No. 767,981. PATENTED AUG. 16, 1904.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED NOV. 25, 1903.

NO MODEL.

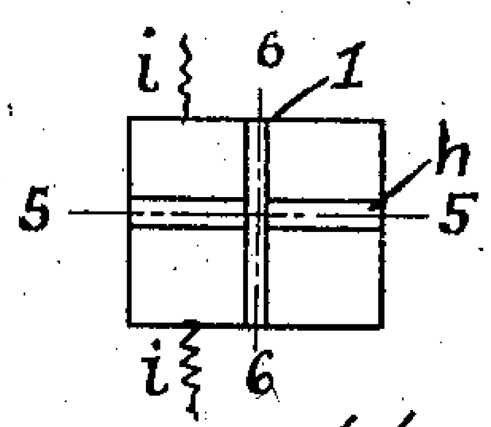

Fig-4-

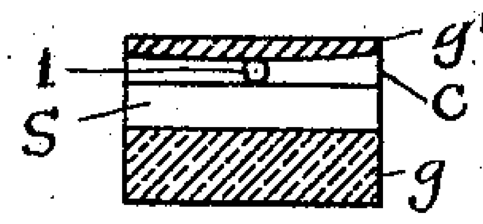

Fig-5-

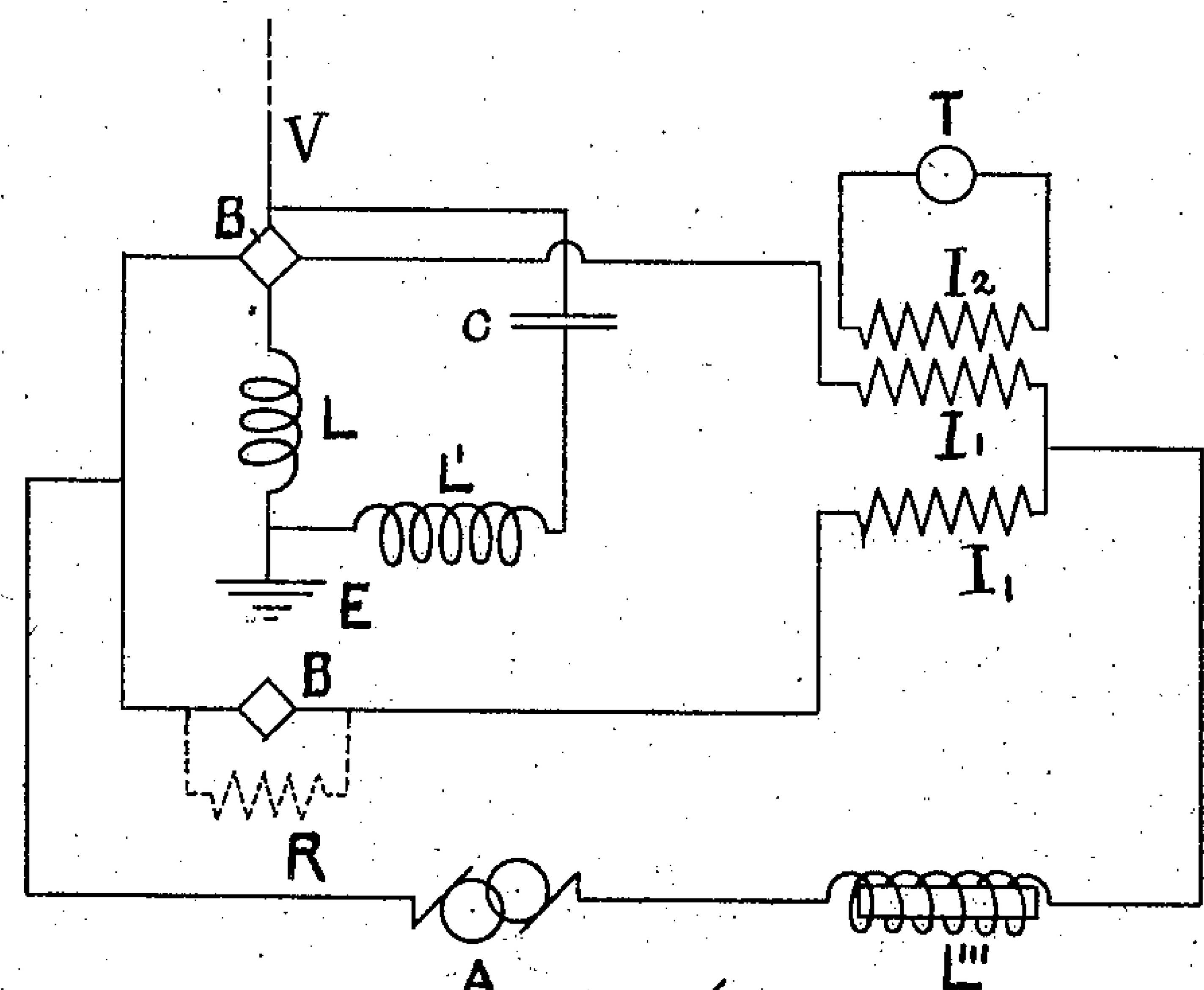

Fig-1-

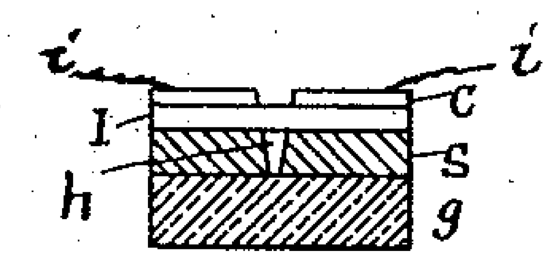

Fig-6-

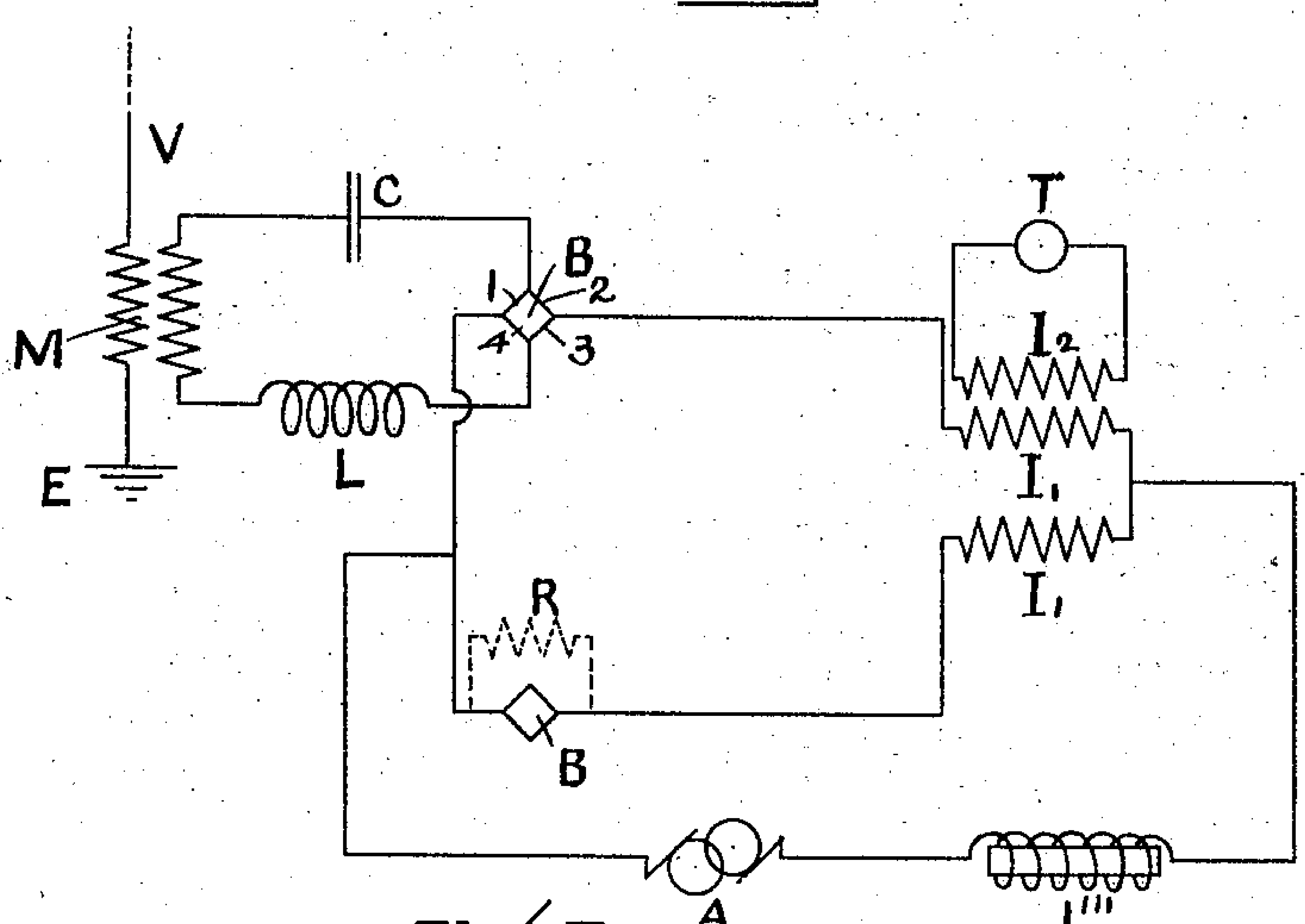

