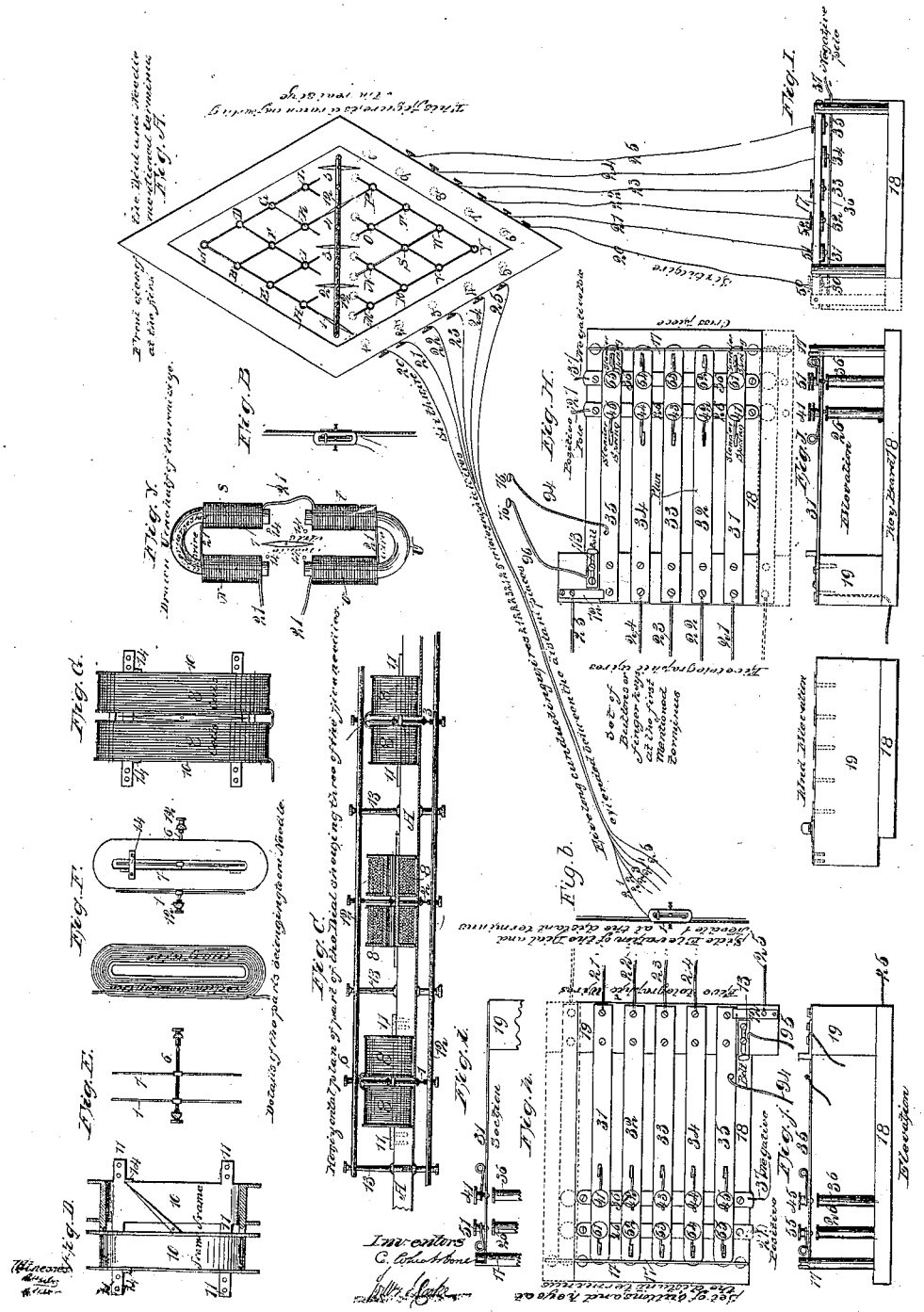
3 Sheets—Sheet 1.

C. WHEATSTONE & W. F. COOKE.

ELECTRO MAGNETIC TELEGRAPH.

No. 1,622. Patented June 10, 1842.



3 Sheets—Sheet 2.

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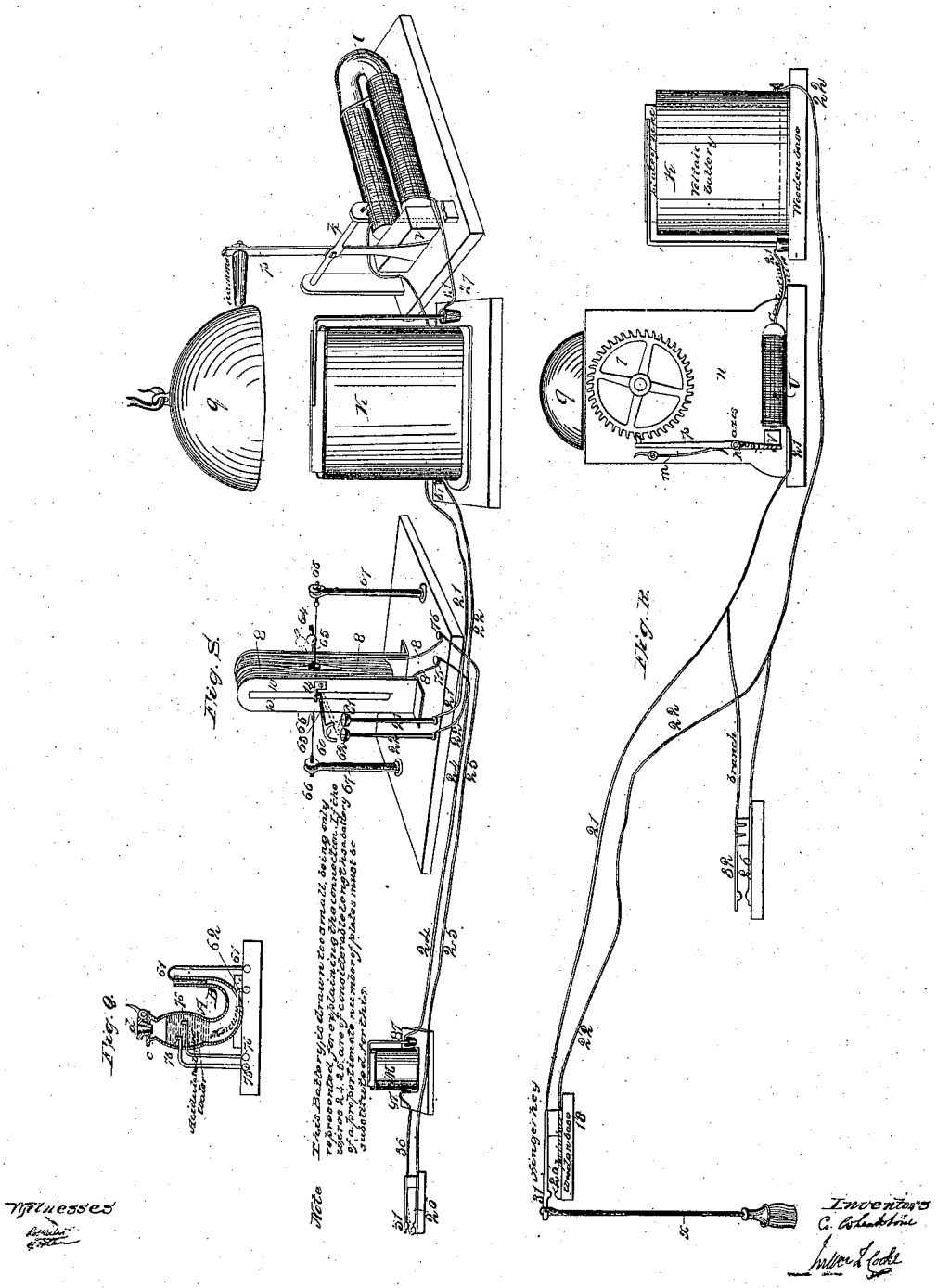

Witnesses

Inventors
C. Wheatstone
Wm. F. Cooke

C. WHEATSTONE & W. F. COOKE.

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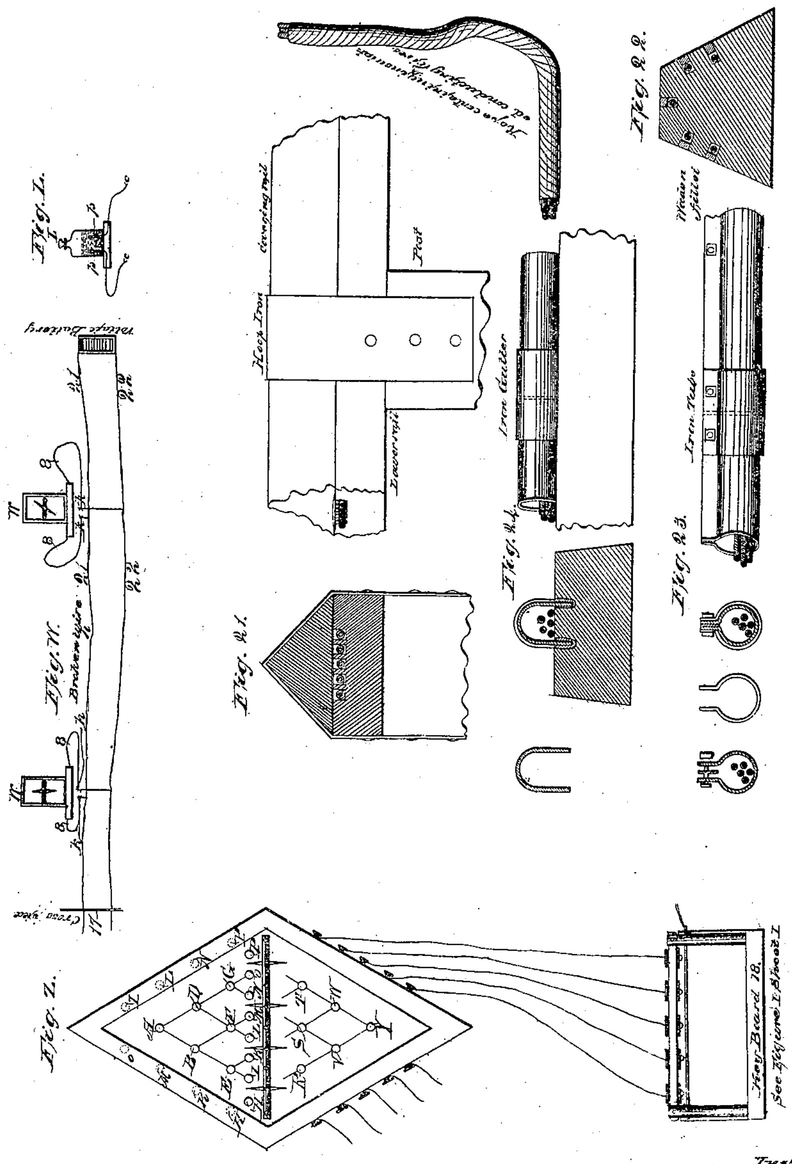

Witnesses.

Inventors
C. Wheatstone
William F. Cooke

UNITED STATES PATENT OFFICE.

CHARLES WHEATSTONE, OF CONDUIT STREET, HANOVER SQUARE, IN THE COUNTY OF MIDDLESEX, AND WILLIAM FOTHERGILL COOKE, OF BREEDS PLACE, HASTINGS, IN THE COUNTY OF SUSSEX, ENGLAND.

IMPROVEMENT IN THE ELECTRO-MAGNETIC TELEGRAPH.

Specification forming part of Letters Patent No. **1,622**, dated June 10, 1840.

To all whom it may concern:

We, CHARLES WHEATSTONE, of Conduit Street, Hanover Square, in the county of Middlesex, esquire, and WILLIAM FOTHERGILL COOKE, of Breeds Place, Hastings, in the county of Sussex, esquire, severally send greeting:

Whereas we have discovered or invented certain new and useful improvements in giving signals and sounding alarms in distant places by means of electric currents transmitted through metallic circuits; and whereas we desire to obtain an exclusive property in our said invention or discovery throughout the United States of America, and we are, therefore, about to make due application to the Commissioner of Patents in and for the said United States, expressing such our desire:

Now, therefore, know ye that, in compliance with all the laws and statutes of the said United States, and more particularly of an act passed on or about the 4th day of July, 1836, entitled "An act to promote the progress of useful arts, and to repeal all acts and parts of acts heretofore made for that purpose," we, the said CHARLES WHEATSTONE and WILLIAM FOTHERGILL COOKE, do hereby and by the three sheets of drawings hereunto annexed, fully, clearly, and exactly describe our said invention or discovery and the manner and process of making, constructing, using, and compounding the same; and we do hereby and by the said sheets of drawings fully explain the principle of our said invention or discovery and the several modes in which we have contemplated the application of that principle or character by which our said invention or discovery may be distinguished from other inventions, and do particularly specify and point out the parts, improvements, or combinations which we claim as our own invention or discovery in the following manner—that is to say:

We shall first describe certain apparatus or mechanism which is constructed according to our said improvements for giving signals and sounding alarms in distant places by means of electric currents transmitted through metallic circuits, and then at the conclusion of this our specification we shall point out the particular improvements whereof the exclusive use is granted by the said Letters Patent.

