

March 5, 1940.

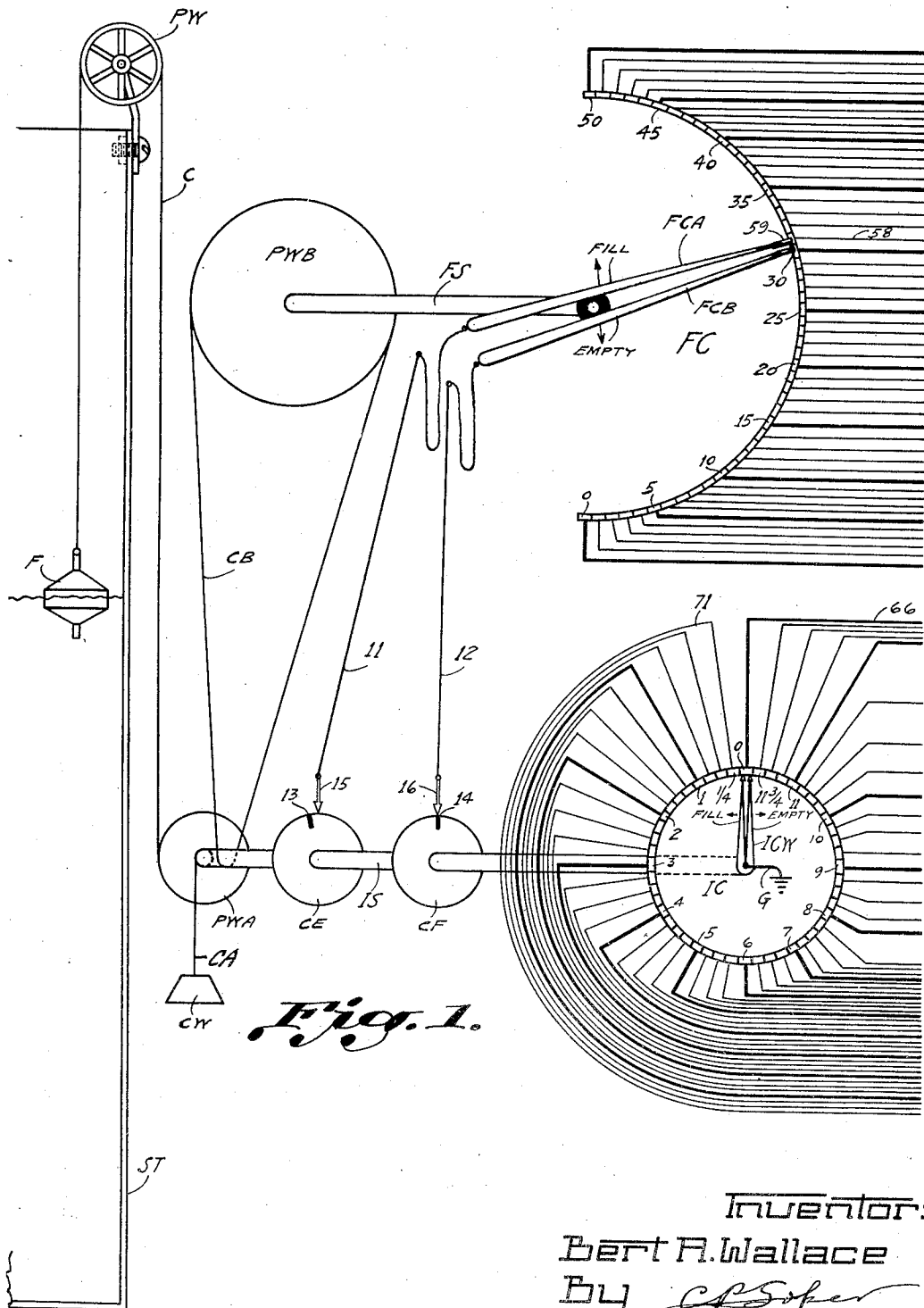
B. A. WALLACE

2,192,421

REMOTE READING REGISTER

