ON THE

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MUNICIPAL ELECTRIC TELEGRAPH;

ESPECIALLY IN ITS APPLICATION TO

FIRE ALARMS.

BY

WILLIAM F. CHANNING, M.D.

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ON THE MUNICIPAL ELECTRIC TELEGRAPH.

The Electric Telegraph has two distinct offices. The first is to interlink distant communities, and to this its applications have been hitherto chiefly confined. The second which is hardly less important is to bring into coöperation the members or parts of single communities. Just in proportion as Civilization advances this application is to have a larger development. The Electric Telegraph is to constitute the nervous system of organized societies. For purposes of general intelligence and regulation, of alarm and police, the Municipal Telegraph, that is the Telegraph within the City or Town, has already numerous applications, which are of rapidly increasing importance. A single one of these, the application of the Telegraph to signalizing and communicating alarms of fire, with its incidental use for purposes of police, will be the subject of the present paper. The general conditions on which the security and uniform operation of the Telegraph, in all its Municipal applications, depend will also be considered.

At an early period in the history of the Electro-magnetic Telegraph in this country, the writer described its application to Fire Alarms, and published in the Boston Daily Advertiser of June 3, 1845, a general statement of principles which will be here more fully developed, and which are the basis of the System now in process of construction by the City of Boston. This is believed to have been the first publication in which the application of the Telegraph, not only to the purpose of simple signalizing, but also to that of giving public alarm in case of fire, was announced. Nearly ten years previous to this date, Professor Joseph Henry had devised an experiment, which, however, was not published until within the last two years, in which a distant bell could be struck by means of the release of a heavy weight suspended from his large electro-magnet,—the circuit of which, connected with a local battery, was opened by a small intensity receiving magnet operated by a long or Telegraphic circuit.

The Telegraphic Alarm System, subsequent to 1845, became the subject of occasional publication and its adoption was at length recommended by Hon. Josiah Quincy, Jr., Mayor of the City of Boston, in his official address of January, 1848. At this time Mr. Moses G. Farmer, Telegraphic Engineer, of Boston, directed his attention to the subject, and contrived his very beautiful secondary striking apparatus which will be hereafter described. Two models of this instrument were constructed for the City of Boston and were found to strike a large bell, with which they were connected, with certainty and precision. Sufficient confidence however, was not then felt in the Electric Telegraph, and the experiments were prosecuted no further by the City. In March of the present year (1851) I submitted to the City Government of Boston a detailed plan of the Telegraphic System of Fire Alarms, adapted to the conditions, geographical and otherwise, of the City, and accompanied with estimates of the expense of construction. In June, this plan was adopted, and an appropriation of $10,000 was made to carry it into effect. Mr. M. G. Farmer was appointed superintendent, and has contributed largely from his own resources to all subsequent adaptations and details of arrangement. The System now approaching completion in Boston, with the results of experience in its construction, will be described and illustrated in the course of the following pages.

During the present year the towers or belfries, seven in number, containing the fire bells of the City of New York, have been connected by a Telegraph wire, so that an alarm which had become known to the watchman in one, might be signalized to all the others. The indicating instruments used at these stations are of the most simple description, consisting of a small electro-magnet, armature and bell, with a local battery operated by a receiving magnet on the Telegraphic circuit. Accounts have also been received of the construction of a Fire Telegraph in Berlin by M. Siemens, Lieutenant of Engineers, but whether confined as in New York to simple signalizing, or connected also with automatic apparatus for public alarm, does not appear. The same Telegraph wire is described as connecting electrically the public clocks, or rather dials of Berlin, by a similar application of the electro-magnet, apparently to that made in this country three years ago by Mr. Farmer, to which reference will be made in another connection.

The Electric Telegraph in its common use, or as commonly regarded, is an agency for the transmission of intelligence or impressions to a distance. In this its functions are analogous to the sensitive nerves of the animal system. The Electric Telegraph, especially in its Municipal uses, may superadd to this the production of important mechanical effects, either by its own electro-magnetic energy, or by calling into action other machinery.

The analogy here with the functions of the motor nerves and apparatus of the animal system is equally strict and important. In any system of Municipal organization in which it is attempted to supply a living bond by means of the Telegraph, the distinction between these functions must be recognized; and in any system in which it is desired to employ both of these, to obtain unity of action from a variety of parts, it is necessary that the analogy furnished by the animal system, should be preserved in the relation of these functions. In other words there should be a Centre to which all impressions from the circumference or extremes should first be conveyed over one set of conductors, and from which after an act of intelligence, the impulses to corresponding action should proceed over another. Here is the brain and nervous system of the animal or of man. The Telegraph when employed for any office of social organization of a high order must conform to the same analogy.

As a first condition of the Fire Alarm Telegraph, we have therefore an Electric Centre, where the batteries and certain instruments, with a single operator, are placed,—and two classes of circuits or conductors, one of them *afferent*, *sensitive*, or "Signal," by which the intelligence of a fire is communicated to the Centre, the other, *efferent*, *motor*, or "Alarm," by which the impulse is sent out to the machinery by which the alarm-bells are struck.

The arrangement and security of the Conductors is a subject of primary importance in all applications of the Municipal Telegraph. As a first remark then, experience shows that a simple Telegraph wire, stretched across a City over the house tops, is more certain and reliable as a means of communication in the variable conditions of weather, season, and crowded thoroughfares, than any system of intercourse depending upon sight, sound, or transportation. To illustrate this, the wires of the House Telegraph, extending over a mile through the City of Boston, were interrupted only twice in the course of a year and a half, having been broken both times by snow falling from the eaves of houses, beneath which they had been improperly placed. The Bain wires during the same period, had been broken only once, and then by workmen engaged in building a house with which they interfered. When it is considered that the wires are an open channel of communication by night as well as by day, it will be conceded that no such immunity from accident can be found in any other system, at all commensurable in its functions with the Telegraph. There are however many important safeguards in the erection and arrangement of Conductors in the City, by which the security from interruption of Electric Circuits may be rendered almost absolute, and these will now be considered.

The Conductors commonly used consist of iron wire, supported by insulators upon the houses. These wires, where erected with a view to permanence and stability, should be of the best Swedish iron, and be limited in size and strength only by the strength of the supports which it is practicable to employ. The largest iron wire in common use within our cities is No. 9, which weighs about 325 lbs. to the mile. The construction of the Alarm System in Boston, was commenced with wire No. 8, weighing about 400 lbs. to the mile. It was found however that the brickwork would not often hold the insulators, with the weight of so heavy a wire, without the intervention of brackets of unusual strength, into which the insulators were screwed. In the South Boston Circuit, wire No. 10, weighing rather less than 300 lbs. to the mile, was employed, as giving on the whole greater security, without exceeding very much, by the mode of support, the usual cost of such works. The length of the wire in the Municipal Telegraph of Boston is about 49 miles, and it has probably been erected with greater care and thoroughness than any similar structure in the country.

In a System, however, of such public importance, and designed to be permanent in its character, no effort should be spared to give a massive strength to every part, and ample provision should be made for the careful and judicious survey of routes and selection of the places of attachment for the wires. It is also to be considered that a structure liable to frequent derangement, would be a source of just annoyance to real estate holders in the City, whose buildings are needed for the support of insulators. For these reasons, Mr. Farmer would recommend the appropriation of $150 per mile for the conductors of the Municipal Telegraph, so as to allow the use of large and often elevated brackets, supporting No. 8 wire in carefully selected positions. This is a more elaborate method of construction than has yet been attempted. The wire of the same size, erected in Boston, has cost about $73 per mile, and should possess great strength and stability after it has been tested by exposure, and any weak parts have been replaced.

