WOOD'S PLAN

OF

TELRGRAPHIC INSTRUCTION,

ARRANGED BY THE

PROFESSORS AND TUTORS

OF

"MORSE'S TELEGRAPH INSTITUTE"

SYRACUSE, N. Y.

PRELIMINARY CHAPTER.

Prior to the organization of "Morse's Telegraph Institute" Association, there existed, nowhere, any *system* of telegraphic instruction. Hitherto, it had been all *chance*.

The establishment of the Institute to supply a positive, and an oppressive want, became necessary by reason of the great scarcity of Telegraphic Operators.

Its opening developed the kindred necessity of adopting such a plan of instruction as that, while it should furnish the main landmarks for the teacher, by laying before him a *system* adapted either to *class* or *personal* instruction, as might be desired, it should, at the same time, comprehend the full paper and sound operating courses, and especially aim at making easy to the student *learning to read by sound*.

This plan of instruction will, in this later respect, be found adapted to the capacity of every student, whether of moderate or lively telegraphic application, requiring no modification of the character of any exercises, and but a simple increase of the number of repetitions of the letters of the word, either for *hand* or ear practice, to such extent as may be required by any pupil acquiring telegraphy unnaturally.

While this work will be found an important auxiliary in obtaining a knowledge of telegraphy, even by persons absent from the Institute; because, among so many students constantly in attendance thereat, several are found, daily practicing lessons exactly adapted to that stage of advancement at which any student may have arrived, in *reading by sound*.

This work, in connection with ample arrangements for practice within the Institute, and upon the public lines connected therewith, will be found perfect for the preparation of any person for the RESPONSIBLE duty of Telegraph Operator.

INSTRUCTION.

EXERCISE I.

DIRECTIONS FOR LEARNING TO OPERATE

Sit facing the table with the right arm resting upon it; place the first two fingers on the key, with the thumb pressing slightly up from the lower side.

In learning to operate, a person should be governed by the same rules, which apply to penmanship. *First*, obtain control of the hand by writing *firm dots*, making no attempt to form letters until the hand is well disciplined. Speed is acquired by practice, but firmness and good spacing are the results only of great care and attention.

Write long dashes firmly and connectedly, until they can be made of uniform length and *very closely* together. Shorten the dashes as your fingers get disciplined until they become dots. Then make many dots before attempting to form letters.

The following alphabet should be committed to memory, but not practiced on the key:

MORSE'S TELEGRAPHIC ALPHABET.

a	**b**	**c**	**d**	**e**	**f**	**g**
· —	— · · ·	· · ·	— · ·	·	· — ·	— — ·
h	**i**	**j**	**k**	**l**	**m**	**n**
· · · ·	· ·	— · — ·	— · —	——	— —	— ·
o	**p**	**q**	**r**	**s**	**t**	**u**
· ·	· · · · ·	· · — ·	· · ·	· · ·	—	· · —
v	**w**	**x**	**y**	**z**	**&**	**,**
· · · —	· — —	· — · ·	· · · ·	· · · ·	· · · ·	· — · —
.	**;**	**?**	**!**	**“ “**	**¶**	
· · — — · ·	· — · — ·	— · · — ·	— — — ·	· — · — · —	— — — —	
( )	*italics*	1	2	3	4	5
· — · · —	— · · · —	· — — ·	· · — · ·	· · · — ·	· · · · —	— — —
6	**7**	**8**	**9**	**0**		
· · · · · ·	— — · ·	— · · · ·	— · · — ·	——		

The characters for *Quotations, Parenthesis* and *italics* must be placed both before and after the matter quoted or italicized.

EXERCISE II.

DOTS. – FOR HAND AND MEMORY.

6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
p p p p p p p p p p p p p p p p p p
h h h h h h h h h h h h h h h h h h
s s s s s s s s s s s s s s s s s s s s s s
I I I I I I I I I I I I I I I I I I I I I I I I
e e e e e e e e e e e e e e e e e e e e

DOTS AND SPACES.

o o o o o o o o o o o o o o o o o o
c c c c c c c c c c c c c c c c c c c
r r r r r r r r r r r r r r r r r r r r
y y y y y y y y y y y y y y y y y y
z z z z z z z z z z z z z z z z z z z
& & & & & & & & & & & & & & &

EXERCISE III.

DASHES. – TIME EXERCISE.

t t t t t t t t t t t t t t t t t t t t t t t t
l l l l l l l l l l l l l l l l l l l l l l l l l
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
m m m m m m m m m m m m m m m
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5

DOTS AND DASHES.

a a a a a a a a a a a a a a a a a a a a
u u u u u u u u u u u u u u u u u u
v v v v v v v v v v v v v v v v v v v
4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
n n n n n n n n n n n n n n n n n n n
d d d d d d d d d d d d d d d d d d
b b b b b b b b b b b b b b b b b b b
8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
f f f f f f f f f f f f f f f f f f f f f f f f
x x x x x x x x x x x x x x x x x x x x
q q q q q q q q q q q q q q q q q q q
w w w w w w w w w w w w w w w
g g g g g g g g g g g g g g g g g g g
k k k k k k k k k k k k k k k k k k k
j j j j j j j j j j j j j j j j j j j j j j j j j j j

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9

FRACTIONS.

Telegraphic fractions are made by first writing the numerators and leaving a space, then one dot and another space, and lastly the denominator; thus for ½ , . __ __ .   .   . . __ . . ; ¾ , . . . __ .   .   . . . . __ , etc.

EXERCISE IV.

This and the following exercises are adopted both to hand practice and to the cultivation of the ear for receiving by sound. To a large proportion of students they will be found in their present form exactly adapted, numerous repetitions of the most difficult ones essential. To those acquiring sound qualifications the most unnaturally, more than three repetitions of each letter of every word should be given for a time- in number according to the capacity of the student.

EXAMPLES:

aaa sss	aaa rrr eee
aaa hhh	aaa ccc ttt
aaa nnn	aaa rrr mmm yyy

~ THRU ~

zzz iii bbb eee ttt	zzz eee aaa lll ooo uuu sss
zzz iii zzz eee lll	zzz eee ccc hhh iii nnn

[Wood’s original contains 26 specific exercises not reproduced here]

EXERCISES FOR THE HAND AND EAR.

This, and the succeeding exercises, should be practiced with *great care*, by spacing correctly, and making the space between the words twice as long as that between the letters. Make every letter distinct in itself, and avoid running them together:

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   I have not seen him for some time. You may now learn any thing
you desire. I have no doubt you will succeed in whatever you
undertake. I am sure he considers it a great mistake. I
understand it is your intention to remain in this country. You
will have little to do unless you come at once. I must not have
my mind occupied with trifles. For a long time we have known
nothing of his intentions. You must now return as soon as you
can. There are many things you will have to learn as soon as you
are able. I fear you will make many mistakes.
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[Wood's original contains 12 specific additional exercises not reproduced here]

GENERAL OFFICE ORDERS.

The following are the most general Office Regulations, and every operator, upon taking charge of a station, must first ascertain the Rules and Regulations of his office and line, as established by his Superintendent, and observe the motto, "Obey orders, if it break owners."

1st. No abbreviations are to be allowed transmitting messages. Every word must be written out.

2d. When numbers, dates or prices occur, they must first be sent in words, and then repeated in figures, thus; One hundred twenty five (125.)

3d. If any part of the address, body or signature of a message is of special importance, or liable to be misunderstood, such word or words must be repeated immediately after check.

4th. When a message is sent from one circuit of any line to another circuit, or line, the name of the destined office should be sent in full, to the repeating station, instead of by signal letter.

5th. The exact time each message is received from the customer should be noted, in hours and minutes, at the lower left hand corner; the check under the signature; and the time sent, and wire upon which it was sent, at top, with the initial letter of the operator before the time, and that of the copyist after the wire. The copyist will note the sender's letter, time, wire, and his own letter at the top, and the check at lower left hand corner.

6th. Operators copying messages must right them in a plain, neat hand, either for delivery to customers or to other lines; and must count the words before proceeding from one message to another, and especially before answering "O. K." In counting words, count only body of message, which is contained between the address and signature, exclusively. In receiving messages from customers, count twice and be sure you are right- much time is thus saved.

7th. If your customer omits to give a full address of his correspondence, ask it of him. If your customer be a transient person, and his message requires an answer, apparently, note his own address, under time received, at the lower left hand corner, to facilitate delivery of answer. Always ascertain whether messages going beyond telegraph lines, are to be sent by mail or special messenger.

8th. Always be upon the watch, in receiving messages from customers, or in transmitting and receiving them upon line, for any thing which may cause error or delay, and shun it. Be twice right rather than incur the risk of being once wrong. Never *guess* at any thing in telegraphy. Our worst errors occur thus.

