

Dec. 4, 1923.

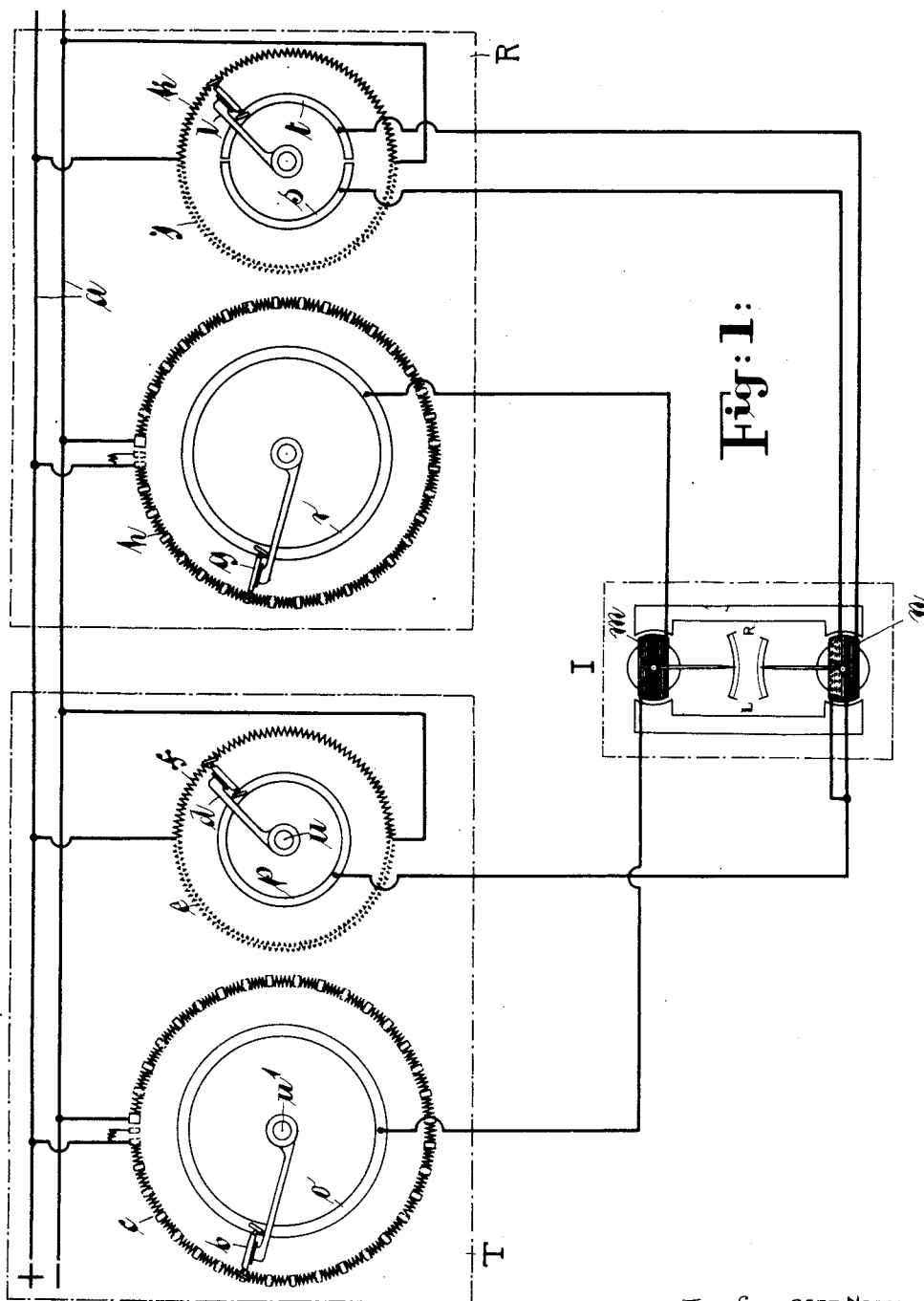
J. C. NEEDHAM

1,476,538

ELECTRICAL APPARATUS FOR CONTROLLING INDICATORS AT A DISTANCE

Filed March 9, 1923

5 Sheets-Sheet 1



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ELECTRICAL APPARATUS FOR CONTROLLING INDICATORS AT A DISTANCE

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5 Sheets-Sheet 2

Fig. 2.