In the selection of buildings for the support of the Conductors, public edifices, such as churches, school houses, &c., should be preferred, and next to these, lofty and isolated buildings, in order to remove the wires, as much as possible, from danger of interference. Two wires, or, at least, related wires, should not be attached to the same building or block of buildings. The Conductors should be so much elevated above the roofs of houses, that their insulation should never be impaired by contact with fallen snow.

The stretches of wire, in the Municipal Telegraph, should be as long and few as practicable, consistent with security, in order to avoid loss by imperfect insulation, and the multiplication of places of support, where alone, interference with the wires is possible. In Boston it has not been considered prudent to extend the stretches of the Alarm System generally over two hundred feet, on account of the occasional storms of snow and rain in the winter, in which great accumulations of ice are formed upon the wires. A single stretch however of the House line, of over 800 feet between the towers of neighboring churches, has continued undisturbed for two years. In cities in this country South of Boston, stretches of 300 or 400 feet may be allowable.

From the strength of the conductors they can not be easily interrupted either by accident or design, and in the latter case recourse must almost necessarily be had to instruments. The place of such violence would be apparent, and the broken wire, from its weight and tension, would fall at once to the ground. Detection would therefore be easy. The wires, used for an important public object, would, of course, be protected by law. The police and members of the fire department should be instructed at once to report a broken wire that it may be repaired.

As the interruption of a wire is a possible, though not a probable or frequent occurrence, the principle of Double Conductors must be introduced into any System, in which absolute uniformity of action is required. This is necessary in the chronometric application of the Telegraph, where electric pulsations are sent over the wires every second to measure and mark uniform time on a hundred dials. It is equally necessary in the application of the Telegraph to purposes of public alarm where reliance is placed on the unerring certainty of its operation in a sudden emergency. Hence, between each station of the Fire Alarm System, there are two conducting wires following different routes. A proportionate increase of conducting power is an incidental advantage of this use of two-fold wires.

By a strict regard to the principles of construction and arrangement, which have thus been considered, *the interruption of the circuits of the Municipal Telegraph becomes practically impossible.*

The ground can not be used as any part of the circuit of the Municipal Telegraph without introducing a source of irregularity. A connection, accidentally or intentionally made between the wire and the ground, in such case, would complete an "open" circuit, or throw part of a "closed" circuit out of use. A duplicate conductor would also cease to be an advantage or security, where the circuit would be permanently completed by the interruption and falling of a single wire to the ground. In the Fire Alarm System, the circuits are composed exclusively of wires, and these, in the process of erection, are separated as widely as possible, especially in the case of corresponding wires, whose cross-connection would complete a circuit. Between the different Stations the wires diverge widely, and at Stations where they may come together for the purposes of signalizing, they are carefully protected. Hence *false alarms*, by an abuse of the wires, are rendered nearly impossible.

Another important result from the exclusive use of wires is *double insulation.* If the ground were used there would be only one insulator between it and the wire above, forming part of the same circuit, but, with wire conductors alone, there are two insulators, besides the buildings and intervening ground, which the current must traverse to make the circuit complete between corresponding conductors. Another useful result of the same arrangement is that the ground is left as a reserve, and can be used temporarily with a separate battery for special police communications, in connection with, or addition to, both of the Signal wires.

As the insulator forms an important part of every Telegraphic System, the form used in the construction at Boston, which is Batchelder's patent, is shown in fig. 1. The cast iron cap is represented by the black line in the section. This is lined throughout with glass, by the operation of blowing, or with porcelain. The shank is then introduced with a hot mass of glass, or any fused or semi-fused material, by which it is firmly fixed in its place. This is represented by the shaded portion. Between the lower edge of the cap and the shank, in the section, there are four inches of glass surface. The reëntering angle of the lower part of the cap protects the glass within from missiles, and is calculated in a storm of wind and rain to drive the latter downward, and thus preserve the insulation. The wires pass over the top of the insulator. The shank, which should be longer than is represented, screws into a bracket or the ridgepole of a house.

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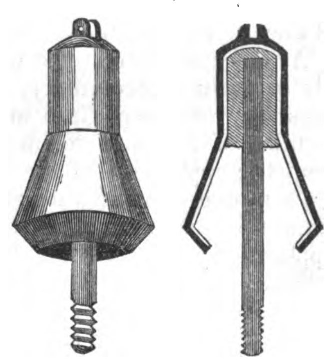

From the difficulty of always obtaining suitable places of support in cities for the conductors carried through the air, the use of insulated wires, buried in metallic tubes, may be resorted to sometimes with advantage, in the Municipal Telegraph. By sinking the tubes beneath the reach of accident or frost, great security may be obtained, but with a great increase of expense. Thus the cost of insulated conductors, laid underneath the streets of cities, may be estimated at from $600 to $1,000 per mile.

To ensure regularity of action as well as for purposes of safety, Dischargers of atmospheric electricity have been provided at every

Signal and Alarm Station of the System in Boston, numbering sixty in all. These were constructed by Mr. Farmer, on the principle of conducting to the earth all free electricity, or electricity above a certain degree of tension, and will be figured hereafter. So large a number of these, employed in connection with the circuits of forty-nine miles of wire, above the buildings, can not fail to exert an important influence in silently discharging accumulations of atmospheric electricity. A general protection against danger from this source may thus be incidentally afforded by the Municipal Telegraph.

In a perfect system of Fire Alarms it is necessary that communication should be *instantaneous*, *universal* and *definite*. The Electric Telegraph, by its peculiar properties, affords the means of fulfilling all of these conditions. Its pulsations are transmitted in an inappreciable time over the wires of the Municipal circuit. By the multiplication of Stations in the course of the Signal wires, by which all parts of the City are brought into communication with the Centre, and by the electro-mechanical connection of the various alarm bells with the Centre, the means both of signalizing and public alarm, are made universal. By the use of electro-magnetic machinery, by which District Signals may be struck or tolled upon the alarm bells, at will, the System becomes definite.

In the communication of a definite alarm, the division of a City into Fire Districts becomes necessary. These will vary in each City according to its size and other conditions. The number should be sufficient to localize a fire without unnecessary complication. The following are the District Divisions which have been adopted in Boston: I, North,—II, West,—III, Centre,—IV, South Centre,—V, South End,—VI, South Boston,—VII, East Boston.