Fig-2-

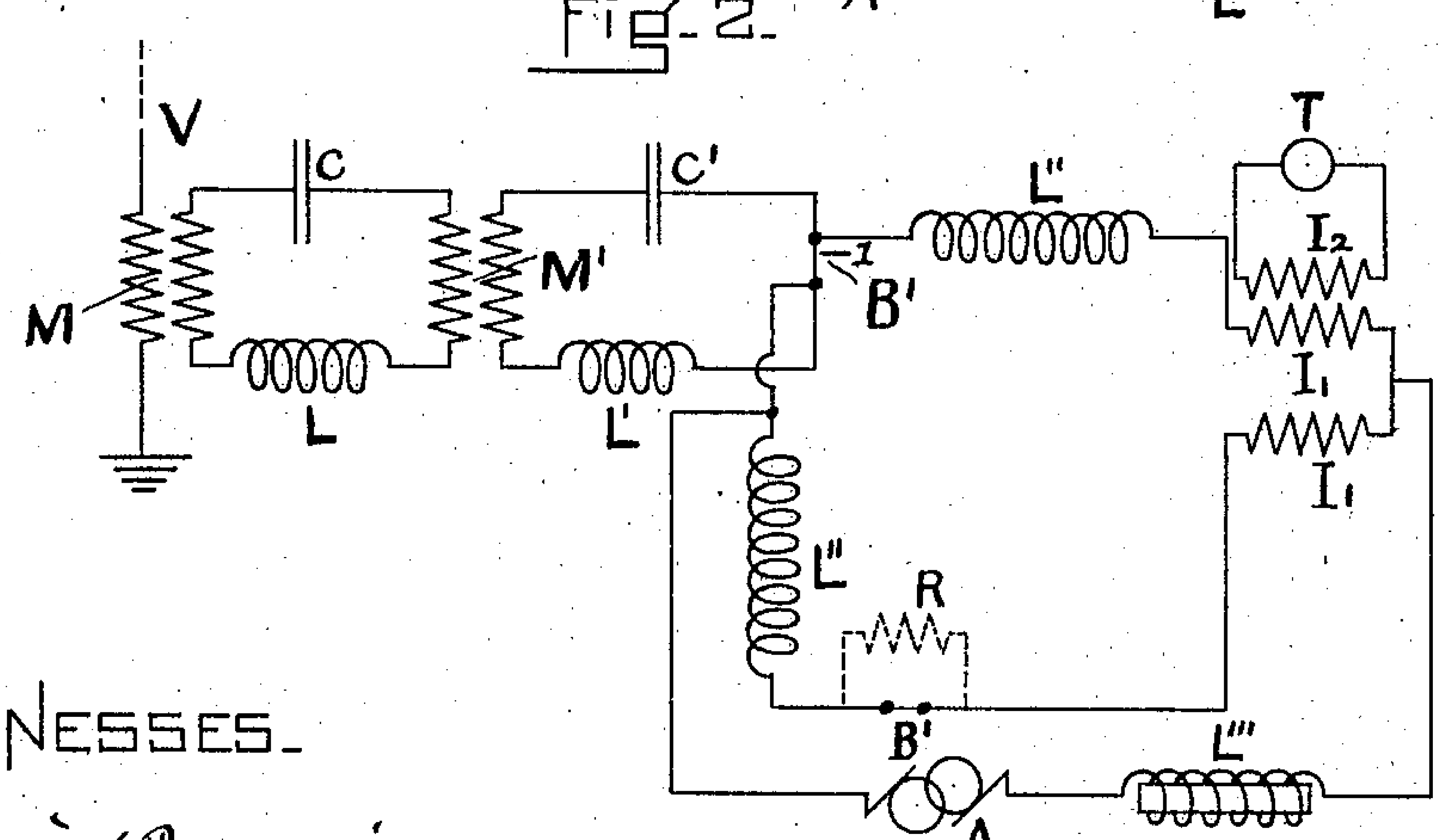

Fig-3-

WITNESSES-

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No. 767,981. Patented August 16, 1904.