The description of the apparatus or mechanism will be facilitated by considering it as being composed of the following principal portions, which operate in concert for giving signals or sounding alarms in distant places: One of those portions is situated at a convenient place (which may be called a "terminus") and adapted for being operated upon by a person who intends giving signals or sounding alarms in distant places. Another portion (with duplicates of it, if required) is situated at the distant places where other persons are to receive the intended signals or alarms, and is adapted for exhibiting such signals or sounding such alarms; and note, there may if required, be several duplicates of the last mentioned distant portion, situated one beyond another in different distant places, all which duplicates will operate simultaneously—that is, they will exhibit like signals—or they may sound like alarms in all the several more and more distant places at the same time; but the place where the most remote of all the said duplicates is situated may be called the "distant terminus."

And for communicating between the several portions of the apparatus which are situated, as aforesaid, at a distance one from another, a number of metallic rods or wires, which are suitably arranged and prepared for conducting electric currents throughout their lengths, are extended from the first-mentioned terminus and portion of the apparatus aforesaid to reach through all the other aforesaid more and more distant portions thereof to that portion which is at the distant terminus, the arrangement of the said conducting-wires being such that they form as many distinct lines of extension or courses capable of conducting electric currents from one terminus to the other as there are wires, each wire being kept distinct or insulated from all the other wires; also, that in extending from the first-mentioned terminus and portion of the apparatus to the nearest duplicate of the distant portion thereof, (if there be any such duplicates,) and in thence proceeding onward to another more distant duplicate, and so on to the most remote of those duplicates which is situated at the distant terminus, each wire must preserve its own continuous course of extension distinct and insulated from all the other wires, so as to

be qualified for transmitting or conducting an electric current throughout its whole length from the first-mentioned terminus and portion of the apparatus to the most distant portion thereof at the other terminus without interruption to the continuity of the said current in passing through as many duplicates of that most distant portion as may be established at intermediate places between the two termini; but, note, it is not an essential part of the apparatus that there should be any such duplicates of the distant portion, for in cases where it is not required to give signals or sound alarms at any intermediate places between the two termini, the first-mentioned portion of the apparatus being situated at one terminus, as aforesaid, and the other distant portion thereof being situated at the other terminus, the several conducting-wires will extend from one terminus and portion to the other terminus and portion, the several wires being in all cases insulated and kept distinct one from another.

And, further, the first-mentioned portion of the apparatus, which is situated at one of the termini, as aforesaid, should be provided with some such kind of electric apparatus as is usually termed a "voltaic battery," and which may be on any construction which is capable of exciting or producing electric currents through metallic circuits—that is to say, if one end of a great length of insulated conducting rod or wire of metal (forming a continuity of metal) is brought into contact with one pole of such a battery and the other end of the same wire is brought into contact with the other pole of the same battery, so that such rod or wire forms what is termed a "metallic circuit," then a continuous electric current will be transmitted throughout all the length of such wire or metallic circuit in consequence of a continual transmission of electric action, which, as soon as such a circuit is formed, begins to proceed from one pole of the battery and along or through all the length of the conducting-wire with a very great velocity of transmission, in order to return to the other pole of the same battery, the electric current thereby performing a circuit from the battery and back again thereto; and the said electric current or transmission of electric action in a circuit will continue without interruption or cessation so long as the metallic circuit is maintained—that is, so long as the aforesaid contacts of the two ends of the conducting-wire with the two poles of the battery (and so long as the continuity of metal throughout the whole length of that wire) is continued, provided that the battery is kept in working order—but note, by continuity of metal in the conducting-wire, it is not meant that the whole length of such wire is necessarily made of one unbroken piece of metal, but merely that the ends of every separate piece of metal, whereof the whole length is composed, are effectually connected together with suitable contacts for conducting electric currents.

And the person who intends giving signals or sounding alarms at a distance, can do so by application and pressure of his hands or fingers upon suitable buttons or finger-keys belonging to that first-mentioned portion of the apparatus which is situated at one terminus, the mechanism of those buttons or keys being adapted (according as they may be pressed) for establishing the requisite contacts and connections between the poles of the voltaic battery and the ends of certain of the said conducting-wires, so as to form those particular wires into a metallic circuit for the transmission of an electric current from one pole of the battery along one or more of the said particular wires to the distant portion of the apparatus at the other terminus, and thence back again through some other (or some others) of the said particular wires to return to the other pole of the same voltaic battery, and thereby perform an electric circuit. The manner whereby such an electric current through a metallic circuit is caused to give signals or sound alarms in distant places will be hereinafter explained. The said electric current which is so transmitted through those particular wires which are thus formed into a metallic circuit passes, without interruption to the continuity of the current, in making its progress from the battery, through all the several duplicates of the distant portion of the apparatus, which may, as before explained, be situated at intermediate places between the two termini, or else the said current repasses, without interruption to the continuity of the current, in making its return toward the battery, through all the said duplicates; but in either case the electric current is caused to produce a like and simultaneous effect upon all the several distant portions of the apparatus—that is to say, whatever effect the electric current produces upon the most remote portion of the apparatus, which is situated at the distant terminus, it will also produce a like and simultaneous effect upon all the several duplicates of that portion which may be situated at intermediate places between the two termini, and the said transmission of such an electric current will continue so long as the pressure is continued on the aforesaid buttons or finger-keys, but no longer, because the metallic circuit is broken and becomes null the instant that the said buttons or keys are released from pressure, and that a cessation thereby takes place in those contacts and connections which had been for the time established, as aforesaid, between the two poles of the voltaic battery and certain of the conducting-wires, in order to form those particular wires into a metallic circuit for the transmission of an electric current through them, as aforesaid.

And note, by applying pressure of the hand or fingers upon other suitable buttons or finger-keys among divers such with which the said first-mentioned portion of the apparatus is provided, contacts and connections may be formed between the aforesaid ends of the par-

ticular conducting-wires before mentioned and the contrary poles of the said voltaic battery to those poles thereof with which the same ends were before connected, wherefore, although the same metallic circuit will be formed among the several conducting wires as before, nevertheless the transmission of the electric current will take place in a contrary direction through that metallic circuit, and such reversal of the direction of the transmission of the electric current through the same metallic circuit is caused to produce corresponding differences in the appearance and signification of the signals which are given (in manner hereinafter described) in distant places by transmission of an electric current through the same metallic circuit.

And note, by pressure upon other suitable buttons or finger-keys among a diversity thereof, the ends of other of the conducting-wires with which the apparatus is provided may be connected with the poles of the battery, so as to be formed in like manner, as already described, into a metallic circuit, but which will be a different circuit from that already described, because it will be formed by different wires, and so, according to the number of conducting-wires with which the apparatus is provided, several different metallic circuits may be formed, and the transmission of an electric current through each of such different metallic circuits as may be so formed (although excited by the same battery) may be caused to give a different signal in distant places, each of which signals is susceptible of two different significations, according as the current is caused to proceed through the particular metallic circuit in one direction or in the contrary direction.

And note, also, the apparatus or mechanism may be so arranged as that by pressure upon suitable of the said buttons or finger-keys two (or in some cases more) of the said different metallic circuits may be formed out of the several conducting-wires at the same time for the contemporaneous transmission of two or more distinct electric currents which may be excited by the same battery, and although each of such currents should only give one signal, (with one or other of those two significations which belong thereto, according to the direction in which the current acts,) nevertheless the combination or concurrent exhibition of two or more signals by means of as many distinct electric currents may have a different signification to that signification which would appertain to the exhibition of either of the signals by itself. But note, two concurrent signals may be exhibited at the same time without forming two distinct currents, as last mentioned, but by the transmission of only one electric current through one metallic circuit, because as each circuit is composed of two conducting-wires united for the time into one circuit, each wire may be considered as one half of that circuit, and the electric current in proceeding along one wire or half of the circuit in a direction from the battery toward the distant terminus may give one signal, and the same current in returning along the other wire or half of the circuit in a direction toward the battery (in order to complete its circuit) may give another signal, the simultaneous and concurrent exhibition of which two signals may have a different signification from that which would appertain to the exhibition of either of the signals by itself or to the concurrent exhibition of either of the said signals with any other signal with which it might be brought into concurrence. But notwithstanding the two contemporaneous signals may be thus exhibited in concurrence by transmission of only one electric current through one metallic circuit which is composed of two wires, nevertheless the two signals which are so brought into concurrence may be differently paired, or their concurrence may be diversified at the pleasure of the operator, because if each distinct conducting-wire out of a number of such is adapted to produce its appropriate signal by transmission of an electric current through that particular wire, then by pressure of suitable buttons or keys, as aforesaid, any two of such wires may be conjoined into one metallic circuit, and the electric current which is transmitted through that circuit will exhibit two concurrent signals, which may, at the pleasure of the operator, be the concurrence of any two of the whole number of individual signals which the several wires are qualified to produce individually.

And by virtue of the several means above described the apparatus or mechanism may be arranged so as to be qualified to form (at the pleasure of the operator) a variety of different metallic circuits, each such circuit being adapted to give its own appropriate signal; but, nevertheless, the electric current which will be transmitted through each of those circuits can be made to give two different significations to the signal belonging to that circuit, according to the direction of the current; or the apparatus or mechanism may be so arranged as to be capable of forming two or more metallic circuits with a distinct electric current through each circuit at the same time, in order to exhibit two (or in some cases more) signals in concurrence; or the apparatus or mechanism may be arranged so as to be capable of giving two signals in concurrence by the transmission of an electric current through one metallic circuit, with capability of diversifying the concurrence of the two signals which will be brought into concurrence by the formation of one metallic circuit; and hence, by one or other or all of those various means, a sufficient diversity of signals and change in the significations of those signals can be given in distant places for constituting a telegraphic language or mode of communicating letters of the alphabet and numeral or symbolic characters.

And, furthermore, the manner whereby the

aforesaid transmission of electric currents through metallic circuits is caused to give signals or to sound alarms in distant places is either by the angular motions which such currents are capable of giving to magnetic needles which are poised upon centers of motion and placed in suitable proximity to the said conducting-wires through which such currents are transmitted; or else by the attractive force of occasional magnetism which such currents are capable of exciting in masses of iron which are not magnets themselves, but which are placed in suitable proximity with the said conducting-wires through which such currents are transmitted; or else by the evolution of gas proceeding from water which is decomposed, by causing such electrical currents to pass through it; or else by any two or by all of the said modes of action, combined in such manner as is suitable for giving such signals or sounding such alarms at a distance, as may be required.

And respecting the adaptation of magnetic needles for giving signals the same may be made like compass-needles, but fixed on axes passing through their centers of motion, and those axes mounted delicately on pivots at their ends in the manner of the arbors of watch-wheels, so as to render the needles capable of moving very freely with angular motion about their centers of motion. Each needle must have some slight tendency given to it to induce it to point in one particular direction whenever it is left to itself and uninfluenced by the electrical current. The simplest, and perhaps the best, mode of giving such a tendency is by gravitation, in which case the axis of the needle must be horizontal, or nearly so, and, one end of the needle being made rather heavier than the other, that heavy end of the needle will always point downward when the needle is left to itself; and whenever the needle does so point upward and downward it denotes that it is quiescent, or at rest, and that it is not giving any signal.

One of the conducting-wires before mentioned is disposed vertically or in a direction parallel to the needle when the same is at rest, the wire being situate as near to the needle as can be to avoid touching, and when an electric current is transmitted, in manner already explained, through the said wire so as to pass in proximity to the needle, that current will give the needle a slight tendency to move about its center with an angular motion or deflection from its previous parallelism to the wire.

If the transmission of the current through the wire is in one direction the needle will acquire a slight tendency to deflect one way from the said parallelism, but if the transmission is in the contrary direction the tendency will be to deflect the other way. But note, as the tendency to deflection thus given to the needle is but slight, it requires to be multiplied by the same means as is resorted to for a like purpose in the instruments well known by the name of "galvanometers"—that is, by causing the conducting-wire to form many convolutions around the needle or around a narrow space within which the needle is left at liberty to move, but without touching any of the convolutions that the wire makes, the order of the said convolutions of the wire being such as that the wire shall always transmit the electric current in one direction at one side of the plane in which the needle moves, but shall transmit the current in the contrary direction at the other side of that plane.

