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G. W. PICKARD.

MEANS FOR RECEIVING INTELLIGENCE COMMUNICATED BY ELECTRIC WAVES.

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Fig. 1.

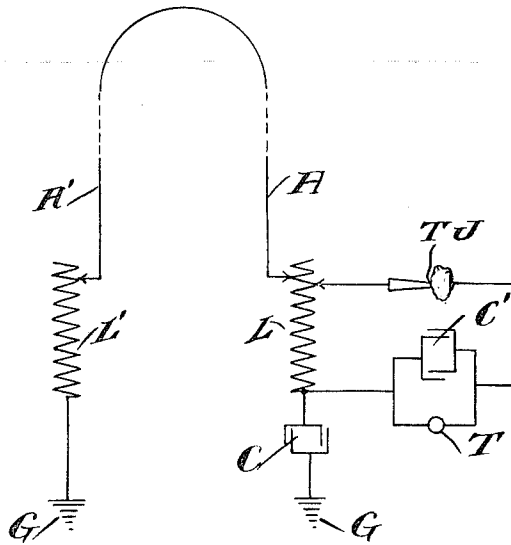


Fig. 2.

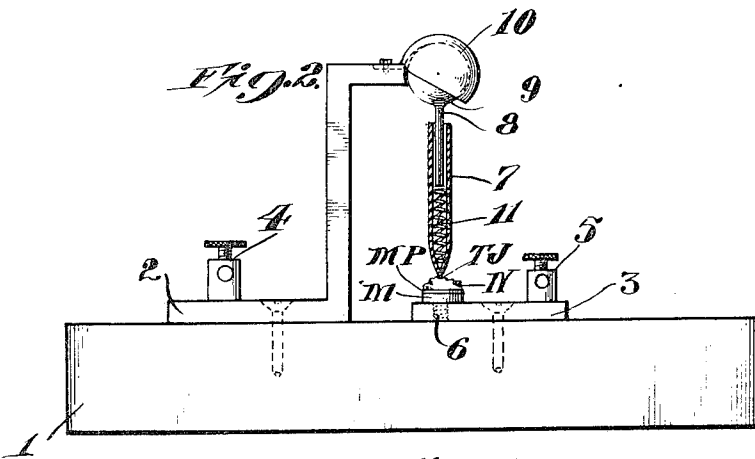
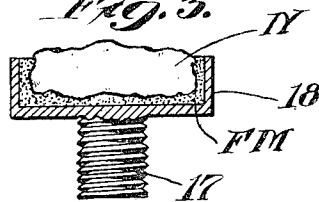


Fig. 3.



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# UNITED STATES PATENT OFFICE.

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MEANS FOR RECEIVING INTELLIGENCE COMMUNICATED BY ELECTRIC WAVES.

No. 836,531.

Specification of Letters Patent.

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*To all whom it may concern:*

Be it known that I, GREENLEAF WHITTIER PICKARD, a citizen of the United States of America, and a resident of the town of Amesbury, State of Massachusetts, have invented certain new and useful Improvements in Means for Receiving Intelligence Communicated by Electric Waves, the principles of which are set forth in the following specification and accompanying drawings, which disclose the form of the invention which I now consider to be the best of the various forms in which the principles of the invention may be embodied.

This invention relates to means for receiving intelligence communicated by electric waves.

The object of the invention is to provide a commercially-useful means for operating a device for translating the communications into intelligible form exclusively by the energy of the oscillatory current generated by the receipt of the waves.

To this end the object is to practically utilize a combination of the phenomena of the generation of heat by electrical energy at a thermo-junction and of the generation of electrical energy by the heat energy at a thermo-junction.

That these objects have been actually accomplished by this invention has been demonstrated by practical tests, consisting of the intelligible reception of communication over long distances in connection with commercially-employed wireless-telegraphy installations.

Of the drawings, Figure 1 is a diagrammatic illustration of a well-known form of wireless-telegraph receiving-station apparatus, this being the apparatus with which the invention has been actually used. Figs. 2 and 3 are a side elevation and section, respectively, of the present preferred embodiment of the detector employed in the invention in its present most efficient form, Fig. 3 being a slightly-modified form.

In Fig. 1 the general arrangement is the well-known loop form of wave-interceptor A A', operatively provided with the usual adjustable capacity C, inductance L, adjustable in both the wave-interceptor and oscillation-receiving circuits, the inductance L', adjustable in the wave-interceptor circuit, and the connections of the latter circuit to ground at G.