Filed Nov. 25, 1935

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

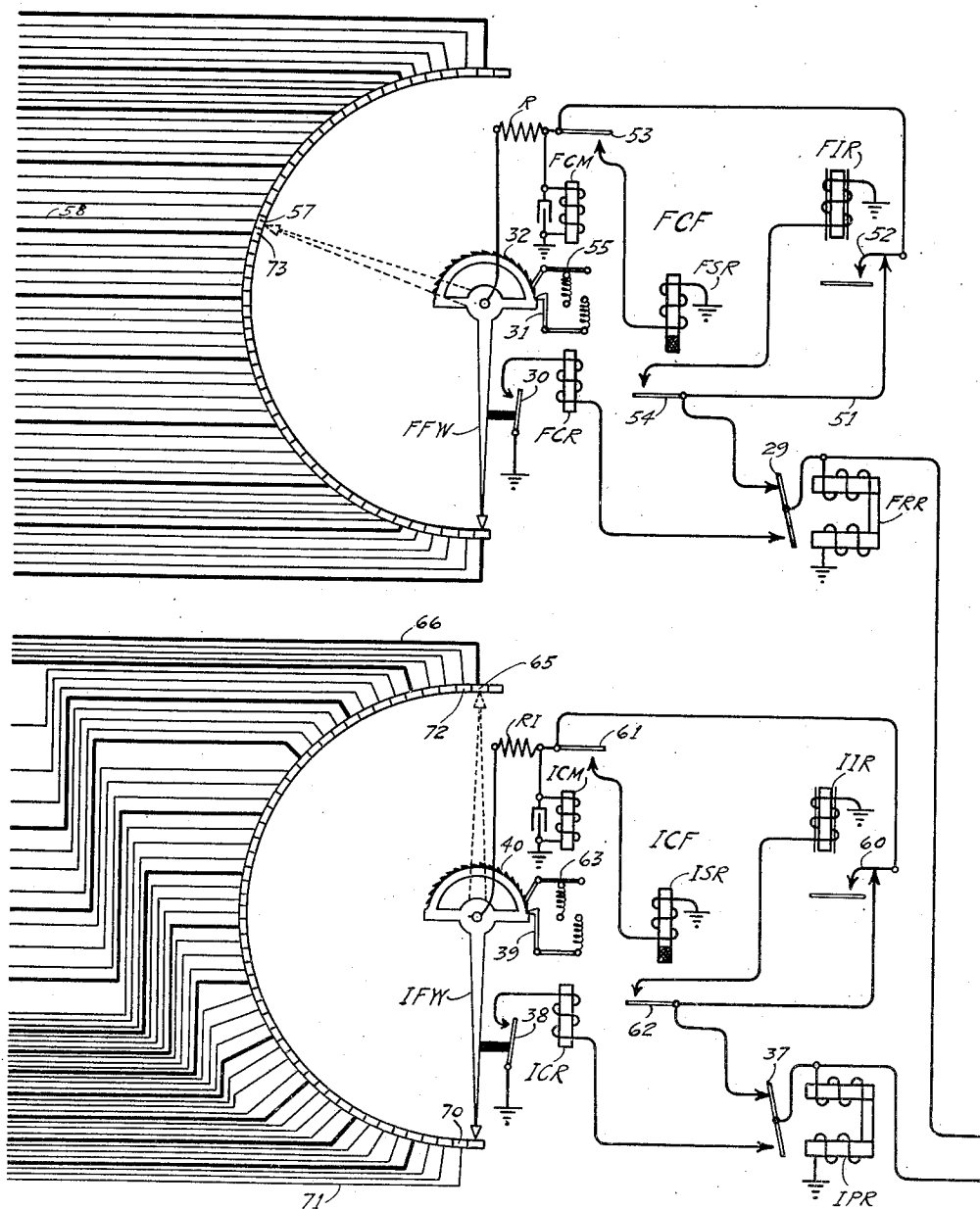


Fig. 2.