To produce such convolutions of the wire it must be coiled around the space in which the needle moves, all the ascending parts of the coils being at one side of the needle—that is, toward one end of its axis—and all the descending parts of the coils being at the other side of the needle, (or near to the other end of its axis.) With this arrangement of the conducting-wire each ascending as well as descending part of the several coils will transmit the electric current in the proper direction for giving the needle a tendency to deflection one way or other, according to the direction in which the current is transmitted through the coiled wire, and the concurrence of an adequate number of such coils may be made to multiply the before-mentioned slight tendency of the needle to deflection until it becomes sufficient to turn the needle (notwithstanding the gravitation of its heavy end) with a sudden and decided motion to one side or other of its quiescent or vertical position the instant that the transmission of an electric current through the wire is commenced by the formation of two of the conducting-wires into a metallic circuit by pressure on suitable buttons or finger-keys as already mentioned.

The extent of deflection or angular motion that the needle is permitted to perform in consequence of the tendency to deflection which it then acquires is limited by fixed stops, and the instant that by pressure on the said buttons a metallic circuit is formed, and an electric current begins to be transmitted through the coils of wire, the needle moves suddenly from its quiescent or vertical position until it comes to rest in an inclined position against one of its said stops; and it will remain motionless in that inclined position so long as the current is continued; and when the needle is at rest in such an inclined position it will point to some character, letter, figure, or symbol which is marked on a suitable dial or tablet, and it is by so causing a needle to point to such character, letter, figure, or symbol that a signal is given. When the needle is thus made to incline to one side of its quiescent or vertical position as far as its top will allow, it will point to and signify one character, letter, figure, or symbol on the dial or tablet; but when, by reversing the direction of the electric current through the coiled conducting-wire, as already mentioned, the needle is made to incline to the other side of its quiescent or vertical position,

it will point to and signify a different character, letter, figure, or symbol on the same dial or tablet. And the instant that the electric current through the coiled conducting-wire is discontinued by releasing the buttons or finger-keys from pressure, and thereby breaking or nullifying the metallic circuit through which the electric current was transmitted, then the needle returns by the gravitation of its heavy end to its quiescent or vertical oposition, in which it will not point to or signify any character, letter, figure, or symbol on the dial or tablet, and the needle will remain at rest in that quiescent or vertical position until the transmission of an electric current is resumed in manner before stated. And it will in most cases be expedient to affix another second magnetic needle upon the same axis as that needle already mentioned, which is included in the space within the coils of the conducting-wire, as aforesaid, the said second needle being parallel to the former, but so far along the axis thereof as to be beyond or exterior to those coils of the wire within which the first-described or principal needle is situated.

The second needle, which may be called the "exterior needle" must be reversed end to end in respect of the first-described or principal needle, which may be called the "interior needle" —that is to say, if the north pole of one needle points directly upward when they are both in their vertical or quiescent position, the north pole of the other needle must point directly downward. By this reversal of the poles the exterior needle will be in proper relative position in respect to those coils of the conducting-wire which are nearest to it, so as to be suitably situated for receiving the deflecting influence of those coils, and therefore the exterior needle will be caused to concur with the interior needle in assuming the required inclining position. Also, by their reverse poles the two needles neutralize each other's terrestrial magnetism, or tendency to assume the direction of dipping-needles or of compass-needles, the two needles when thus reversed forming what is well known by the term of an "astatic combination."

The exterior needle is that which should point to the characters, letters, figures, or symbols which are marked on the dial or tablet before mentioned in preference to the interior needle, which is too much concealed within the coils of the wire to be convenient for that purpose. The axis of the two needles may pass through the plane of the said dial or tablet and have the exterior needle fixed on at the front of that plane, the coils of conducting-wire and the interior needle being behind the same plane.

And note, it must be understood in all cases not only that the several conducting-wires with which the apparatus is provided are effectually insulated one wire from another wire, as before mentioned, but also that the different coils which the same wire is caused to make, as aforesaid, around the space in which the interior needle is included, are also effectually insulated one coil from another adjacent coil, in order that the electric current which is to be transmitted through the conducting-wire may be really transmitted from one end of each wire to the other end thereof without being able to find a shorter course or circuit by lateral transmission out of one coil or wire into another adjacent coil or wire.

The requisite insulation of the wires may be made in the usual manner of preparing the wire used in the instrument called "galvanometers"—viz., by surrounding or covering the metal of the wires with coils of thread of silk or cotton or other suitable substance, and such thread covering may be coated with some suitable resinous varnish which will be impervious to moisture.

An apparatus or mechanism containing a suitable number of magnetic needles of the kind above described (astatic or otherwise) for pointing to or exhibiting upon a suitable dial or tablet all the various characters, letters, figures, or symbols which are intended to be used in giving signals in distant places is to be provided at that portion of the apparatus which is situated at the distant terminus hereinbefore mentioned, and (if required) duplicates of the same apparatus or mechanism are to be provided at any intermediate places between the two termini, where simultaneous and like signals are required to be given. Also, another such duplicate is to be provided at the hereinbefore first-mentioned terminus, in view of the operator who intends to give signals in the several more and more distant places (the most remote whereof is the distant terminus) by aid of the other several duplicates of the said apparatus or mechanism.

The conducting-wires must be arranged so that there is one such wire for each of the astatic or other needles which is contained, as aforesaid, in every duplicate of the apparatus, that one wire first making its convolutions or series of coils around one of the needles in the duplicate which is situated at the first terminus in view of the operator; thence extending onward in continuation from the endmost of those coils to the next nearest duplicate apparatus, and there making like convolutions around the corresponding needle thereof; then extending onward to the next nearest duplicate, and making like coils around its corresponding needle, and so on to that apparatus which is situated at the distant terminus, where the same wire must also make like convolutions around the corresponding needle of that apparatus. In like manner another such conducting-wire, which is insulated from the other wires, is extended in a similar course of coiling round another needle in each of the several duplicates of the apparatus, and so with other wires, in order that every distinct needle in each duplicate may have its distinct insulated wire, but that all the corresponding

needles in each duplicate may be connected by the same wire.

There may also be an additional wire or wires extending direct from one terminus to the other without making any coils or having any connection with any needles.

Now, if one of the before-mentioned wires which is connected with a set of corresponding needles is formed (by pressing suitable buttons or finger-keys) into a metallic circuit by conjunction with a wire which has no connection with any needles, then the electric current which is transmitted through that circuit will cause simultaneous and like motion in all the said corresponding needles, but in no others. If such current is transmitted in one direction, all those said corresponding needles will incline one way, and will all point to and signify one and the same character, letter, figure, or symbol on their respective dials or tablets; but if the current is transmitted in a contrary direction, the same needles will incline the other way, so as to point to and signify another character, letter, figure, or symbol on their said dials or tablets.

That duplicate of the portion of the apparatus which contains needles, and which, as before mentioned, is placed at the terminus in view of the operator, enables him to see what signals he is actually giving when he presses particular buttons or finger-keys, and thereby he m avoid making mistakes.

The apparatus containing needles at the distant terminus will exhibit like signals, which may be observed by the person who is to receive them, and so will the several duplicates of the apparatus containing needles which may be situated at different intermediate places between the two termini, for, as before mentioned, the needles belonging to every distant portion of the apparatus will exhibit the same signals at the same time.

It is obvious that by releasing the last-mentioned buttons or finger-keys and pressing others instead thereof another of the before-mentioned conducting-wires which is connected with another different set of corresponding needles from those last mentioned may be formed into a metallic circuit with the same (or with another) wire which has no connection with any needles, and then the same effects as before mentioned will be produced, but upon different needles, and will therefore give different signals, and so on, any other one of those wires which, as before mentioned, is connected with a set of corresponding needles, may, whenever it is required, be formed into a metallic circuit for bringing into operation and giving signals by the corresponding needles to which that wire belongs; but so long as only one needle in each duplicate of the apparatus or mechanism containing needles is rendered operative at the same time, so long will the signals thereby given be confined within a series of simple significations or two significations to each needle, according as it is made to incline and point one way or the other way; and in order to bring two or more needles in each duplicate into concurrent operation at the same time, so as to obtain diversity of significations from their concurrence, two or more distinct metallic circuits may (by pressure upon suitable of the buttons or finger-keys) be formed at the same time out of two or more of those wires which have no connection with needles, together with as many of those wires which belong to sets of corresponding needles, and then the transmission of a distinct electric current through each such circuit, although from the same battery, will actuate two or more needles at once in each of the duplicates of the apparatus containing needles, and it is obvious that any two of the needles contained in each duplicate may be thus brought into concurrent operation, according as the buttons or finger-keys are pressed; or, instead of thus forming two or more distinct metallic circuits for transmission of as many distinct electric currents, another and more convenient mode of obtaining the same result, of actuating two needles at once, is to form a metallic circuit by conjunction of any two of those conducting-wires before mentioned whereof each one is connected with its own set of corresponding needles, and then the one electric current which will be transmitted through the metallic circuit so formed will actuate both such sets of corresponding needles—that is, it will actuate two needles in each of the duplicates of the apparatus containing needles—and by pressure on suitable of the buttons or finger-keys any two of the said last-mentioned conducting-wires may be formed into the one metallic circuit which, as aforesaid, is to bring two needles into concurrent and cotemporaneous operation, wherefore any two out of the whole number of needles in each duplicate of the apparatus containing needles may be so brought into concurrent and cotemporaneous operation, and that is done without making use of any of those other wires, before mentioned, which have no connection with any needles; but one of the latter wires must be used for forming part of any metallic circuit whereby it is required to bring only one of the needles in each duplicate apparatus into operation by the electric current which is transmitted through that circuit.

And in cases where it may be required to bring three of the needles in each duplicate of the apparatus into concurrent and cotemporaneous operation the same may be done by forming two distinct metallic circuits for two distinct electric currents, one of those circuits being formed by conjoining one of the said wires which has no connection with any needles to one of the wires belonging to a particular set of needles, the other circuit being at the same time formed by conjunction of two other of the last-mentioned wires belonging to particular sets of needles; but, note, three needles in each duplicate apparatus may

be brought into concurrent and cotemporaneous operation by one electric current of the metallic circuit, for that current is formed by coupling two of the wires which belong to particular sets of needles with one pole of the battery, and only one such wire with the other pole of the same battery, in which case one half of the circuit will consist of one wire, and the other half thereof will consist of the said couple of wires, wherefore the transmission of the electric current through the last-mentioned half of its circuit will be divided between the two wires of the said couple, and, although so divided, it will actuate both the sets of needles belonging to those two wires at the same time that the corresponding transmission through the first-mentioned half of the circuit will be confined to one wire, and will only actuate the one set of needles belonging thereto, thus making three sets of needles in all which are brought into concurrent and cotemporaneous operation by transmission of only one electric current.

And note, it is obvious that four sets of needles may, if required, be brought into concurrent and cotemporaneous operation by transmission of only one electric current if the metallic circuit for that transmission is formed by coupling two of those wires which belong to particular sets of needles to each pole of the battery, in which case the transmission of the electric current through both the halves of its circuit will be divided between the two wires of each couple, and, although so divided, it will actuate all the sets of needles belonging to all those four wires which are thus coupled, and whereof the couples are conjoined into one circuit for the transmission of one electric current.

And note, in order that the conducting-wires may be capable of being conjoined together, any one or two of them with any other one or two of them, into a metallic circuit, or into metallic circuits for the formation of a variety of such circuits, as before explained, the said wires must all (or else so many of them as are intended to retain that capability) be connected together at the most distant terminus by one cross-piece of metal in a suitable manner for the free transmission of electric currents from that distant end of any one wire to the corresponding end of the other wires, wherefore when the contrary ends of any one, two, or more of the same wires (which ends are at the first-mentioned terminus) are to be brought by pressure on the buttons or finger-keys into connection with the two poles of the voltaic battery in any of the various ways of connecting them which may be necessary for forming the wires which are so connected into such metallic circuits as are required, it will in all cases happen that the said two or more wires which are so formed into a circuit or into circuits will be already suitably connected by the said cross-piece of metal at the distant terminus for the transmission of electric currents through those circuits; and, notwithstanding that the said cross-piece of metal also forms a communication between the distant ends of the wires then for the time belonging to those circuits and the distant ends of other conducting-wires which do not for the time belong to those circuits, nevertheless, as the last-mentioned wires have no connection at their other ends with the poles of the battery, the electric current will not be transmitted (or not in any sensible degree) through those last-mentioned wires, because the current will be confined to the other wires which are actually connected with the poles of the battery, and which therefore constitute the intended metallic circuit or circuits.