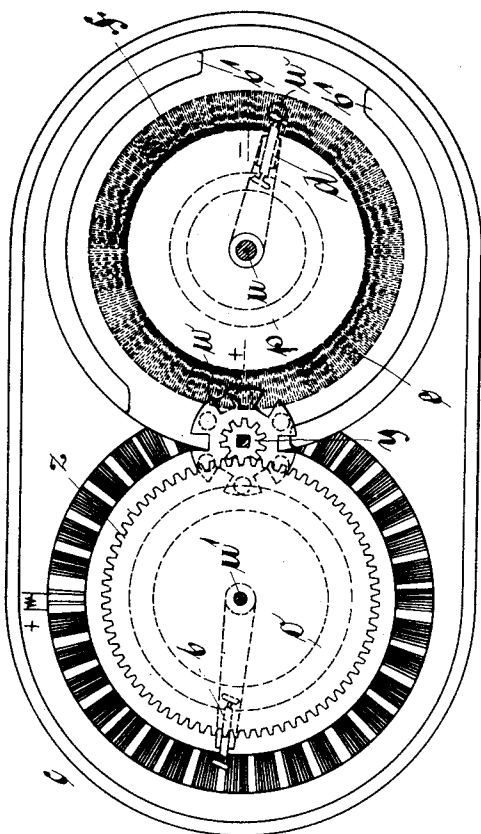
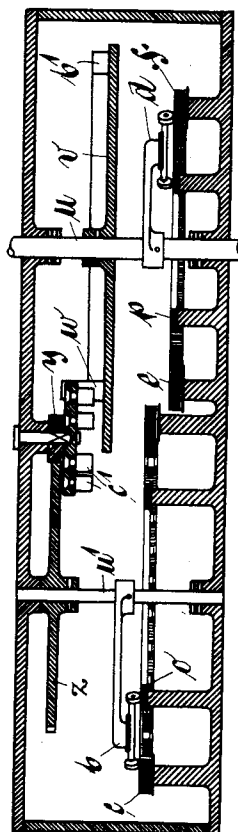


Fig. 3:



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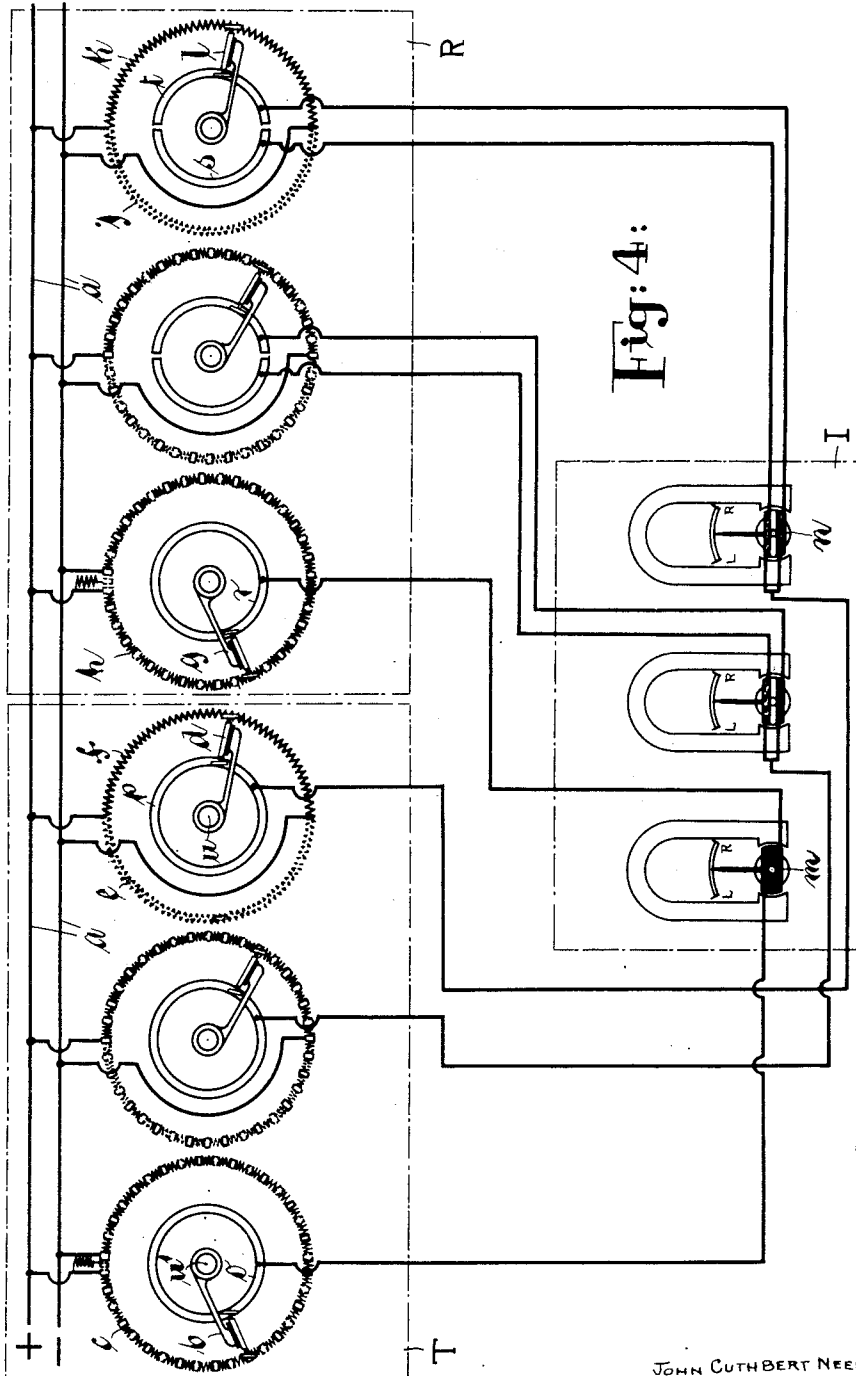
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ELECTRICAL APPARATUS FOR CONTROLLING INDICATORS AT A DISTANCE