9th. Never permit your messages to be scattered promiscuously upon your desks, in any stage of their transit from customer to correspondent. *Here* is the greatest cause of messages not reaching their destination. Have one, and only one place to lay them down, if needed before hanging upon office hooks; have an office hook for every station to which you send directly; put each one on its proper hook; in transmitting, remove from the hook, permanently, only so many as you can take the utmost care of; send them in the order taken; have those *to be sent*, and those *sent*, in two well defined piles, far enough apart to surely guard against getting mixed; after being sent, or received, have only one place in which to lay them for booking, and one place in which to deposit them for delivery, always using the utmost assiduity in their prompt delivery. The utmost care in observance of above directions will prevent miscarriage of messages, as well as disagreement of daily check reports.

10th. Spare no effort to have the business of your office, in every department, done with *neatness*, *accuracy*, and *dispatch*.

INSTRUMENTS AND WIRES.

11th. Instruments must always be taken out of circuit during thunderstorms and at night, and in such a manner as not to prevent the wire from working through.

12th. Offices, instruments, batteries, and all things connected therewith, must be kept clean and neat, always in order and fit for business; and care should be taken to make requisition in due season, upon the supply clerk, for material about to be required.

13th. See that no bad joints or escapes are allowed at your office in main circuit; see, also, that changes in wires, ordered at your office, are all carefully made; that your buttons are in order, and connections perfectly made each time.

14th. Ground wires must only be used in cases of breaks, and to expedite business, and then as short a time as possible; and when taken off, be careful that the circuit is closed and quiet on that side of your ground wire where your instrument is, so as not to interfere with a message which may be passing over the other circuit.

OFFICE MANAGEMENT.

15th. All communications are strictly confidential. The statute imposes a heavy fine and imprisonment for breach of secrecy, and any operator divulging the contents of a telegram, will be summarily dismissed and prosecuted.

16th. Offices must always be kept private, and no idlers or loungers allowed therein. Operators are requested to have their offices present a quiet and business like aspect.

17th. The circuit must never be allowed to remain open for any purpose whatever. *Struggling for circuit* will not be permitted, under any circumstances. The numeral "17," a few times repeated, will be heeded and an explanation allowed; but said numeral must never be used, under penalty of summary discharge, unless the transmission of the information or message cannot, with reasonable propriety, be dispensed with.

18th. During business hours there must be no gossiping over the line; even conversation on business should be brief. The use of profane, abusive, or obscene language, is strictly forbidden, either about the offices or upon the line.

19th. Blanks, used to copy and send out messages upon, must never be allowed to be taken from the office, or used for any other purpose, under any pretence whatever.

20th. Messages must be neatly filed daily, with at least the surname on each, and the band dated; and must then be kept in a private and secure place for three years, for reference if desired; after which they may be burned by order of the Superintendent, but must never be exposed before burning.

21st. Daily, weekly, or monthly reports, must be prepared in accordance with the forms and blanks furnished, and must be forwarded, in the prescribed manner, to the proper office of the company, as soon as due and complete. A strict record of the character, and manner of each remittance, must be filed at the office, so reporting, together with a copy of the report, at every settlement.

22d. Expenditures of any considerable magnitude should not be incurred, by Managers, without consulting with and sanction of the Superintendent. Every item paid out, of half a dollar or over, should be returned with a proper voucher. Strict economy is enjoined in the management of Telegraph Offices, and in the care and use of stationary, battery, fuel, lights, or other supplies. Remnants of old wire, zinc, copper deposits, platinum, and the like, should be carefully saved, and a report of same, as on hand, be made to the Superintendent when enough have accumulated worth reporting.

23d. Managers will be held strictly accountable for the faithful performance of every duty of any persons connected with their respective offices, including line repairers and messengers.

ABBREVIATIONS.

The following are used in news telegrams, conversations, &c., but are not admissible in any kind of messages, except the above and unimportant office dispatches, as a means of saving time in the use of wires:

[Wood's original contains 24 pages of abbreviations not reproduced here]
[A few examples are shown below]

Ab., abolish, able	**Ja.**, jail	**S.**, was
Bd., bad, bond	**K.**, take, o'clock	**T.**, the
C., can	**L.**, law	**U.**, you
Dmg., damage	**M.**, noon	**V.**, very
E., of the	**N.**, no, not	**W.**, will
F., of	**Obdt.**, obedient	**X.**, next
G., gave, ground	**P.**, price	**Y.**, yes
H., have	**Q.**, question	**Zl.**, zeal
I., by	**R.**, for	

GENERAL RULES FOR AFFIXES.

1.	When **ing** is to be added to the original word only add				**g.**
2.	When **d, or ed,**	"	"	"	**d.**
3.	When **ance, ence, ice,** and the like,			"	**e.**
4.	When **tion, sion, ion, en, cian,** and the like,			"	**n.**
5.	When **tive, sive, ive,**		"	"	**v.**
6.	When **al, tial, cial, shal, l,**		"	"	**l.**
7.	When **ble,**	"	"	"	**b.**
8.	When **s, ness, ous, ize,**		"	"	**s.**
9.	When **ly, bly, aly, ary,**		"	"	**y.**
10.	When **ant, ent, int, ate, ite,**		"	"	**t.**
11.	When **ity, ality, ility, atory,**		"	"	**ty.**
12.	When **ist, est,**	"	"	"	**st.**
13.	When **er, ure, or,**	"	"	"	**r.**
14.	When **ful,**	"	"	"	**fl.**
15.	When **ism,**	"	"	"	**m.**
16.	When **ancy, eney,**	"	"	"	**cy.**
17.	When **less,**	"	"	"	**ls.**
18.	When **ie,**	"	"	"	**k.**

The preceding abbreviations are made to conform to those in use upon a *majority* of lines, and should be thoroughly learned and correctly written whenever used, in order to prevent difficulty in the transfer of operators from one line to another, as is often desirable.

TELEGRAPHIC NUMERALS.

1- Wait a moment.
2- Give precise standard time.
3- Get immediate answer from _______ .
4- Where shall I go ahead ?
5- Keep Still.
6- I am ready.
7- Don't know.
8- Busy on other line.
9- Get answer, sure, and quick.
10- Has _____ train reached your station ?
11- Did you get my last ?
12- What time did _____ train leave your station ?
13- Report when _____ train leaves your station.
14- Write more firmly.
15- Separate words more.
16- What is the weather ?
17- Very Important – Hurry Up.
18- What is the trouble ?
19- How many cars has _____ train ?
20- I will see.
21- Collect special messenger's charges for delivery, which are guaranteed.
22- Paid here.
23- Message for all offices.
24- Have you anything for me ?
25- Write dots.
26- Write alphabet.
27- Take off ground wire.
28- Do you get me ?
29- Report special messenger's charges, to be paid here.
30- Finis.
31- How do you understand my last message ?
32- I understand that _____ .
33- Deliver this only to whom addressed.
34- If statement ready, go ahead.
35- Connect wires through straight.
36- Requires correspondent to prepay answer.
37- If correspondent will not prepay answer it will be paid here.
43- Answer will be paid here
73- Compliments to _____ .

These numerals comprise, it is believed, all in common use; the above are those employed upon most lines; whenever they differ from those in use, operators will find it advantageous to adopt *these*, as numerals frequently follow messages through several circuits.

THEORETICAL INSTRUCTION.
MAGNETISM.

There exists in nature a mineral, a compound of iron and oxygen, which is possessed of a peculiar property, knowledge of which was even familiar to the ancients. It consists in the power to attract small particles of iron or steel, and to yield a similar power to pieces of the same metal, which may be rubbed against it. This mineral is called *loadstone*, signifying a stone that leads, and the phenomenon it exhibits is termed MAGNETISM, from the word *magnet*, a name given the loadstone as well as those bodies, which have acquired its property. The word magnet is derived from Magnesia, a city of Asia Minor, from whence, by some accounts, the loadstone was first obtained.

Artificial magnets are made usually of steel, frequently shaped like a horse-shoe, and will retain their magnetism for a long time. The ends of a magnet are called its *poles*- one *positive* and the other the *negative pole*. The *keeper* or *armature*, of a magnet, is a bar of iron made to connect the two poles, and assists in preserving the magnetism. Iron may be magnetized, but generally loses its magnetism, and the softer the iron the more quickly this loss ensues.

Magnets may be made of any shape, and if a magnet be broken into a number of pieces, each piece will become a separate magnet, having polarity at its opposite points. Magnets of greatest strength, however, are those made in the form of a horse-shoe, constructed of several thicknesses of thin steel first separately magnetized and afterwards bound together. The form of the horse-shoe has the advantage over all others, inasmuch as the poles may both be presented to an object at the same time, allowing the whole power of the magnet to be exerted upon it. This force bears much analogy to that of gravitation, its power varying with the inverse ratio of the square of the distance at which it is exerted.

An iron bar may be rendered magnetic by other modes than that of rubbing it in contact with a magnet, as by hammering, powerfully twisting, holding near but not touching the pole of a strong magnet, or by passing a current of electricity around but not through it. When made by the latter means it is called an electro-magnet, which form of magnets will be considered as the subject of another chapter.