The fundamental division of Circuits into those of Signal and Alarm has already been stated; the one conveying the intelligence of a fire from the Signal Stations to the Central Office,—the other, communicating the impulse to mechanical action from the Central Office to the bells. As the completion or interruption of the Circuit is the condition by which the effects of the battery are obtained in the Telegraph, the Signal Circuit is so arranged that it can be completed or interrupted by means of a Signal Key or Signal Crank at any of the Stations, which are distributed at suitable intervals throughout the City. In fig. 2, the arrangement of the Signal wires with an open circuit is shown. B represents the battery, p and n its positive and negative poles. It will be seen that a conductor starts from each pole, and following the course of the circuit, returns to its point of departure. S, S, S are three Signal Stations. The battery circuit may be completed by the depression of either of the keys K, K, K, or of one of any number of keys similarly situated between the wires. It will be observed that either or both of the wires may be broken in a single place, and yet every Signal Station will be in communication with both poles of the battery, following the conductors round in one or the other direction. By this arrangement, therefore, the principle of double conductors is preserved. As an additional safeguard, the interruption of either of the wires in a single place would be known at the Central office within an hour, by means of testing apparatus. The wires will be seen to diverge between the Stations, taking routes widely separated. At the Signal Stations themselves where the wires approach, there is the possibility of a cross connection, if the open circuit is used. The building selected for this purpose should therefore be isolated or have a roof as little accessible as possible. This difficulty is obviated by the use of the closed circuit. In this case, depressing the Signal key would break instead of completing the circuit, and the wires would be arranged between the Stations like the links of a chain, as in fig. 3. Owing to the difficulty of keeping the wires sufficiently separated in all parts of the System in Boston, and the occasional use of posts, as in crossing the South Boston bridge, the closed circuit will be partially if not altogether used with the Signal wires.

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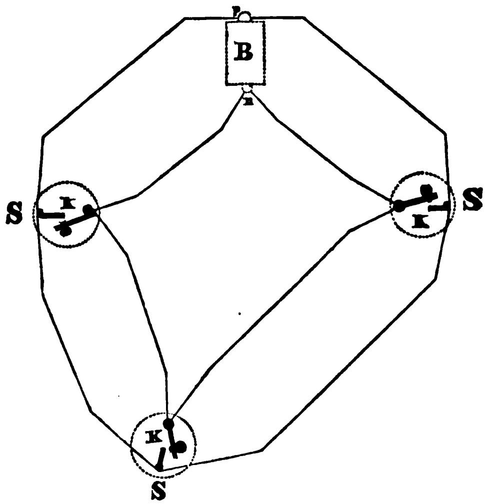

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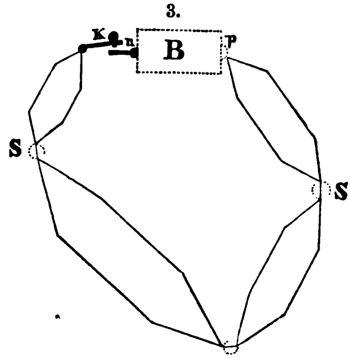

The Alarm Circuit is so arranged that it may be completed by depressing a key at the Central Office. In fig. 3, B represents the battery at the Central Office, and K the Alarm Key. S, S, S, are Alarm Stations, such as churches, where the machinery is placed by which the bell is struck when the Circuit is completed. Several of these may be included in the same Circuit. The double Conductors are seen diverging between the Stations, at which they unite in a single wire.

The general grounds for the division of the Circuits, according to their functions of Signal and Alarm, have already been stated. The immediate and practical reasons for such an arrangement will now be perceived. It is necessary, in the first place, to have so important a system under the control of some department or agent of the City government, and to provide for intelligent direction at its Centre. It is necessary also to provide means to complete the Circuit of the alarm bells with perfect regularity and at proper intervals, which would be impossible, except by machinery placed at the Central Office. It is also important to preserve the Signal Circuit distinct, that it may be available for purposes of police.

In towns or Cities of small size, a single Signal Circuit and a single Alarm Circuit may be sufficient to include all the Stations which it is desirable to establish. In larger cities however, advantage will be found in increasing the number of Circuits of both classes. In Boston, economy, both as regards length of conductors and battery power, induced the division of the City into North, South and South Boston Circuits. These arrange themselves naturally about the Centre, and each division has its separate and independent Signal and Alarm Systems. At the Central Office the Circuits of a similar class may all be connected into one, or, which is preferable, they may be kept entirely distinct. An additional security is thus obtained against interruption of the system. If by an improbable chance a single Signal or Alarm Circuit should be interrupted, the integrity of all the others would be preserved, and they would still be available for the performance of their usual functions. The North, South and South Boston Signal Circuits are respectively about $3\frac{1}{4}$, $4\frac{3}{4}$ and 6 miles in length, and the North, South and South Boston Alarm Circuits, respectively, about 3, $3\frac{1}{2}$ and 4 miles.

East Boston, which constitutes the Seventh District, is situated on an island and has no circuit of its own, though a pipe enclosing insulated wires could at any time be sunk under the channel. An alarm will therefore for the present, be signalized across the channel by sound in the usual manner, and will thence be communicated to the Centre by a special Signal Station near the East Boston ferry. In the South Boston Circuit the wires are carried under the draw of the bridge, enclosed in a pipe.

The Central Office, the Signal Stations and the Alarm bell Stations have all instruments peculiar to themselves. As the point from which the initial impulse proceeds in the actual operation of the System, the instruments and connections of the Signal Stations will be first described.

The Signal instruments are contained in a strong cast iron case, and connection is made between this and the Conductors on the top of the building by a wrought iron pipe enclosing insulated wires. Entire protection to the instruments and wires is thus obtained. The Committee of Construction in Boston have wisely decided to place these boxes on the outside of buildings, in places well selected, generally opposite a lamp. These Stations are distributed throughout the City at distances not greater than a hundred rods from each other, so that no house shall be distant more than fifty rods from one of them. Thus there are 18 Signal Stations in the North Circuit, 16 in the South, and 7 in the South Boston Circuit.

The Signal Box, belonging to the Boston System is represented in fig. 4. The box and door consist each of a heavy casting.

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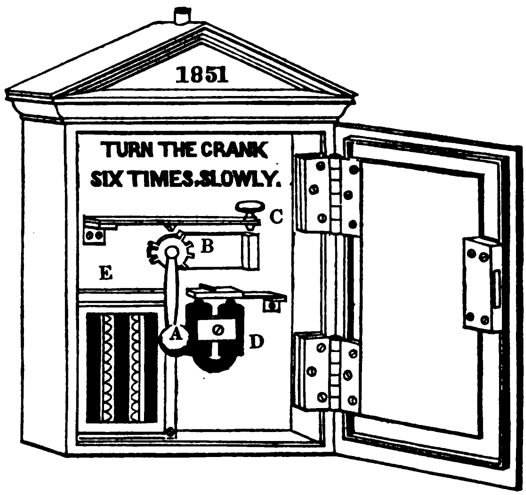

The hinges and lock are of the most substantial kind. The outside of the door has upon it the words Signal Station, with the number of the Station, and a panel containing a notice of the place where the key is to be found, and perhaps also an extract from a City Ordinance for the regulation and protection of the System. The Signal Crank with a heavily weighted handle is seen within the box at A. It was devised by Mr. Farmer and myself, to obviate the irregularity which might arise from the manipulation of the Signal Key by ignorant or incompetent persons. The axis of the crank carries a circuit wheel B provided with a number of teeth or cams, each of which, in revolving, completes the circuit momentarily by a sliding contact with the key C. These cams are divided into two groups, seen in the figure, one on each side of the circuit wheel, the principal of which groups numbers from one to seven cams, according to the number of the District in which the Signal box is placed. This communicates the District number to the Central Office. The other group consists of from two to four cams, placed closely together, and so formed as to complete the circuit for longer or shorter periods and produce a record at the Central Office, of dots and lines, indicating the number of the Station. The box contains instructions to turn the crank six times. The effect of this, with the Crank represented in the figure, would be to communicate the Signal of the Fourth District, alternating with that of the fifth Station, (a dot, a line and a dot,) six times in rapid succession, to the Central Office, where it would be indicated and registered by proper machinery. The object of the repetition of the Signal is to draw attention and ensure its correct reception. A different number of revolutions of the Crank or its rapid rotation would not affect the character of the Signal. The weighted handle always carries the Crank back to its original position.