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5 Sheets-Sheet 3



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ELECTRICAL APPARATUS FOR CONTROLLING INDICATORS AT A DISTANCE

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5 Sheets-Sheet 4

Fig: 5:

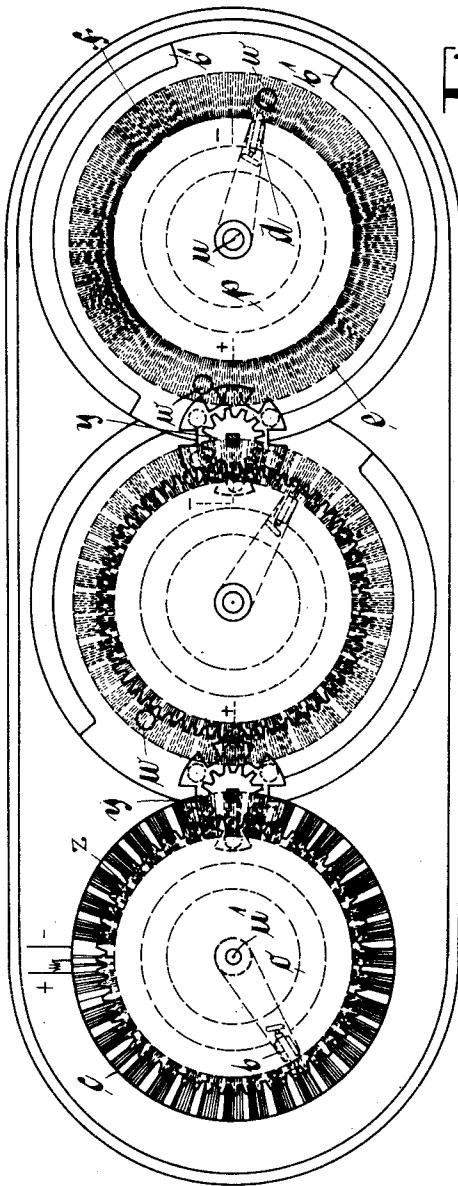
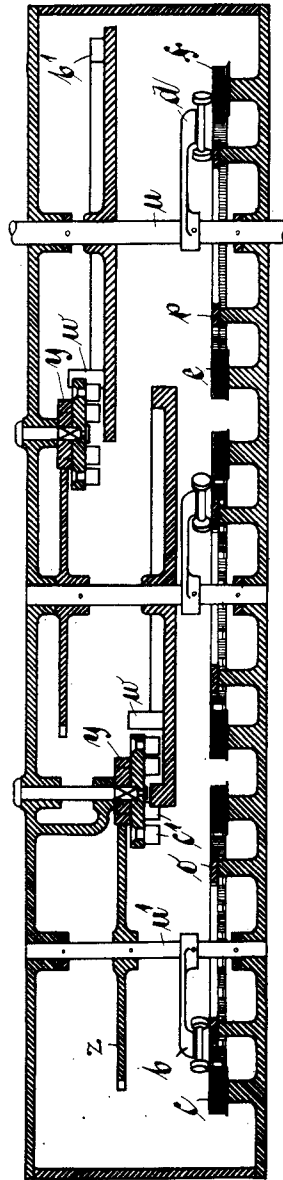


Fig: 6:



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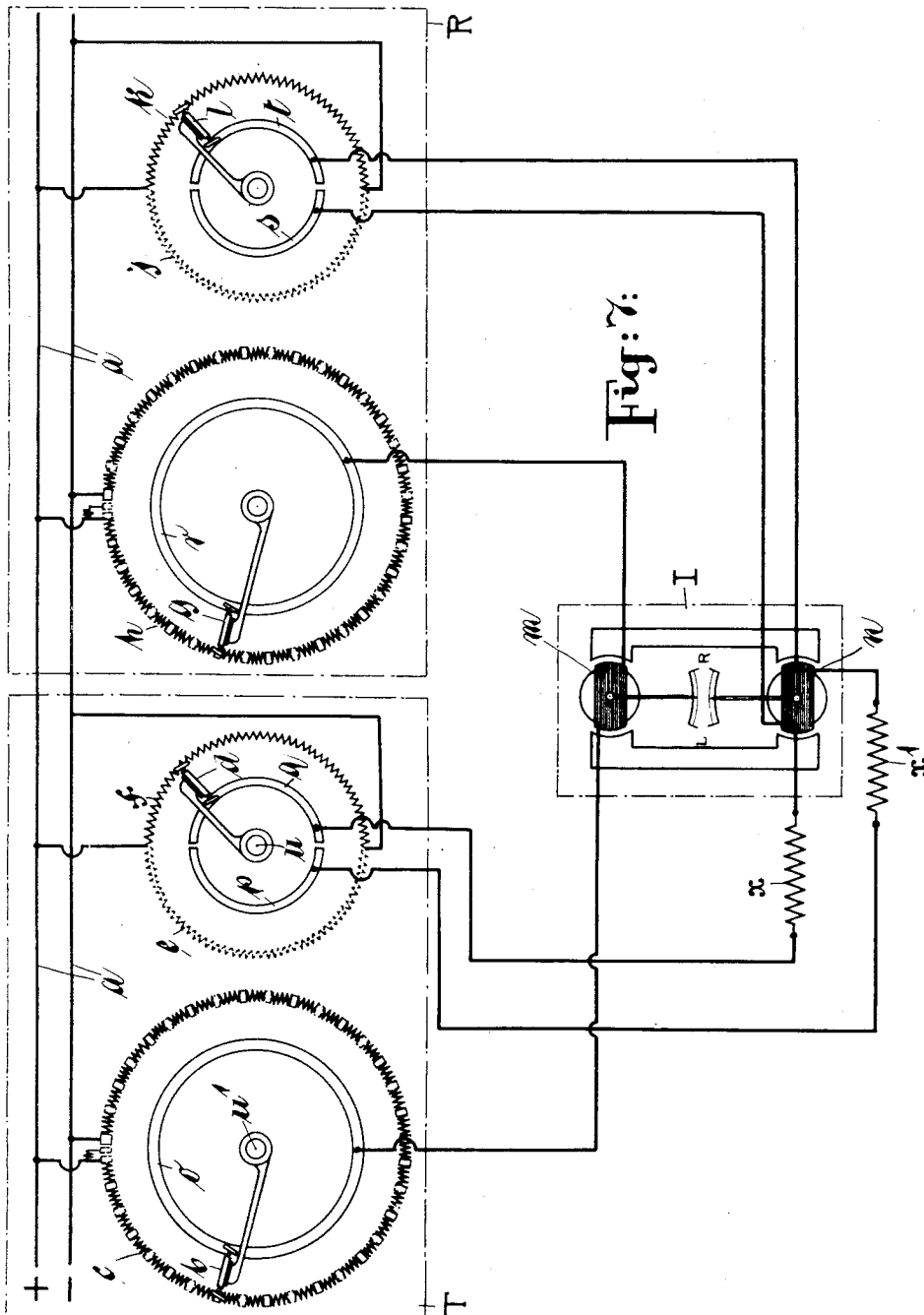
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ELECTRICAL APPARATUS FOR CONTROLLING INDICATORS AT A DISTANCE

Filed March 9, 1923

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE.

JOHN CUTHBERT NEEDHAM, OF LONDON, ENGLAND, ASSIGNOR TO EVERSHED & VIGNOLES, LIMITED, OF LONDON, ENGLAND, AND HIMSELF.

ELECTRICAL APPARATUS FOR CONTROLLING INDICATORS AT A DISTANCE.

Application filed March 9, 1923. Serial No. 623,967.

To all whom it may concern:

Be it known that I, JOHN CUTHBERT NEEDHAM, a subject of the King of Great Britain and Ireland, residing at London, England, have invented new and useful Improvements in and Relating to Electrical Apparatus for Controlling Indicators at a Distance, of which the following is a specification.

My invention relates to electrical transmissions of the type in which the movement of an appliance intended to be directed from a distance affects the indications of an indicator in such a way that the indicator shows when the appliance has moved into a desired direction corresponding in some way to a direction given to some part of the directing transmitter.

An example of this type of apparatus is shown in British Letters Patent 8784 of 1891, in which Fig. 6 of the drawings shows appliances at transmitting and receiving stations, each embracing a contactor moved by the motion of the appliance over an electrical resistance, the two electrical resistances being coupled in parallel across a common source of electrical energy and the contactors being connected by a wire in which one or more galvanometers of some kind are inserted to show when a balance of potentials has been arrived at. This type of transmission is commonly known as the bridge system, since the electrical connections are those of a Wheatstone bridge. Another transmission of the kind is that in which any movement of the transmitter is caused to make a succession of or to vary electrical contacts, the number of contacts or variations depending upon the amount of movement, each contact or variation causing a motor at the receiving end to move through a certain definite angle and to impart motion in this way, step by step, to a pointer. In this case the receiving appliance mechanically moves a second pointer and the two pointers have to be made to correspond. This type of transmission is known as the follow-the-pointer method, and the mechanism employed in it is commonly called a step-by-step mechanism.

The utility of the bridge system has hitherto been limited by the fact, that if (as is commonly the case) the transmitter is adapted to transmit the angular position or orientation of a sight or the like, it is impracticable to subdivide the circle of con-

tacts very closely and it may be difficult to make the smallest division less than half a degree of arc unless the instruments are very large. The step-by-step mechanism is not subject to limitation in this direction, since by using worm or other gear of large ratio the number of contacts made per degree of movement of the transmitter may be increased almost indefinitely; but this system is subject to the very serious drawback that there is no necessary connection between the position of the transmitter and the position of the receiver, so that they are liable to get out of step. Even if started in step, they are liable to get out of step through tripping. The follow-the-pointer mechanism in fact only shows, when working properly, that the receiver has been moved through the same angle as the transmitter, but it does not in any way show whether they started at corresponding positions.