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3 Sheets-Sheet 3

MASTER REGISTER

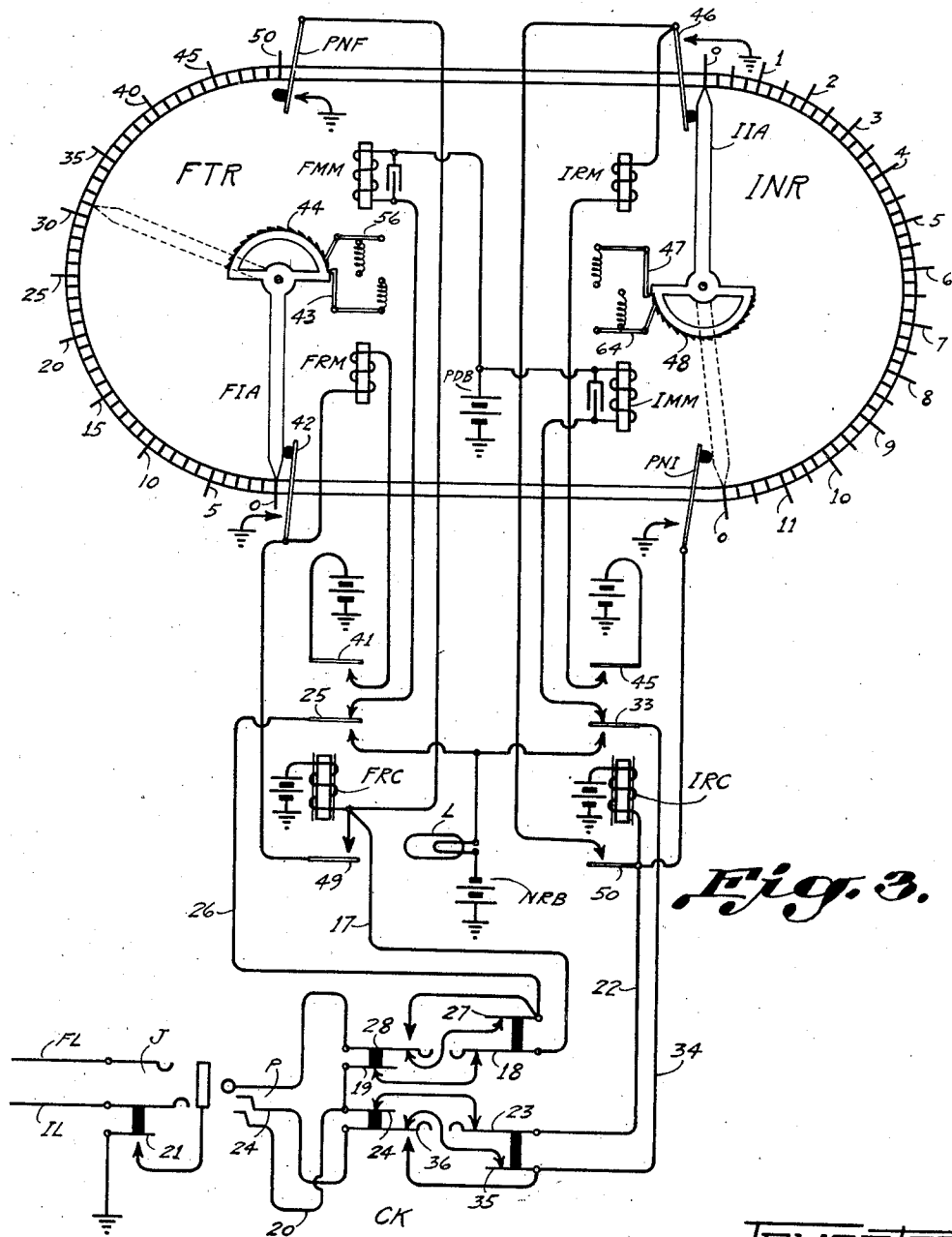


Fig. 3.

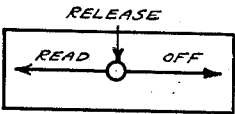


Fig. 4.

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UNITED STATES PATENT OFFICE

2,192,421

REMOTE READING REGISTER

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Application November 25, 1935, Serial No. 51,553

7 Claims. (Cl. 177—351)

My present invention relates to an electrical system providing a reading at a central point indicating or showing the setting of variable contacts which are located and controlled at a distant point. It is particularly applicable for registering or indicating the amount of the contents of tanks of a group, as oil tanks.

The devices generally used in such systems to indicate the fluctuations of the contents of large storage tanks, such as those used by oil refineries, have not been particularly satisfactory as it has been necessary to visit each tank individually and inspect its associated indicator to ascertain the amount of liquid in the tank or else to have one indicator located at the central point for each tank located at a remote point.

It is an object of my invention to provide a simple, efficient and practical means for indicating directly at the central point the amount of the contents in the respective tanks.

A feature of my invention is the provision of one master register upon which can be indicated the amount of the contents of any of the associated tanks.

Another feature of my invention is the provision of means whereby the master register is automatically synchronized with any remote equipment.

A further feature of my invention is the simultaneous reading of the master register of all of the groups of contacts associated therewith.

A still further feature of my invention is the continuous reading upon the master register of all the groups of contacts individually.

Still another feature of my invention is the provision of means whereby a single wire and ground circuit is required for each group of contacts.

Another feature of my invention is the automatic correction upon the master register of any change in the contacts at any time.

Another feature of my invention is the provision of means for the synchronized control of the master register between the different groups of contacts for associated registration such as feet and fractions of an inch or decimal digit connections.

Another feature of my invention is the provision of means whereby the only battery supply required is located at the central station.

Further objects of my invention will be readily apparent from the following specification considered with the accompanying drawings which represent a particular preferred embodiment of my invention.

The drawings comprise Figs. 1, 2, 3 and 4, and when Fig. 2 is placed to the right of Fig. 1 and Fig. 3 is placed to the right of Fig. 2 they show a complete circuit arrangement of my invention. Fig. 4 shows the three positions of the control key CK.

