(No Model.) 2 Sheets—Sheet 1.

A. MUIRHEAD.

SUBMARINE DUPLEX TELEGRAPH.

No. 327,097. Patented Sept. 29, 1885.

Fig. 1.

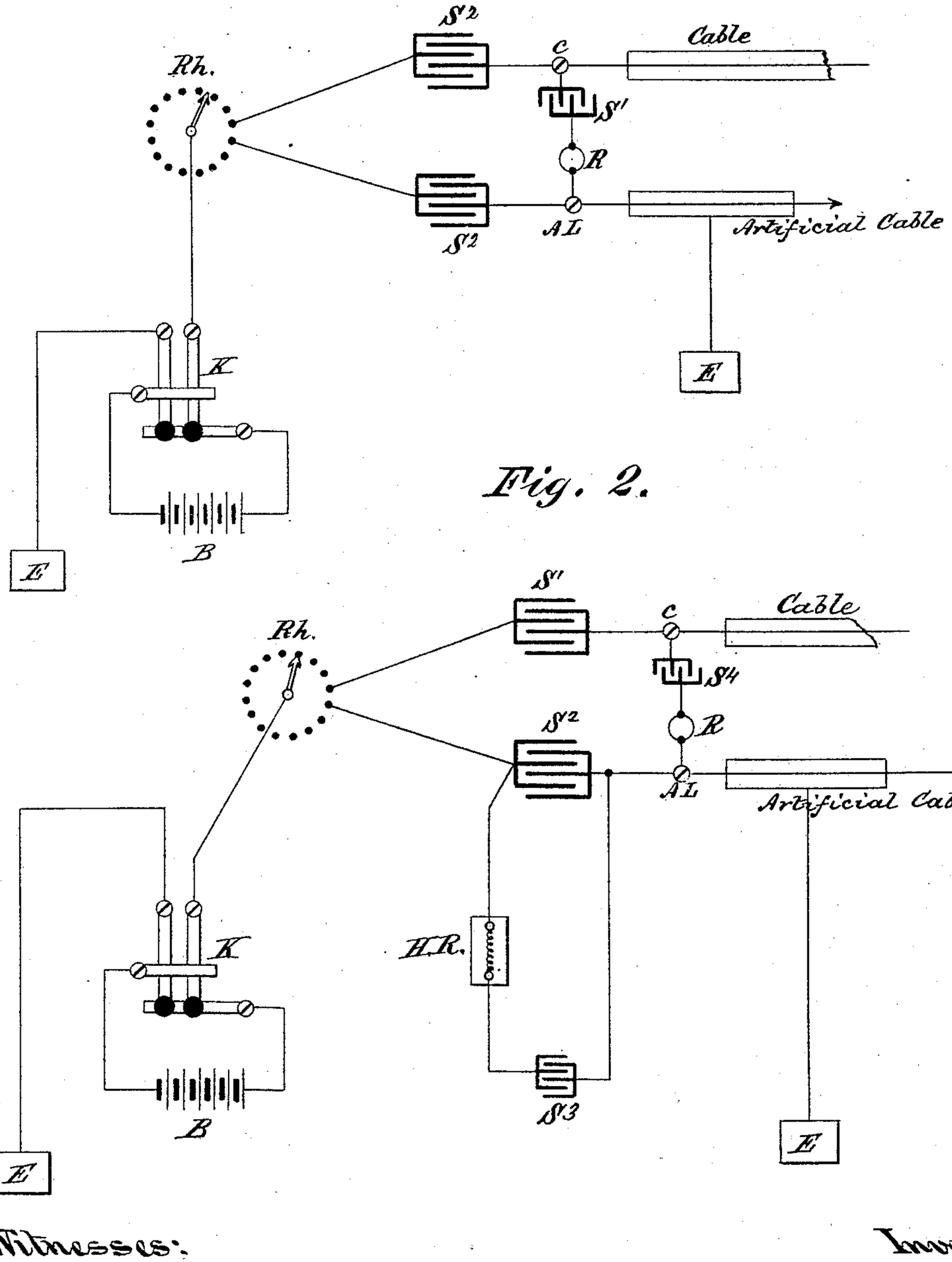


Fig. 2.