And, furthermore, the apparatus or mechanism hereinbefore set forth, although it has been hitherto described as if it were merely for enabling a person stationed at the first-mentioned terminus to give signals to other persons situated at the distant terminus, and also, if required, at such other intermediate places between the two termini as may be provided with duplicates of that portion of the apparatus which is at the distant terminus, nevertheless, with suitable additions to what has been hereinbefore explained respecting that last-mentioned portion, it is equally capable of enabling a person stationed at the distant terminus to give signals to the person stationed at the first-mentioned terminus, and also, if required, to other persons stationed at all the said intermediate places, so as to communicate intelligence in either direction for carrying on a mutual telegraphic conversation between the persons at the two termini. The said additions are another voltaic battery and set of buttons or finger-keys with suitable mechanism for them exactly like those parts already mentioned as being situated at the first-mentioned terminus. The said additional battery and set of buttons or finger-keys, being applied to that portion of the apparatus which is situated at the distant terminus will enable the person who is stationed there to connect the distant ends of any of the conducting-wires with the poles of the distant battery, so as to form those wires at the will of that person (according as he chooses to press the buttons or finger-keys) into suitable metallic circuits for the transmission of electric currents from one pole of the battery at the distant terminus along those conducting-wires which constitute one half of the circuit to the other first-mentioned terminus, and from thence back again along those other conducting-wires which form the other half of the same circuit to the contrary pole of the same battery, and such transmission is caused to produce all the same signals and diversity of signals by means of the different needle ,ass already explained, the transmission being equally operative upon the needles in all the several duplicates of the apparatus which contain needles.

The arrangement of the buttons or finger-

keys is precisely the same at both termini, and their connections with the voltaic battery are similar, except that the distant battery has its poles reversed in respect of the poles of the other battery—that is to say, the connections which are made between each pole of the distant battery and its several buttons or finger-keys correspond exactly to those connections which are made between the contrary poles of the other battery and its like buttons or finger-keys. Wherefore, if by pressing any particular buttons or finger-keys they will cause the needles to give a particular signal or signals at every portion of the apparatus containing needles, it follows from the similarity of arrangement and reversal of the poles of the distant battery that by pressing the corresponding buttons or finger-keys at the other terminus they will cause the needles to give a like signal or signals at every such portion. Wherefore, all that has been hereinbefore explained respecting the mode of giving signals by a person stationed of the first-mentioned terminus to other persons stationed at the several more and more distant intermediate places and at the distant terminus is also to be understood to be equally applicable to the mode of giving signals by a person stationed at the distant terminus to others stationed at the intermediate places and at the first-mentioned terminus. And note, it is by that duplicate of the portion of the apparatus containing needles which, as hereinbefore stated, is placed in view of the person stationed at the first-mentioned terminus that he is enabled to see and receive the signals which the person at the distant terminus intends to give to him.

And note, although in general it is intended that the operator stationed at one terminus shall complete the signals or series of such which will constitute a distinct idea or communication from him before the person at the other terminus begins to return any signals in reply, nevertheless the apparatus and mechanism will admit, if required, of some signals being made by one party at the same time that other different signals are making by the other party, because some of the conducting-wires may be formed into a circuit with the battery at one terminus, while others of those wires are formed into a distinct circuit with the battery at the other terminus, and it is obvious that distinct electric currents may be transmitted through those circuits at the same time without interference of one with the other, and each of those distinct transmissions will produce its own proper effect upon different needles.

And note, there is a cross-piece of metal for connecting the ends of some or all the conducting-wires at the first-mentioned terminus similar to that cross-piece already mentioned as being at the distant terminus, and for a similar purpose as already explained—viz., it is for keeping the wires connected, in readiness for forming any of those metallic circuits which they may be required to form with the distant battery—but when such a cross-bar is provided at both ends of each of the wires it follows that whenever any one of those ends is to be connected with its battery in order to form one half of a circuit, the said end must be previously disconnected from its said cross-piece. This disconnection is most conveniently effected by the same pressure on the button or finger-key which causes the intended connection of the said end of the wire with its battery to be effected.

And before proceeding to state the mode of exciting occasional magnetism and of decomposing water, we shall explain the detail and drawings of an apparatus and mechanism which is constructed according to the foregoing description.

Figures A and B, Sheet I, is the dial or tablet, on which twenty letters are marked, in order to be pointed to, when required for giving signals, by five magnetic needles, 1, 2, 3, 4, and 5, which are the external needles of as many astatic needles, whereof the details are drawn full size in Figs. C, D, E, F, and G. 6 in all those is the horizontal axis whereon the two astatic needles are fixed fast, 1 being the exterior needle and 7 the interior needle, which latter is included within the numerous coils, 8, that the conducting-wire makes around a slight frame, 10, of thin wood, (or of metal, which must not be iron or contain iron.) The use of the frame 10 is to retain the coils in place and to preserve a narrow space within the coils for the interior needle, 7, to move in, as shown in Fig. F. The frame 10 is in two parts side by side, (see Figs. D and G,) leaving a small interval between them for the axis 6 to pass through, as is shown in the horizontal plan, Fig. C, and that interval also enables the axis 6, with the interior needle, 7, to be inserted into its place in the narrow space within the coils. The two parts of the frame 10 are united together by their two endmost pieces passing across from one part to the other and being common to both, also by other cross-pieces, 11, which serve likewise to fasten the frame 10 to the back of the vertical board A in Fig. A, which forms the dial.

The pivots at the two ends of the axis 6 are sustained in pivot-holes formed in the ends of screws which are screwed through two horizontal metal bars, 12 12, one in front of the dial A and the other at the back, both bars 12 being sustained at the ends of horizontal pillars 13, which project out each way from the vertical board. The dial A is very thin at the places where the coils 10 apply behind it, in order that the exterior needle, 1, which is in front of the dial A, may not be far distant from the coils 8. The conducting-wire which is to operate on each needle (or on each pair of needles 1 7, which constitute one astatic needle) is first coiled, as at 8, around one half of the frame 10, and then it crosses over to the other half and proceeds to coil around the same,

the coils being in the same direction in both. The effect of the two halves is nearly the same as one continuous coiling would be. The said coiled wire is copper wire closely covered with silk thread, in the same manner as is used for galvanometers, being about one-thirtieth part of an inch in diameter, which is of a smaller size than we prefer for the other parts of the conducting-wires, which are extended between distant portions of the apparatus, those wires being copper, about one-twelfth of an inch diameter. A great length, and consequently multiplication of coils, may be obtained with the small wire without rendering the mass of coils 8 so large as to remove the exterior coils too far from the interior needles, 7, to exert a due influence thereon. A length of about two hundred yards in the coils 8 8 around each interior needle, 7, and making about eight hundred convolutions, is what we have found most suitable.

Note, in order more effectually to insulate the coils of wire, one coil from another coil, it is best to line all that part of the frames 10 with which the coiled wire will come in contact with woven-silk cloth—that is, in case those frames are made of metal—and also to interpose a small piece of woven-silk cloth between each successive layer of coils which are laid over a preceding layer of coils just at the two ends of the frame 10, where the bending of the wire causes the coils to apply closer to the preceding coils than they do in the straight parts; also, in winding on the succeeding coils, which are to lie side by side on the frames 10, they should not be laid so close together as to press very tight laterally one against another. The five needles, which are placed side by side in a row, being all of them astatic, as before explained, do not exert magnetic influence on one another; but each astatic needle, when left to itself—that is, when left free from the influence of any electric current through the coiled wire 8—will settle into a vertical position by preponderance of its heavy end.

The stop before mentioned, by which the angular motion of the interior needle is limited when, by action of an electric current through the coiled wire 8, the needle is deflected from its vertical position, is fixed at 14 to the sides of the frame 10, across that opening thereof wherein the interior needle, 7, moves. Those stops must be of metal not susceptible of magnetism, and may be wound with silk thread, to diminish any tendency of the needle to rebound when it moves suddenly toward and strikes them, that the needle may rest quietly against them.

Note, stop-pins fixed into the face of the dial A to intercept the ends of the exterior needle 1 would answer the same purpose as the stops 14. In either case the stops must be so fixed as to limit the inclination of the needle either way to conformity with the inclining lines marked on the face of the dial-figure A, which contains twenty letters, disposed at the several intersections of those inclining lines, and the concurrent pointing of two of the five needles always designates some particular letter, which is the signal that they give by so pointing in concurrence. For instance, on the drawing needle 1 inclines with its upper end toward the right hand, and needle 4 inclines with its upper end toward the left hand. The mutual convergence of the upper ends of those needles toward each other shows that the signal they are to give is to be found in the upper half of the dial, and the respective directions in which those two needles point being continued upward by aid of the inclined lines marked on the dial, their intersection is the letter B, which is the signal they now give; but if the lower ends of those needles had converged toward each other instead of their upper ends, then the signal they would give would be found in the lower half of the dial at the intersection of their respective lines of inclination, at the intersection of which is the letter V, and so on of all the other needles; but note, this dial is only adapted for giving signals by the concurrent pointing of two needles, and there are five conducting-wires, 21, 22, 23, 24, and 25, each belonging to its respective needle, (or pair of needles,) which constitute five astatic needles, 1, 2, 3, 4, and 5, so that there is no wire of that kind which, as before explained, is not connected with any needles, such wire being unnecessary unless it be required to give signals by inclination of only one needle, and the dial figure A is not adapted to give signals by one needle.

The dial A and exterior needles are covered in front with a glass, and the coils and interior needles behind the dial are inclosed by boards framed to the vertical board of the dial in the manner of a close box, to keep off dust and dampness.

Figs. H, I, and J represent a set of buttons or finger-keys whereby the person who intends to give signals in distant places can at pleasure connect the ends of any of the five conducting-wires with either of the poles of a voltaic battery, which is assumed to be charged and properly prepared for action.

31, 32, 33, 34, and 35 are five finger-keys, of metal, fixed fast by one end of each key to a piece of wood, 19, which is erected on one end of the key-board 18. The other end of the key may be pressed down, and then the key will bend like a spring, but with a tendency to rise up again when permitted. To these five keys the ends of the five conducting-wires 21, 22, 23, 24, and 25 are connected, at the fixed ends of the keys, and the keys, being conducting-bars of metal, may be considered as prolongations of the several conducting-wires, so that the movable ends of the keys may be considered to be the ends of the conducting-wires, which have been hereinbefore mentioned as being occasionally connected to the poles of the battery.

17 is the cross piece of metal before mentioned, for connecting those ends of all the several wires, one to another, in readiness for forming part of some metallic circuit. The cross-piece 17 is fixed upon legs erected upon the board 18, so as to extend horizontally across the ends of all the five keys, which spring upward by their elasticity so as to touch beneath the cross-piece 17, and that forms the stop to the springing up of each key. There are two buttons, as 41 51, for instance, applied to each key, as 31, for instance, for the operator to press down either one or other with his fingers, one of which buttons, 41, being pressed, will bend down the key 31, and connect that key (and consequently the conducting-wire 21, whereof it forms the end) with one pole—say the positive pole—of the voltaic battery, in consequence of the lower end of the stem of the button 41 going down in contact with a fixed cross-bar, 26, called the "pole bar," which is connected with the positive pole of the battery by any suitable connecting-wire, 27, and at the same time by the bending down of the key 31 its extreme end is disconnected from the cross-piece 17, and thereby the end of the wire 21 becomes disconnected from its previous connection with the other four wires; wherefore, by pressure on the button 41, the key 31, which may be considered to be the end of the conducting-wire 21, is become connected with the positive pole of the battery, so as to form one-half of a metallic circuit. But in order to constitute a complete metallic circuit which will transmit an electric current, some other wire must be connected with the negative pole of the same battery, and to do that another button, (54, for instance,) which is one of the buttons belonging to the key 34 of the conducting-wire 24 being pressed down, will bend down its key 34 so as to disconnect the end thereof from the cross-piece 17, and also the end of the button 54 will go down into contact with another fixed pole-bar, 36, which is connected by a wire, 37, with the negative pole of the battery, and therefore by such pressure on the button 54 the key 34, which may be considered to be the end of the wire 24, is become connected with the negative pole of the same battery; and note, this being done only on that set of buttons or finger-keys, Figs. H I J, which is situated at one terminus, the other like set of buttons or finger-keys at the other terminus, which are represented by Figs. *h i j*, will stand with its corresponding keys 31 and 34 in those figures (which keys may be considered as the distant ends of the said two conducting-wires, 21 and 24) in contact with the cross-piece 17, Figs. *h i*, and there by the said two distant ends of the wires 21 and 24 are connected together. The instant that the said two buttons 41 and 54 are thus pressed an electric current will begin to be transmitted along the two wires 21 and 24, in the following manner, namely: From the positive pole of the battery along its connecting-wire 27 and pole-bar 26 and button 41, (which has just been pressed down into contact therewith, as above explained,) and thence along the key 31 of that button, and along the conducting-wire 21 of that key to the coils (8, Fig. C) which that wire makes around the interior needle, 7, Fig. C, belonging to the exterior needle, 1, Fig. A; and the said transmission of the electric current (being in the direction from the positive pole of the battery through those coils) causes the needle 1, Fig. A, to incline instantly from its previous vertical or quiescent position to turn its upper end toward the right hand as far as its stop 14 will allow it to go, and the electric current so transmitted through the coils belonging to the needle 1 thence proceeds along all the long extension of the conducting-wire 21 to the nearest of the distant portions of the apparatus containing needles, which, supposing for a moment that there are no duplicates at intermediate places between the two termini, will be that portion or dial and set of needles which is situated at the distant terminus, and which is represented edgewise by Fig. *b*, and is in every respect a duplicate of what has been already described by Figs. A, B to G. At that distant terminus the electric current, which, as aforesaid, is transmitted through the conducting-wire 21, and which wire there makes coils around the first needle of the dial, Figs. *a b*, will, in passing through those coils, incline that first needle with its upper end to the right, the same as before described respecting the other dial, Fig. A, and the electric current so transmitted through the said coils thence proceeds along the continuation of the conducting-wire 21, Figs. *b* and *h*, to the key 31, Figs. *h* and *i*, and along that key to the cross-piece 17, with which the key 31 is in contact; thence, passing laterally through the piece 17, the electric current gets to the key 34, which is also in contact with 17, and begins its return toward the battery along the conducting-wire 24, and thereby to the coils which that wire makes around the fourth needle of the dial, Fig. *b*, at the distant terminus; and the said transmission through those last-mentioned coils being in a direction toward the negative pole of the battery, causes the said fourth needle to incline with its upper end toward the left hand, and the electric current transmitted through the said coils thence proceeds along all the long extension of the conducting-wire 24 to return to the first-mentioned terminus, supposing, as before, that there are no duplicates at intermediate places between the two termini; and at the first-mentioned terminus the electric current, returning along the conducting-wire 24, is transmitted through the coils which that wire makes around the needle 4, Fig. A, and that transmission being in a direction toward the negative pole of the battery, as before mentioned, respecting the fourth needle of the distant dial, Fig. *b*, causes the needle 4 to incline with its upper end to the left hand, as is represented in Fig. A, and