Tank apparatus

Fig. 1 shows a storage tank ST, the fluctuation in the contents of which causes the rise and fall of a float F to which is secured a cable C which passes over a pulley wheel PW located at the top of the storage tank ST and is secured to pulley wheel PWA rigidly fastened to an inch shaft IS. It may be here noted that the cable C drives the shaft IS and the shaft FS is driven from the shaft IS at a ratio of 1 to 12 through the medium of the flexible belt or chain CB. The various drive pulleys and the connections are such that the shaft IS is driven by the cable C to cause its associated brush or wiper to move from one inch contact to the next inch contact to indicate by inches the change in the height of liquid in the tank while the shaft FS is driven at one twelfth the rate of shaft IS and thus causes its brushes or wipers to move from contact to contact to indicate by feet the change in the height of the liquid in the tank. In the embodiment shown the contacts associated with the inch contact wiper ICW are arranged to give one quarter inch indications on the indicator. The operation is the same when the contacts are arranged to give indications for each change of one inch in the level of the contents of the tank. A counterweight CW acts on the shaft IS by means of the cable CA which is so arranged as to wind upon itself on the shaft IS to compensate for additional weight of the cable C as the contents of the tank decrease. In other words, as the cable CA is wound upon the shaft IS, due to the successive turns, the cable becomes displaced a greater distance from the center of the shaft IS and the weight CW exerts a greater stress on the shaft IS, thus offsetting the greater weight of the cable C between the float F and pulley PW as the contents of the tank decrease.

Commutators CE and CF are also secured to the inch shaft IS as well as an inch contact wiper ICW. The inch contact wiper ICW is a associated with an inch contact bank IC which comprises in this particular embodiment a group of 48 contacts, one for each quarter inch of a foot.

The rotatable foot shaft FS has rigidly secured thereto a pulley wheel PWB. A pair of foot contact wipers FCA and FCB are secured to the foot

shaft FS and engage successive contacts in the foot contact bank FC as shaft FS rotates. These wipers FCA and FCB are rather close together and so arranged that they rest upon the same contact most of the time, but as the level of the contents of the tank approaches an exact foot level the wipers rest on adjacent contacts. As the contents of the tank increase and closely approach the next foot level the leading wiper FCA engages the next highest contact while the lagging wiper FCB remains on the first contact. As the contents of the tank decrease from an exact foot level the wiper FCB engages the next lower contact while the wiper FCA remains on the previously engaged contact. A cable CB passes around the pulley wheel PWB and the inch shaft IS. The pulley wheels and shafts are so arranged that upon the movement of the float F a quarter of an inch, the inch contact wiper ICW is moved one contact and that for each one foot movement of the float F the inch contact wiper ICW will make a complete revolution and will again rest upon the contact marked "zero" in the inch contact bank IC. The foot contact wipers FCA and FCB each move one contact for each complete revolution of the inch shaft IS.

The contacts of the inch contact bank IC are electrically connected to a contact bank of an inch contact finder switch ICF shown in Fig. 2 of the drawings and the contacts in the foot contact bank FC are connected to a contact bank associated with a foot contact finder switch FCF also in Fig. 2. Associated with the contact bank for the inch contact finder ICF is an inch finder wiper IFW adapted to be driven by an inch contact motor magnet ICM which in turn is controlled by an inch interrupter relay IIR and an inch switch relay ISR. This switch is of the type which advances the contact wiper one step upon the restoration of the driving magnet ICM. An inch polarized relay IPR controls an inch contact release magnet ICR which restores the inch finder wiper to normal.

The foot contact finder shown in Fig. 2 comprises apparatus similar to that disclosed in the inch contact finder, that is, the foot contact motor magnet FCM steps the foot finder wiper over the contacts associated therewith under the control of the foot interrupter relay FIR and the foot switching relay FSR. The release of the switch is controlled by the foot polarized relay FPR and the foot contact release magnet FCR.

The apparatus shown in Figs. 1 and 2 is located at the storage tank and each set of variable contacts has a single conductor extending from it to the master register shown in Fig. 3 which is located at the central point which preferably may be a pumping station or control station. These conductors are the conductors IL and FL which terminate in a jack J, shown in Fig. 3, located at the control station.

Register apparatus

The master register in the preferred embodiment shown comprises a foot register FTR and an inch register INR. The foot register is graduated into fifty steps corresponding to the fifty contacts shown in the foot contact bank FC and the foot indicator arm FIA is stepped over the various contacts by the foot motor magnet FMM. The release of the foot indicator arm is controlled by the foot release magnet FRM. A foot register conditioning relay FRC is provided.