Let a common sewing needle be magnetized and then balanced and suspended by a means of a slight thread. It will be found to turn until it has assumed a north and south direction, where it will remain stationary as long as it remains undisturbed. Move it from this position, and it will return again as often as left to itself, each end always pointing in the direction it first assumes. If now we examine the polarity of the needle, we shall find that the end, which pointed to the north, was the positive, the other the negative pole; and from this fact the poles of a magnet are called also *north* and *south poles*. This principle is employed in the simple device so valuable to the world known as the mariner's compass.

Present next, to the needle thus suspended, the positive pole of a common bar magnet, and the negative or south pole of the needle will turn towards it, even at a distance of some inches. If brought nearer, that pole of the needle will fly against and adhere to the magnet. But if we present the positive pole of the magnet to the positive pole of the needle, directly contrary results are observed. These two like poles cannot be made to approach each other while the needle is freely suspended. Invariably will they be repelled, the needle always turning upon its axis and presenting its negative pole to the magnet. But now if the negative pole of the magnet be presented to the needle, the positive pole of the needle will be attracted and its negative repelled. All magnets obey this law – the like poles repelling, and the opposite poles attracting each other.

STATIC ELECTRICITY.

The word electricity is derived from the Greek *amber*; for from this substance the first electrical manifestations were obtained. Thales, of Miletus, wrote upon the phenomena of electricity 600 years B. C.; but little progress was made by the ancients in their investigations of the science. The development of our knowledge of this subject, is due to the labors of modern philosophers, and dates from the investigations of Dr. Gilbert, published in 1600.

Various kinds of electricity are known to exist, as atmospheric, thermo, and animal electricity; electricity induced by an electrical current, electricity induced by magnetism, electricity induced by friction, and electricity generated by chemical action. We have, however, but three distinct means of heat, motion, and chemical action. However varied may be the apparent sources of electricity, it is yet proper to add, that the belief is fast gaining ground among scientific men of this day, that *motion*, or that which disturbs the molecular forces of matter, alone originates an electrical state.

If a stick of sealing wax or a rod of glass be rubbed briskly with a piece of silk, it will be observed to have acquired the singular property of attracting bits of paper, fibres of wood, or small pieces of pith or cork. Take, for instance, two balls or pith suspended separately by means of silk threads, and approach them with an electrified rod of glass. The balls will immediately fly against and adhere to the glass, but after remaining a moment they will fly off, and will seem to dodge it in every conceivable way if it again be made to approach them. In this experiment the balls are first attracted by the electrified body, and subsequently repelled. They will also, to some extent, repel each other after having been under the influence of the rod, proving that they have become electrified by contact with it. While they are thus influenced, if one of the balls be touched with the finger it will lose its electricity and will fly again to the rod, repeating the phenomena first observed.

This experiment may be exhibited upon a larger scale by the employment of the electrical machine to excite the electricity. This machine may be very simply constructed by fixing to a thin circular plate of glass an insulated crank; by means of which it may he turned. A silk rubber and metal points are to be adjusted in contact with the glass, the latter connected with a conductor to collect and transmit the electricity. Upon turning the crank the friction of the rubber against the glass excites electricity, which is collected upon the points. Two pith balls connected with the conductor may be made to diverge, and sparks may be drawn in rapid succession from it while the machine is in motion. A person standing upon glass with one hand upon the conductor may be highly electrified, and sparks may be drawn from prominent parts of his body, giving a prickling sensation. His hair will stand out from his head, but otherwise no inconvenience from a moderate charge of electricity is felt.

The electricity produced by this machine may be made to excite considerable electrical power by the use of the Leyden Jar, the principles of which were accidentally discovered during some experiments that were being conducted at Leyden in 1745. It is simply a common glass jar coated both on the inside and outside with tin foil to within about three inches of the top; a metal conductor in contact with the inner coating extends from the mouth of the jar. It is charged or filled with electricity upon the principle of electrical induction, or the apparent power which electricity has of producing results apart from the channel through which it is passing. The conductor of the jar is applied to the conductor of an electrical machine in motion, and the outer coating is connected with the ground. The disturbance of the electricity upon the machine communicates a like disturbance to the inner coating of the jar. Now notwithstanding the fact that there is no electrical communication between the inner and outer coatings, still the charging of the former drives a portion of the electricity of the latter through the conductor to the ground. The electricity of the inner coating now strives to supply the deficiency of the outer, but is held in its place by the glass sides of the jar, which it is unable to pass. If communication be made between the inner and outer coatings, the equilibrium of the fluid is at once restored and the jar is said to be discharged, or in other words the electricity becomes equally diffused upon the inner and outer surfaces. By the simultaneous discharging of a large number of such jars, very powerful electrical results may be obtained, such as the production of sparks several inches in length, the perforation of non-conducting bodies, the melting of refractory metals, and the destruction of animal life. By means of the electrical machine and the Leyden Jar the early experimenters in electricity were enabled to make many important additions to the knowledge of this branch of physics.

The kind of electricity of which we have thus far treated, exhibits itself constantly in a state of rest except at the instant of discharge. It is called frictional, or *static electricity*, to distinguish it from chemical, or *voltanic electricity*, which is ever in motion. It is static, or in a state of rest, except when moving to restore the electrical equilibrium, which has been disturbed; it is then said to be in the *dynamic state*. Voltaic electricity exhibits itself continually in the dynamic state, and is frequently called an *electric current*.

There have been various theories of the nature of electricity, and perhaps none more simple or comprehensive than that of Franklin. He supposed that all bodies possess a certain natural amount of electricity in a state of equilibrium; that when in this state they neither attract nor repel each other, and that electrical manifestation are observed when the equilibrium is destroyed. A body having more than its natural share, of electricity, freely parts with it unto another body having a lesser amount. The first instance, the particles of electricity are held in equilibrium by their attraction for the atoms of matter of which a body is composed. But when, as in the latter case, a body has more than its share of electricity, these particles have a stronger attraction for the atoms of a body which has a lesser quantity; and the two bodies appear to be attracted towards each other In this state the body having the greater quantity is said to be charged with *positive electricity*, and the body having the *lesser quantity* is charged with *negative electricity*; or in other words, the two terms, *positive* and *negative* are given to designate the electrical state in which a body may be. It was supposed that particles of electricity, as well as atoms of matter, repelled each other, so that when two bodies had an equal amount of electricity, either greater or less than the natural quantity, they repelled each other. The theory supposes the existence of one fluid.

The philosopher, DuFay, had previously to this discovered that the electricity excited in glass, precious stones and other vitreous bodies, as well as in the hair of animals, wood, etc., differed from that excited in amber, copal, gum lac, silk and paper, and that bodies charged with the same kind of electricity repelled, but those charged with opposite electricities attracted each other. Hence he deduced the theory of two electricities- that of glass, etc., or *vitreous electricity*, and that of amber and the resins, which he called *resinous electricity*- each repelling its own kind and attracting the other.

Other interesting theories exist in regard to the nature of this subtle fluid, as well as modifications of those already given, but the province of this work forbids any discussion of them. The two theories that have found general favor have been given, and it may be further added that no theory in science is accepted as a law. It is received merely as a generalization of fact, to be respected so long only as it coincides with them. The discovery of new facts irreconcilable with the theory suffices to weaken its weight, and so far as the theories above given are concerns it is proper to state, that phenomena have already been observed which in a measure apparently contradict them.

CONDUCTORS.

In the investigations of this science, it was early observed that some substances transmitted electricity much more easily than others. No part of the study of the electric telegraph demands a more careful attention than this fact, for upon it is dependent our ability to communicate between distant points.

Substances, which transmit electricity freely, are termed *conductors*, while those, which present an obstacle to its transmission, are called *non-conductors*. No substance can be strictly said to be a non-conductor of electricity, for it is ascertained that its passage through any known substance is only a question of time. But its passage through some is so slow and difficult, that they become practically of great value in the construction of telegraph lines as insulators of wire from the poles, which support it. They prevent a waste of the electricity to a great extent from the difficulty it meets in passing through them.

The following is a list of substances, which conduct electricity in the order in which they are given- the better conductors first, the poorer last. Though not faultless, it is sufficiently correct for practical use:

Silver
Copper
Gold
Mercury
Cadmium
Zinc
Platinum
Iron
Lead, *and other Metals*
Well-burnt Carbon
Plumbago
Concentrated Acids
Dilute Acids
Saline Solutions
Metallic Ores
Animal Fluids
Sea Water
Spring Water
Rain Water
Ice- *above 13 deg Fahr.*
Snow
Living Vegetables
Living Animals
Flame
Smoke
Vapor
Salts *soluble in water*
Rarified Air
Vapor of Alcohol
Vapor of Ether
Moist earth and rock
Powdered Glass
Flower of Sulphur
Dry Metallic Oxides
Oils, *heaviest the best*
Ashes of vegetable bodies
Ashes of animal bodies
Dry transparent crystals
Ice- *below 13 deg Fahr.*
Phosphorus
Lime
Dry Chalk
Native Carb. Of Barytes
Lycopodium
Caoutchouc
Camphor
Silicious and argillaceous stones
Dry Marble
Porcelain
Dry Vegetable bodies
Wood- *that has been strongly heated*
Dry Gases and Air
Leather
Parchment
Dry Paper
Feathers
Hair and Wool
Dyed Silk
Transparent Precious Stones
Diamonds
Mica
All Vitrefactions
Glass
Jet
Wax
Sulfur
Resins
Amber
Gutta Percha
Shellac

The conductibility of the same substances is often different under different circumstances. An increase of the temperature of a metal alters its conducing power. A large wire conducts better than a small one. Water is a better conductor than vapor, and ice below 13 deg Fahr. Is a poorer conductor than either, while ice above that point conducts nearly as well as water. Tallow and wax are conductors when melted, but bad conductors when hard. The resins, when drawn in threads, are very imperfect conductors, while glass, under similar circumstances, or when heated to redness, has its conducting power increased. Substances which are otherwise poor conductors, may become very passable ones by the absorption of moisture, or the collection of a film of moisture, on their surfaces. Owing to this fact, glass is never reliable as a perfect insulator unless coated with Lac Varnish, which prevents the adherence of moisture in a continuous film.