The record made at the Central Office by the revolution of the Signal Crank can not be imitated by any person not having access to the Signal Boxes. A great additional safeguard from any abuse of the wires is thus obtained.

The Signal Key C can be used in the ordinary manner, to communicate to the Central Office any system of Signals which may have been agreed upon for police or other purposes. Communications may be received, in return, from the Central Office, by means of the little electro-magnet and armature D, which is introduced in the course of one of the Signal wires. The click of the armature constitutes here the audible signal. This would also be heard on operating the Signal Crank or Key, if the circuit was duly completed, of which it would thus give indication. It would be heard also if another Station was in the act of communicating to the Centre, and it would thus prevent confusion in signalizing.

The Discharger of atmospheric electricity is represented at E. It consists of three strips of brass, resting on varnished wood and covered with a glass plate, with strips of India rubber cloth interposed. The central strip communicates with the ground and has serrated edges which are presented in close proximity to the strips on each side. These strips communicate each with one of the Signal wires. Any free electricity or any intense charge of induced electricity in the wires would thus be discharged, by means of the sharp edges, offered by the ground conductor.

Where the closed circuit is used, the instruments in the Signal Box would undergo a very slight change. The Signal Key would complete the circuit by contact, when at rest, and would break it when depressed by the cams. The electro-magnet D would be included constantly in the circuit, and the click of the armature would be heard on its release, when the Circuit was broken.

The instruments in the Signal Box are attached to a false back of wood, behind which the communicating wires are disposed. The socket for the reception of the wrought iron pipe containing the insulated conductors, is seen on the top of the box.

Each Signal Station is in charge of a person or family in the immediate neighborhood, whose duty it is to open the Box in case of an alarm and turn the Crank. This act is so simple that it might be performed by a child. Certain members of the Fire, Watch and Police Departments, are also provided with keys to the Signal Boxes. The object to be secured in this arrangement, is abundant access to the Signal Apparatus in case of fire, and yet a sufficient guarantee against its abuse. A periodical report should be required from the agents in charge of the Stations.

Connection may at any time be made between the ground conductor of the electrical Discharger and one of the Signal wires, for the purpose of special Signalizing to the Central Office, without the indication of the signals at any intermediate Station.

The Centre of the System in Boston is established in the City Building adjoining the City Hall. From its roof which is isolated, the wires, elevated on a bracket, radiate in all directions.

The instruments at the Central Office are in part receiving and in part transmitting, besides the batteries for the whole system, and the testing and registering instruments employed in the regulation of the Circuits.

The receiving apparatus consists of an Office Alarm for each of the three Signal Circuits, and a single electro-magnetic Register, of the Morse construction, with which they communicate in common. The Alarm is represented in fig. 5. It is a simple electro-magnet, with an armature attached to the upright lever which carries the hammer. The bell is of large size. For the purpose of obtaining a powerful blow from the hammer, sufficient to rouse any one sleeping in the Office, it may be operated by a local battery with a receiving magnet interposed between it and the Signal Circuit. The Office Alarm with the local circuit ar-

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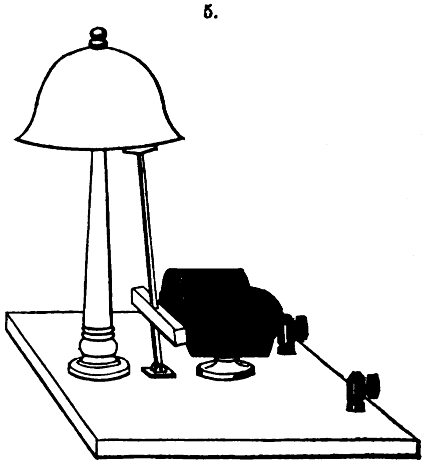

rangement, is an apparatus identical with one figured in Cooke and Wheatstone's English patent of 1837, to which I take pleasure in referring it.

The Register used is the common electro-magnetic register, arranged so as to start and stop itself. It is made to run faster than usual, so as to record legibly the Signals made by the Signal Crank, even when turned rapidly. The Register may be operated by the same local circuit as the three Office Alarms. A Switch is provided to disconnect the Alarm of any Circuit, when the Register is used for continued communication. The Alarms connected with the different Circuits are provided with bells of different tone, so that it is immediately perceived, by the sound, from which circuit any Signal proceeds.

It is often desirable to send a communication back to the Signal Stations for purposes of police, or, it may be, to inform an officer of the Fire Department of the number of the Station from which an Alarm of Fire has been signalized. For these and similar objects, a Key like that which will be described in connection with fig. 8, is placed at the Central Office, in the course of the Signal wire which embraces the little electro-magnets in the Signal boxes; or, if a closed circuit is used, a simple break-circuit Key is introduced in each Signal Circuit. Thus the number of a station signalizing an alarm of fire, or any other Signal, may be counted out, in answer to an enquiry, upon the electro-magnets in all the Signal Boxes of a Circuit, by the Agent or operator at the Central Office.

The Signal Battery may be common to any number of open Signal Circuits, the extremities of each Circuit being connected with its poles as shown in Fig. 2. The same battery may also be used for signalizing back to the Stations in the manner just described. For the Boston System, and with Circuits of not over six miles, twelve pairs of the Odds and Ends battery of Smee, as constructed by Davis,* should be amply sufficient. Where great power is not required from a battery for telegraphing, this form is more constant and manageable than any other, at least with the open circuit. As a fact of general interest in all applications of the Telegraph, I will state that this battery is, according to my experience, many times more enduring in its action, with an open circuit, than the common form of Smee's battery in which the same elements are employed, or than any other battery commonly used, in which the zinc rises above the solution, and is exposed to the influence of the air and water line. Where the closed circuit is used, a battery is necessary for each Signal Circuit. For this purpose a Daniel's battery or possibly an Odds and Ends battery of twelve pairs may be applied.

* Davis's Manual of Magnetism, 2nd edition, p. 56.

The transmitting apparatus, connected with the Alarm Circuit, consists of a common Signal or rather Alarm Key, and of the District Keyboard. The purpose of both these instruments is to complete at suitable times the circuit, by which the machinery at the Alarm Stations is thrown into action.