The inch register is divided into forty-eight sections and the inch indicator arm IIA is driven

over these sections by the inch motor magnet IMM and is released by means of the inch release magnet IRM. An inch register conditioning relay IRC is also provided and operates in conjunction with the foot register conditioning relay FRC to disconnect positive driving battery PDB from the line and to connect negative release battery NRB to the line.

It is to be noted that all the relays, except the release relays at the tanks, and electromagnets at both the control station and tank can be operated from a single source of current which while shown on the drawing as different sources may be combined as one. The exception above noted consists of the polarized relays and the release magnets located at the tanks which receive their energy from a source of current also located at the control station. Thus it is seen that all the batteries necessary for operating the system are located at the control station.

The lamp L is provided to serve as a protection means when negative release battery is connected to the line. A control key CK which has three positions, namely, read, release, and off, connects the master register to a plug P. When the key is in its off position contacts 27, 18, 23, and 35 are open and the conductors leading to the indicating apparatus are cut off. The key is shown in the drawings in its middle or release position in which position contacts 27, 18, 23, and 35 are closed, and contacts 10, 24, 28, and 36 are also closed. When the key is in its "read" position contacts 19 and 24 are open and contacts 28 and 36 are moved to their alternate positions to make direct connection with the conductors 26 and 34. The key is normally kept in its off position and it is apparent that when the key is moved from its normal position to the read position it must pass through the release position, as will be more fully explained hereinafter. A jack J is provided for each of the tanks in the remote field and the conductors lead from the respective jacks to the variable contacts located at the respective tanks.

System operation

Having generally indicated the character of the equipment I will describe the operation of my system as shown.

Operation at tank

As the contents of the storage tank ST are increased the float F rises and causes the rotation of the inch shaft IS. For each one-fourth inch rise of the float the inch contact wiper ICW moves to the next contact. The inch contact wiper ICW is shown as two wipers, both of which contact the same contact due to their adjustment. However, they may engage two adjacent contacts in the moment of transition from one contact to the next. The wiper ICW and the inch shaft IS are connected to ground G. For each complete revolution of the inch shaft the wipers FCA and FCB move one step over the foot contacts. The foot contact wipers FCA and FCB are electrically connected respectively to the commutators CE and CF by conductors 11 and 12 and brushes 15 and 16. Commutator CE has an insulated portion 13 and commutator CF has an insulated portion 14. The wiper FCA is connected to ground G through the commutator 13 and inch shaft IS at all times except the instant when the wiper ICW passes from the zero contact to the 11 $\frac{3}{4}$ contact which it does as the storage tank ST empties. At this instant the

contact 15 rests on the insulated portion 13 and the ground connection for the wiper FCA is broken. The wiper FCB is connected to ground G through the contact 16 and commutator CF at all times except the instant when the inch contact wiper ICW passes from the 11¾ inch contact to the zero contact, which it does as the contents of the storage tank ST are increased.

This synchronized control between the two wipers is necessary because the proper contact must be connected to ground to prevent the selection of the wrong contact by the finder switch of Fig. 2. The inch wiper ICW and the foot wipers FCA and FCB at all times are in the position to indicate the proper level of the contents of the tank ST and as shown in the drawings indicate a 31 foot level in the tank ST. The foot contact finder FCF and the inch contact finder ICF of Fig. 2 are normally as shown in the figure and the wipers shown in dotted lines indicate their proper position for the 31 foot level in the tank ST.

Should the operator at a central station at which the master register is located desire to ascertain the amount of contents in the storage tank ST she will insert the plug P into the jack J associated with the lines FL and IL leading to the foot contact finder FCF and inch contact finder ICF of Fig. 2 associated with the storage tank ST and will throw a control key CK to its release position as shown in Fig. 3.

Automatic synchronization of register

The insertion of the plug P and the operation of the key CK to its release position closes energizing circuits for the foot register conditioning relay FRC and the inch register conditioning relay IRC. The circuits for these relays can be traced from grounded battery through the winding of FRC, conductor 17, closed contacts 18 and 19 of CK, conductor 20, the sleeve contacts of the connected plug P and jack J, alternate contact 21 of jack J to ground. The circuit for the relay IRC can be traced from grounded battery through the winding of relay IRC, conductor 22, closed contacts 23 and 24 of CK, conductor 25, sleeve contacts of jack J and plug P, alternate contact 21 of J, to ground. The relay FRC through its alternate contact 25 connects negative release battery NRB to the foot line FL and establishes an energizing circuit for the polarized relay FPR of the foot contact finder FCF of Fig. 2. The foot polarized relay FPR is energized by current flowing from the negative release battery NRB, lamp L, alternate contact 25 of FRC, conductor 26, closed contacts 27 and 28 of CK, tip contact of plug P and jack J, foot line FL, through the winding of the foot polarized relay FPR to ground. Relay FPR energizes and its contacts 29 assumes its alternate position to close an energizing circuit for the foot contact release relay FCR which is energized by current flowing from the negative release battery over the previously described path through alternate contact 29, the winding of foot contact release relay FCR and off-normal contact 30 to ground. Of course, if the foot finder wiper FFW is in its normal position the off-normal contact 30 will be opened and the relay FCR will not energize. Upon the energization of the foot contact release relay FCR the pawl 31 is withdrawn from the ratchet 32 and the foot finder wiper FFW is returned to its normal position under the influence of a coil spring not shown. When the wiper FFW returns to normal the off-normal

contacts 30 is opened and the circuit for the foot contact release relay FCR is broken.