UNITED STATES PATENT OFFICE.

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SPACE TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 767,981, dated August 16, 1904.

Application filed November 25, 1903. Serial No. 182,628. (No model.)

To all whom it may concern:

Be it known that I, JOHN STONE STONE, a citizen of the United States, and a resident of Cambridge, in the county of Middlesex and State of Massachusetts, have invented a certain new and useful Improvement in Space Telegraphy, of which the following is a specification.

This invention relates to space or wireless telegraphy by electromagnetic waves in the form of electroradiant energy; and it more particularly relates to electroreceptive or electric translating devices adapted to utilize in their operation the dissipative energy of the electrical oscillations or oscillatory electric currents developed by electromagnetic waves in the circuits in which they are included. Electroreceptive devices of such character have long been known for detecting and measuring the energy of electromagnetic waves, and they are generally known as "bolometers." In my application Serial No. 119,211 I have described the application of such electroreceptive devices to selective electric signaling and have therein pointed out that in order to be sensitive and rapidly responsive to changes in thermal condition the fine wires or strips of such bolometers should be of small thermal time constant compared with the thermal time constant of the bolometers heretofore used and that in order to be of small thermal time constant the fine wires or strips should have small mass, (*i. e.*, they should be of short length and small section,) low specific heat, and imperfect heat insulation. I have also pointed out that for greater efficiency the bolometer wires or strips should be of high-resistance temperature coefficient and of high specific resistance. I have also shown that as the oscillatory currents developed in the receiving-conductors of space-telegraph systems are of small amplitude it is necessary to employ some means whereby the currents developed in the receiving system by electromagnetic waves may be amplified in order that an appreciable amount of energy may be dissipated in the bolometer wires or strips without making the latter of excessively high resistance. For amplifying the currents developed in the receiving system by electromagnetic waves of a definite predetermined frequency I employ a resonant circuit or a group of resonant circuits attuned to such frequency. The resonant circuits strongly oppose the development therein of currents of frequencies different from that to which they are tuned, so that by means of such resonant circuits the bolometer fine wires or strips are protected from extraneous electrical forces which might otherwise destroy them.

The reason the bolometer strip or wire is preferably made of a material having a high specific resistance is to obtain the smallest possible mass with wires or strips of a given resistance. Although the specific resistance of the material of which the wire or strip is preferably constructed should be high, the actual resistance of the wire or strip itself should be low, so as not to mask the resonant rise of current in the resonant circuit in which the wire or strip is included, as I have pointed out in my prior patents in which other forms of receivers or wave-detectors are employed and in which I have shown that the selectivity of a resonant circuit varies inversely as the resistance of such circuit and is, in fact, equal to $\sqrt{\frac{L}{C R^2}}$.

By employing a resonant circuit it is possible to use bolometer wires or strips of much larger mass than it would otherwise be possible to use in order to effect the dissipation of a given amount of energy in said wires or strips. It is not possible to lay down any specific rule concerning the mass or geometric constants of the bolometer wire or strip, as such mass must be determined by the amount of energy radiated in the form of electromagnetic waves and by the distance over which transmission is to take place and as it must also be determined in a way by the locality in which the receiving-station is placed—*i. e.*, if the receiving-station is placed in a locality free from electromagnetic disturbances—the wire or strip may be of smaller mass than if it be placed in a locality subject to frequent and violent electrical disturbances. By having regard to the electrical conditions surrounding the proposed receiving-station in designing the bolometer wire or strip the safety of the latter may be better insured, although it follows in a general way that more energy must be employed to transmit signals over a given distance when the bolometer wire or strip is required by the electrical characteristics of the locus of the receiving-station to be of larger mass than if the wire or strip is made of the minimum possible mass, and therefore of the maximum sensitiveness.