thence from the said last-mentioned coils the electric current returns along the conducting-wire 24, Fig. A, to the key 34, Fig. H, and along that key and through its button 54 (which has just been pressed down in contact with the pole-bar 36) the electric current enters that bar, and thence, by the connecting-wire 37, passes to the negative pole of the battery, thus completing its long and very intricate circuit above described, but which may be briefly recapitulated to be proceeding from the positive pole 27 along all the continuous extension of the wire 21, including all the coils that it makes around needle 1, Fig. A, and around the first needle of Fig. *b* to the cross-piece 17, Fig. *h*, at the distant terminus, and passing laterally by that piece 17 to the other wire, 24, returns along all the continuous extension of that wire, including all the coils that it makes around the fourth needle of Fig. *b*, and around needle 4, Fig. A, to return to the negative pole 37 of the battery. The said long and circuitous transmission of the electric current begins instantaneously on pressing down the two buttons 41 and 54 so as by their respective contacts with the pole-bars 26 and 36 to conjoin the two wires 21 and 24 into a metallic circuit, and the needles belonging to those two wires assume their respective inclining positions almost instantaneously, wherefore they present precisely the same appearance at the same time on the dial, Fig. A, at one terminus, and on the dial, Fig. *b*, at the other terminus, the signal which they indicate being the letter B on both dials; and note, if there were duplicates of the apparatus containing needles situated at intermediate places between the two termini, the same would be exact duplicates of that which has been already described by Figs. A to G, and the conducting-wire 21 would in passing through each such duplicate make coils around the first needle thereof, and the wire 24 would make coils around the fourth needle of each such duplicate, wherefore the effect of the electric current would be the same on the needles in each of the duplicates, as already described respecting the dials at the two termini, and the same signals will be exhibited by the needles of all the several dials, as well at intermediate places as at the two termini. The electric current will continue to be transmitted through the circuit so long as the two buttons continue to be pressed, provided that the battery continue in vigor, and the two needles, which have in consequence been thrown into an inclining position, will continue steadily in their inclining and pointing position; but when the operator who has given them that position (in the present case that is he who is at the first-mentioned terminus, and who has pressed the two buttons 41 and 54, Fig. H) has kept them pressed down during a sufficient and previously appointed time for the person at the distant terminus to have observed the needles of the dial there, Fig. *b*, and to have recorded the signal which two of the needles thereof point to—that is, in the present case, the first and fourth needles pointing to the letter B—then the person at the first-mentioned terminus releases the two buttons 41 and 54, Fig. H, whereupon their keys 31 and 34 spring up by their own elasticity, raising the lower ends of the stems of the buttons from contact with the two pole-bars 26 and 36, and thereby disconnecting the two wires 21 and 24 from the poles of the battery, and the ends of the keys 31 and 34 come up in contact with the cross-piece 17, that contact connects the two wires 21 and 24 together; and the instant that the buttons are so released, the metallic circuit being thereby broken, the electric current ceases, and then the two needles of each dial which had been inclined by action of that current into pointing positions fall back quickly to their quiescent or vertical positions by the gravitation of their heavy ends; and as soon as the person at the distant terminus perceives that the needles have done so, he knows that the intended signal—B, for instance—is completed, and he prepares his mind either to receive another succeeding signal which may be sent to him, or else to return an answer to what he has received, or to make some appointed signal in acknowledgement of the receipt, the best and surest mode of doing which will be to repeat or send back the same signal he has just received as the final signal of a series. For this purpose the person at the distant terminus has only to press the two corresponding buttons, (in this case buttons 41 and 54, Fig. *h*,) and they will connect the conducting-wire 21 with the negative pole of the battery at the distant terminus and the wire 24 with the positive pole thereof, and thereby the first and fourth needles will be caused to point out the letter B on all the dials, Figs. A and *b*, just as before described, because a metallic circuit will be formed and an electric current will be tramsmitted through those two wires 21 and 24 in the same direction through each of them as already described, although excited by the battery at the distant terminus.

And all that has been now fully described in respect to two of the wires 21 and 24, with their keys 31 and 34 and their buttons 41 and 54 and their needles 1 and 4 in each of the several dials and duplicates thereof, is equally true of any other two of the five conducting-wires with their corresponding keys and buttons and needles, and cannot, therefore, require further description. But note, each key is provided with two buttons, as hereinbefore mentioned, whereof one button is for connecting that key and its wire with the positive pole of the battery and the other button is for connecting the same key and wire with the negative pole of the same battery.

The use of two buttons is to be enabled to cause each needle to incline either way from its perpendicular position and thereby to point to a different letter on its dial. For instance, if

the buttons 51 and 44 are pressed down instead of 41 and 54, although they belong to the same two keys 31 and 34 and wires 21 and 24 and needles 1 and 4, as already described, nevertheless the result will be to transmit the electric current through both those wires 21 and 24 in a contrary direction to that already described, and consequently to incline the needles in a contrary direction—that is, needle 1 will turn its upper end to the left and needle 4 will turn its upper end to the right—consequently their convergence or concurrence will be downward, and by examination of the lower half of the dial, Fig. A, it will be found that they will point to the letter V thereon, which will be the signal given by pressing the two buttons 51 and 44 in like manner as the letter B was the signal given by pressing the two buttons 41 and 54 as before explained.

It only remains to state that the stems of the two buttons to each key are fitted through sockets or holes in the key and have a certain latitude of motion up and down through those sockets independent to the key, but the extent of that motion is limited by two shoulders on each of the stems of the buttons, and slender springs affixed to each key are applied to each button to bear the same upward in its socket as far as the lowermost shoulder on the stem will allow the button to rise up from the key. The said springs of the buttons are more yielding than the elastic flexure of the keys; the consequence is that whenever a button is pressed it first moves down in its socket through the key by the yielding of its own slender spring without moving the key until the upper shoulder of the stem comes to act upon the key, and then the further continuance of the pressure on the button bends down the key until the lower end of the stem of the button touches on the one or other of the pole-bars 26 or 36 beneath it, so as to form the intended connection of the key with one of the poles of the battery; but the other button of the same key, which is not pressed, being borne upward as far as it can go up in its socket through the key by its own slender spring, will not be carried down low enough by the bending of the key to cause its lower end to touch that pole-bar 26 or 36 which is beneath it. By this means there is no risk of both buttons of the same key forming contacts at the same time unless both were to be pressed upon, which is never to be done.

And note, all the contacts which are to form part of the metallic circuit which is to be established must be rendered secure that the metals do actually touch. The springs by which the stems of the buttons are urged upward in their sockets being fixed to the keys, will insure a sufficient contact of the buttons and their keys. The elasticity of the keys will insure their contacts with the cross-piece 17 whenever that contact is required, and where the communicating wires are connected to the keys the thread-covering and varnish must be removed and the bare metal of the wire held in actual contact with the metal of the keys by screws, and the additional precaution of soldering will be proper. And in like manner the junctions of the several pieces whereof the long extension of each conducting-wire is formed should be united by removing the thread-covering and looping or twisting or otherwise joining the ends, so that the metal of one comes in actual contact with the metal of the other, and such contact may be rendered secure by soldering, and then a covering of thread is to be wound about the joint.

The long extensions of the conducting-wires, which may be called "telegraphic wires," may be lodged in channels formed in wood rails and lined with any suitable resinous matter, with a covering-rail of wood over the channels to protect the wires from injury and from damp. Such wooden rails may be, according to the section, Fig. 21, Sheet III, formed in as long pieces as can be readily procured. The rail containing the wires may form the lower half and the covering-rail the upper half of a square rail, which may be fixed with one of its angles upward on the tops of upright posts fixed in the ground, in the manner very commonly used for post-and-rail fences along embankments and other places on public roads. The rails, being lodged in angular notches on the tops of the posts, are bound down and secured therein by straps of broad hoop-iron bended over the upper angle of the rail and reaching down the sides of the posts and nailed thereto. Large posts may be applied at the junctions of the pieces of rails to receive and sustain the adjacent ends of two pieces, and the joint may be made firm by any suitable application of iron.

The joints of the pieces composing the upper half, may be interspaced to those of the lower half, and smaller supporting-posts may be applied in the intervals between any joints.

As many parallel channels as there are conducting-wires may be cut out with circular saws along the middle part of the lower half of such rails, and after these rails are laid in place on their posts, and the channels being lined with suitable resinous varnish, then the wires, suitably covered with thread, if necessary, and varnished, may be lodged in the channels, and fillets of wood may be driven in to fill up each channel over the wire, which, being thus inclosed, the upper half or covering-rail may be applied, with felt interposed in the joint, and secured by the iron straps over the posts, and such other intermediate bands of iron as will be requisite for fastening the two securely together like one rail to keep out wet and give it sufficient strength to resist injury; or the bottom half may be a square rail with a covering-rail, as in Fig. 21, placed angle upward over it, that form being best for a covering, because the rain-water will not rest upon it. Fig. 22 is a section of another form of rail, containing distinct channels for the several wires,

each of which channels is closed by a fillet of wood driven into it. Such rails may be laid under ground when that is more convenient than to place them above ground upon posts, and some parts of a long line may be under ground and other parts above ground, and may extend along the sides of public roads, or railways, or otherwise, as is most convenient and suitable to go from one terminus to the other.

And for telegraphic communications between places which are too distant for an electric current to be transmitted all the way with sufficient vigor to be certain in its operation, a chain of apparatuses, as hereinbefore described, must be established to communicate one to another through the whole distance, in which case what has been called the "distant terminus" of one apparatus will be situated close by the commencing terminus of the next apparatus, and the signals received there from one apparatus must be sent forward by the next, and so on, all which requires no explanation, because it is well known in the usual system of telegraphic communication, and forms no part of our present invention. And the same may be said of the telegraphic language or system of signals and their significations. Those systems which are well known and in use for other telegraphs may be used or they may be modified, but they form no part of our invention. And note, instead of inclosing the several conducting-wires in distinct channels, as above described, they may all be carried along one channel, for, provided that they are kept dry, their covering of thread and varnish will form a sufficient insulation of each wire from its neighbors.