The inch register conditioning relay IRC causes the restoration to normal of the inch finder wiper IFW by closing its alternate contact 33 which connects negative release battery to the inch line IL and causes the energization of the inch polarized relay IPR. The relay IPR is energized by current flowing from negative release battery NRB, lamp L, alternate contact 33 of IRC, conductor 34, closed contacts 35 and 36 of CK, sleeve contacts of plug P and jack J, conductor IL, winding the inch polarized relay IPR to ground. The inch polarized relay IPR moves contact 37 to its alternate position to establish an energizing circuit for the inch contact release relay ICR which is energized by current flowing from the negative release battery over the previously described circuit, through alternate contact 37 of IPR, relay ICR, and off-normal contact 38 to ground. The relay ICR energizes and withdraws a pawl 39 from the ratchet 40 and allows the inch finder wiper IFW to be restored to normal under the influence of a coil spring not shown. The restoration to normal of the inch finder wiper IFW opens the off-normal contact 38 which breaks the energizing circuit of the inch contact release relay ICR which restores to normal. If the inch wiper IFW was already in its normal position the off-normal contact 38 would be opened and the inch contact release relay ICR would not operate.

The closing of alternate contact 41 of the foot register conditioning relay FRC causes the restoration to normal of the foot indicator arm FIA if it is not in its normal position. If the foot indicator arm FIA is in an operated position the off-normal contact 42 will be closed and the energizing circuit for the foot released magnet FRM will be established. The relay FRM will be operated by current flowing from grounded battery through alternate contact 41 of FRC, the winding of the foot release magnet FRM, and alternate contact 42 to ground. The magnet FRM will withdraw the pawl 43 from the ratchet 44 and the foot indicator arm FIA will restore to normal under the influence of a coil spring not shown, and open the off-normal contact 42 to break the energizing circuit of the foot release magnet FRM. The inch indicator arm IIA is restored to normal in a similar manner by the operation of the inch register conditioning relay IRC which closes its alternate contact 45 to establish an energizing circuit for the inch release magnet IRM.

Current flowing from grounded battery through alternate contact 45, the winding of inch release magnet IRM and off-normal contact 46 to ground will energize the magnet IRM causing it to withdraw the pawl 47 from the ratchet 48 and allow the inch indicator arm IIA to be restored to its normal position by a coil spring not shown in the drawing. The restoration to normal of the inch indicator arm IIA opens the off-normal contact 46 and breaks the energizing circuit of the inch release magnet IRM.

The master register is thus synchronized with the remote equipment located at the tank by having all of the connected apparatus restored to its normal position before any registering operation can be had.

Registering operation

The attendant next moves the control key CK to the "read" position which opens the energizing

circuits of the relays FRC and IRC causing them to restore to normal and open the energizing circuits of the lamp L and the polarized relays FPR and IPR. To prevent the premature operation of the registering means by a too rapid movement of the control key CK locking circuits are established for the relays FRC and IRC through their alternate contacts 49 and 50 to the off-normal contacts 42 and 46 associated with the respective indicator arms. Therefore, the indicator arms FIA and IIA will positively be restored to normal even though the control key CK is too quickly moved to its "read" position.

Foot register operation

After the relays FRC and IRC are returned to normal, positive driving battery PDB which has its negative side grounded is connected through the foot motor magnet FMM, normal contact 25 of FRC, conductor 26, alternate contact 28 of control key CK, tip contact of the plug P and jack J, line FL, normal contact 29 of the foot polarized relay FPR, which only operates upon negative release battery, conductor 51, normal contact 52 of FIR through the winding of foot contact magnet FCM to ground. The foot magnet FMM of the foot register FTR is energized to condition the foot indicator arm FIA for movement and the foot contact magnet FCM of the foot contact finder FCF conditions the foot finder wiper FFW for movement. The closing of alternate contact 53 of FCM establishes an energizing circuit for the foot switching relay FSR which is of the slow operating type. The relay FSR is operated by current flowing from positive drive battery PDB over the previously traced circuit through alternate contact 53 of FCM, through the winding of FSR to ground. Relay FSR closes its alternate contact 54 to establish an energizing circuit for the foot interrupter relay FIR which is energized by current flowing from the positive drive battery PDB over the previously traced circuit through alternate contact 54 of relay FSR, through the winding of the foot interrupter relay FIR to ground. This last relay energizes and opens its contact 52 to interrupt the energizing circuit of the foot switching relay FSR which restores its contact 54 to normal thereby opening the energizing circuit of the foot interrupter relay FIR which relay is of the slow-to-release type; and also deenergizes the foot contact magnet FCM which through the release of its armature 55 steps the foot finder wiper FFW to its first contact.