EARLY EXPERIMENTS IN ELECTRICITY.

It is interesting to note the progress to those ideas, which, crude at first, were finally wrought out in the invention of the electric telegraph. Stephen Gray, in 1720, obtained evidences of electricity through a packed thread above 600 feet in length, after insulating and suspending the same by means of silk. His experiment was made before the invention of the Leyden Jar, and he used the glass rod, excited by friction, as the source of electricity. In the year 1747, the President and several Fellows of the Royal Society, with Dr. Watson at their head, stretched a wire for a distance of four miles, near the city of London, and a discharge of electricity through the wire was observed at several points along its length. The line crossed the river Thames and for a part of the distance was laid upon the ground, yet the spark passed all of the points watched as near simultaneously as human means could determine. At various times, between the years 1774 and 1816, electric telegraphs were invented, employing the electric machine or Leyden Jar as the source of electricity, and signalling by means of sparks, the divergence of pith balls, or the chemical decomposition of water.

VOLTANIC ELECTRICITY.

Until the commencement of the nineteenth century, philosophy had no knowledge of the means of exciting electricity by chemical action. Prof. Volta, of Pavia, during the year 1800, invented what is called the *voltanic pile*, which produced a continuous current of electricity by the action of an acid upon a metal. He was led to its construction by a controversy, which at that time was being warmly urged, between the electricians and anatomists, respecting the origin of muscular motion. Galvani, of Bologna, had ten years previously discovered that if two metals in contact were made to touch the leg of a frog, one metal upon the muscles and the other upon the nerve, muscular contractions ensued. He founded a theory of muscular motion upon this phenomenon, which was adopted by the anatomists and warmly controverted by the electricians.

Galvani and the anatomists contended that the muscular action in the frog's leg was due to *animal electricity* therein, and that the metals were mere conductors of the same. By the pile of Volta, however, electricity was clearly generated from metals, by means of which not only was repeated the experiment of Galvani, but many other interesting experiments were exhibited; the anatomists were silenced and a new and fruitful field opened for philosophical investigation. Though the credit of discovering this source of electricity dearly belongs to Prof. Volta, yet the branch of science, which treated of it, was for a long time called galvanism. By general consent, however, the word voltaism is used synominously with the former, which usage will he preferred in this work with such terms as are derived from it, as the voltaic current, the voltaic battery, etc.

The voltaic pile is constructed as follows Two thin circular metal plates, like copper and zinc for example, are laid together with a piece of moistened paper between them, and are called a *pair*. A number of these pairs are arranged one upon another, care being taken that the copper of one and the zinc of the next shall be in contact. To each of the outside, or end plates, is soldered the wire for the convenience of experiment. When these wires are brought together and made to touch each other, a strong electrical current becomes manifest, flowing along the wires from the copper to the zinc plates. A single pair will give evidence of electricity, while a number thus arranged proportionably increases the voltaic effect.

The voltaic pile was soon disused, for as the moistened paper became dry the pile lost its power, and it was taken to pieces and again renewed at the expense of much inconvenience and labor. Prof. Volta suggested the improved arrangement of placing each pair in separate vessels containing a weak solution of acid, connecting by means of wire the zinc of one vessel with the copper of the next in the same order that the metal plates of the pile had been laid. A battery of this description was afterwards constructed by Prof. Volta, and called the *couronne de tasses*. The presence of an acid is not necessary in this apparatus, though its addition greatly increases the effect. Various other modes of construction of the voltaic battery have been invented, having in view many practical advantages.

It is found, however, that the generation of electricity in them all is accompanied by the decomposition of the liquids in which the metals are placed. An atom of oxygen of this water uniting with the zinc leaves free an atom of hydrogen, which combines with the oxygen of the next particle of water, setting free its hydrogen to unite with the oxygen of the next, and so on; the hydrogen being transferred from particle to particle until the copper plate is reached, which, having nothing further to unite with it escapes. In the opinion of the profound philosopher and electrician, Faraday, the particles between the two plates are thrown into a state, the oxygen of each being directed and moving towards the zinc, and the hydrogen in an opposite direction towards the copper. The metals themselves assume polarity, the one giving signs of positive and the other of negative electricity. By connecting the two plates with wire, an opportunity is afforded the electricity of one to neutralize the electricity of the other; or in other words a channel is made by means of which the electrical equilibrium which has been disturbed by action of the battery may again be restored, the electricity following from its source, or the point where chemical action is going on, through the fluid, one plate and the connecting wire to the other plate and forming what is denominated an electric or voltaic current.

The student must remember that this form of electricity is called a *current* simply from its assumed analogy to the ponderable fluids, and not that its fluid character has ever been proven.

Voltaic electricity differs from static in being of greater quantity and much lower intensity, a difference, which is productive of widely dissimilar effects. Quantity electricity is possessed of very great heating and chemical power, but passes through conductors with much less facility than the other. Indeed, electricity may be generated from a powerful quantity battery which will fuse platinum wire, and yet will fail to give a spark after passing through a wire six hundred feet in length; on the other hand, Rechankorff's apparatus, improved by Ritchie, for exciting intensity electricity, has produced sparks through the air eighteen inches in length, and perforated glass two and a half inches in thickness. Such electricity will dissipate itself over many non-conductors with apparent facility.

A voltaic current of greater or less quantity or intensity, may be produced by varying the size of the metal plates used in the battery, enlarging the plates to obtain a quantity and increasing the number of pairs to obtain an intensity battery.

For telegraphic purposes voltaic electricity is used, for from this source we obtain that constant supply which is required for continuous communication between telegraphic stations. By a proper construction of the battery a current of such intensity may be bad as will produce a distinct effect, under favorable circumstances, through a telegraph wire twelve hundred miles in length, though with some loss of power by dissipation over the insulation employed, and from the resistance to its passage which it meets from the wire itself.

ELECTRO-MAGNETISM.

The term *electro-magnetism* is given to that branch of the science, which treats of magnetism developed by electricity. A current or electricity passing through a wire conductor will influence a magnetic needle if the same be brought near it, the needle assuming a position at right angles to the conductor. The same current passing around a bar of iron or steel will induce magnetism therein, and the softer the iron the sooner will this magnetism be lost when the current is broken. Temporary electro-magnets of great power may be made and unmade as rapidly as the electric current passing around them can be broken and renewed. In Morse's system of telegraphing, magnets of this kind are universally employed to supply the motive power for producing signals; since such motive power may be created at any distance to which the voltaic current may be sent.

The history of the discovery of electro-magnetism and of its subsequent progress, is briefly as follows: In the year 1819, Orsted, at Copenhagen, discovered the deflection of the needle in the presence of a current of electricity. In the year 1820, Schweigger, of Germany, discovered that surrounding the needle with a coil of wire increased the deflecting power. In 1820 Arago and Ampere, of France, magnetized sewing needles placed within a glass tube, by passing an electric current through a wire coiled about the outside of the same. In the year 1829, Sturgeon magnetized an insulated iron bar by means of electricity sent through a copper wire coiled about it. In the year 1828, Prof. Henry insulated the wire conductor by winding the same with cotton or silk. This being wound closely and in several layers about an iron bar greatly increased the magnetic power obtained from a given current.

The electro-magnet employed in the Morse system of electro-magnetic telegraph is constructed upon the principle discovered by Prof. Henry. It consists of a bar of soft iron shaped like a horse-shoe magnet, around each arm of which a long copper wire, covered throughout with silk, is wound in layers as already described. In winding the wire about the second pile, care should be taken that it be in a contrary direction to that wound about the first, for it be all wound in the same direction the two poles will have the same polarity, the forces of each repelling the other, and the armature will not be attracted.

Morse's System of Electro-Magnetic Telegraph.

BATTERIES.

At the time when Prof. Morse commenced experimenting with his telegraph, a great obstacle was met in the want of a sustaining battery, none having at that time been invented. So great was this deficiency, that doubts were entertained as to the possibility of the electric telegraph ever being made commercially valuable.