Witnesses:
E. F. Rice Jr.
J. Muirhead.

Inventor:
Alexander Muirhead
by Cary & Whitridge
his Attorneys.

N. PETERS, Photo-Lithographer, Washington, D. C.

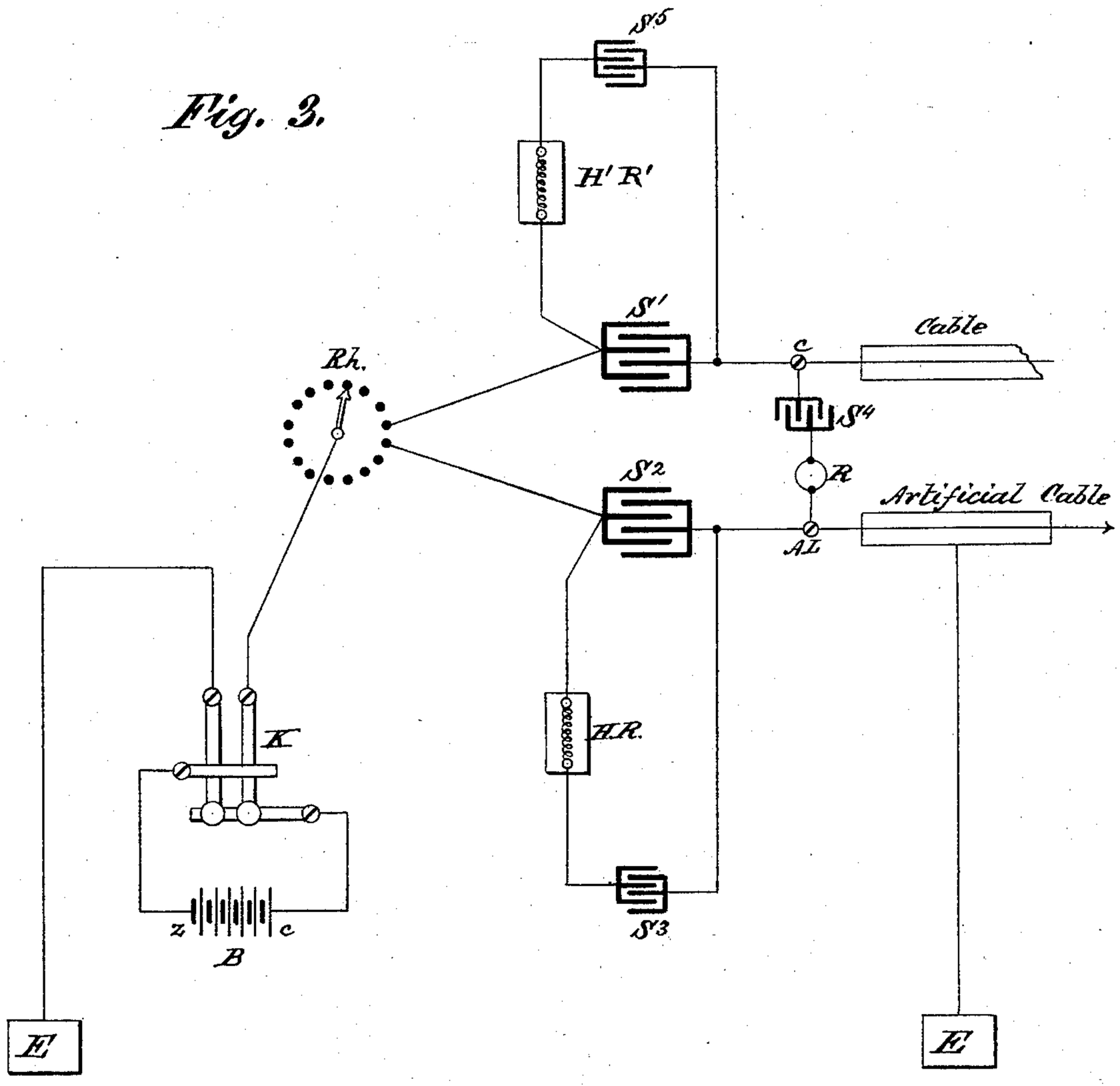
(No Model.) 2 Sheets—Sheet 2.