The deenergization of the foot motor magnet FMM of the master register restores its armature 56 and causes the movement of the foot indicator arm FIA to the first contact which closes the off-normal contact 42. The foot interrupter relay FIR being of the slow-to-release type permits the deenergization of the motor magnets FMM and FCM and then restores its contact 52 to normal to again close energizing circuits for the foot motor magnets FMM and FCM which again operate and cause the operation of the foot switching relay FSR and the foot interrupter relay FIR to repeat the stepping of the foot finder wiper FFW and the foot indicator arm FIA. This stepping continues in the above described manner until the foot finder wiper FFW engages a grounded contact which in the embodiment shown is the thirty-first contact in the bank as the contents of the tank ST are at the thirty-one foot level. When the foot finder wiper FFW reaches the thirty-first contact a

shunt circuit for the foot contact magnet FCM is established, current flowing from the positive drive battery PDB through winding of the foot motor magnet FMM over the previously described circuit to contact 53 of foot contact magnet FCM, thence through resistance R, foot finder wiper FFW, contact 57, conductor 58, contact 59, wiper arm FCA, conductor 11, contact 15, commutator CE, inch shaft IS to ground G. The motor magnet FMM is operated by current flowing over the above described circuit, but its operation has no effect on the system at this time; the motor magnet FCM does not receive enough current to cause its operation.

Inch register operation

Meanwhile the inch contact finder ICF and the inch indicator arm IIA have been stepping in unison to ascertain and indicate the inch level of the contents of the tank ST. Positive drive battery PDB supplies current to cause the energization of the inch motor magnet IMM and the inch contact magnet ICM. This current flows from positive drive battery PDB through the inch motor magnet IMM, normal contact 33 of IRC, conductor 34, contacts 35 and 36 of CK, sleeve contacts of the connected plug P and jack J, inch line IL, normal contact 37 of IPR, normal contact 60 of IIR, through the winding of the inch contact magnet ICM to ground. The motor magnets IMM and ICM energize to condition their respective associated wipers for movement. The closing of contact 61 of inch contact magnet ICM establishes an energizing circuit for the inch switch relay ISR which is of the slow-to-operate type which relay closes its alternate contact 62 to establish an energizing circuit for the inch interrupter relay IIR which is energized by current flowing from the positive drive battery over the previously traced circuit to alternate contact 62 of ISR through the winding of the inch interrupter relay IIR to ground. The inch interrupter relay IIR energizes and opens its contact 60 to interrupt the energization of motor magnet IMM and ICM to restore them to normal and cause their associated armatures 63 and 64 to move the inch finder wiper IFW and the inch indicator arm IIA one step. The deenergization of the inch contact magnet ICM opens the energizing circuit of the inch switching relay ISR at normal contact 61 which relay restores its contact 62 and thereby opens the energizing circuit of the inch interrupter relay IIR which is of the slow-to-release type but which after a short interval does release and close its contact 60 to reestablish the energizing circuits of the motor magnets IMM and ICM to cause the continued stepping operation of the wiper IFW and the inch indicator arm IIA until the proper contact is reached by the inch finder wiper IFW.

When the grounded contact which in this case is 65 is reached by the wiper IFW a shunt circuit for the inch contact magnet ICM is established. This circuit can be traced from the grounded positive drive battery PDB through the winding of the inch motor magnet IMM, normal contact 33 of IRC, conductor 34, alternate contact 36 of key CK, ring contacts of the connected plug and jack, inch line IL, normal contact 37 of relay IPR, normal contact 60 of relay IIR, resistance R1, the wiper IFW as shown in dotted lines, contact 65, conductor 66, the zero inch contact of the inch contactor IC, wiper ICW to ground G. This shunt circuit prevents the operation of the motor magnet ICM and also of

the inch interrupter relay IIR and the inch switch relay ISR and accordingly the wiper IFW remains on contact 65 and the inch indicator arm IIA of the inch register INR remains on the zero contact of the inch register, as both the foot indicator arm FIA and the inch indicator arm IIA remain stationary the attendant knows that the proper contacts have been reached by the wipers FFW and IFW and that the contents of the storage tank ST are exactly at the thirty-one foot level.