DANIEL, OR SULPHATE OF COPPER BATTERY.

In the year 1836, Prof. Daniel invented a battery, which surmounted the difficulty. In the batteries constructed previously to that date, particles of the zinc became transferred to the surface of the opposite plate, and hydrogen gas evolved in he process would also collect there, obstructing the action and causing fluctuations in the strength of the current. After a short time this impediment became so great as to effectually stop the battery, and it became necessary to take it apart and to thoroughly cleanse the surfaces of the plates.

Prof. Daniels' device consists in keeping the zinc and copper surfaces separated by some substance which prevents the passage of particles of zinc, but which opposes no obstacle to the voltaic action. He used various materials for the separating wall such as animal membrane, bladder, unglazed earthen-ware, stout paper, thin wood, closely woven linen cloth, etc. The form of this cell in common telegraphic use, is that of a narrow, deep, porous, earthen-ware cup which receives the zinc case in a shape to fit it. Around the outside of the porous cup is a cylinder of copper, the whole enclosed in a glass sufficiently large to receive it. The jar on the outside of the porous cup is filled with a solution of sulphate of copper, and the cup itself is filled with water, pure, salt, or slightly acidulated. The effect of the salt or acid is to hasten the action of the battery, for when water alone is used its full power is not attained until after the lapse of several days. The circuit of this battery is complete when the zinc and copper are connected above the liquids by a conducting wire, the current finding its way through the same from plate to plate. Several of these cups may be joined together, by connecting in a similar manner the copper of one cup to the zinc of the next.

The chemical action of this battery is as follows: The oxygen of the water, or acidulated water, inside the porous cup combines with the zinc, while the hydrogen thus liberated unites with the oxygen of the sulphate at the surface of the copper cylinder outside, reviving the copper of the sulfate which is deposited thereon, keeping its surface ever clean and new.

These batteries are set up as follows: Place the copper cylinder in the glass jar, the porous cup inside the cylinder, and the zinc inside the porous cup. Fill the porous cup with soft water, slightly acidulated if hasty action is desired, the rest of the jar with water to within half or three-fourths of an inch of the top of the porous cup. Saturate the water outside of the porous cup with sulphate of copper, additions to which should be made from time to time as the battery becomes weaker. Connect the copper of the first cup with the zinc of the next, the copper of that with the zinc of the third, and so on till all are connected, and attach the conducting wires to the poles of the battery.

GROVE BATTERY.

The Grove cell was invented by Prof. Grove in 1839, and is very extensively employed upon telegraph lines in this country, principally on the main or long circuits. Its action is of a higher intensity than any other battery yet invented. Two metals-zinc and platinum being employed- the former, in the shape of a cylinder surrounds a porous cup, which contains the latter bathed in strong nitric acid. The whole is set in a glass tumbler, or jar, four inches high and three and a half inches in diameter, and containing sulphuric acid and water. The zinc cylinder weighs about three pounds, and has an arm projecting from the upper edge and overhanging the adjoining cell. The porous cup is three inches high and one and a half inches in diameter, and has a rim upon its edge by which it rests upon the upper edge of the zinc. In this cup hangs a thin strip, of platinum suspended from the zinc arm of die next adjoining cell. This battery is set up as follows: Commence at one end of the battery by placing that zinc which has the zinc connection attached inside the glass jar, and a porous cup inside of the same. Take another zinc with a strip of platinum attached and place it in the adjoining jar, allowing the arm to rest over and the platinum to fall into the porous cup of the cell last arranged. Proceed in the same manner with the rest until the last cell is reached. This receives the separate strip connecting with a screw-cup for binding one of the conducting wires. Fill now the porous cups nearly half full with strong nitric acid, and the glass jars outside with twelve parts of water and one of sulphuric acid. One cup of this battery has strength equal to about two of any other kind in use.

Considerable care is needed to prevent waste of electricity by local action and cross currents in this form of battery. The former is in a measure prevented by amalgamating the surface of the zinc cylinders with mercury as often as they are cleaned, which should be done daily. The acids must be changed once a week to keep up the strength of the current. The latter mischief results from the collection of moisture upon the outside of the jars and table, which conducts the electricity from one cell to another, and is in a measure prevented by insulating each cup.

BUNSEN BATTERY.

This battery substitutes carbon for platinum, which may be used either inside or outside of the porous cup, and is surrounded by nitric acid and water of equal proportions. The metal used is zinc, which is surrounded by sulphuric acid diluted with twenty-four parts of water by measure.

Sulfuric acid may also be used to surround the carbon instead of nitric with good effect. This battery is said to approach the Grove in strength, with greater consistency of action. It is little used in this country, but for telegraphic purposes it obtains almost universal favor upon the continent of Europe.

CHESTER'S MAIN BATTERY.

The Chester is an improvement in form of the *Smee battery*. It is constructed by placing in close proximity, but not touching, two plates, one of zinc and the other of some platinized metal, and suspending the same in a glass jar from a supporting bar of wood running the length of the battery. The zinc plate is continuously amalgamated by, resting its foot in a little cup containing two tablespoons full of mercury. The platinized plate is roughened, preventing in a measure the adherence of hydrogen. The liquid used is one part sulphuric acid to ten of water, its power is about one-half that of a Daniel cup, and one-fourth that of a Grove.

The same enterprising gentlemen have invented a new battery, somewhat in form like the Grove cell, but using the electropoion fluid as a substitute for sulphuric acid. Its constancy is greater than the Grove battery, and its use is said to give much satisfaction.

Zinc is used in all of these batteries for the metal decomposed in producing the voltaic current-gradually wearing away, though not always in proportion to the amount or intensity of current produced.

In the practical working or telegraph lines, batteries equal in power to several hundred Grove cells, are often employed. These are advantageously distributed along the line at stations, as near as may he, equidistant from each other. The wire, which departs from the positive pole of the battery at one station, enters the negative pole of the battery of the next.

MORSE'S TRANSMITTING APPARATUS.

The first transmitting apparatus used by Prof. Morse in the exhibition of his telegraph, was a port rule filled with a line of telegraphic types which was moved along by machinery, each type in turn elevating and depressing a lever, and plunging at each elevation the ends of two conducting wires into mercury cups. By this means the current was broken and closed in a manner corresponding with the forms of the types, and the opening and closing of the circuit was made to print characters at the other end of the wire.

This arrangement was laborious and unwieldy, and after several times improving it, he abandoned the idea altogether, and adopted the principle of the present finger, or lever key, for breaking and closing the circuit.

The signal characters used by the Morse telegraph are a certain combination of dots and dashes, which represent the letters of the alphabet, the numerals, the points, etc. We have already observed, that when a voltaic battery is properly set up, the current may be transmitted along a conducting wire to a great distance, passing from one pole of one battery to the opposite pole of another. The path of this current along the wire is a part of the electric circuit. Now the signals used in this system of telegraphy are made by simply breaking and restoring, or in technical phrase, *opening* and *closing* this circuit; and the transmitting apparatus consists of a simple device constructed for this purpose, which is called a *key*.

THE KEY.

The parts of a key are the frame, the lever, the hammer, the anvil, the circuit-closer, and the screws. The lever moves up and down on a fulcrum, and has an ivory finger-piece at one end for the fingers of the operator to rest upon, and a *set-screw* fixed at the other end gives greater or less play as suits the fancy of the operator. The fulcrum of the lever fits into the sockets of two screws, which pass through two upright pieces of a brass frame upon which the lever rests. Connected with this *frame* are two screws, which pass through the table, binding the key firmly and coming out beneath. To the ends of these are screwed little screw-cups to receive the ends of the wires. The front one of these binding screws is insulated from the brass frame of the key, through which it passes, by a piece of ivory, and its head is elevated slightly above the frame and directly beneath the *lever*. Upon its head a platina point is soldered called the *anvil*, and directly above the anvil is another platina point fixed in the *lever* and called the *hammer*. A spring presses the lever up and away from the anvil. The finger of the operator depresses the lever and brings the hammer and anvil together. When in the latter position the current passes from one wire to the other through the key, the two parts of which are brought together at the platina points. Upon removing the pressure the spring again presses the platina points apart and the current is broken.

The circuit-closer is a device for connecting the two insulated parts of the key when the same is not in use, though it is sometimes made apart from and fixed upon the table beside that instrument. The circuit should always be closed when the key is not in use, and when an operator desires to write he first opens the circuit by turning the circuit-closer. Then placing the message before him he rests his fingers upon the ivory piece at the end of the lever, and by a series of short and rapid depressions ho signals its contents to the distant station.

THE RECEIVING APPARATUS.

While engaged in his early experiments upon the telegraph, Prof. Morse became apprehensive that the magnetism to be obtained from the electric current would diminish in proportion as the circuit lengthened, and become insufficient for practical purposes. He says. "To remove this probable obstacle to my success, I conceived the idea of combining two or more circuits together, each with an independent battery, making use of the magnetism of the first to close and break the second, the second the third, and so on." This arrangement was termed the "combined circuit," and was publicly exhilarated in March 1837. Experiments demonstrated, however, that magnetic power, though much weakened, could be obtained from a current through a line several hundred miles in length.