To obviate the difficulty of completing the circuit by the Alarm Key, with the absolute regularity necessary to strike the District Signals upon the bells, the District Key-board is introduced. This instrument, which in its simple form was early employed in the Telegraph, is represented in fig. 6. The Keys, with

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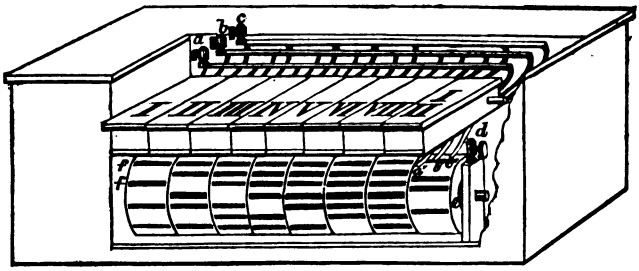


one exception, are seen marked with the numbers of the Districts. Below the Key-board is a cylinder, which is moved by clock-work at a given rate when the instrument is in operation. The cylinder is of wood having a metallic core, *e*. Strips of metal, *f f*, connected through with the core, are set into the wood of the cylinder, so as to form groups under the several Keys, equal in number to the District Signals, marked upon them. Thus, under the Key of District One, single strips widely separated are seen, under the Key of District Two, two strips, and after a considerable interval, two more, and so on. It is obvious, with this arrangement, that if each key should bring a conductor to bear upon the surface of the cylinder beneath, it would complete electric communication through to the core, at regular intervals corresponding to the District Signals.

For the sake of economy of battery power and the security of distinct circuits, it is desirable to throw the force of the Battery upon the three Alarm Circuits separately and in succession. This is effected by attaching three metallic springs *a′*, *b′*, *c′*, to the under surface of each key. These springs when the key is depressed, bear upon the cylinder in an oblique line, that is, *a′* in advance of *b′*, and *b′* in advance of *c′*. The other extremities of these springs make an ample bend behind the Key-board, to allow freedom of motion to the keys, and are then fastened respectively to the metallic bars *a*, *b*, *c*, the corresponding spring of each key being attached to the same bar. Now on depressing any key, the strips of the revolving cylinder come in contact with the three springs in succession, and if the Alarm Circuits are each connected at one extremity with the three screw cups *a*, *b*, *c*, and at the other, through the Alarm Battery with the screw cup *d* and core *e*, the current is thrown on to each of these circuits in quick succession, and at intervals corresponding to the number of the District marked upon the key.

The figure is represented with seven District Keys, and an eighth, intended for the Signal "All Out," the use of which will be described hereafter. The number of the keys may be increased at pleasure. A key for fast striking, that is once in about two seconds, will be introduced in the Boston System as a means of general alarm, before striking the District Signals. Three spare keys will also be assigned for the direction of engines, belonging to different sections of the City, or for other purposes. The system of alarm, by means of the Key-board, may also be further developed, after some practice, if not at the time of its first introduction, by providing keys which shall cause not only the number of the District, but also that of the Signal Station, nearest the fire, to be struck upon the bells. Thus for example, the District number would be struck with blows, separated from each other by an interval of two seconds; then a pause would intervene of four seconds; then the number of the Station would be struck with blows having an interval again of two seconds; and finally a pause of eight seconds would follow before the commencement of another Signal. With a key for each Station, in addition to those for other purposes, this would require in Boston a Key-board of forty-eight keys.

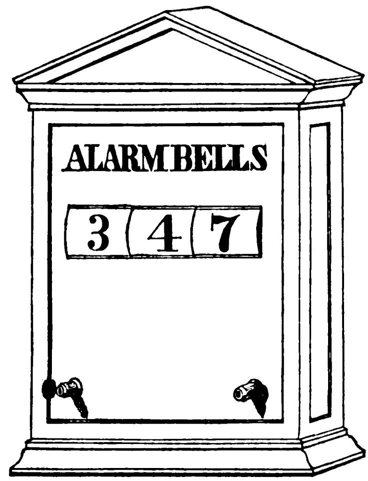
The clock-work which carries the cylinder is not shown in the figure, but it can be regulated so as to give any interval which may be desired or may be necessary between the strokes of the alarm bells. The keys are so arranged that the depression of any one liberates the clock-work and sets the cylinder in motion, and the subsequent release of the same key stops the clock-work at the end of one revolution of the cylinder. While the key is held down the electric impulses continue to be sent out at measured intervals over the wires.

It may often be desirable to confine an alarm to only one or two of the Circuits. This is easily effected by a Switch placed upon each Circuit, so as to shut it off at will from connection with the cylinder.

The Battery connected with the District Key-board and Alarm Circuits consists of about twenty-five pairs of Grove's arrangement of large size. Very considerable power is required to produce the necessary electro-magnetic effects at the Alarm Stations, even through circuits not exceeding four and a quarter miles in length. A great economy of battery power is therefore obtained by the action of the Key-board, which communicates the same Signal in succession to the different Circuits.

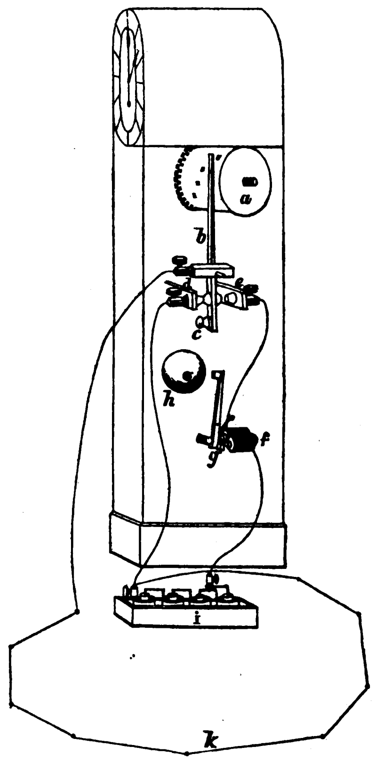
In connection with each of the Alarm Circuits, as they pass out of the Central Office, is an Alarm Bell Register for indicating the number of Electric impulses sent over the wires, and the corresponding number of blows struck upon the bells by the hammers of the Striking Machines. In form it is similar to a register in use for other purposes. The movement resembles that of Mr. Farmer's electro-magnetic clock. There are three cylinders, seen partially in the figure, whose circumference is divided decimally and marked with figures, representing in their place, units, tens, and hundreds. The armature of an electro-magnet carries a ratchet, which at every impulse of the current moves the unit cylinder forward one figure, at every tenth impulse moves the cylinder of tens also forward one figure, and at every hundredth impulse moves the cylinder of hundreds forward one figure, in addition to both the others. The indications of this instrument are very important in connection with machines carried by weight. Thus, if alarms are very frequent, the Alarm Bell Register may show that the striking machines require to be wound up in anticipation of their regular time.

7.



It is essential to have systematic means of testing all the Circuits, employed in the Fire System. Where a closed Signal Circuit is used, an interruption from any cause, gives of itself a Signal at the Central Office. Where an open circuit is used, as it is, in connection with the Alarm machinery, or may be, in connection with the Signal apparatus, other means must be employed. The Testing Clock is shown in fig. 8, (see next page.) It is a common once-striking clock, of which the hammer and bell are removed, and the cylinder *a*, so connected with the striking movement as to make one revolution at the usual time of striking. On this cylinder are pins arranged spirally, equal in number to the number of Circuits which it is desired to test. These pins in the course of their revolution, deflect each a testing key *b*, of which keys, for the sake of clearness, only one, with the corresponding parts is shown in the figure. The upper part of the testing key is made thin and elastic, so as to yield slightly to the passage of the pin. Its arrangement in the figure shows its application to testing the continuity of one of the Signal wires, represented in fig. 2. In its usual position, the testing key is held by a spring, in contact (which should be a sliding contact,) with the little anvil *d*. It will be seen that the wire *k*, connected with the zinc pole of the battery *i*, makes a perfect circle, returning into itself through the screw-cups connected with *d* and the axis of the testing key. When moved by the revolution of the cylinder, the key breaks the contact at *d*, and makes contact with the little anvil *e*, which is connected through the electro-magnet *f*, with the platina pole of the battery. Hence it completes the circuit, if the wire *k* is unbroken, and the bell *h* is struck by the hammer carried by the armature and lever *g*.