In Fig. 1 the circuit L, T J, C', T receives the oscillations generated in the wave-intercepting loop, the inductance L being adjustable in the oscillation-circuit, which is well adapted for use with the thermo-couple detector, as it includes the adjustable condenser C' and the device T in shunt to this condenser. The device T is preferably a telephone-receiver and may be any other form of device, such as a sensitive galvanometer, which will indicate an abrupt flow of direct current. The detector should in use be maintained in good electrical connection in the oscillation-circuit, and the thermo-junction T J should also be a good electrical contact. The lead to the shunt-connected condenser C' and the telephone T is taken from the lower end of the inductance L, so that the telephone and its parallel-connected condenser are in series between the detector and a part of the inductance L, which is of lower potential with respect to the ground, the advantage of this arrangement of receiving means being that it obviates the establishment of a deleterious local condenser action which would otherwise take place in the leads to and the windings of the indicating device if connected in a circuit through the detector.

A further advantage of the arrangement is that the proximity to the human body of the telephone or other indicating device does not affect the tune of the circuit, and it does not form a deleterious shunt-path to ground through the human body, owing to the fact that the potential of the circuit between the detector and the lower inductance connection is during the receipt of the oscillations and with respect to them of the same potential as that of the earth.

The detector, roughly indicated at T J in Fig. 1, is shown in detail in Fig. 2. 1 is a wooden base to which are secured an angular metal support 2 and a metal plate 3, provided with binding-posts 4 5 for the leads of the oscillating circuit of Fig. 1. One element of the detector is the chuck, which is removably screwed into the plate 3 by the part 6. This chuck consists of a piece of metal M, to which is soldered a metallic plating M P, such as copper or silver, which plating is deposited on the material N in order to minimize the generation of thermo-electromotive force between the material and the metal M by providing a large area of surface contact between them with respect to the area of the

junction T J of Fig. 1. The deposition may be by electroplating or by fusing a layer of the material N upon a metallic surface, or otherwise, and, as shown in Fig. 3, it is sufficient to place the material N in a liquefied mass of fusible metal F M in a chuck-cup 18, provided with a screw 17, so that when the metal F M cools and solidifies the material N will be firmly embedded in and in good electrical contact with the metal F M.

The operative thermo-junction (T J of Fig. 1) is located at the lower end of the hollow metallic sleeve 7 of Fig. 2, which junction is of less surface area with the material N than at the surface M P. This sleeve slides along the metallic projection 8, depending from the metallic ball 9, the ball forming a ball-and-socket universal joint with the part 10, of thin metal, which is stamped to shape and secured to the metallic support 2 so as to complete the circuit.

The sleeve member 7 of the thermo-junction may be of any suitable metal which is a good conductor of electricity. The other member N of the thermo-junction should have a high thermo-electromotive force and a high electrical resistance in order to concentrate as much as possible of the energy of the received oscillations, in the form of Joulean heat, at the point at which the heat energy is converted into an electric current by reason of the different physical characteristics of the two elements forming the thermo-couple. The member N should have a high thermo-electromotive force in order to obtain the maximum percentage of regenerated energy. The thermo-junction between the members N and 7 should be a good electrical contact, and this is secured by the spring 11, which presses the sleeve-contact against the member N. This should be a good electrical contact in order to permit the energy of the received oscillations to have ready access to the thermo-junction and to exclude all varying-resistance action of a loose contact or coherer nature which if it occurred would offer serious opposition to the electromotive forces set up by the received oscillations, and thereby prevent the flow of the feeble oscillatory currents which if not so opposed operatively heat the thermo-junction, to generate a thermo-electromotive force to cause the loud clear click in the telephone.

The member 7 of the thermo-couple is metallic; but the best results so far have been had with the member N of a non-metallic natural element, such as silicon, which possesses in a high degree the desired properties of high electrical resistance and high thermo-electromotive force. It appears to be most useful either in the massive amorphous or graphitic solid form. This material may be used commercially when pressed into good electrical contact between two good conductors, such as copper, irrespective of the apparent rela-

tive surface areas; but this is not the most sensitive form, because two operative thermo-junctions are formed, one at each contact of the material with the two conductors. The combined thermo-electromotive forces at these two junctions act in opposition to each other with respect to the telephone and if the two junctions are of equal resistance the oscillations will cause the same temperature rise in each junction, and consequently the same thermo-electromotive force will be generated at each junction, but of opposite signs, resulting in a complete annulment of any useful action. In practice, however, it is impossible to obtain equal resistance at each junction by connecting the simple material between two conductors in the circuit, and hence the amount of heat generated will always be so much greater at one junction that there will exist a sufficient preponderance of thermo-electromotive force of one sign to operate the sensitive indicating device T of Fig. 1. However, by providing a relatively very large area of surface contact at the junction which it is desired to make of lower resistance, as by the metal plating or embedding in Figs. 2 and 3, it is possible to obtain nearly all the thermo-electromotive force as of one sign, and this is the preferred embodiment of the invention.