The whole number of conducting-wires may be bound together in a bundle by a wrapping of coarse thread and varnished over, that may, if required, be covered again with a spiral fillet of hemp, and then covered with pitch or tar to keep out wet. The one channel receiving a set of wires, either when so bound together or when detached one from another, may be formed in wood rails put together in two halves, or in iron troughs or tubes formed of hoop-iron bended up and put together in two halves, and united with screw-bolts at suitable intervals, having tarred felt interposed in the joint between the two halves; or tubes may be formed by bending up hoop-iron with a sufficient longitudinal opening left between its meeting edges to introduce the wires one by one and afterward closing up the opening by inserting tarred felt and pinching the edges together thereon by screw-bolts applied at suitable intervals.

Fig. 23 represents such a tube and explains how the ends of the several pieces thereof may be united by sockets of the same description, made large enough to receive the ends of the tubes.

Fig. 24 explains how a rail of wood may have an inverted gutter or trough of iron applied upon it to cover over and protect the wires which are laid upon the wood without being let into channels therein. The two edges of the inverted iron trough may be let into two channels cut in the wood, and cemented in with pitch or tar, and the iron may be fastened to the wood by iron staples applied over it and driven into or otherwise fastened to the wood. The junctions of the several lengths of iron may be covered over with short lengths of similar gutter-iron, but of larger size, to form sockets for receiving the two ends of the lengths which are to be joined; and note, the set of buttons and finger-keys represented in Figs. *h i j*, Sheet I, are of exactly the same construction as what has been hereinbefore described in Figs. H, I, J, Sheet *r*.

And note, the apparatus represented in Sheet I (as the same has been hereinbefore described) must necessarily give all its signals by the concurrent and cotemporaneous operation of two needles, because each of the five conducting-wires makes coils around one of the five needles in each dial; and whereas two wires must of necessity be employed to form any metallic circuit, it follows that whichever two of the five wires may be so employed they must bring two needles into concurrent and cotemporaneous operation. Wherefore, in order to give signals by operation of one needle at a time, another or sixth wire may be added to extend direct from one terminus to the other without forming coils around any needles, and the two ends of that sixth wire must be connected to a sixth key, which is added to the set of keys at each terminus, that key having its two buttons precisely the same as all the others. Then it is obvious that the apparatus will be qualified for operating at pleasure upon one needle at a time as well as upon two needles at a time, as already described, or upon three needles at a time, or upon four at a time, or upon five at a time, for each set of buttons and keys will consist, as before, of two rows of buttons, those in one row being adapted on pressure to cause the needles belonging to them to incline and point in one direction, the buttons in the other row on pressure causing the same needles to incline and point in a contrary direction, all which is as before described; but, now, instead of five, there are six such buttons in each row, the additional key, with its two buttons, may be disposed at the commencement of the series of five already described—that is, by the side of the first key, which is marked 31 in Figs. H and *h*, Sheet I, and its two buttons are marked 41 51—the additional key may be marked 30, its two buttons 40 and 50, and the additional or sixth wire 20, and they may be considered as the blanks or zero of the series; and it is obvious that on pressing down either of the blank buttons 40 or 50 no needles will be moved in consequence of so pressing, but by pressing down at the same time any other one of the buttons the particular needle thereto belonging will be moved by itself alone, and

that one way or other, according to the row in which the button that is pressed is situated.

The dial, Fig. A, as it has been already described, containing twenty letters, none of them can be pointed out by single needles, but a row of numeral figures may be marked in red ink, as there shown, and it will be apparent that when only one needle is inclined at a time it will point to some one of the red figures 1 2 3 4 5 6 7 8 9 0 on the dial, and not to any of the letters thereon, and if thought more convenient such numeral characters may be marked in red around the border or margin of that part of the dial which contains the letters.

But note, in cases where the use of six conducting-wires may be objectionable on account of the expense of very long lines thereof, five wires and five keys, with ten buttons, as before described, and as represented by Figs. H and *h*, may be retained exactly, but the fifth key, 35, and wire 25 will be the blank, which has no connection with any needles, and one of the five needles of each of the dials will be omitted, and only four of them used, with a suitable dial, such as is represented by Fig. Z, Sheet III, which dial is adapted to give significations by the pointing of any one needle as well as by the concurrent and cotemporaneous pointing of two needles.

And now, respecting the means of applying the attractive force of occasional magnetism which may be excited in masses of iron by electric currents, as hereinbefore alluded to—

Fig. Y, Sheet I, represents a mode of actuating a magnetic needle, 7, which may, for the present, be supposed to be one of those belonging to the dial, Fig. A, and that the parts represented in Fig. Y are placed at the back of the vertical board of the dial A, in place of the frames 10, represented in Figs. D to G. U U, Fig. Y, are two pieces of soft malleable iron, bended into the form of a fork or of the letter U, or what is termed a "horseshoe form," one such horseshoe being over the needle 7 and the other under it, but both being in the same plane in which the needle is to move. The four extremities of the two horseshoes come very near to the fixed stops 14 14, by which the inclining motion of the needle 7 either way is to be limited, in manner already explained.

21 is the conducting-wire by which the needle 7 is to be actuated. That wire is covered with silk, as before explained respecting Fig. G, but it is now wound in continuous spiral coils around the four ends or prongs of the two horseshoes, U U,—that is to say, the wire 21 having made a number of coils around one prong of the upper horseshoe U, with coil over coil, until a considerable mass of coils is accumulated thereon, (at *r*, for instance,) then passes across to the other prong of the upper horseshoe and makes another mass of like coils, *s*, after which the continuation of the same wire, 21, descends and makes a like mass of coils, *t*, around one prong of the lower horseshoe, and then passes across to form a like mass of coils, *v*, around the other prong, and from the last of those coils the wire 21 continues in its course of extension, in the same manner as if it had formed coils as before explained by Fig. G. When an electric current is transmitted through the wire 21 and all its several coils *r s t v*, magnetism will, as is well known, be excited in the horseshoes so as to convert them for the time into two voltaic magnets, and in consequence of their relative positions in respect to the needle 7 they will concur in inclining it from its vertical or quiescent position as far as its stops 14 will allow it to go. If that electric current is transmitted in one direction it will cause the needle 7 to incline one way; or if the current is transmitted in the contrary direction it will cause the needle 7 to incline the other way; or, if the electric current is discontinued, then the two horseshoes will cease to be magnetic, and will allow the needle to return to its quiescent or vertical position by the gravitation of its lower end, which must be heavier than its upper end, as already fully explained respecting the needles having heavy ends; wherefore the effects produced upon the needle by the means explained in Fig. Y will be similar in every respect to the effect produced thereon by the means hereinbefore described in respect to the Figs. D to G.

And note, the two horseshoes U U are to be fixed fast to the back of the vertical board A by any convenient means, but the four extremities of the prongs of the horseshoes U U must not be so situated as to be too near to the ends of the needle 7 when the same is inclined as far either way as its stops 14 will allow it to go, because the magnetic attraction of the needle itself for the iron ends of the horseshoes (although that iron has ceased to be magnetic) might, if they came too near together, impede the free return of the needle to its vertical position by the gravitation of its heavy end. And note, the needle 7, Fig. Y, corresponds to the interior needle 7, Figs. E, F; but the exterior needle belonging to Fig. Y, which is to be in front of the dial, is to be a mere pointer, of brass or copper, and not a magnetic needle, wherefore the needle actuated in the manner of Fig. Y will not be according to an astatic combination, which it is advisable for the needles Figs. E F to be, as already explained. And respecting the sounding of alarms in distant places by means of electric currents transmitted through metallic circuits, the same may be effected by the attractive force of occasional magnetism excited in masses of iron by such currents, and may be applied in a distinct apparatus which is only adapted for sounding alarms without giving any other signals than such alarms. (See Sheet II.)

Fig. R^n is a well-known piece of clock-work, having a bell, *q*, which is sounded, when required, by a hammer actuated by the wheel-

work, that wheel-work being turned by force of a spring or a weight, with a cord and barrel which has been previously wound up, but all motion of the wheel-work is stopped by a detent, *p*, mounted on a horizontal axis, *k*, catching into the teeth of any of the wheels *l*, as will best suit; and when that detent *p* is removed out of the way of the teeth of the wheel *l*, then the alarm begins sounding its bell—all which is so well known as to require no further explanation, particularly as there are or may be various constructions of such alarms. Our improvements therein only relate to the mode of disengaging and re-engaging such detent *p* by means of electric currents.

Let K represent a voltaic battery on any of the constructions commonly used—and one of the most simple, consisting of a flat vessel of copper filled with acidulated water and having a plate of zinc suspended therein, will be sufficient.

21 is a conducting-wire extending from one pole, which is in this case the positive pole, 27, of the battery, to coil around the two prongs of a soft-iron horseshoe, U, first around one prong thereof, and then around the other prong thereof in the manner shown in perspective in Fig. S, Sheet II, and as has been already explained respecting Fig. Y, Sheet I; but now there is only one horseshoe instead of two, and no magnetic needle, and after making such coils the continuation of the conducting-wire 21, Fig. R, is extended to such place as is most convenient and accessible to the person who intends to sound the alarm, and there the said wire 21 is connected to a finger-key, 31, which is fixed fast by one of its ends, and the other end is capable of being bended down by pressure to bring it down into contact with a pole-bar, 26, which is fixed beneath it, and from which another conducting-wire, 22, proceeds to the other (which is in this case the negative) pole, 37, of the battery K. When the key 31 is not pressed it springs up by its own elasticity so as not to touch its pole-bar 26, and no metallic circuit is formed, and so long as that is the case the detent *p* of the alarm is kept by action of its own spring, *m*, in the way of the teeth of the wheel *l*, so as to prevent the alarm from sounding; but there is a mass of soft malleable iron, V, fixed across the lever or tail end of the detent *p* and extending horizontally across parallel to the axis *k* of the detent, the two ends of the piece of iron V being opposite to and at a small distance from the ends of the two prongs of the horseshoe U, as is shown in perspective at Fig. S, Sheet II; but neither the piece V nor the horseshoe U being magnetic they do not attract each other.

The person who intends sounding the alarm can do so by merely pressing down the key 31, which he may either do by applying his hand or finger to the key 31 or by pulling down a cord or bell-pull, *x*, which may be appended to it. In either case, by bending down the key 31 to touch its pole-bar 26 the required circuit is formed, and an electric current being transmitted through the conducting-wire 21, which is coiled round the prongs of the horseshoe U, it excites magnetism therein or converts it for the time into a voltaic horseshoe-magnet, which attracts the piece of iron V at the lower end of the detent *p* and draws it toward the end of the horseshoe U, although it is not allowed to touch them. The upper end of the detent is thereby withdrawn from out of the way of the wheel *l*, and then the alarm commences sounding or hammering its bell by its own action derived from its previously-wound-up weight or spring, and if the key 31 is kept down so long, the alarm will continue to sound until its said weight or spring is run down; but if the key 31 is released, so that it can spring up and separate from its pole-bar 26, then, the circuit being broken, no electric current will be transmitted through the coils of the wire 21, and the temporary magnetism of the horseshoe U will cease altogether, and it will no longer attract the piece of iron V, but the spring *m* of the detent *p* will withdraw the piece V from the horseshoe U, and will bring the upper end of the detent *p* into the way of the teeth of the wheel *l*, so as to stop the motion thereof, and consequently the sounding of the alarm.

And note, in order that no adhesion may take place between the ends of the piece of iron V and the iron ends of the horseshoe U, it should not, as before mentioned, be allowed to actually touch those ends, which may be managed by suitable stops to limit the motion of the detent *p* about its axis *k*; or else two small copper studs may be fixed into the ends of the horseshoe, or into the ends of the piece V, to form prominences of copper, which may be allowed to come in contact, and they will prevent the contact of the iron with the iron 32 26. Fig. R shows a duplicate key and pole-bar, which may be provided in another different place from those already described at 31 and 26. The key 32 having a branch from the conducting-wire 21, and its pole bar 26 having a like branch to the conducting-wire 22, they will give the means of sounding the same alarm from that different place as well as from the place first mentioned, and so on as many other keys and pole-bars as may be required may be provided at different places for sounding the same alarms.

The said apparatus, Fig. R, may be applied in dwelling-houses, inns, theaters, or other large buildings, for the same purposes as the ordinary system of bell-hanging, and where the situation does not require too great a length of conducting-wires 21 22 in the metallic circuit, so that the electric current will be able to excite a sufficient vigor of magnetic attraction in the horseshoe U, the upper end of the detent *p* may have a hammer-head fixed upon it, in order to strike against and sound the bell *q*, in the manner represented in perspective, Fig. S, by a direct action of the force of the

occasional magnetism which is excited in the horseshoe U.

