles an hour, according to its size, the state of the weather, etc. In some of the earliest work ruptures were frequent, but at the present time cable laying is usually conducted with great celerity, even in the Pacific ocean, where depths of 5,000 or 6,000 fathoms are reached.

Submarine signaling.—While regular telegraphic signals can be transmitted over short lengths of cable, their use is impracticable with long submarine cables, and hence other means have to be adopted of causing the electrical impulses to pass from one end to the other. It might be supposed that strong and large currents would be required, but the contrary is really the case, and apparatus of the most delicate character is employed, while the volume of current is very small. Cable messages are transmitted in two ways. In one the mirror galvanometer is used. The movements of a mirror carried on the needle of the galvanometer deflect a small beam of light over a scale marked on a sheet of white paper. A current passing in one direction through the galvanometer coils deflects the spot of light to the left, while a current passing in the opposite direction deflects it to the right. When the needle is still, the reflected beam of light from its little mirror forms a bright motionless spot on the paper; but a very minute movement of the mirror is considerably amplified by reflection, and the operator finds it easy to read the signals thus sent by the cable keys at the other end of the line. Such receiving apparatus is extremely light in weight, the mirror and the magnet weighing only from one and one-half to three grains, so that the passage of an extremely small current through the galvanometer coils will transmit visible signals.

It can readily be understood that such processes, while ingenious, are easily susceptible of interruption, and that the strain upon the operator, watching in the dark, the movement of the dot of light, is quite trying. Moreover, no record is left. The other form of apparatus, due primarily, like the cable mirror galvanometer, to Lord Kelvin and known as the syphon recorder, has very generally superseded the mirror galvanometer, and this gives a record. In this apparatus the moving member affected by the passage of current through adjacent coils carries a delicate glass syphon, one end of which dips into a reservoir of ink, while the other end is brought very near to the surface of a traveling paper tape. The ink discharged from the syphon as it moves to and fro makes a permanent record on the tape in a series of strokes looking like the line of a serrated mountain ridge, the dots being represented by upward movements and the dashes by downward movements. In the Kelvin syphon recorder, in order to compel this ink to flow out of the syphon, both the ink and the paper are oppositely electrified, the effect being to cause the ink to be ejected so as to produce a line of minute dots. The recorder sometimes failed to operate in damp weather, owing to the dissipation of the electrostatic charges on the paper and ink, but Cuttriss has successfully overcome this difficulty by keeping the syphon in constant vibration by means of electromagnets in the circuit.

Wireless telegraphy.—The aim in wireless telegraphy is to establish electrical communication between two stations without the use of wires for conveying the impulses of the current. In its more modern acceptation the term is limited to aerial or space telegraphy, depending upon the use of the ether as distinguished from some of the earlier work in which bodies of water were used as media for conveying signals. Such utilization of water dates back to the time of Franklin, who in 1748 made some experiments across the Schuylkill at Philadelphia, while in 1842 Morse transmitted signals across an 80-foot canal without wires. In such experiments the actual media for conveying the current were water and earth, which, like the wires, are tangible substances rather than intangible, like the tenuous ether.

This work was resumed in a more practical manner nearly half a century later by Mr. Edison and other inventors in connection with train telegraph systems, the object of which is to communicate with a moving train remote from stations or signaling points. One means of accomplishing this consisted in a sliding or rolling contact with the train, like the trolley now employed in street cars. But the fundamental idea of wireless train telegraphy being the absence of contact, the Edison and other systems depend on electro-magnetic or electrostatic induction for the transmission of signals. Special apparatus installed in the signaling station sends currents at a high rate of pulsation over wires paralleling the track along which the train passes. These impulses are transmitted to the passing train by means of either coils of wire wound lengthwise around the car or, preferably, a metallic roof or side on the car. This metallic surface thus acts as one large plate of a condenser. The signals sent are readily received, and messages can be sent in like manner from the moving train to the parallel circuits along the track. In such work it has been usual to employ a telephone as the receiver of the usual dots and dashes as well as the telegraph key and buzzer, and it is stated that messages have been sent through the air in this manner between a fixed circuit and a moving train through a distance as great as 600 feet. Similar methods have been worked out by Mr. Edison and others for communication with ships at sea, with balloons, etc. A full account of such ingenious methods can be found by those interested in Maver's "American Telegraphy and Encyclopedia of the Telegraph."

The wireless telegraph systems of the present day and of the period embraced in this report utilize the free ether of space. The mechanism consists of apparatus for creating electro-magnetic vibrations which are propagated at the speed of light in all directions and are of various wave lengths. These electro-magnetic waves are analogous to the vibrations imparted to the surrounding air by a sonorous bell or tuning fork or to the ripples which, when a stone is dropped into a body of water, follow each other in rapid succession in every direction until the whole impulse has died out. Sound waves travel at the rate of 1,120 feet a second, and the number of vibrations to the second depends upon the wave length of the note struck. Such a rate of speed is very slow compared with that of wireless telegraphy, for, accepting the electro-magnetic theory of light, from the fact that light travels at 186,000 miles per second, it is seen that the etheric transmission of an electro-magnetic wave is practically instantaneous for telegraphic purposes. Wireless telegraphy depends on the ability of the apparatus at the receiving end of the line to respond sympathetically to the vibrations of the ether, just as objects attuned to the same fundamental note respond when a tuning fork is struck in its vicinity.