He then devised the present combination, which consists of one main circuit connected by a receiving magnet, with as many short office or local circuits as may be desired; upon these short circuits are the registers and sounders, and not upon the main line as originally contemplated. He further says, "In the present combination the purpose of the battery on the main line is to close and break the short independent office circuit which works the register. This new combination of parts was a most valuable improvement upon my first plan."

THE RELAY MAGNET.

The relay magnet is placed in the main circuit and constructed in the form of an electro-magnet. A soft iron bar is bent in the form of a horse-shoe magnet, and each pole closely wound with many coils of fine silk-covered copper wire, in layers like a spool of thread. This magnet is secured in a horizontal position upon a small stand, screw-cups being placed at one end to receive the wires of the main line or circuit, and to connect them to the magnet. Now the manner in which this magnet opens and closes the local circuit is as follows: Right in front of its poles is fixed a straight upright brass lever, with an armature attached, which is furnished at the end with a platina point, and which forms the terminus of one wire of the local circuit. The terminus of the other wire is a straight upright brass standard, with a top-piece partially enclosing the end of this brass lever. In this top-piece are two set-screws, to regulate or adjust the play of the lever, which moves back and forth between them. The front one furnished with a platina point to correspond with the platina point of the lever, which in working strikes against it, and the other with an insulating point of ivory to prevent the lever from connecting the circuit when it falls back against it. The brass lever swings on a fulcrum at its base, and when a current passes through the magnet from the main wire, the armature and lever are attracted towards the magnet, which brings the platina points together, permitting the local current to pass between them and thus closing the local circuit. When the main circuit is broken the armature is pulled back from the magnet by the action of a small spiral or rubber spring, thus pulling the platina points apart and breaking the local circuit. In this manner is kept up, on the local circuit, a consistent repetition of the signals traversing the main wire, with the advantage of more magnetic power to record them. The term *local circuit* implies a local battery, which generates the needed force to work the register, a force that could not be practically obtained from the main current.

THE REGISTER.

The register used on the local circuit consists of an electro magnet, having its armature fixed to a brass lever, which moves on a fulcrum near its center, and has in the end opposite from the armature a point of steel. Whenever the magnet attracts the armature, this steel point is pressed against a grooved roller revolving in a system of clock work. Around this roller, and moving along as it revolves, is a strip of paper against which the point works, pressing it into the groove and making indentations of dots and dashes upon the same as the circuit is opened and renewed. The principles by which this register records the signal letters have not been altered from the plan originally conceived by Prof. Morse, yet the register itself has been greatly improved in its construction and finish. It has a brass frame fastened upon a base, and containing the clock work which moves the paper along over the grooved roller, and which is run bay a weight wound up by a key similar to winding a common time piece. A stop-slide checks the clock work or sets in again in motion, a small spring pulls the point lever away from the paper when the armature is released from the helices, set-screws regulate the play of the lever, and screw-cups upon the end of the base receive the local wires. The paper is unwound in long strips from a reel by the turning of the clock work, continually presenting thereby a fresh surface to the steel point. The marks, or indentations, thus made are easily read, and the work of the register is simple and effective, having exerted without doubt a great influence upon the growth and perfection of Morse's telegraphic system. But there has arisen another instrument, called the *sounder*, which has superseded the register in all the leading American stations.

THE SOUNDER.

This simple instrument has coils, or helices, similar to those used in the register, and has a lever to which its armature is affixed, but bears little further resemblance to the latter instrument. The coils are upright and fastened to the stand or base. The lever is of brass, and plays between set-screws of an upright brass standard, as the armature is attracted by the magnet or pulled away again by a spiral spring which for that purpose is attached to the end of the lever. The instrument by this motion produces a series of clicks, which indicate the characters written. To an experienced operator these simple sounds are as readily understood as the varied inflections of the human voice, and by its means business is conducted more rapidly, and with less liability to error, than by use of the register. The telegraph speaks a language of its own, and two persons by it may talk to each other though hundreds of miles apart, or hear conversations between others at distant stations, as readily as if the persons themselves were present.

Prof. Morse took out letters patent in the year 1846 upon his manner of combining the main and local circuits. It has been the practice to dispose of the right to use this patent to telegraph companies at a certain stipulated sum per mile. Within the past few years there have sprung up opposition, or rival companies, which have built telegraph lines between the principle cities of the United States from Boston to St. Louis, and are contemplating still more extensive construction. The patent upon the local circuit belongs to the old companies along these routes, and these companies have not deemed it advisable to allow the use of it to their younger competitors.

THE RELAY SOUNDER.

Upon these new lines an instrument is in use designed to work the line without the local circuit. It is constructed very similarly to the common relay magnet, but having no part of a local circuit attached to it. They require a some what stronger current than that which suffices to work the ordinary relay, and the coils of the magnet itself are little larger than those of the relays usually employed. It will be observed that though this form of magnet makes a sound distinct enough to be easily read, it does not produce sufficient power to work the ordinary register, and so far as we are aware no form of the latter apparatus has been yet devised that can be successfully worked independent of the local circuit. The rival lines must for the present, therefore, be compelled to transact all their business by sound, a necessity that will naturally beget greater care, skill, and it is to be hoped, greater perfection in the working of the electric telegraph. When such a system is adopted, perfect writing, perfect reading, and faithful devotion to business will be among the qualifications required of an operator, and the ambitious aspirant for telegraphic positions must cease not until he reaches the greatest attainable perfection in his calling.

OFFICES, OR STATIONS.

At every place of importance along the route of a telegraph line, offices are opened, operators and apparatus furnished, and every thing made ready to receive and transact its telegraphic business. These offices are also called stations, and are divided into two classes, the *main* and the *local station*; the former comprising offices where the main battery, or parts of it, are stationed, and the latter the remainder of the offices along the line. The local stations have no other battery beyond that needed to work the local circuit. Upon those lines, which dispense with the local circuit, no battery at all is required at these stations, but simple main wire passes through the office into which the key and sounder are inserted.

MAIN STATIONS.

Upon a telegraph line of any considerable length, main stations should be established as frequently as every one hundred miles. One-half of the battery should be equally divided between the two stations at the ends of the line, and the remaining half equally distributed among the intermediate main stations. About thirty Grove cells to one hundred miles of wire is deemed the number at which the line can be most practically and economically worked. In fine weather messages may be transmitted and received, without being repeated, over a wire twelve hundred miles in length, the batteries upon which are divided as above, but the working of a line at such great distance is weak, and impracticable the daily transaction of business. About five hundred miles is the limit for the working of a well-insulated line strongly and clearly in good weather, and one-half that distance in wet stormy weather. Notwithstanding the best telegraphic insulation used, there is a large escape of electricity over the insulators and through the air during rainy days, and a current of sufficient strength must be had to supply such escape and to leave a margin over and above for the working instruments. Such stronger current is practically supplied by diminishing the working distance proportionate to the amount of escape; or in other words, working the line for such length as it will work strongly and well, and repeating at the station where the current ceases the business to be sent beyond it.

REPEATERS.

A number of devices have been invented to insure the repetition of a message without rewriting; for, in a distance of several thousand miles, the labor of receiving and rewriting messages becomes a very considerable and important item. The invention of Prof. Morse, for combining two main circuits so that the current of the first shall close the circuit of the next, works very simply and beautifully one way, but will not of itself work back in the opposite direction, a desideratum essential to the practical transmission of telegraphic matter. The difficulty of combining two circuits so that each shall open and close the other, lies in the fact that opening the first opens the second at the repeating station, which in turn opens the first at the same place, after which, no current can be transmitted over either circuit until one or the other is closed. Now as there is no other power to close these circuits but that obtained from such current, it simply follows that by it they cannot be closed. Contrivances are, however, in use by which a circuit is kept closed at the repeating station while an operator at the other end of such circuit is writing. Objections, nevertheless, exist against each form heretofore used, owing principally to the necessity of keeping them adjusted to the varying strength of the current. The simplest kind is the one first used, and which, in the face of all others, still maintains the favor of telegraphists by reason of the simplicity and perfection of its work.

It is known as the Cornell repeater, or switch, and its operation is as follows: Take, for instance, a line from New York to Chicago, with a repeater inserted at Buffalo. Each of the main circuits passes through its relay at Buffalo, and then on to the armature lever of the relay of the opposite circuit, where it may be opened and closed similarly to a common local circuit. It passes next to the battery or the ground. But to prevent the Chicago relay from opening New York circuit while New York is writing, a switch is placed so as to cut out New York's circuit from Chicago's armature lever, and to pass it direct1y from its relay to the battery or ground. The same switch is also contrived to cut out the Chicago circuit from New York's armature lever when Chicago is writing, having four points, two opposite ones of which being connected, establishes the circuit from New York's relay to the ground or battery, and the other two opposite ones performing the same office for Chicago by the simple moving of the switch lever back and forth.