But in other situations the length of the conducting-wires 21 22 in the metallic circuit may be so great that the magnetism excited in the horseshoe U will not exert a sufficient force of attraction for the piece of iron V to remove the detent *p* from the teeth of the wheel *l*. In such situations the apparatus Fig. S is to be preferred, wherein the voltaic battery K and the iron horseshoe U, together with the piece of iron V at the lower end of the detent *p*, are all the same, as already described respecting Fig. R, and the hammer for sounding the bell *q* of the alarm may be either at the upper end of the detent *p*, as represented in Fig. S, or else the hammer may be moved by clock-work, as already mentioned, and as is represented in Fig. R, the office of the upper end of the detent *p* being in that case to catch the teeth of the wheel *l*, in order to prevent the sounding of the alarm until the detent is removed, as already explained. But instead of forming a long metallic circuit, to extend all the way from that battery K to the distant place or places where the person who attends to sound the alarm may be situated, and thence back again to the battery K, as is the case in Fig. R, the battery K, as is the case in Fig. S, is devoted solely to the purpose of exciting occasional voltaic magnetism in the horseshoe U by transmission of an electric current through no greater length of metallic circuit than is most suitable for that purpose—that is to say, a considerable part of the length is accumulated in the coils around the prongs of the horseshoe U. The electric current which is to be transmitted through the long circuit which extends to the said distant places is derived from a distinct battery, M, Fig. S, and that current does not operate directly upon the alarm, but it causes the other battery, K, (which may for distinction be called the "alarm-battery") to be brought into action in order that it may sound the alarm, in manner already explained

It may therefore be considered that the battery M and the electric current which is transmitted from it through the long metallic circuit formed by the two conducting-wires 24 25 is caused to produce the same effect on the alarm apparatus as has been already described to be done by pressing down the key 31, Fig. R, in contact with its pole-bar 26, viz: It establishes the requisite contact between the ends of the wires 21 and 22, Fig. S, to form them into a metallic circuit for the transmission of an electric current from the positive pole 27 of the battery K along the wire 21 and through the coils which that wire makes around the two prongs of the horseshoe U and back again along wire 22 to the negative pole 37 of the same battery K. This connection is effected by causing the two ends of a small fork, 60, Fig. S, to descend into two small cups, 61 62, formed at the upper end of two upright pillars, 21 22, which may be considered as prolongations of the wires 21 22.

A small quantity of mercury is contained in each of the cups 61 62, and when the fork 60 is brought down to dip therein, as is represented by dotted lines, it forms the two wires, 21 and 22, into a metallic circuit, and that will cause the alarm to begin sounding the same as would follow from pressing the key 31, Fig. R; but when the fork 60 is raised up, as represented in Fig. S, that circuit is broken and the alarm ceases to sound in the same manner as would follow from releasing the key 31. This being understood, it is easy to explain how the small fork 60 is brought down or raised up by the motion which is given to a magnetic needle by transmission of an electric current from the distant battery M through a long metallic circuit, which may be formed, when required, by the long wires 24 and 25. The fork 60 is formed out of one end of a slender lever, 63 64, which is fixed on the horizontal axis 65 of a magnetic needle which is placed within a set of coils, 8, which the wire 8 makes around a frame, 10, in the same manner as already described respecting Figs. D, G, Sheet I, the only difference from the structure there represented being that the axis 65 of the needle, instead of being mounted on pivots at its ends, is suspended by the tension of horse-hairs, which are extended horizontally in prolongation of the axis 65 from each end thereof to small regulating-screws 66 66 supported at the upper ends of two small standards 67 67, which are erected on the same wooden base as the upright pillars 21 22 for the cups 61 62, and the frame 10 for the coils 8 of wire is also erected on that same base; also, that frame 10, instead of being made in two parts, as is represented by Fig. D, and as before explained, is here represented in one part, with a small tube projecting out horizontally to admit the axis 65 of the needle and keep the coils of wire 8 apart out of the way of the axis 65.

The lever 63 64, which carries the fork 60, is fixed on the axis 65 at right angles thereto, and also at right angles to the magnetic needle, which latter is concealed in Fig. S within the frame 10. The end 64 of the lever 63 64 has a small weight, which overbalances the weight of the fork 60, so as to raise the same up out of the cups 61 62 as high as the stops 14 will permit whenever there is no electric current transmitted through the coils 8 8; but the two ends of the wire 8 composing those coils are connected at 75 76 with the ends of the two long conducting-wires 24 and 25, as is clearly shown in Fig. S. The wire 24 is connected with the positive pole 87 of the battery M, and from the negative pole 97 of the same battery a connecting-wire, 36, extends to the finger-key 31, and to the pole-bar 26 beneath that key the wire 25 is connected; wherefore, if the key 31 is pressed down into contact with its pole-bar 26, the two long conducting-wires 24 and 25 will become united into a metallic circuit for the transmission of an electric current through the following course, viz: From the positive pole 87 of the battery M along the

long conducting-wire 24 to the button 75, and thence through the wire 8, which is coiled around the frame 10 in the space whereof the magnetic needle is situated, and continuing from those coils to the button 76 there enters the other long conducting-wire, 25, and along that to the pole-bar 26, and through that and its key 31 and connecting-wire 36 to the negative pole 97 of the battery M, and the said transmission through the coils 8 causes the magnetic needle to incline from its perpendicular in the proper direction, and so much as is requisite to put the fork 60 down into the cups 61 62, which, as already stated, will cause the alarm to begin sounding by the action already fully described in respect to Fig. R; but when the key 31, Fig. S, is released, then the said metallic circuit is broken, whereupon the electric current, ceasing to be transmitted through the coils 8, ceases to influence the magnetic needle, and therefore, by the preponderance of the weight 64, the fork 60 is raised up out of the cups 61 62 as high as the stop 14 will allow, and then the sounding of the alarm ceases for the reason already explained in respect to Fig. R; and note, it is obvious that the weight or spring which actuates the clock-work of the alarm might as that weight descends or that spring unwinds be made to pull a string which is tied around the wrist of a person who is asleep or who is dull of hearing, and thereby give an additional chance of his attention being called by the sounding of the alarm beyond that of merely hearing the sound.

And the apparatus above described and represented in Sheet II may also be applied, in concert with the apparatus hereinbefore described and represented in Sheet I, to form part of our complete apparatus for giving signals and sounding alarms in distant places, and will form a very important part thereof, because the person who intends giving signals in distant places can first call the attention of his correspondent or correspondents at the distant places by sounding the alarm or alarms previously to commencing giving visible signals. For this purpose an apparatus with an alarm, like Fig. S, but constructed and adapted to be actuated with clock-work, as in Fig. R, is to be provided at each terminus or place where there is a set of buttons and finger-keys, Figs. H, I, J or Figs. *h*, *i*, *j*, Sheet I, and also at each intermediate place where duplicates of the dials with needles may be situated; but the long conducting-wires 24 and 25, Fig. S, together with the battery M and finger-key 31 and pole-bar 26, are not required, because the functions of those parts are to be performed by two of the five long conducting or telegraphic wires—viz., 21 and 25, Sheet I—together with their sets of buttons and finger-keys; for it is evident that the sounding of the alarms may be performed by transmission of the same electric current which produces some particular signal—for instance, that convergence of the upper ends of needles 1 and 5 which signifies the letter A on the dial Fig. A, and which is occasioned by the transmission of an electric current through the wires 21 and 25 and their keys 31 and 35; but as it would be inconvenient to suffer the alarms to be sounded every time when the signal-letter A is to be exhibited, the alarm should be only kept connected with those two wires in the intervals between the making of telegraphic communications when the apparatus is not in use and on proceeding to resume the use of it for giving signals. The prelude or first thing will be for the person at the first-mentioned terminus to make the signal for letter A by pressing down buttons 41 and 55, which, producing all the same results as pressing down the key 31, Fig. S, in the manner already fully described, will begin sounding the alarm at the distant terminus, and also those at the intermediate places, those buttons 41 and 55 being held down only a very short time and then released; and the sounding may be repeated, if necessary, until the attention of the person at the distant terminus is called to it, and as soon as he is ready to receive signals he will communicate that fact by sounding the alarm at the first-mentioned terminus, which he does by pressing the buttons 41 and 55, Fig. *h*, and by those means a mutual understanding will have been established between the two persons that they are both prepared to commence a telegraphic communication, he who commenced by first sounding an alarm having the right of precedence therein, and then, the alarms being unnecessary for the present, each person may disconnect his own alarm from the telegraphic wire; but that is merely to avoid the annoyance of its being sounded every time the signal-letter A is made by either person in the course of their communication; but when the person who has, as before stated, acquired the right of precedence therein intends to put an end to it for the present, he expresses that intention by some unusual signal which has been previously agreed upon—such, for instance, as pressing down at once two of the buttons 41 42 in one row and two of the buttons 54 55 in the other row, which will turn the upper ends of the needles 1 and 2 to the right and the needles 4 and 5 to the left, and immediately after the making of such signal it is to be imperative on each person to connect his alarm with the telegraphic wires and to wind up its clock-work weight or spring, if necessary, in order that the alarms may never fail of being ready for sounding during all cessations, however short, in the telegraphic conversation, and in order that every resumption of the conversation may be preluded by sounding an alarm. And as to the several alarms at intermediate places between the two termini, they will all begin to be sounded at the same time with that alarm at either of the two termini which is first sounded, and the persons who are stationed at those intermediate places, on hearing the sound and

looking at their own respective dials, will discover from which terminus the intended communication will afterward be sent, because the signals which follow after the sounding of the alarm must be adapted to convey that information. The above particulars of the application of the alarms being understood, it is easy to explain the manner of connecting or disconnecting them with the telegraphic wires.

The alarm at the first-mentioned terminus is to be connected by a short cross-wire, 94, extending from the key 35 of the telegraphic wire 25, Fig. H, to the button 75, Fig. S, (instead of the wire marked 24 in that figure,) and the telegraphic wire 25, Fig. H, is to be disconnected from its key 35 by sliding a small bolt, 73, and is to be connected by means of that bolt and a short cross-wire, 95, to the button 76, Fig. S, (instead of the wire marked 25, in that figure.) To effect the said disconnecton of the telegraphic wire 25 from its key 35 it is not joined directly thereto but to a spring-piece, 72, Fig. H, which, by bearing down on the end of the key 35, connects the wire 25, therewith whenever the alarm is to be kept out of use; but when the alarm is to be connected, then the small sliding bolt, 73, being pushed with its end beneath the spring-piece 72, will lift the same up from its previous contact with the key 35, but in so doing the bolt 73 makes contact with the spring-piece 72, which is connected with the telegraphic wire 25, and the short cross-wire 95 being extended from the bolt 73 to the button 76, the bolt 73 establishes the required connection between that button and the wire 25. The consequence is, that when the bolt 73 is pushed under the spring-piece 72 the electric current transmitted along the wire 25 in producing signal-letter A must pass through the coils of wire 8, Fig. S, and in so doing will cause the alarm to be sounded, as already fully explained in respect to Fig. S; but when the bolt 73 is withdrawn, the said electric current will not pass through the said coils 8, Fig. S, and consequently the alarm will not be sounded, although the letter A is exhibited. In like manner, to prepare the alarm at the distant terminus for action, it requires to be connected with the telegraphic wire 25, Fig. *h*, so that the electric current which is transmitted along that wire 25 when letter A is exhibited will also be transmitted through the coils 8, Fig. S.

The mode of connecting the alarm to the set of keys, Fig. *h*, may be an exact duplicate of that which has been explained in Fig. H. Another way of preventing the alarms from sounding uselessly during the telegraphic conversation is to apply some stop to the motion of their clock-work in like manner as in a stop-watch, which will preclude the necessity of disconnecting the wires, which may be always left in action. This is particularly applicable to the alarms at intermediate places.

And respecting the application of the evolution of gas proceeding from the decomposition of water by the transmission of electric currents, (see Fig. Q, Sheet II,) A B is a glass vessel, somewhat like an inverted siphon, but with one leg, A, much larger than the other leg, B, which latter is only a narrow tube. The lower part of the siphon is filled with mercury so high up as to occupy all the communication between the two legs, and above the mercury acidulated water is poured into the large leg, A, so as to occupy some depth therein. The upper part of the large leg, A, is closed by a cover, C, and two platina wires, 75 76, are passed horizontally through perforations through the thickness of the glass to pass into the midst of that water, with their ends turned upward therein.

The two wires 75 76, Fig. Q, correspond to the wires marked with those numbers in Fig. S, and the two points of those wires which are immersed in the water answer the purpose of the coils 8 8 around the magnetic needle in Fig. S; for when an electric current is transmitted through the wire 75 to the wire 76 (the points whereof do not touch each other) the electric current must pass through the water, and in so doing will decompose the same into its elements of oxygen and hydrogen in the state of gases, which ascend in bubbles through the water, and by accumulating in the space above that water beneath the close cover C will press downward on the surface of the water, and thereby press on the mercury so as to raise the same in the small leg B until the mercury comes up high enough to touch and surround the end of another platina wire, 61, which turns over and descends down into the small leg, B, but only so far down therein as not to touch the mercury when the same stands at its natural level; but, nevertheless, so far as that the said end of the wire 61 will become immersed in the mercury when the same is raised in the small leg, B, by the aforesaid accumulation of the gases proceeding from the decomposition of the water contained above the mercury in the large leg A. The said wire 61 answers to the cup 61, Fig. S, and there is another platina wire, 62, the extreme end of which is inserted through a perforation in the lower part of the glass, so that its end is always immersed in the mercury contained in that lower part.