Dr. Wollaston has described a method for producing wire of excessively small diameter, which method consists in incasing a fine platinum wire in silver, reducing the composite wire so formed, and then dissolving away the silver casing with warm nitrous acid. In this way wire of diameter as small as one fifty-thousandth of an inch was produced, as fully set forth on page 615 of the *Encyclopedia Britannica*, 9th edition, Vol. XXIV, published by Little, Brown & Co., Boston, 1888, in an article entitled "Wire," to which all those wishing to practice my invention are referred for further details concerning the manufacture of wire suitable for use in the bolometer described herein, although such wire has long been in commercial use and may be obtained and, in fact, is usually obtained before the silver casing has been removed. The manufacture of such wire is also described in a publication entitled *A Treatise upon Wire*, by J. Bucknall Smith, published by John Wiley & Sons, New York, 1891, page 10, and it was first described by Dr. Wollaston in the *Philosophical Transactions of the Royal Society of London*, 1813, Vol. 103, part I, page 114. Such wire so produced may be employed in the system herein described, and I also recommend the employment of a bolometer-strip produced as follows: A sheet of gold-leaf, which may be one micron in thickness or greater, is cast in a block of paraffin and sliced by a microtome into strips of any desired width, which may be as small as one micron in width, after the manner in which stained sections well known in microscopic biology are produced. In lieu of the gold-leaf of commerce I may deposit gold electrolytically on a conducting backing, dissolve away the backing, and treat the resulting gold-leaf as above explained. The strips of gold-leaf produced by either process or a short length of platinum wire produced by the Wollaston process may be mounted for use in a bolometer in the following manner, so that a very small length of the strip or wire is operative as a source of resistance in the resonant circuit: On a perfectly plane glass plate deposit a silver film in the manner now well known, and upon this film of silver electrolytically deposit a much thicker film of some softer metal, as gold, copper, &c. The thickness of this second film is several times the thickness of the bolometer wire or strip. The surface so produced may be polished or burnished. Across the surface so produced a line should be scratched by an extremely fine-edged engraving instrument, dividing the surface into two parts electrically insulated from one another by the line so scratched, as shown by connecting the two surfaces to a battery and a highly-sensitive galvanometer. Across this scratch the bolometer wire or strip should be laid so as to form an electrical connection between the two separated metal films, when a slightly convex surface of glass is pressed down on said strip or surface. The bolometer as now mounted is ready for use, the connections being made with the two metallic surfaces as terminals. The device is preferably maintained in an atmosphere of hydrogen or nitrogen or other gas which will not support combustion of the material of the bolometer strip or wire, said gas being preferably maintained at as low a temperature as practicable. By so maintaining the gas at such low temperature I can control a greater amount of current by a given change of resistance in the bolometer strip or wire, and so have a greater amount of energy available for the operation of the signal-indicating device. In order to maintain the balance of the Wheatstone's bridge or induction-balance in which the bolometer is included, it is preferred to maintain this low temperature constant.

In the drawings which accompany and form a part of this specification, Figures 1, 2, and 3 illustrate in diagram arrangements of circuits and apparatus at a space-telegraph receiving-station. Fig. 4 is a plan view of the bolometer with the upper slightly convex glass plate removed. Fig. 5 is a section taken on lines 5 5 of Fig. 4. Fig. 6 is a section taken on lines 6 6 of Fig. 4.

V is an elevated conductor. M M′ are transformers, preferably step-down transformers. C C′ are condensers. L L′ are inductances. L″ L″ are choking-coils. L‴ is an impedance. I′ I′ constitute the primary, and I^2 the secondary, windings of the induction-balance. T is a telephone or other signal-indicating device. B is a bolometer consisting of four wires or strips 1, 2, 3, and 4 of equal resistance. B′ is a bolometer consisting of a single wire or strip 1. A is a source of rapidly-varying current, which may consist of an electrically-actuated tuning-fork carrying permanent magnets, the movement of which tuning-fork creates a rapidly-varying electromotive force in an associated circuit.

Referring to Figs. 4, 5, and 6, *g* represents a perfectly plane glass plate upon which a layer of silver *s* is electrolytically deposited, and *c* represents a somewhat thicker layer of softer metal, such as gold or copper, deposited on said layer of silver. *h* represents the scratch produced by a very fine-edged engraving instrument across the aforesaid films. 1 represents the bolometer strip or wire connecting the two sections of the deposited metallic films. g' represents the slightly convex plate of glass placed above the bolometer wire or strip 1, whereby the latter is caused to sink into the soft-metal film *c* in order to make perfect electrical contact therewith. *i i* are the leads connected to the upper film *c*, whereby the bolometer may be included in the resonant circuit.