One of the first significant demonstrations of the existence and passing of these electric waves in space was made by Prof. Joseph Henry, who, by means of disruptive spark discharges from a frictional electrostatic machine on an upper floor of his house, succeeded in magnetizing needles in the cellar 30 feet below, in spite of the two floors and ceilings intervening. The definite discovery of these radiations came much later, however, and was made in 1888 by the late Heinrich Hertz in Germany. Similar studies had been made in England by Oliver Lodge, S. P. Thompson, and others. As early as 1885–86 apparatus was patented whose operation depended upon the effect produced upon particles of dust, etc., by the electric oscillations. This was a primitive form of the coherer action, more closely identified and developed by Branly, and finally worked out by G. Marconi in his now well-known system of wireless telegraphy, patents for which were applied for in June, 1896.

In the Marconi system the electro-magnetic waves, produced by special high tension disruptive discharge apparatus and given off to the ether by means of wire antennae carried up into the air for a considerable distance, are intercepted at the remote receiving station by similar high wire antennae and brought down for registration to a coherer. This coherer consists of a small glass tube about the size of an ordinary pocket pencil. In this tube are two pole pieces of silver, to which the wires of the circuit run, and between them is a gap of about one thirty-fifth of an inch loosely filled with a mixture of nickel and silver filings or particles, to which a little mercury has been added to increase the sensitiveness. The arriving electric oscillations have the effect of drawing the filings together to form a continuous circuit, so that the resistance within the tube, high when the filings are loose, is diminished when they cohere, and a current then flows from the local battery. This closing of the coherer circuit closes also the telegraphic recording circuit. At the instant that the impulses received make their record the tongue, or tapper, of an electro-magnetic bell gives the tube a sharp jolt, which causes the particles to separate, and the tube is ready to receive the waves constituting the next signal. When the apparatus is properly tuned for receiving the waves, messages can be regularly transmitted and clearly received.

In March, 1899, after preliminary experiments over shorter distances, Mr. Marconi established wireless telegraphic communication between South Foreland, England, and a station near Boulogne, on the other side of the strait of Dover. His disruptive apparatus consisted of a 10-inch induction coil, by means of which he caused sparks to pass across a spark gap of about three-fourths of an inch. The waves that resulted from the electrical disturbance were given off into the ether by copper wire antennae raised by a pole 150 feet into the air. Messages were sent and received by the Morse code at the rate of 15 words a minute, the distance being 32 miles. Prof. J. A. Fleming, who was present, says: "The messages were automatically printed down in telegraphic code signals on the ordinary paper slip at the rate of 12 to 18 words a minute. Not once was there the slightest difficulty or delay in obtaining an instant reply to a signal sent." This work attracted a good deal of attention, but was eclipsed by that done on December 12, 1901, when Mr. Marconi succeeded in transmitting the three successive dots which constitute the letter *S* of the Morse alphabet clear across the Atlantic from the permanent Marconi station at Poldhu, Cornwall, to a temporary station at St. Johns, Newfoundland. One year later regular dispatches were transmitted over the same etheric route, including congratulatory messages between King Edward VII and the Governor-General of Canada.

Since that time considerable news matter has been sent across the Atlantic by the Marconi system, but up to the time of the preparation of this report no regular commercial service had been established. Meantime, however, the Marconi and De Forest systems have been installed in a large number of Atlantic steamships, which are thus enabled to communicate with tower stations along the shores of the Old World and the New and carry on in the aggregate a considerable wireless telegraphic traffic. The steamships also maintain telegraphic communication among themselves for business purposes, and the writer of this report was able to witness, in March, 1905, the maintenance of communication between five such steamships in mid-Atlantic, the two extreme members of the group being 1,000 miles apart.

In the United States, as in Europe, the development of wireless telegraphy has been quite rapid; systems of great ingenuity and merit have been elaborated and commercially established by Dr. Lee De Forest, Prof. R. A. Fessenden, John S. Stone, and others. All the navies of the world have adopted wireless telegraphy of some kind, and, in addition to the systems named, the "telefunken" is in quite general use for such purposes in Europe as well as commercially. In that of the United States have been elaborated improvements enabling men-of-war to communicate over distances of hundreds of miles. The main desideratum at the present time is the means of placing transmitting and receiving stations in exclusive connection, so that no others can intercept the dispatches.

The best work done with wireless telegraphy up to the present time has been across large bodies of water rather than on land, and various ingenious theories are advanced to account for this phenomenon. Remarkable results have nevertheless been secured on land. Mr. Marconi, in Europe, has transmitted messages from England across the continent of Europe to Italy, and during the Louisiana Purchase Exposition in 1904 Doctor De Forest transmitted messages from St. Louis to Chicago. During the late Russo-Japanese War a very considerable use was made of wireless telegraphy by both combatants, and it was also used most successfully by the London Times, whose special correspondent on board a small steamer equipped with a De Forest apparatus was able to send dispatches from the scene of action around Port Arthur direct to the Chinese coast. This work was, however, stopped summarily by the Russian military authorities, and the important question of the right of a newspaper or any neutral to establish within the sphere of conflict means of communication which could be used to the serious disadvantage of one or the other of the powers at war has, with cognate matters, become the subject of diplomatic discussion.