The difficulties of the step-by-step mechanism do not occur in the bridge system, since in this system a definite position of the transmitter corresponds to a definite position of the receiver and the current can be cut off or switched on with the transmitter and receiver in any position, having always the effect of giving the correct signal to bring them into corresponding position.

My present invention has for its object to secure the advantages of the bridge system while increasing its sensibility. According to this invention each transmitter or receiver includes a number of rotating elements mechanically connected together so that each makes a number of revolutions during one revolution of the next in succession; each element being associated with an electrical contactor or contactors adapted to make contact on a resistance or resistances, which are coupled in parallel between the positive and negative poles of a source of supply. It will be understood that the source of supply may differ for different elements of a transmitter; but must be the same for corresponding elements in receiver and transmitter. Each of the transmitter elements corresponds to a similar element in the receiver, said element being similarly geared to its neighbours and similarly associated with a contactor or contactors. The contactors of each corresponding pair of transmitter and receiver elements are connected electrically through a balancing

galvanometer or indicator thereby enabling the receiver to follow the motions of the transmitter accurately, if it is moved until all the indicators show balance. In many cases two geared elements suffice to give the requisite degree of accuracy.

The transmitter includes a resistance hereinafter referred to as a terminal resistance connected between the positive and negative mains said terminal resistance being tapped at equal intervals and connected to a series of studs which may be disposed round a circle over which a contact arm is adapted to move thus connecting the studs in succession to a contact ring and thence to the coil of the terminal resistance indicator. The corresponding element of the receiver is similarly arranged, so that when the contactor of the transmitter rests on a particular stud a current flows through the indicator coil unless the corresponding contactor of the receiver is on a corresponding stud. In the other element of the transmitter hereinafter referred to as the primary resistance, two resistances are connected in parallel between the positive and negative mains, each when circularly arranged being disposed over 180° of arc. These primary resistances are conveniently made by winding a wire so that it forms a continuous rheostat with bare wires equally spaced round a circle and by taking tappings to the positive and negative mains at the ends of a diameter. Contact may be made on successive turns of the wire by a roller or the like moved by a contact arm the circuit being through a contact ring to the coils of the primary resistance indicator. The receiver also includes similar primary resistances and contact rings, said contact rings in either the transmitting and receiving instruments in some cases being split one part being connected to one coil and the other part to the other coil in the indicator said coils being similar to each other but oppositely wound.

Obviously the indicator may have one coil only, the contact rings being split in both receiver and transmitter.

The contactor of each primary resistance is geared to the contactor of its associated terminal resistance so that the contactor on the terminal resistance is moved from one contact to the next when the contactor of the associated primary resistance has been displaced a predetermined angular amount from the position at which the last such change took place.

By the employment of the electrical arrangements and mechanical interconnection hereinafter particularly described, the primary resistance along which the potential drop occurs is traversed repeatedly during one traverse of the potential drop of the next resistance whose contactor is mechani-

cally connected to it so that the primary resistance serves as a means for signalling subdivisions of divisions of the potential drop of the second corresponding in number to the number of traverses effected by the first during one complete traverse of the second. To render this repeated employment of a potential drop practicable it is essential that the transit from one traverse to the next should be effected smoothly, without a sudden change of potential; which is difficult, if not impossible, if the renewal of the traverse involves a sudden step from maximum to minimum potential or vice versa. As illustrated the form of resistance employed in the primary resistance solves the problem, in that such a resistance causes a perfectly smooth oscillation of contactor potential, as the contactor is continuously revolved, and means can easily be provided for causing the indicator used in connection with it to show the correct direction of motion required to create a balance in the circuit.

Any suitable form of mechanical interconnection may be employed; but in the illustrated constructions the arrangement is similar to that of an ordinary mechanical counter, an element of the primary resistance corresponding to the units wheel, and elements of further successive resistances corresponding to tens, hundreds and so on, but obviously the ratio of gear need not be necessarily ten to one.

The transmission may serve any required purpose and convey any kind of signals by indicating the correct position of a pointer on a dial for example and is peculiarly well adapted for communications relating to direction (training or elevation) when any appliance has to be directed from a distance. Referring to the drawings, which form part of this specification,—

Figure 1 diagrammatically illustrates one method of carrying the invention into effect.

Figure 2 is a plan view of the parts diagrammatically illustrated in Figure 1 mechanically associated to produce an instrument.

Figure 3 is a sectional elevation of Figure 2.

Figure 4 diagrammatically illustrates a modified arrangement.

Figure 5 is a plan view of the parts diagrammatically illustrated in Figure 4 mechanically associated to produce an instrument.

Figure 6 is a sectional elevation of Figure 5.

Figure 7 diagrammatically illustrates a modified form of the arrangement illustrated in Figure 1.

Referring to Figure 1, *a a* are the mains connected to a suitable source of electrical energy and the group of elements enclosed

within the dotted lines T, R and I represent the transmitting station, receiving station and balance indicator respectively.