It is preferred to balance the induction-balance in which the bolometer is included by including in one arm thereof a resistance R equal to the resistance of the bolometer B or B′ included in the other arm of said balance, as indicated in dotted lines in Figs. 1, 2, and 3, although, as indicated, a bolometer identical with that in the resonant circuit may be used to balance the induction-balance. It is preferred to employ an impedance L‴ in the circuit of the source A.

The operation of the system is as follows: Electrical oscillations developed in the elevated conductor V by electromagnetic signal-waves the energy of which is to be received are conveyed to the closed resonant circuit C L′ L B, C M L B, or C M L M′ in Figs. 1, 2, and 3, respectively, said resonant circuits operating to greatly increase the amplitude of the oscillations, as I have pointed out in my prior patents. In Figs. 1 and 2 the electrical oscillations so amplified increase the temperature, and therefore the resistance of the bolometer wires or strips, and this increase of resistance unbalances the induction-balance and effects the indication of a signal in the telephone or other signal-indicating device T.

In Fig. 3 the electrical oscillations or currents developed in the resonant circuit C M L M′ are translated to the resonant circuit C′ M′ L′ B′, attuned to the same frequency as the circuit C M L M′, in which said currents operate to increase the resistance of the bolometer strip or wire B′, with the result that an indication is produced in the device T, due to the unbalancing of the induction-balance.

In the system shown in Fig. 2 the electrical oscillations developed by electromagnetic waves in the elevated conductor V are inductively reproduced at increased current in the resonant circuit C M L B by means of the step-down transformer M, and in the system shown in Fig. 3 the electrical oscillations inductively reproduced at increased current in the resonant circuit C M L M′ by means of the step-down transformer M are inductively reproduced at still further increased current in the second resonant circuit C′ M′ L′ B′ by means of the second step-down transformer M′.

It will be observed that the arrangement of the bolometer strips or wires in Figs. 1 and 2 is such as to prevent the electric oscillations developed in the resonant circuits from taking any path other than through the bolometer strips, because said strips constitute a balanced Wheatstone bridge, at the equipotential points of which the connections to the induction-balance are made.

In Fig. 3, which shows another embodiment of my invention in which the wire or strip is employed, some means must be used to prevent the shunting of the electrical oscillations developed in the circuit M′ L′ B′ C′ around the bolometer wire or strip B′ by way of the induction-balance. For this purpose I employ specially-designed inductance-coils L″ L″, placed in each of the arms of the induction-balance. These inductance or choking coils are wound so as to have the greatest possible inductance with the least possible electrostatic capacity. For this purpose the windings of said coils are separated and cores of finely-divided soft iron of the best magnetic quality, preferably cast in a dielectric matrix, are used. Heretofore in designing choking-coils a number of turns of fine insulated wire have been wound closely together upon an iron core, so that although such coil has a certain amount of inductance it usually behaves more like a condenser than like a coil having fixed resistance and inductance and no capacity. For this reason excessive displacement-currents are developed between the windings of such coils, and a large portion of the energy of the high-frequency electrical oscillations is shunted around the receiver by way of said choking-coils instead of being confined to the circuit containing the receiver.

With an inductance or choking coil designed as hereinbefore set forth the energy of the electrical oscillations in the resonant circuit containing the bolometer B′ is practically entirely confined to said resonant circuit and that portion of this energy which is shunted around said bolometer by way of the induction-balance is practically rendered *nil*. Such a choking-coil is not limited in its use to the system herein described, but may be effectively employed wherever a choking-coil is required—as, for example, between a coherer and its local circuit.

I claim—

1. In a system of space telegraphy, an elevated conductor, a closed resonant circuit, inductively associated therewith and attuned to the frequency of the electromagnetic waves the energy of which is to be received, and an electroreceptive device included in said resonant circuit and adapted to utilize in its operation the dissipative energy of the electrical oscillations developed in said resonant circuit.

2. In a system of space telegraphy, a choking-coil consisting of a finely-divided iron core and a number of separated convolutions of wire wound thereon, whereby the inductance of the coil is made a maximum and its electrostatic capacity is made a minimum.