This arrangement for simplicity dispenses with the local circuit. It is found, however, advantageous to introduce the local circuit into this form of repeater, for the greater convenience of the attendant is adjusting. These repeaters may transmit messages from New York to San Francisco, and vice versa, without being rewritten, the attendants understanding by established rules when the switch lever is to be moved back and forth.

WORKING SEVERAL LINES FROM ONE BATTERY.

During the year 1850, Col. Anson Stager made the important discovery that as many as twenty or more main wires, each several hundred miles in length might be worked from the same battery. The conditions required to secure this result are that the wires shall all be connected separately with the battery, or with some large conductor leading from it, and that on each wire the current shall pass through a relay magnet, for if there is a ground connection before a relay is reached, the current will prefer that wire and weaken the others.

LOCAL STATIONS.

The *local stations* are the intermediate offices, or stations, along a telegraph line between the main stations, and on those lines, which use the Morse patent they are all furnished with a local circuit.

This circuit is in no way connected with the main circuit, save as it is opened and closed by action of the main current passing through the relay magnet. It is furnished with a local battery and a register or sounder, which are worked by the force of the battery, interrupted and re-exerted in the manner before mentioned. The battery usually consists of two Daniel Cups, being cheap, constant, and sufficiently strong for the purpose. Chesters' improvement of the same battery and the Grove cell are sometimes employed instead.

Though this circuit, as we have seen, may be dispensed with, yet the advantage it possesses of always affording a distinct and ready means of interpreting the oftentimes faint and inaudible clicking of the relay, gives it an unquestioned superiority upon long lines over such means as have been substituted in its stead.

The care of the local office devolves upon the operator -stationed there, or upon some one of them if the business of the office requires several. It is to these offices that the young operator just entering the telegraphic field is generally allotted, and lie cannot too highly appreciate the responsibility of his position, nor too faithfully fulfill its requirements. The property of the company is placed in his charge, and ifs interests at that station of manifold more value, are committed to his keeping. The telegraph is the servant of the public. It has already become an institution ranking with our railroads, canals, and our post office department, and exerts no small influence in the nation's growth and prosperity. An operator in charge of an office is its representative, and he should be fit for his place. If courteous manners and gentlemanly deportment are repugnant to him, let him seek some other calling; if punctuality, promptness and devotion to business are no part of his nature, he is losing time in this; if he fails to rise in position, if he sees younger men called to more responsible places, he may have little trouble in recalling the irregularities of his habits, or in remembering when and how often he has neglected his business. Let him devote himself faithfully and promptly to the interests of his company and the accommodation of the public, and to him the business will be one of promotion and of pleasure. He may reasonably expect to share its honors and enjoy its profits.

THE RECEIVING ROOM.

In large cities the business of the telegraph requires a corps of attaches and extensive accommodations. The office occupies a location, as near as may be, to the center of business, a room for the reception of dispatches is thrown open to the public, and a receiving clerk is stationed here to transact this part of the business and to give such information as may be desired of him. With the utmost courtesy and politeness he must keep in place at his desk, answering such inquiries or receiving such abuse as he may be favored with, for the business of telegraphing has not arrived at such age that the public may be considered familiar with its working, or willing to bear unexplained its delays. Here he receives the dispatches offered and the money paid thereon, and counting the words he endorses their number on the margin. He minutes in the same place the amount received, and sends them to the operating room where they are filed to await their turn. After they are sent they are registered and filed away.

THE OPERATING ROOM.

The operating room contains the telegraph instruments and all things needed for the transmission and reception of dispatches. Each operator sits at his table with his relay magnet, sounder, and key before him. Here he transmits and receives messages over the wire with which his instrument is connected. Such has been the rapid increase of telegraphing, that two, three, five, and even as many as ten, wires are employed on some lines for transmitting business with that celerity which is absolutely essential in sending telegraphic dispatches. Every wire requires an operator, and when a number of wires enter an operating room they require skillful devices and method for their convenient arrangement. The operators' tables are ranged in neat order about the room, and though within hearing of every other instrument, an operator pays no attention to any but his own. Here at his table he hears every word of business or conversation that is passing over his wire, and he knows by the rules of the company and by what is passing before him when he may use it himself, and placing the message to be sent before him, he takes the key at the proper moment, opens the circuit, and commences to call the office to which it is directed. This call is the repetition of some letter or letters, which by an arbitrary regulation, stands for that station. After receiving a response, he sends the first message on his file, and after that the next, until his file for that office is exhausted. He calls then the next office with which he has business, and proceeds in the same manner until he has cleared out his business, when he gives the finish signal, signing the call of his office, and the circuit passes into other hands. On the best-conducted lines the "circuit" passes around among the offices in a regular order. When in such order the "circuit" reaches an office it is said to belong to such office until its business with other offices, both of sending and receiving from them their business, is completed. Then calling the next office in order it passes the "circuit" over.

The messages are written out upon printed blanks as they are received, each one being examined to see if the numbers of words correspond with the figures given. If all is right, the amount to be collected, if any thing is endorsed thereon, and the message is sent to the delivery department, registered, entered upon the messenger's book, and immediately delivered. This is the whole formality of sending a message by telegraph.

SWITCHES AND SWITCH BOARDS.

Among the apparatus of the operating room, no one thing bears a more important relation to the systematic management and direction of the various circuits, than the simple device known as the switch. It is made of various patterns, and is either simple or compound according to the use for which it is desired; a simple switch, closing a circuit, throwing on a ground wire, or changing the circuit from one wire to another, and a compound switch, connecting several different wires, or circuits, together in as many different ways.

We are indebted to Col. Stager for still another improvement in telegraphy, a very ingenious device used upon the Western Union and other lines, and known as the "switch board." Upon a board, fastened against the side of the room, are straps of brass running across the same from side to side and parallel with each other. At one end of each of these straps are screw-cups for receiving all those wires which come into the office from a certain general direction, each wire being screwed into one of the cups and being connected consequently with one of the brass straps. Upon the other side of this board are the same number of strap, running across the board from top to bottom, and crossing the direction of the front straps at right angles. To these back straps are also connected screw-cups to receive the wires, which come into the office from a general direction opposite to that of the wires of the front straps. Each one of the back circuits, therefore, crosses at some point each one of the front circuits, and at that point of crossing is a little switch lever which is connected with the back strap, and coming through to the front is made so that it may be turned around against the front strap, ensuring electrical communication between them. An operator from any part of the room may observe by the position of the switch levers what circuits are connected.

GROUND WIRES.

Every office, whether local or main, has a ground or earth wire, which is a common wire with a metal plate attached and sunk into a well or pool of water, or buried in the moist earth. This wire is brought into the office and in a variety of ways is of great practical use. If the weather is wet and the signals received are very bad, they may be improved by cutting off the main wire beyond the office and directing the current, after it has passed the relay, through the ground wire immediately to the ground.

LOCATION OF BREAKS.

The ground wire is also used to discover the location of breaks and escapes along the line. Take, for instance, the line from New York to Buffalo, and let a break occur between Syracuse and the next station west. The line immediately ceases to work, every operator becoming conscious of the difficulty, and if it does not resume work they proceed to test it. When an operator receives signals from both sides of his station, he knows the break is not near him, for the current is passing freely on both sides of him; but when he hears nothing, and after repeated trials with his ground wire can get no response from the stations on either side of him, he very reasonably concludes that the break is next to his station on that side and starts out in search of it. The operator at Syracuse, in the case above; by establishing a ground connection, can get signals from any station between him and New York, but can get nothing from the side towards Buffalo. Utica, on the other hand, can get signals from both ways, and know that the lines on both sides of its station are whole. But the operator at Syracuse knows that the wire between him and the station west is broken, for he can hear nothing from that station, and the operator at that station knows the wire is interrupted between him and Syracuse, for he can hear nothing from Syracuse. Repairers from these two stations, therefore, start out to find and to repair the break, traveling towards each other. The other stations put on ground wires and transact such local business as they can do, the through business being detained until the line is repaired.

LOCATION OF GROUNDS, OR ESCAPES.

If instead of a break it is an escape at the same point, which weakens but does not interrupt the working of the line, it requires considerably more labor and skill to discover its location. These difficulties sometimes require testing for from pole to pole. But if the escape is a bad one, it may be located as follows: New York says to Buffalo, "let us test-please open." Buffalo then lifts his key, opening his circuit, and New York shuts and opens his key, discovering that notwithstanding Buffalo has his key open, a strong current can be passed over the wire. The philosophies of this is, that when New York shuts his key the current passes from his battery through his key and along the line to the place of escape and through it to the ground, and thence back again to the ground wire of New York through which it returns to the battery. If there was no escape, the opening of the key at Buffalo would break the circuit so that New York could pass no current along the wire, and by this test the fact is established that there is a ground connection between Buffalo and New York. New York next calls Rochester and repeats the request to test, and Rochester opens his key. New York still is able to pass a current, proving the escape is between Rochester and New York. Syracuse is next called, and when that office opens its key New York discovers that it can pass no current, proving that the line is whole between Syracuse and New York, and that the escape is beyond or west of that station. The line is now tested from Syracuse to the stations between it and Rochester. Syracuse, finding that he can obtain or pass a current when any or all of them open their keys, proving to him that the escape is between him and the first station west- well knowing that if the line were whole between them no current could pass over the wire when the key of that station was open- sends out a repairer to discover the place of the evil and repair the line. This form of obstruction frequently occurs from branches or limbs of trees coming in contact with the wire, and establishing a ground connection by means of the sap through the body of the tree, which is an excellent conductor of electricity.