The transmitting station comprises resistance c , e and f the resistance c for purposes of explanation being termed the terminal resistance and the resistances e and f for the same reason being termed primary resistances. The terminal resistance c as illustrated comprises a series of resistance elements of any kind connected to studs traversed by the contactor b ; or the said resistance c may conveniently be something short of a complete circle of continuously wound wire having a number of turns short-circuited at regular intervals round the ring. Contact is made by the contactor b between the resistance c and a contact ring o , whence the balancing circuit goes through the indicator m , which is an ordinary polarized galvanometer or equivalent instrument, to the receiver R.

The primary resistance comprises two resistances e and f connected in parallel, conveniently formed by a complete circle of turns of bare wire connected at points 180° apart to the positive and negative mains a , thus forming two resistances each disposed over 180° of arc. Contact is made by the contactor d between any turn of these wires and the contact ring p , whence the balancing circuit goes through one of the coils of the indicator n to the receiver R.

The resistances e and f being connected in parallel it is obvious that when the contactor d is rotated with uniform angular velocity the value of the potential at the contactor will be continuously varied through predetermined maximum and minimum values by any convenient number of subdivisions.

The receiver R has resistances corresponding to those in the transmitter T, the resistances being connected across the mains a in parallel with the corresponding resistances in the transmitter T. h is the terminal resistance, g is the contactor and r its contact ring; j is one of the primary resistances corresponding to e in the transmitter T, k that corresponding to f , l the contactor and s t a contact ring, divided for the purpose hereafter described.

It will be seen that the terminal resistances form an ordinary bridge transmission in which the portions of the resistance c on either side of the contactor b are two arms of the bridge and the portions of h on either side of g the other two; while the balancing circuit is from b to g passing through the galvanometer or indicator m .

The primary resistances also form a Wheatstone bridge, but in this case the resistances are duplicated and used alternately in completing a movement of 360°

of the contactor. It will be observed that in this electrical arrangement the contactor can have the same potential at two points (except the maximum and minimum) one on each of the two parallel resistances. For this reason it would be impossible to use a bridge so constructed by itself for signalling, since one could not distinguish which of two signals was intended. But when such a bridge is used in conjunction with another bridge comprising terminal resistances as illustrated it will be seen that owing to the action of the mechanical gear, hereinafter described, between the primary and terminal units a movement of the contactor of the terminal resistance is the necessary accompaniment of a change in the position of the contactor of the primary resistances from one of its two resistances to the other. If therefore the operator of a receiver having correctly balanced the terminal resistance seeks to put the primary resistances contactor in the wrong half of its travel he necessarily throws the terminal resistance out of balance. He can therefore only balance both sets of resistances if the placing of both contactors is correct. To make this clear in Fig. 1 the contacts in the terminal resistance which correspond respectively with the two halves of the resistance of the primary resistance have been indicated by different kinds of lines. The contacts of the terminal resistance shown in full lines operate in conjunction with the resistance and the indicator coil shown in full lines in the primary resistances and the dotted contacts of the terminal resistance with the dotted resistance of the primary resistances and the indicator coil shown by dotted lines. If the indicator in this case had one coil only the direction of deflection would be the same for a given clockwise error of contactor position on one resistance and for a similar contra-clockwise error on the other. In order to enable the indicator to serve as a guide to the proper direction in which motion must be made to secure a balance, the contact ring s , t is split as shown, each half being connected to one of two coils on the indicator I oppositely wound. The direction of the signal given is then correct. Another means of securing the same end is shown in Fig. 5 and described hereinafter.

The resistances electrically associated as bridges may be connected to the same source of supply, or be separately supplied if necessary, as the bridges comprising the primary resistances are or may be electrically independent of the bridges comprising the terminal resistances.

Referring particularly to Figure 1, the two resistances in the transmitter are connected the one to the other and at their points of connection they are connected to

the circuit. It will be seen that there is no point of discontinuity between the connection of these resistances the one to the other, with the result that if the contactor *d* is moved from the upper point of connection with the mains towards the right the potential in the contactor continuously varies and when it reaches the lower point of connection this variation is not interrupted, but is continuous, and when the contactor is still further moved and again passes through the upper point of connection again the variation is continuous and is uninterrupted, i. e. that as the contactor is continuously rotated with uniform angular velocity, the potential of the contactor will be continuously varied through predetermined maximum and minimum values by any convenient number of subdivisions.

In operation, if contactor *d* at the transmitter is on the resistance *f* in proximity to the upper point of connection the out of balance indication will immediately convey to the operator not only the fact that lack of balance exists, but also the direction in which he has to move the contactor *l* in order to obtain the required balance and if the operator closely follows the indications of the coarse adjustment indicator he can arrive at the point of balance by the shortest route, inasmuch as if the contactor *l* were at the position of similar potential on the resistance *j* the coarse adjustment indicator would show out of balance conditions which would necessitate moving the contactor *l* from the resistance *j* to the resistance *k* so as to move the contactor *g* the requisite distance to produce an indication of balance in the coarse adjustment indicator. For this reason it will be seen that an even number of resistances are necessary in the fine adjustments both at the transmitting and receiving stations and further that the mechanical association between the contactors *b* and *g* are mechanically associated with the contactors *d* and *l* so that the contactors *b* and *g* are only moved by the contactors *d* and *l*, respectively, when the said contactors *d* and *l* approach, pass through and recede from positions of maximum and minimum values.