A. MUIRHEAD.

SUBMARINE DUPLEX TELEGRAPH.

No. 327,097. Patented Sept. 29, 1885.

Fig. 3.



Witnesses:
E. J. Rice Jr.
Millard Parker Butler

Inventor:
Alexander Muirhead
by his attorneys
Cary & Whittridge

N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

ALEXANDER MUIRHEAD, OF NORWOOD, COUNTY OF SURREY, ENGLAND.

SUBMARINE DUPLEX TELEGRAPH.

SPECIFICATION forming part of Letters Patent No. 327,097, dated September 29, 1885.

Application filed December 18, 1884. (No model.)

To all whom it may concern:

Be it known that I, ALEXANDER MUIRHEAD, a subject of the Queen of Great Britain, residing at Norwood, in the county of Surrey, in the Kingdom of England, have invented certain new and useful Improvements in Duplex Telegraphy, of which the following is a specification.

My invention relates to duplex telegraphs; and the object of the same is to effect greater and better results from the duplex working of long submarine cables on systems such as that known as the "Muirhead double-block system," as described in Letters Patent of the United States No. 234.490, granted to me on the 16th day of November, 1880, or on any other analogous system of working.

In the accompanying drawings, Figure 1 is a diagram showing the improved arrangement of apparatus for carrying out the invention described in the above Letters Patent, and is substantially a reproduction of Fig. 3 of the drawings accompanying the same; and Fig. 2 is a diagram showing the arrangement and modification of that apparatus for carrying out the present invention. Fig. 3 shows the application of the present invention to both sides of the differential circuit.

In Fig. 1 of the drawings, S' and S^2 are the two sets of condensers, placed, respectively, between the key K and the cable C and the key and the artificial cable A L.

As has been stated in the specification forming a part of said Letters Patent No. 234,490, it has been found practicable to establish and maintain a balance without using bridge-wires, by adjusting the capacity of the condensers S^2 S^2 relatively to each other; but I have since discovered that on very long cables, such as those recently laid between Canso, Nova Scotia, and Waterville, Ireland, (the Bennett-Mackay cables,) it is insufficient and extremely difficult to effect and maintain in practice an exact balance by merely having the condensers S^2 S^2 (sending-condensers) adjusted for capacity. In order to effect a balance sufficiently exact for the purpose of obtaining the greatest possible speed of working, it is necessary not only that the capacity of the condenser S^2, placed between the key K and submarine cable C, should be of the required ratio to that of the condenser S^2 between the key K and the artificial cable A L, but also that their times of charging and discharging should be the same.

As it is practically impossible to construct or build up a number of sets of large condensers even out of exactly the same materials, so that their rates of absorption of charge shall be the same throughout, I resort to the following device, which is the subject of this invention, and which is illustrated in Fig. 2.

The condensers S' S^2 in Fig. 2 correspond with those marked S^2 S^2 in Fig. 1 of the drawings of Letters Patent No. 234.490. A rheostat, R*h*, of low resistance, adjustable to varying resistances, is interposed between the signaling-key K and the condensers S' and S^2. The cable C and the artificial cable A L are connected with these condensers in the manner shown, and a condenser, S^4, and receiving-instrument R are inserted in the circuit between the real and artificial cables.

B represents the battery, and E the earth.

To one of the two condensers, preferably to the smaller of the two—say S^2—I attach another and supplementary condenser. S^3, which is subdivided into small parts, and I insert between one terminal of it and one terminal of S^2 a set of resistance coils (marked H R in the diagram) of high resistance—say of one thousand to one hundred thousand ohms—and I connect the other terminal of S^3 by a simple wire with the corresponding terminal of S^2, as shown.