8.



The knob *c*, on the lower part of the testing key, makes it available for use, at any intermediate time, by hand. The arrangement of this key also shows how a single wire of the Signal Battery can be brought into circuit, for the purpose of communicating back to the Stations. It will be observed that one end of the wire *k* always remains connected with its battery, whether the key *b* is manipulated or not. Its function of signalizing fire is therefore never interfered with.

The testing key applied to the Alarm Circuit connects it momentarily with a battery, perhaps the Signal battery, too weak to set off any of the striking machinery, and yet strong enough to actuate the electro-magnetic alarm within the clock. In the Boston System, if the six wires of the Signal Circuits and the three Alarm Circuits should be tested together, nine bells would be struck in regular succession, at the time of the usual striking of the clock. These should be separated from each other in tone by a musical interval, and bells representing different classes of circuits should be in different parts of the scale. If one of these notes were omitted it would at once be perceived. Taken together, the chime would furnish hourly assurance of the integrity of all the Circuits of the System.

Mr. Farmer has also devised a method of testing, by means of his electro-magnetic clock, affording equal facilities with the mode which has been described. Once each hour the current is thrown, by successive oscillations of the seconds pendulum, upon as many circuits as it is desired to test. This method gives obviously a very wide range, both as to number of circuits and the intervals of time at which the application can be made.

The Alarm Station consists of some building or structure, containing a bell applicable to the purpose of public alarm. Thus the bells of churches, and of school and engine houses are employed in the System at Boston. The instruments at these Stations are the Striking Machine, connected with the Alarm Circuit, and set off by electro-magnetism,—the Discharger of atmospheric electricity, connected with the ground,—and, where required, the Switch for shutting off the current from the striking machinery, when the bell is rung by hand.

The weight, train of wheels and hammer of the Striking Machine, are identical in character with the corresponding part of church clocks,—the machine being so arranged, however, as to strike only once each time that the detent is removed. Greater power is required to liberate this detent than can be directly or readily obtained by means of an electro-magnet, placed in the Alarm Circuit, and actuated by the Alarm Battery at the Central Office. Two modes of obtaining an increase of power, for this purpose, exist; one, by including in the Alarm Circuit a receiving magnet, which brings into action a local battery, operating the electro-magnet by which the detent is liberated. In this case the local battery may consist of three or four pairs of the odds and ends form, which, in an open circuit, need no care for several weeks, if not months, at a time. The other mode is by employing some secondary apparatus, liberated by the electro-magnet in the Alarm Circuit, to raise the detent. This method was applied by Mr. Farmer in 1848, in his very beautiful instrument, which which will now be described.

Fig. 9 (see next page) represents the precise form of the Striking Machines, constructed by Howard & Davis, for the City of Boston. The frame is a most substantial casting. The electro-magnet will readily be recognized, with its armature attached to an upright lever at *c*. The legs of the electro-magnet consist of half-inch soft iron, surrounded with coils of insulated copper wire No. 23, which are three inches long and two inches in diameter. *a* is a falling arm, weighted at the top, which is supported in an upright position by a horizontal lever, resting on the top of the armature lever at *b*. When the armature is attracted to the magnet, the weighted arm *a* falls over until stopped by the adjustable rest in front of it. In falling, a little lever, seen attached to the

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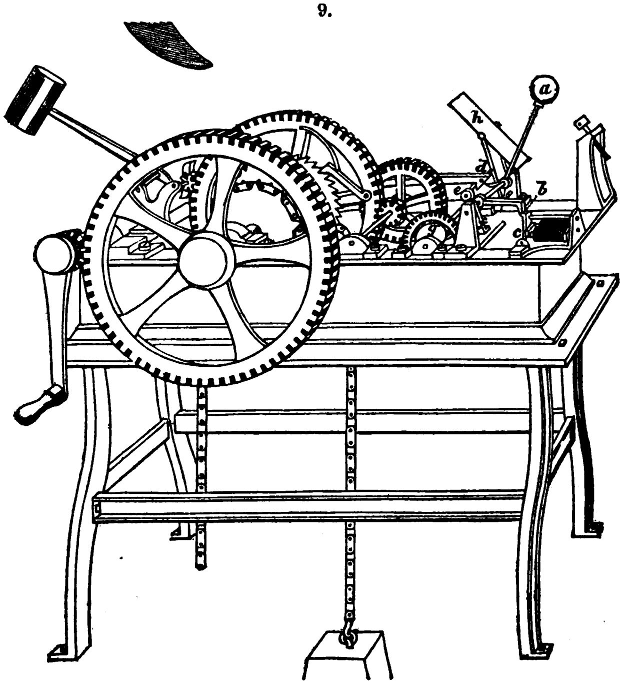


same axis, raises the latch-shaped detent *d*, by means of the pin connected with it. The arm carrying the pin *e*, attached to the same axis with the cam *g*, and connected with the train of wheels of the striking machinery, is thus liberated, and commences to revolve on its axis. In so doing the cam *g* swings forward the bar *f*, attached to the axis of the falling arm *a*, which is thus raised to its original position; the horizontal lever catches again at *b* if the armature has been released, the detent *d* falls, and the pin *e* is arrested at the end of one revolution. This occupies two seconds, and in the meantime the weight of perhaps 2000 lbs. has fallen an inch, and a single blow has been struck by the hammer. If the armature were not released from the attraction of the electro-magnet, the horizontal lever would not catch at *b*, and the machine would continue to strike, until the circuit, influencing the electro-magnet, was interrupted. This indefinite and undesirable mode of striking would be produced by holding down the Alarm Key at the Central Office. To obtain single blows, for the purpose of definite alarm, the circuit must be completed momentarily at suitable intervals, which is best effected by means of the District Key-board. The fly-wheel of the clock work is shown at *h*. The hammer represented in the figure is usually placed in a belfry above, connected with the hammer lever by a wire.

The bells to which the striking machines are applied in Boston, vary in weight from 3,700 to 300 lbs. The machines are of uniform size, but they are carried by weights, varying from 2000 to 800 lbs., on a single chain. It was supposed in the outset that a blow equal in force to that of the common tolling hammers, would be sufficient for all the purposes of alarm, especially as, in the Telegraphic System, an alarm is not propagated by sound, from bell to bell, as in the ordinary method. A greater amount of sound was however considered desirable by members of the Fire Department, and a great addition to the force of the hammer was found necessary to produce adequate vibration in the largest bells. Thus the hammer, judged suitable for the bell of Brattle St. Church, weighs forty pounds, has a handle three and a half feet long, swings through an arc of four and a half feet, and is moved at each blow by a force equal to a weight of 1440 lbs., falling one inch. To liberate the detent of a machine of this power, the weight on the falling arm must be proportionally increased, and the electro-magnetic power required to free the arm will amount to about 14,000 grains when the armature (faced with brass) is in contact with the electro-magnet. The battery provided at the Central Office must be adequate to produce this effect through the Alarm Circuits.