In order to obtain the best results, the above specification should be carefully followed. In such case the operation is wholly as follows: The energy of the received oscillations is converted into heat at the high-resistance junction of the element having high thermo-electromotive force with the low resistance or metallic element, the amount of heat and consequent temperature rise being proportional to the square of the current and the resistance, according to the well-known law of Joule. This heat energy is then, according to this invention, regenerated or converted into a direct electric current. So far I have been able to convert upward of ten per cent. of the energy of the oscillations into direct-current energy. The device is therefore an electrical converter or rectifier, and inasmuch as the potential of the regenerated direct current is different from that of the oscillations it is an electrical transformer. I have termed it a "thermo-electric-regenerative detector" because the energy is in the form of heat at an intermediate stage. In the preferred form of the invention the thermo-electric action is of extraordinary vigor, as is indicated by the fact that the only energy employed to commercially operate the telephone T is that of the received oscillations. All resistance-varying action should be reduced to a minimum, because, so far as it may be permitted to exist, it is in the direction of an increase which involves a reduction in the heat generated and a consequent reduction in the generated thermo-electro-

motive force and the useful effect of the latter upon the telephone. If any resistance-varying action be present in any embodiment of the invention, it will, however, have no other effect except to decrease the useful thermo-electric action, because it cannot alone operate an indicating device and because no auxiliary source of electromotive force can be used which it might vary to operate the telephone. Trials have demonstrated that the use of an auxiliary source of electromotive force with this detector results in an annulment of all effect of the energy of the oscillations upon the telephone—that is, an annulment of the thermo-electric action—and that any resistance variation which might take place was inoperative, as to the auxiliary source, to produce an indication in the telephone.

The remarkable fact that the telephone can be operated in a commercial manner solely by the converted energy of the received oscillations is explained by the statement that that feeble energy which is received at the ordinary commercial wireless-telegraph station is amply sufficient to operate a sensitive receiving instrument, provided that the translation of this energy into the form of a direct current is efficiently accomplished. It is of course necessary in commercial work to effect this conversion, because there is no known indicating means which can be sensibly affected by the received energy of commercial long-distance wireless telegraphy when in the form of high-frequency oscillations, notwithstanding the fact that a sensitive telephone may, as an experimental feat, be slightly affected by the oscillations emitted from a near-by or very powerful sending station.

The energy required to commercially operate a telephone—that is, to produce in it a clearly-defined dot, in, for example, the Morse code—is approximately one-millionth ( $1 \times 10^{-6}$ ) erg. The energy received by the average long-distance commercial wireless-telegraph station is of the order of magnitude of one-thousandth of an erg per dot. The efficiency of the apparatus of this invention, as demonstrated by trial under commercial conditions, is upward of ten per cent. There is thus ample margin for commercial operativeness for the least sensitive form of this invention in the case of the present longest-distance wireless telegraphy.

The speed of reception with this invention is unlimited, since it is not only self-restoring to its sensitive state, but this restoration is practically instantaneous, because the small quantity of heat which is generated by the received oscillations comprising a signal is rapidly conducted away, partly by thermal conduction, to the metal portion of the couple and the remainder by the regeneration into an electric current, which finally expends its energy in the indicating device.

The advantages of the new detector are as follows: It fulfils all requirements of commercial wireless telegraphy as to sensitiveness, speed, stability, and freedom from delicate adjustments. I have found that the continued sensitiveness of the detector is in no wise impaired by severe static discharges. It is also simple and cheap in construction. It is not affected by changes in atmospheric temperature or humidity. Its sensitiveness so far has not been impaired by continuous and continued use. It has no limited number of operative contact-points, as in the case of crystalline masses, which operate by the variation of resistance due to a heating of a small part of the masses. Any portion of any one of the classes of material having high thermo-electromotive force and high electrical resistance, included within this invention, makes an operative thermo-junction with a metallic conductor if held in good electrical contact therewith. This invention requires no auxiliary source of heat, as has been necessary with previous converters designed for high-frequency oscillations.

It is an important, practical, as well as economical advantage of this invention that it essentially dispenses with auxiliary sources of energy in that such sources, such as batteries and the requisite accompanying potentiometers, are expensive in initial cost and in maintenance for operation and repairs and require frequent replacement. There is apparently no limit to the operative life of the detectors included in this invention.

I claim—

As an element of a means for receiving intelligence communicated by electric waves, the substance silicon, substantially as and for the purpose described.

GREENLEAF WHITTIER PICKARD.

Witnesses:

SAMUEL HUBBARD MANSFIELD,  
HENRY AZOR WENTWORTH.