ATMOSPHERIC ELECTRICITY.

Still another and important use of the ground wire is to conduct away atmospheric electricity from the line. It frequently occurs that, during thunderstorms, the working of the line is materially interfered with by atmospheric electricity. This inconvenience is sometimes so great that the adjustment of the relay magnet must be altered with every word, if not every letter, the fingers turning the adjusting screw all the time. But a still greater inconvenience results from the destruction or damaging of the apparatus, the silk coils around the magnets having often been burned by heavy charges of electricity striking the wires. A device to obviate this, which seems to meet the greatest favor upon American lines, has been invented by Charles T. Smith, Esq., and consists of two smooth plates of brass, or other metal, placed one above the other with a strip of tissue paper between them. The lower plate is connected with the ground wire and the upper plate receives the line wire, which passes through it before it reaches the relay magnet. When the lightning strikes the line the charge of electricity enters the upper plate and passes through the tissue paper to the lower plate and from thence to the ground, doing no damage to the relay beyond. The tissue paper found to be burned with a number of small holes. An improvement upon this form consists in placing a number of brass weights, similar to those of a clock, upon a brass plate and separated from it by pieces of tissue paper, the plate being connected with the ground wire and the weights with the line wire. 'The apparatus is called a *paratounerre* or *lightning arrester*, and the latter form allows any number of wires to be connected with one paratounerre by simply increasing the number of weights. In practice, when the main wire runs through the station, the, wires leading to both sides of the magnet are each attached to separate weights upon the paratounerre, that the magnet may be protected from lightning entering the office from either direction.

ELECTRICAL STORMS.

The relays are sometimes, though not often, endangered from electrical storms in the atmosphere accompanying high winds. No thunder or lightning is observed during these storms, but that the electricity of the earth is greatly disturbed is evidenced from the frequent fluctuations in the strength of the current. The instrument, now working regularly, will suddenly exhibit signs of electricity of great power passing through the magnet, the current in some instances being so strong as to spring and even bend the armature lever. After the wave of electricity has passed, the line may be again worked until another wave comes on. These fluctuations succeed each other more or less rapidly, at times completely preventing the working of the line.

AURORA BOREALIS.

Somewhat analogous to the phenomena just mentioned, are those exhibited during the presence of an aurora borealis. The fluctuations of the current, however, during an aurora are usually not so rapid, but the waves are more steady and prolonged, occupying from ten to sixty seconds each. Instances have occurred in which operators have cut off their batteries and attaching ground wires have worked the line by means of the aurora alone. The influence of this singular development of atmospheric electricity is sometimes felt over an extent of many hundred miles. O.S. Wood, Esq., Superintendent of the Canadian telegraph lines, in writing of the great aurora exhibited on the night of the 28th of August, 1859, says: "I never, in all my experience of fifteen years, in the working of telegraph lines, witnessed any thing like the extraordinary effect of the aurora borealis between Quebec and Farther Point last night. The line was in most perfect order, and well skilled operators worked incessantly from eight o'clock last evening till one o'clock this morning to get over in even tolerably intelligible form about four hundred words of the steamer Indian's report for the press; but at the latter hour so completely were the wires under the influence of the aurora borealis, that it was found utterly impossible to communicate between the telegraph stations, and the line was closed for the night."

One wave was always succeeded by another of the reverse polarity, and the current from the batteries was alternately strengthened and weakened, if not utterly neutralized, as the waves pass upon the line.

Atmospheric electricity always develops more or less fixed magnetism in the relay magnets, sometimes to such a degree as to impede their working. They may be cleared out by reversing the poles of the batteries along the line, and it is often well to do this whenever the magnets stick or work hard, for fixed magnetism also is developed during the ordinary working of the line.

INCIDENTALS.

Besides the apparatus described, an office should be supplied with various minor articles, such as stationery, thumb screws, office wire, and also with materials and instruments for repairing temporary obstructions to the line, such as line wire, small wire, rope and pulley blocks, hand vices, climbers, files, &c.; and a small, delicate galvanometer, is very frequently used for testing the strength of the current.

The stations are furnished with battery material by the Superintendent, and the care of the local battery devolves upon the operator of the local station. In the larger stations the care of the battery is attended with considerable time and labor, and is usually placed in the hands of a man hired for that purpose. In those stations where the Grove cup is used the battery room should he apart from the operating room, for the fumes arising from the battery are deleterious to health.

THE TELEGRAPH LINE.

Two voltaic batteries standing within the same circuit, require the positive pole of one to be connected with the negative pole of the other; and if more than two, the same arrangement holds to the last, whose positive pole is finally connected with the negative pole of the first one, by means of the one or more conductors constituting the balance of the circuit. When this is done, the current flows instantaneously throughout the entire circuit; but if we violate this voltaic law, joining positive poles with each other, no current is found, provided the several batteries are of about equal strength.

Upon the early American lines, it was supposed that the conductors, between these opposite poles, must be metallic line wire alone; hence two wires were required for a single circuit, one for sending out the current, the other for its return; this soon gave place however, for many reasons, to the substitution of the earth as the medium for the return current- the discovery of *its* utility having been made by Prof. Steinheil, of Munich, Germany, in 1838. Upon every line, therefore, of whatever length, the wire is now joined at each end with the ground; the current finds a ready path back through the bosom of the earth, never becoming confounded with the many electrical or other currents, traversing the same route. A multitude of circuits require but a single ground wire, which, instead of needing insulation like the line wire, must furnish the most ready and thoroughly moist connection with the earth. A copper plate, imbedded in most earth, is safest.

The resistance of different metals to the electric current, given in the following tabular result of experiments of M. G. Farmer, Esq., of Boston, Mass., furnishes the best idea of their relative conductibility, chemically pure copper being taken as the basis, viz:

Copper Wire, "	"	1.00	Tin Wire	"	"	6.80
Silver "	"	"	.98	Zinc "	"	"	8.70
Gold "	"	"	1.13	Brass "	"	"	8.88
Iron "	"	"	5.63	German Silver		"	11.30
Lead "	"	"	10.76	Nickel "	"	"	7.70
Mercury	"	"	50.00	Cadmium	"	"	2.61
Platinum	"	"	6.78	Aluminum	"	"	1.75

The Resistance of fluids upon the same basis is as follows:

Copper " " " " " "	1.00
Pure Rain Water " " " " "	40,653,723.00
Twelve parts Water and one Sulphuric Acid, "	1,305,467.00
Sulfate of Copper, 1 lb per gallon, " " "	18,450,000.00
Saturated Solution of common salt, " " "	3,173,000.00
" " Sulfate of Zinc, " " "	17,330,000.00
Nitric Acid, 30 deg. B, " " " "	1,606,000.00

Copper wire, No. 16, was originally used upon American telegraphs, but early gave place to strong iron wire, No.9, which is now generally galvanized, or zinc-coated, before being put up, in order to prevent rust from destroying its conducting capacity, which lies, in the greatest ratio, in its surface. Its weight per mile is 320 lbs., and its sustaining power 1600 lbs.

CONSTRUCTING LINES.

Our manner of constructing American telegraphs is still too frail, either to insure good working, reliability, or durability, and hence *economy*. In a very early day, when the amount of capital, which could be introduced, by the utmost influence, into telegraphy, was necessarily limited, and when companies were weak, rigid curtailment of expense might have been discreet; but certainly this ought to cease under the auspices of the Western Union and other heavy companies. No poles should hereafter be set less than one foot in diameter five feet from the cut-off at the butt, nor less than six inches in diameter at the tips; nor should any wire of smaller size than No.6 be used, either as a guarantee of ample strength, or certainly to ensure abundant conducting capacity. The kind of timber employed for poles should be cedar in preference to any other, which grows in sufficient quantities to ensure a supply. Next to this stand chestnut, and some kinds of oak. They should then be set from five feet to such depth as is proportionate to the service required of them, not more than fifteen rods apart for a one wire line, twelve for two, or ten for a three and five wire line. The best quality of galvanized and annealed American wire only should be used. The insulator should be of very heavy glass, either imbedded in dry wood with great skill, or else covered with a good wooden shied.

Glass of the most superb character, and glass only, should be allowed contact with the line wire, tie wire, or iron hook by which wire is suspended, and glass alone should sever the connection between them and the supporting posts.

We hope to see, under the management of heavy wealthy companies, more of the English style of durability, like that of Canada, practiced in constructing telegraphs, and carried to that extreme that our lines will be doubled in size of poles and wires, and the substitutability of their other appointments.

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