The striking machines are calculated to strike 1000 blows with a fall of the weight equal to 83·33 feet on a single chain, that is, at the rate of one inch to a blow. Where a great expenditure of power is required, and the weight is applied by a single chain with a limited fall, the number of blows which can be obtained from a single winding is necessarily diminished. Thus the number of blows with the three largest bells in Boston, will not probably exceed 450 or 500. Fortunately these bells are near the Central Office, and can be easily wound up when the Alarm Bell Register, represented in fig. 7, indicates that they are nearly run down.

The striking machines should be wound weekly, and a detailed report made, by the person winding them, to the Central Office, where it should be entered on the journal. All intermediate windings should be entered in a similar manner.

The time required between successive blows of the Striking Machines is two seconds. The revolution of the cylinder in the District Key-board, fig. 6, should be graduated so as to complete the circuit, for consecutive blows, at precisely this interval. The average number of blows, in striking District Signals with intervals of five seconds after each Signal, is about twenty per minute. From fifty to a hundred blows would be sufficient, ordinarily, for a single alarm.

A single Alarm Circuit may include a number of Alarm Stations. In all of these, in which the conditions are similar, the blows upon the bell should be synchronous. No matter how widely scattered over a City, the Signals would be struck on the different bells practically at the same moment of time. Differences however in size, friction, proportion, would always exist, sufficient to make a slight difference in the instant of striking between a number of bells. Even if this were not so, difference in distance would cause the sound of one bell to reach the ear before another. Hence District Signals are always distinguished by listening to the sound of a single bell. The effect of the District Key-board is to strike in succession the bells of different Circuits. The interval in sound, however, thus occasioned, would not be so great as that produced by distance in bells of the same Circuit.

In Boston there are eight Telegraphic Alarm Bells in the North Circuit, nine in the South Circuit and two in the South Boston Circuit. These bells are for the most part the same previously employed for the purpose of alarm. The irregularity of surface in the City indicated the use of a number of bells, instead of the employment of a few large ones as in New York. The resistance to the battery current in the South Circuit, 3½ miles in length and including nine Alarm Stations, is greater than in either of the others. The coils on the electro-magnet of each striking machine offer a resistance equal to a mile of single No. 8 wire, or to half a mile of double wire. The nine Stations would be equal therefore in resistance to 4½ miles of Circuit, which gives a total resistance of eight miles of double No. 8 wire, through which the Battery must act.

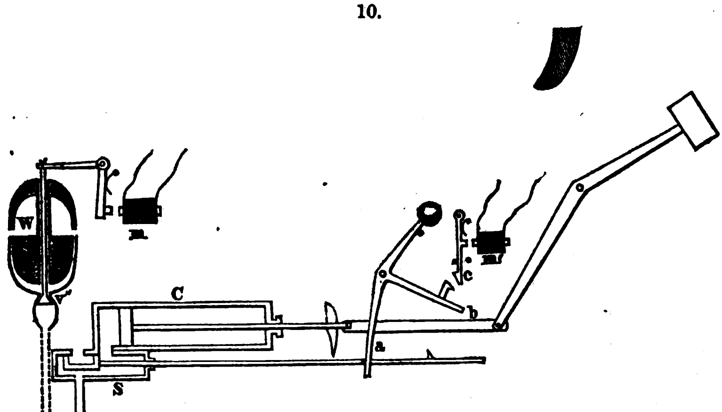
The Dischargers of atmospheric electricity at the Alarm Stations are similar in principle to those already described, and need not be farther considered. Where the bells are rung for other purposes, it is necessary that there should be a lever within reach of the bell ringer, communicating with a Switch above, for the purpose of turning the current off from the coils of the Striking Machine through a short circuit, during the period of ringing the bell. Otherwise the bell or hammer would be liable to injury in case the actions of ringing and striking should proceed at the same time. A little electro-magnetic alarm may also be provided to notify the bell ringer of the commencement of an alarm of fire, to which it would be his duty to give precedence. A Switch, which should be automatic, or dependent simply on the commencement and cessation of the motions of ringing, would on many accounts be desirable.

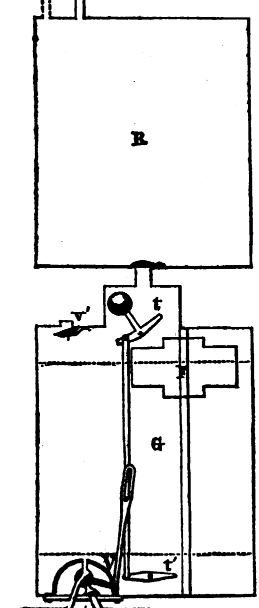
The operation of the System has been shown in its detached parts. It will now be illustrated consecutively through all its stages. A fire having broken out in the neighborhood of the fifth Signal Station in the Fourth District, of which the Box is represented in fig. 4, the person in charge of this Station, or, at night, a watchman, opens the Signal Box and turns the Crank six times. The Alarm at the Central Office is struck every time that the circuit is closed, and the Register records, at the same moment, the District Signal of four consecutive marks, six times repeated, alternating with the Telegraphic Signal, a dot, a line and a dot, indicating the number of the fifth Station. The Agent at the Central Office, if aroused at night by the Alarm, refers to the Register where he finds a distinct and permanent record. He turns immediately to the District Key-board and depresses the key of the fourth District. The Battery is at once thrown on to the Alarm Circuits, and the Signal of the fourth District, *one*, *two*, *three*, *four*, is struck upon the 19 Alarm Bells at nearly the same instant of time, and continues to be repeated at short intervals as long as the key of the District is held down. The Agent, meanwhile, observes the motion of the numeral cylinders in one of the Alarm Bell Registers, fig. 7, and raises his finger from the key when a sufficient number of blows have been struck. He then turns to the Journal of the Office and enters the time, and the number of the District and Station, from which the alarm proceeded.

In the mean time the engines are running from all quarters towards the District, and some officer of the Fire Department, wishing to know the number of the Station, nearest the fire, opens one of the Signal Boxes in passing, and makes the most simple signal, say *one*, *one*, *one*, or "writing dots," by tapping on the Signal Key. This is received by the Central Agent, who proceeds at once, by means of the key provided for that purpose, to count off the number of the Station originating the alarm, on the electro-magnets in all the Signal Boxes of the Circuit through which the enquiry is made. The engines are thus directed to the exact part of the District from which the alarm proceeded, and they should be farther guided by a map of the City, prepared for the purpose, with the number of the Stations and Districts marked upon it. If the number of the Station as well as of the District should be struck primarily on the alarm bells, any inquiry would of course be rendered unnecesssary, and a direction would be at once furnished to the place of a fire, within the distance of fifty rods.

At length the fire is suppressed, perhaps in a short time. A very important function of the System is now to be developed. The engineer, on the ground, who has chief control, sends to the nearest Signal Box and communicates the Signal *one*, *one-two*,—*one*, *one-two*, which signifies "All Out." This is received by the Agent at the Central Office, who immediately depresses the key of the District Key-board, marked in fig. 6 with the characters I, II. This Signal is forthwith struck and repeated a few times on all the bells. The engines in various and perhaps distant parts of the city turn back. A different signal might be employed to order back the South Boston or North End engines, and two spare keys, having connection with only a single circuit, may be added to the Key-board for this purpose; or the Agent may send such a signal over any Alarm Circuit by means of the Alarm Key.