Figs. 2 and 3 illustrate a typical means for the mechanical interconnection of the bridges the transmitter only being shown, as the receiver is similar to it. The contactor *d* is adapted to be moved by any form of directing appliance, mechanically associated with it by suitable gearing (a handle and index selecting certain signals on a dial for example, or a sight of any kind) through the shaft *u*. To this shaft is fixed a wheel *v* carrying two pins *w* which engage at each half revolution of *u* with a Geneva gear wheel, moving it through a fraction of a revolution at each engagement. This in-

termittent motion is transmitted through an ordinary pinion *y* and wheel *z* in any desired ratio to the shaft *u'*. Pins *c' c'* on the Geneva wheel engage with locking rings *b' b'* on the wheel *v* to prevent the Geneva wheel from turning except through its engagement with pins *w*.

In this manner the contactor *b* of the coarse-adjustment is caused to make a step of any desired number of degrees of rotation whenever the contactor of the fine-adjustment passes the points, separated by 180° at which the connections of its resistances are taken off to the supply; while it remains at rest except when taking this step. Owing to the fact that one of the primary resistances goes through its whole potential gradient in half a revolution it is necessary for the intermittent gear to operate twice during each revolution of the contactor of the primary resistances. When the terminal resistance contactor is on its correct contact, and therefore balanced, the contactor of the primary resistances is on the particular resistance on which a balance of potential indicates correspondence of position in transmitter and receiver. This prevents a false position of balance of the indicator in the mid-wire circuit of the primary resistances being accepted as correct. In the drawing successive steps of the terminal resistance are made 10° of arc, and as the contactor of the primary resistances moves 180° before the contactor of the terminal resistance takes the next step, 180° of movement of the contactor of the primary resistance corresponds to 10° of movement of the contactor of the terminal resistance. If the handle, sight or other operating mechanism is geared to the shaft *u* through an 18:1 gear it will make one revolution for one revolution of the shaft *u'* of the terminal resistance. Since the element of the terminal resistance has 36 points of arrest, its contactor will have an angular position corresponding to that of the handle or sight within 1/36th of 360°, that is, to the nearest 10°; whilst the contactor of the primary resistances, moving through 18 times the angular movement of the handle or sight, will move over 180° during 10° of handle movement; thus giving (other things equal) eighteen times as much change of potential for a 10° movement of the handle as the terminal resistance does, and increasing the possible sensitivity accordingly.

In using such a mechanism the sight or other operating appliance is moved to the desired direction or signal and in so doing sets the contactors of the resistances in the transmitter to certain points thereon. The apparatus at the receiving end has then to be moved in the direction indicated by the indicator of the terminal resistance until

the terminal resistance is in balance. The contactors of the terminal resistances in transmitter and receiver will then be on corresponding positions on their resistances, and the contactor of the primary resistances in the receiver will be somewhere on that resistance which corresponds to that on which the primary resistances contactor in the transmitter is resting. Attention is then directed to the indicator of the primary resistances and movement of the apparatus made in the direction indicated until that also is balanced, when the contactors of the primary resistances will also be in corresponding positions on their resistances. The shaft *u* may of course be moved in any suitable manner other than those mentioned.

By suitably choosing the amplitude of the coarse steps and the ratio of gear the subdivision can be carried as far as the sensitivity of the indicator will render useful, and hereafter means are described by which a further subdivision can be effected with a degree of accuracy only limited by mechanical considerations.

Although certain forms of resistances, methods of contacting, systems of mechanical interconnection and electrical connections are shown, for the purpose of explanation it will be understood that many modifications may be employed without departing from the invention.

The mechanical limitations of accuracy in transmission will generally make it useless to multiply the electrical subdividing mechanism, but the degree of subdivision can be indefinitely increased if required. A third bridge arrangement comprising intermediate resistances may be added, intermediate of the terminal and primary resistances bridges of the arrangement previously described, the contactor of said intermediate resistances being moved intermittently by the contactor of the primary resistances and moving the contactor of the terminal resistances intermittently twice in every revolution, such intermissions being electrical if not also mechanical.

A typical electrical arrangement is indicated in Fig. 4 and a typical mechanical connection of the three bridges being indicated in Figs. 5 and 6.

It will be observed that by multiplying the bridge arrangements in this way any limitation due to insufficient sensitivity of the galvanometers or indicators can be removed to any degree which the inevitable mechanical errors may render useful.