3. A receiver for space-telegraph signals comprising a bolometer wire or strip of small

cross-section and low resistance, bridged across a narrow gap separating two metallic masses.

4. A receiver for space-telegraph signals comprising a bolometer wire or strip of small thermal time constant bridged across a narrow gap separating two metallic masses.

5. A receiver for space-telegraph signals comprising a bolometer wire or strip of small thermal time constant imposed upon two metallic masses separated by a narrow gap and forming an electrical connection between said metallic masses.

6. A receiver for space-telegraph signals comprising a bolometer surrounded by an atmosphere maintained at a low temperature by artificial means.

7. A receiver for space-telegraph signals comprising a bolometer surrounded by an atmosphere maintained at a constant low temperature by artificial means.

8. A receiver for space-telegraph signals comprising a bolometer surrounded by an atmosphere of inert gas.

9. A receiver for space-telegraph signals comprising a bolometer surrounded by an atmosphere of inert gas maintained at a low temperature by artificial means.

10. In a system of space telegraphy, an elevated receiving-conductor, a circuit, attuned by capacity and inductance to be more responsive to electromagnetic waves of one frequency than to like waves of different frequencies, inductively associated with said conductor, and an electroreceptive device included in said circuit and adapted to utilize in its operation the dissipative energy of the electrical oscillations developed therein.

11. In a system of space telegraphy, an elevated receiving-conductor, a resonant circuit inductively associated with said conductor and attuned to the frequency of the waves the energy of which is to be received, means for swamping the effect of the mutual inductance between the elevated conductor and the resonant circuit and a bolometer fine wire or strip included in said resonant circuit.

12. In a system of space telegraphy, an elevated receiving-conductor, a resonant circuit inductively associated with said conductor by means of a step-down transformer and attuned to the frequency of the waves the energy of which is to be received, and a bolometer fine wire or strip included in said resonant circuit.

13. In a system of space telegraphy, an elevated receiving-conductor, a circuit, attuned by capacity and inductance to be more responsive to electromagnetic waves of one frequency than to like waves of different frequencies, inductively associated with said conductor by means of a step-down transformer, and an electroreceptive device included in said circuit and adapted to utilize in its operation the dissipative energy of the electrical oscillations developed therein.

14. In a system of space telegraphy, an elevated receiving-conductor, an electroreceptive device adapted to utilize in its operation the dissipative energy of the electrical oscillations developed in the circuit in which it is included, and a plurality of resonant circuits, connected inductively in series by means of step-down transformers, interposed between said elevated conductor and said electroreceptive device, said resonant circuits being attuned to the frequency of the waves the energy of which is to be received.

15. In a system of space telegraphy, an elevated receiving-conductor serially connected with the primary winding of a step-down transformer, a resonant circuit including the secondary winding of said transformer and also including the primary winding of a second step-down transformer, and a second resonant circuit including the secondary winding of said second step-down transformer and also including an electroreceptive device adapted to utilize in its operation the dissipative energy of the electrical oscillations developed in said second resonant circuit, said resonant circuits being attuned to the frequency of the waves the energy of which is to be received.

16. In a system of space telegraphy, an elevated receiving-conductor, an electroreceptive device adapted to utilize in its operation the dissipative energy of electrical oscillations developed in the circuit in which it is included, and means for conveying the electrical oscillations created by electromagnetic waves in said elevated conductor to said electroreceptive device at increased current.

17. In a system of space telegraphy, an elevated receiving-conductor, an electroreceptive device adapted to utilize in its operation the dissipative energy of the electrical oscillations developed in the circuit in which it is included, and a resonant circuit or a group of resonant circuits interposed between said elevated conductor and said electroreceptive device, said resonant circuits being attuned to the frequency of the waves the energy of which is to be received.

18. In a system of space telegraphy, an elevated receiving-conductor, a resonant circuit inductively associated with said elevated conductor and attuned to the frequency of the waves the energy of which is to be received, and an electroreceptive device included in said resonant circuit and comprising a bolometer fine wire or strip surrounded by an atmosphere of inert gas maintained at a constant low temperature by artificial means.

In testimony whereof I have hereunto subscribed my name this 24th day of November, 1903.

JOHN STONE STONE.

Witnesses:
G. A. HIGGINS,
BRAINERD T. JUDKINS.