10.





The inconvenience of using very heavy weights in the Striking Machines and the limitations which thence arise, as to the force of the blow or number of strokes, make it desirable to employ other sources of power, such as the pressure of water, confined in pipes within cities, and also the pressure of condensed air. Fig. 10 represents an apparatus contrived by Mr. Farmer and myself, by which the pressure of the water in the pipes is made to furnish a constant supply of condensed air, either to operate the air whistle W, or the air-engine C, carrying the hammer of the bell. G is the section of a stout metallic cylinder—F is a cylindrical float upon a sliding rod. A three-way valve V screws on to the bottom of G by a cap, and is operated by the handle and rod inside. When the water rises to the upper of the two dotted lines, the top of the float raises the tail-piece t of a small lever, carrying an upright arm, with a heavy ball on the top. This ball passes beyond the perpendicular and falls over on the other side, as seen in the figure, reversing at the same moment the three-way valve by a simple arrangement. The water which before entered now begins to flow out. The valve v′ opens and admits air. The float falls until at last it rests on the tail piece t′ of a corresponding short lever below, by which the heavy ball is raised to the perpendicular and thrown over on the other side, reversing the three-way valve again, so that the water enters. The water, on entering each time, condenses the air into the reservoir R, from which a valve prevents any return. This process continues till the air in R has reached a condensation equal to the pressure of the column of water in the pipes. Any loss of pressure from either leakage or use is at once supplied by the action of the generator G. All the parts in the generator liable to oxydation, are made of brass.

The reservoir R may easily contain several hundred charges for the cylinder C, so that if the water should be withdrawn from the pipes for a day or more, no interruption in the means of alarm would take place. With a pressure of two or three atmospheres, such as can be obtained from the Cochituate water in the lower part of Boston, a cylinder, C, of only two or three inches diameter, applied directly to a hammer as above, would give all the power which could be desired for the largest bell, without any limit as to the number of strokes, or necessity of winding. The electro-magnet m′, armature and catch c, on which the corresponding part of the falling arm rests, when raised from the position in the figure, will be easily recognized. When the armature is attracted to the magnet the falling arm drops, and the foot, a, catches a pin on the sliding valve and throws it back, admitting the air into the cylinder. The cam and projection on the end of the piston rod, respectively reverse the sliding valve, and raise the long arm b of the falling lever, at the end of the stroke. In the apparatus represented, the generator G must, of course, be placed in a low situation, such as a cellar, and out of the reach of frost.

The air whistle, operated by hand, was proposed a year ago in Boston as a means of alarm. Its efficiency for this purpose can hardly be overrated. The simple mode of connecting it with the Telegraph, represented in the figure, has been proposed by Mr. Farmer. The air valve v″ is operated by a rod, attached to the armature lever of the electro-magnet m, which is actuated by a local battery connected with the Telegraphic circuit. The same object may be accomplished, without a local battery, by a little falling lever and air engine apparatus. Two or three air whistles of large size in a City, would be almost sufficient of themselves for a System of Alarm.

The use of the water meter of Mr. Huse, as a source of power for striking the bells, has suggested itself, and has also been especially brought to my notice by Mr. Joseph M. Wightman of Boston.

This very useful and ingenious instrument can be best described as the converse of a rotary pump. I have satisfied myself that the falling arm liberated by the electro-magnet, could be made to open the water-valve, and that a meter supplied by an inch or inch and a half pipe, would furnish ample power to lift the hammer required for any of the City bells. For this purpose an arm may be placed across the axis of a meter, each end of which, in revolving, would raise the lever connected with the hammer handle above. The hammer would thus be raised at every half revolution of the meter. As the pressure of the water is liable to vary, or as it may be completely withdrawn, an intermediate reservoir of water under the pressure of air, condensed by the previous entrance of water from the pipes, the return of which is prevented by a valve, would seem to be necessary. This is the chief objection to its use. Greater electro-magnetic power would be required to work a water-valve, than the air-valve represented in the last figure.

The principal instruments employed in the Fire Alarm System are included under no existing patent, although Mr. Farmer reserves to himself the right to those parts of the mechanism which he has originated. The electro-magnetic Register, patented by Professor Morse, constitutes, however, an exception. It is desirable to use this instrument for the record at the Central Office, as its principle is in harmony with the rest of the System. On this account, and also to set at rest any other claim under the patent of the electro-magnetic Telegraph, I should recommend, in all cases of construction the purchase of the right to the use of the Morse instruments in connection with the System. This has accordingly been done by the City of Boston.

The following table furnishes an approximation to the cost of different parts of the System, erected in Boston, which is of interest in connection with future constructions.

Average cost per mile of 49 miles wire, (erected) .	$68 72
" " of wire No. 8, per mile, ...	73 00
" " " " No. 10, " "	62 50
Striking machine, fig. 9, (including 800 lbs. weight,)	165 00
Signal Box, apparatus and connections, complete, .	10 00
District Key-board, fig. 6, (with 12 keys), . . .	75 00
Alarm Bell Register, fig. 7, ...	10 00
Office Alarm, fig. 5, ...	8 00

The estimate, furnished by me to the City Government of Boston, of the cost of construction of the System, was about $8000, not including superintendence or the right to the use of the Morse instruments. It is believed that this estimate has not been exceeded by the actual cost of the parts included in it. An addition has been made to the number of Signal Stations and to the length of the Signal wires, and also to the proposed power of the Striking Machines, by which the total expense will be increased perhaps more than a thousand dollars. The cost of superintendence and of the patent right will probably amount to nearly two thousand dollars.

The System can be introduced into small towns where two or three bells and a few Signal Stations are to be connected with the wires, at a cost, for the mechanical part, not exceeding one thousand or fifteen hundred dollars,—and into larger towns or cities at a proportionate rate. In the smaller towns the same wires may be used for both Circuits, that is, to constitute a closed Signal Circuit with a feeble battery, and subsequently an Alarm Circuit, by switching on, at the Central Office, a powerful Alarm Battery. This would diminish the cost of the Circuits nearly one half, but the principle of double conductors, in this case, should still be preserved.

In the approach of the System to its completion in Boston, no doubt exists as to its mechanical efficiency, and to the precision of its operation, except where departures, almost unavoidable in a first experience, may have been made from the principles of construction, already indicated. The introduction of the System may be influenced by moral causes, but these have not been found, heretofore, to embarrass the working of the Telegraph in this country. Here is simply a test of the civilization of our people. Local and peculiar obstacles may also affect the System in its introduction. It is believed that none of these difficulties will prove insurmountable in the trial about to be made in Boston, but that with patience and experience the uses of the System will be fully developed. Should it be otherwise, the System is still correct in principle, and will wait its own time for general adoption.

Great credit is due to the government of the City of Boston for the liberality with which it has tried this experiment. To the Superintendent, Mr. Farmer, intelligently seconded by the Committee of construction, the praise of great practical efficiency and skill should also be awarded.

The application of the Telegraph to Fire Alarms is a step in Municipal organization which has become necessary and must lead to others of a higher order. The beautiful chronometric application of the Telegraph, by which a single clock registers its time on an indefinite number of dials throughout a city, by the simple magic of the electric circuit, is also one which deserves to be brought into immediate public use.

Boston, Nov. 11, 1851.