In effecting the balance the artificial cable A L is first of all made electrically equal to the cable C. The condensers S' and S^2 are then inserted and their capacities adjusted by means of the subdivided condenser S^3. After obtaining in this way the nearest balance, a slight increase is made in the capacity of S^3—say by one microfarad—and by trials the amount of resistance required in the resistance-coils H R is ascertained. This produces a flow of charge in the circuit of S^2 and S^3 together equal to that flowing into the condenser S'.

By way of illustrating and explaining my improved method of duplex balancing, I give the conditions required in balancing one of the above-mentioned "Mackay-Bennett" cables, which are as follows: On the northerly

of the two main cables S′ is equal to one hundred and twenty microfarads, S^2 to one hundred and twenty microfarads, S^3 to fifteen one-hundredths of a microfarad, and the resistance-coils H R to one hundred thousand ohms. In this case the combination of the small capacity in S^3 with the resistance of the coils H R produces a flow of charge of slower rate, which superposed upon that of the condenser S^2 produces the same effect as the charging and discharging of the condenser S′.

Under certain conditions it has been found desirable to provide for an additional adjustment through the condenser S′, Fig. 2, in the actual line, as well as through the condenser S^2 in the artificial line. In such cases the condenser S′, Fig. 2, is provided with a resistance-circuit composed of a resistance-coil and a supplementary condenser precisely similar to those used in connection with the condenser S^2, and shown by H R and S^3, respectively, in Fig. 2. The adjustment is then effected through both condensers, instead of through one, as before. This arrangement is represented in Fig 3, in which S′ and S^2 are the main condensers in the circuit, S^3 and S^5 the adjustable supplementary condensers, and H R and H′ R′ the resistance-coils in either resistance-circuit surrounding the main condensers. By way of illustrating and explaining the method of duplex balancing shown in Fig. 3, I give the conditions required in balancing the southerly of the two above-mentioned cables at the station at Waterville, Ireland. Here S′ is equal to seventy-nine microfarads, S^5 to one microfarad, and H′ R′ to thirteen thousand ohms. S^2 is equal to eighty microfarads, S^3 equal to one and fifty-one one-hundredths microfarads, and H R to thirty-eight thousand ohms. The effect produced is substantially the same as before, and is in some cases more favorable.

The present invention is not limited to the hereinbefore-described system, but is applicable to any other system of working in which it is required to balance one cable against another by means of condensers, either in the case of double-cored cables or cables under separate armatures.

I claim as my invention—

1. The combination, substantially as hereinbefore set forth, in an electrical or telegraphic circuit, of an adjustable condenser in the circuit, an electrical circuit surrounding said condenser for modifying the capacity of the same, an artificial resistance in said modifying-circuit, and a supplementary condenser also in said modifying-circuit, for the purposes set forth.

2. The combination, substantially as hereinbefore set forth, in an electrical or telgraphic circuit, of the receiving-instrument, the adjustable rheostat, the separate condensers in the circuit, one connecting with the actual and the other with the artificial or compensating line, the adjustable supplementary condenser, and the adjustable resistance-coil in connection with one of said condensers with the key and battery and the condenser in the bridge or circuit between the actual and the artificial lines.

3. The combination, substantially as hereinbefore set forth, in an electrical or telegraphic circuit, of the receiving-instrument, the adjustable rheostat, the separate condensers in the circuit, one connecting with the actual and the other with the artificial or compensating line, the electrical circuits surrounding said condensers for modifying the capacity of the same, the adjustable supplementary condensers, and the adjustable resistance-coils in said modifying-circuits with the key and the battery and the condenser in the circuit between the actual and the artificial line.

In testimony whereof I have hereunto subscribed my name this 10th day of December, 1884.

ALEXANDER MUIRHEAD.

Witnesses:
E. T. RICE, Jr.,
J. MUIRHEAD.