This apparatus, Fig. Q, is to be used as a substitute for the magnetic needle and coils of wire around it in Fig. S for the purpose of enabling an electric current which is transmitted through a very long metallic circuit, and which consequently acts but feebly, to continue to accumulate its action until it has attained sufficient force to form the requisite contacts for bringing an alarm-battery into action for the purpose already described in respect to Fig. S. Therefore, the apparatus, Fig. Q, being substituted for the magnetic needle and its surrounding coils of wire in Fig. S, the connections which are therein made to the buttons 75 and 76 must in Fig. Q be made to the ends of the wires 75 and 76 therein, and likewise the con-

nections which are made to the two cups 61 and 62, Fig. S, are to be made in Fig. Q to the ends of the two wires 61 and 62 therein, which being done, the apparatus, Fig. Q, will, by its operation above described, form the requisite metallic contacts between the end of the wire 62 and the end of the wire 61 by the mercury in which they both become immersed to form them into a metallic circuit, and thereby produce all the same effect as already explained respecting Fig. Q for bringing the alarm-battery K, Fig. S, into action when it is required to sound the alarm. And note, after the apparatus, Fig. Q, has performed its intended office of forming the ends of the wires 61 and 62 into a metallic circuit, and has caused the alarm to be sounded, it will not immediately separate that contact of itself, because the gas will continue for some time accumulated in the upper part of the large leg A; therefore, after the alarm has been sounded the person whose attention has been called to it may apply his finger to open a small valve, *d*, in the cover of the large tube, A, in order to let out the gas therefrom, and then the mercury, subsiding to its level in both legs, will sink below the end of the wire 61, leaving the same disconnected from its contact with the mercury, so as to break the metallic circuit which has been formed thereby.

And note, as the long conducting or telegraphic wires used in our said apparatus may be liable to be broken or otherwise deranged, it is necessary to have some efficient and easy method by which the precise place of injury or derangement may be ascertained without disturbing to any great extent the tubes, troughs, or rails wherein those telegraphic wires may be lodged.

The particular wires in which the injury or derangement may have occurred will discover themselves, from the defective working of the corresponding telegraphic needles at the two termini. At given intervals along the line each of the conducting-wires should have a short lateral branch-wire proceeding from it and reaching out therefrom to some secure place, where the ends of all those branch-wires will be accessible when required for making proof of the wires. These branch-wires are provided for the purpose of connecting any two of the long conducting-wires with an instrument which may be called a "detecter" or "prover." Two convenient forms of such an instrument are represented in Sheet III.

Fig. W is a prover, which consists of a multiplier with its magnetic needles included in its coils of wire exactly like those hereinbefore described, (Figs. D to G, Sheet I,) but mounted on a stand with a protecting-case of wood, having a glazed front, and each of the two ends 8 8, Fig. W, of the coiled wire proceeding from the instrument terminate with any convenient clamp of metal, for the purpose of taking hold with those two of the ends of any two of the branch wires before mentioned with a good contact, and then the instrument will form part of a metallic circuit with those two of the conducting-wires to the branches whereof it is connected. The other kind of prover, Fig. L, is a glass vessel or bottle fixed on a wooden stand and containing two pieces of platina wire, *p p*, insulated from each other, with their lower ends soldered respectively to pieces of copper wire *c c*, each terminating with a clamp such as above described. The bottle is to be nearly filled with diluted sulphuric acid or other good conducting fluid, when required for use.

In applying either of these instruments to prove the defective state of the telegraphic wires, I will speak, for example, of only two wires, and the mode of proving those two will apply to any others. (See Fig. W, Sheet III.) 21 22 are two of those wires, which extend from one terminus to the other, and I will suppose one of them to have been broken at H.

To find out the place H where it is so broken, those ends of the two wires 21 22 which are at one terminus should be connected with the opposite poles of the battery at that terminus. The person who is to examine the state of that conducting-wire which is known to be broken must proceed to that place nearest to the terminus where there are a set of lateral branch wires, *k k*, proceeding from the conducting-wires, as before mentioned, and there he must apply one or the other of the provers above described, with the two wires 8 8 thereof attached to the ends of the branch wires *k k* belonging to the two conducting-wires 21 22, which have been, as before mentioned, connected with the poles of the battery. If the defect does not exist between the terminus and the first proving-place the prover will act on that place—that is to say, if the prover W is used, its needle will be inclined, or if the prover L is used, gases will be evolved at the platina wires from the decomposition of water. The prover is then to be carried forward to the next proving-place, where lateral branch wires are provided, farther off from the terminus, and so on. Necessarily (by applying the prover at each proving-place more and more remote from the terminus) a place will be found where the prover ceases to act, and that cessation of its action will indicate that the defect exists between the two last places which were tried. The portion of the tube trough or rail included between these two last-mentioned places is then to be opened near the midway of the distance between those two places, and at that midway the wires 21 22 must be proved by connecting the wires 8 8 of the prover immediately to each of them. In this manner the half in which the defect exists may be detected. Then that half may be again subdivided and the process continued in the same manner by repeated bisection until the place of the defect is ascertained within very narrow limits, and the tubes must be opened to expose the wires and repair the defect. And note, in order to

be able at all times to identify the several conducting-wires, it will be expedient to use varnish of different colors in preparing them, wherefore one color will always distinguish the wire 21, another color the wire 22, and so on of the others.

Having now described our said improvements, we, the said CHARLES WHEATSTONE and WILLIAM FOTHERGILL COOKE, do hereby declare that the new invention or discovery wherein we desire to obtain an exclusive property, as hereinbefore mentioned, consists in the following particulars:

1. In the improvement hereinbefore described for the purpose of communicating determinate angular motions to magnetic needles by means of electric currents transmitted through metallic circuits, and the adaption of such angular motions for the purpose of giving signals in distant places; and whereas some experiments have been heretofore made by others upon giving signals by means of the well-known instruments called "galvanometers," which are for measuring the force of electric currents passing through metallic circuits, we wish it to be understood that we make no claim to the application of the multiplying coils of conducting-wires, hereinbefore described, around the magnetic needles; but the improvement we have made in the adaptation of magnetic needles to the purpose of giving signals is in disposing the needles in vertical planes, (the axes whereon they are fixed being horizontal,) and in making the needles heavier at one end than the other, in order to give them a decided preponderence or tendency to hang perpendicular and point upward when they are not influenced by electric currents, and in limiting the angular motions of the needles, when they are so influenced, to some certain determinate extent, by providing fixed stops against which the needles may recline and continue at rest for a time, in suitable inclining directions for pointing out on a vertical dial the significations of the signals they are to give, and in case two or more such loaded needles are to be placed near together in the same vertical plane for pointing out signals on the same dial, then in the adaptation of astatic needles—that is, two reversed needles fixed on the same horizontal axis—for giving signals in such cases. But note, the astatic mode of combining magnetic needles for galvanometers being well known, we make no claim to the use of astatic needles for giving signals, unless such astatic needles are, as before mentioned, disposed two or more in a vertical plane and are loaded at one end and have their angular motion limited to a determinate extent by stops.

2. In the improvement hereinbefore described of combining several magnetic needles so that they will point out on one dial, suitably marked, the significations of the signals which they are to give by the determinate angular motions which are communicated to them by electric currents, those signals being given in some cases by the inclination and pointing of one needle, in other cases by the concurrence and mutual pointing of any two needles, or in some cases by the concurrence of three or four needles, as may be most suitable for the sort of signals which are intended to be given.

3. In the improvement hereinbefore described of arranging and combining any suitable number of conducting or telegraphic wires into a set capable of being operated upon by buttons or finger-keys at each end of the set, and having a voltaic battery and also a dial with magnetic needles, as aforesaid, at each end of the set, with power of using those parts in such manner that at the pleasure of the operator any two or more such wires may have one or other of their ends connected to the two opposite poles of the battery belonging to that end, the contrary ends to those ends which are so connected being at the same time conjoined together, so as to form the said two or more wires into a metallic circuit or circuits for the transmission of an electric current or currents throughout the length of two conjoined wires as a means of giving signals by the angular motions that such current or currents will communicate to magnetic needles which are subjected to the influence of such currents, or of sounding-alarms by the conjoined action of magnetic needles aforesaid, or of the evolution of gas from decomposition of water by such currents and of occasional or temporary magnetism excited in masses of soft iron by such currents; and whereas either end of any wire or wires of such set, as aforesaid, is capable of being connected with either pole of its appropriate battery, a diversity of metallic circuits can be formed with a capability of transmitting an electric current in either direction through each such circuit, and of thereby giving a diversity of signals from a few wires.

4. In the improvement hereinbefore described in the arrangement and combination of each set of the buttons and finger-keys, whereby the ends of all the several conducting-wires constituting the set thereof are kept conjoined one to another in readiness for becoming parts of any such circuits as may be formed by connecting the opposite or distant ends of the wires with the distant battery; but, nevertheless, the several buttons and keys hold all the several ends which belong to them in due order for enabling the operator to disjoin any two or more ends from their fellow-ends by an instantaneous touch, which likewise connects the ends so disjoined with either pole of the battery belonging to the keys, and vice versa, the same self-action of the keys whereby they disconnect the said ends from those poles when the buttons are released likewise rejoins those ends to their fellow ends in the set.

5. In the improvement hereinbefore described, whereby a set of combined conducting-wires, as aforesaid, having a voltaic battery and a set of buttons or finger-keys, and also

a dial with magnetic needles for giving signals, as well as an apparatus for sounding alarms at each end of the set may also have duplicates of such dials with needles and apparatus for alarms at intermediate places between the two ends, all such duplicates operating simultaneously with each other and with the two end dials and alarms to give like signals and to sound like alarms.

6. In the improvement hereinbefore described, and represented at Fig. Y, Sheet II, of the drawings hereunto annexed, for communicating determinate angular motions to magnetic needles by subjecting them to the attractive forces of occasional or temporary magnetism which is excited in soft iron by means of electric currents, for the purpose of giving signals in distant places by such determinate angular motions of needles.

7. In the improvement hereinbefore described, and represented at Fig. R, Sheet II, of the drawings hereunto annexed, for sounding alarms in distant places, either by direct application of the attractive force of occasional or temporary magnetism which is excited in soft iron by means of electric currents transmitted through metallic circuits, or else by applying the said attractive force of such occasional magnetism to let off ordinary clock-work alarms and permit them to sound by the mechanical force and action of their own mechanism.

8. In the improvement hereinbefore described, and represented at Fig. S, Sheet II, of the drawings hereunto annexed, for sounding alarms in distant places by the aid of an additional voltaic battery, (or alarm battery, which is brought into action when required for sounding the alarm, the sounding thereof being either by direct application of the attractive force of occasional magnetism or by applying such force to let off clock-work alarms, as above (seventhly) stated; but according to this, our eighth, improvement the requisite occasional magnetism is excited by an electric current derived from that additional battery, the metallic circuit by which that current is so derived from the said battery being formed (when the same is required to act) by an angular motion, then communicated to a magnetic needle which is disposed within multiplying coils of conducting wire, through which an electric current is transmitted from a distance, the said angular motion of the needle being caused to make the requisite contacts for forming the metallic circuit of the additional or alarm battery.

9. In the improvement hereinbefore described, and represented in Fig. Q, Sheet II, of the drawings hereunto annexed, for effecting the contact requisite for forming a metallic circuit by which an additional or alarm battery is brought into action for the purpose of sounding alarms in distant places, as above (eighthly) set forth, but which contact in this, our ninth, improvement is effected by means of the evolution of gas arising from the decomposition of water, which is included within a small close vessel from which the gas cannot easily escape, wherefore it presses down on the water and thereby raises up a small column of mercury from the bottom of the vessel into the open leg of an inverted siphon-tube which is connected with the vessel, so as to raise the mercury up into contact with the end of a wire in order to form the required circuit.

In witness whereof we, the said CHARLES WHEATSTONE and WILLIAM FOTHERGILL COOKE, have hereunto set our hands this 19th day of December, 1837.

C. WHEATSTONE.
WILLM. F. COOKE.

In presence of—
ROBT. WILSON,
Solicitor, 1 Copthall Buildings.
G. T. WILSON,
His Clerk.