It may here be pointed out that in transmitters and receivers of the type in which an intermittent movement of the contact arm is produced by a continuous rotation of the driving mechanism it is desirable that the contact surface on which the contactor bears when in one of the stationary positions

should be of substantial width so as to allow for a certain amount of backlash if the intermittent gear or other operating mechanism should be come slightly worn. If this desideratum were the only one the preferable construction in such a case would be to have a series of studs connected by resistances in the ordinary way, the contactor moving over the studs only. It has been found, however, that it is undesirable to make the transition from the potential corresponding to one stationary position to that corresponding to the next suddenly and from that point of view the construction involving a contactor moving over successive turns of continuously wound wire is preferable. This construction however does not give sufficient width for the contact at the stationary positions but both requirements can be secured by providing a continuously wound wire in the ordinary way and short circuiting a few turns about each stationary position of the contactor. This is equivalent to having a series of studs connected by resistances, both the studs and resistances making contact as the contactor passes over them; or to having several studs connected to the resistance between those representing consecutive stationary positions.

Referring to Fig. 4 it will be noted that the terminal and primary units are identical with those shown in Fig. 1 and that the intermediate unit has two resistances in parallel across the mains in the same manner as the primary unit, certain turns being short circuited about each point of rest of its contactor, in the same manner as the terminal resistances unit and for the purpose described hereinbefore.

With this arrangement three indicator movements are provided, one for each unit. That for the terminal resistances unit being a plain galvanometer, the other two being double wound.

In operation the transmitter having been set as required will set all the three contactors of the resistances in certain angular positions, and the receiving element when revolved will move all three corresponding contactors in the receiver. By movement of the directed appliance the operator will first balance the terminal resistance indicator, next the intermediate resistances indicator and finally the primary resistances indicator. Any number of intermediate resistance units may be introduced, and electrical subdivision carried thus to any length. The degree of electrical accuracy obtained by multiplying the resistance units in the manner indicated is unlimited, and can be easily made far higher than the necessary limitations of mechanical accuracy will permit to be of any use.

Fig. 7 illustrates an arrangement which requires only a single winding in the indi-

cator for the primary and intermediate resistances. The contact ring of the transmitter T is split into two halves p and q so that the contactor d contacts with one half 5 contact ring when it is moving over one of the two parallel resistances e f and on the other half ring when it is traversing the other parallel resistance. The half contact rings p q are connected to the resistances 10 x' and x respectively, the other ends of the resistances x' and x being connected to the opposite ends of the coil n of the indicator I. These points are also connected to the two half contact rings s t of the corresponding 15 resistance in the receiver R. It will be observed that the contactor d of the transmitter T in passing from the contact q to the contact p breaks contact with resistance x and makes contact with resistance x' , thus reversing the connection to the coil of the indicator. The contactor l of the receiver when moved from the contact t to the contact s also reverses its connection to the moving coil. If therefore the potential 20 of the contactor l relatively to the contactor d is say positive the indications given by the indicator reverse according to whether d and l are on the resistance drawn with the full lines or on that drawn with the dotted 25 lines, thus securing that the indication shows the correct direction of motion required to create a balance in the bridge.

I claim:—

1. In a signaling system a transmitter and 35 a receiver, said transmitter and receiver each comprising similar terminal resistances and similar primary resistances said terminal resistances each being divided into a number of equal subdivisions and said primary resistances each consisting of a continuous resistance, a source of energy connected across 40 said terminal resistances in parallel, a source of energy connected to said primary resistances the positive connection forming a point of maximum positive potential and the negative connection forming a point of maximum negative potential so that there is a steady change in potential around said resistances, a contact arm in the transmitter 50 and a contact arm in the receiver for said terminal resistances, an indicator and means for connecting said indicator in circuit with said contact arms, a contact arm in the transmitter and a contact arm in the receiver for the primary resistances, a second 55 indicator and means for connecting said

indicator in circuit with said latter contact arms, means for operating said transmitter and means for operating said receiver, said means in each case comprising means for 60 moving the primary contact arm from one point of maximum potential to the next adjacent point of maximum potential when the terminal contact arm moves over one subdivision of the terminal resistance. 65

2. In a signaling system a transmitter and a receiver, said transmitter and receiver each comprising similar terminal resistances and similar primary resistances said terminal resistances each being divided into a number 70 of equal subdivisions and said primary resistances each consisting of a continuous resistance, a source of energy connected across said terminal resistances in parallel, a source of energy connected to said primary 75 resistances the positive connection forming a point of maximum positive potential and the negative connection forming a point of maximum negative potential so that there is a steady change in potential around said resistances, a contact arm in the transmitter 80 and a contact arm in the receiver for said terminal resistances, an indicator and means for connecting said indicator in circuit with said contact arms, a contact arm in the transmitter and a contact arm in the receiver for the primary resistances, a polarized indicator comprising two oppositely wound coils, means for connecting one of 85 said coils in circuit with said latter contact arms when the terminal resistance contact arm of the receiver is on an even subdivision and for connecting the other of said coils in circuit with said latter contact arms when the terminal resistance contact arm of the receiver is on an odd subdivision, means for 90 operating said transmitter and means for operating said receiver, said means in each case comprising means for moving the primary contact arm from one point of maximum potential to the next adjacent point of maximum potential when the terminal contact arm moves over one subdivision of the terminal resistance. 95 100

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses. 105

JOHN CUTHBERT NEEDHAM.

Witnesses:

CHAS. S. R. BULLOUGH,
OLIVE WEST.