Contents of tank rise one-quarter inch

Should the contents of the storage tank ST rise one-quarter of an inch from the thirty-one foot level while the master register is connected thereto, the inch contact wiper ICW will move from the zero contact to the one-quarter inch contact and in so doing will remove ground from the shunt circuit above described which will permit the operation of the inch motor magnets IMM and ICM as well as the subsequent operation of the inch interrupter relay IIR and inch switching relay ISR. The operation of these relays will of course deenergize the motor magnets IMM and ICM to step the inch finder wiper IFW to the last contact in the bank which is unwired. The inch indicator arm IIA is stepped past the zero indicating position to close the past normal contacts PNI which complete an energizing circuit for the inch conditioning relay IRC. The conditioning relay IRC opens its normal contact 33 to disconnect the positive drive battery PDB from the inch line IL and closes its alternate contact 33 to connect the negative release battery to the line IL. The inch polarized relay IPR shifts its contact 37 to its alternate position to close an energizing circuit for the inch contact release relay ICR which relay operates to remove the pawl 39 from engagement with the ratchet teeth 40 to permit the wiper IFW to restore to its normal position. The closure of contact 45 of the inch register conditioning relay IRC closes an energizing circuit for the inch release magnet IRM which magnet is energized by current flowing from grounded battery through the alternate contact 45 of relay IRC, the winding of inch release magnet IRM, alternate contact 50 of IRC to ground at past normal contact PNI. The magnet IRM withdraws the pawl 47 from engagement with the ratchet teeth 48 and the inch indicator arm IIA is restored to normal under the influence of the spring as previously described. The restoration of the indicator arm IIA restores the past normal contacts PNI to their normal position thereby opening the energizing circuit for the inch relay IRC which restores its contact 33 to its normal position to disconnect the negative release battery NRB from the line and to connect the positive drive battery PDB to the line. The inch polarized relay IPR and the inch contact release relay ICR are also restored to normal and the off-normal contact 33 associated with the inch finder wiper IFW is also opened. The closure of normal contact 37 of the inch polarized relay IPR again closes the operating circuits for the inch motor magnets IMM and ICM which cause the subsequent operation of the switching relay ISR and interrupter relay IIR to step the wipers IFW and the indicator arm IIA until the grounded contact is reached by the inch finder wiper IFW which in this case is the first contact 70 at which time the shunt circuit is again established from resistance RI, wiper IFW, contact 70, conductor 71, the quarter inch contact of the inch contactor IC,

wiper ICW to ground G. The inch indicator arm IIA will stop at the first mark on the register to indicate the quarter of an inch and as the foot indicator arm FIA is still on the thirty-first mark on the foot register the level of the contents of the tank will be indicated as thirty-one feet, one-quarter inch.

Level falls one-quarter inch from thirty-one feet

Should the level of the contents of the storage tank ST fall one-quarter inch below the thirty-one foot level the inch contact wiper ICW will move to the eleven and three-quarter inch contact thereby opening the shunt circuit of the motor magnets IMM and ICM and permitting the same to operate to step the inch finder wiper IFW and the inch indicator arm IIA to their past normal position, at which time the inch past normal contacts PNI will be closed to cause the operation of the inch register conditioning relay IRC, the inch release magnet IRM, the inch polarized relay IPR and the inch contact release relay ICR, which relays energize as above described to restore the wiper IFW and the inch indicator arm IIA to normal. As the first contact is not grounded the wipers will continue to step until the inch finder wiper IFW engages the eleven and three-quarter inch contact 72 at which time the shunt circuit for the motor magnets IMM and ICM will again be established to ground G at wiper ICW and the eleven and three-quarter inch contact. At this time the inch indicator arm IIA will be indicating the eleven and three-quarter inch level.

At the same instant that the inch contact wiper ICW breaks connection from the zero bank contact the commutator CE breaks the ground connection from the overlapping foot contact wiper FCA which is on bank contact 31. This removes the shunt circuit from the foot finder switch motor magnets FCM and FMM and these magnets operate in unison to step their respective wipers to their past normal position at which time the past normal contacts PNF are closed to establish an energizing circuit for the foot conditioning relay FRC which relay opens its normal contact 25 to disconnect the positive drive battery PDB from the foot line FL and closes its alternate contact 25 to connect the negative release battery to the foot line FL to cause the operation of the foot polarized relay FPR which relay causes its armature 29 to move to its alternate position to complete an energizing circuit for the foot contact release relay FCR through the closed off-normal contacts 30. The release relay FCR withdraws its pawl 31 from the ratchet teeth 32 to permit the wiper FFW to return to its normal position. At the same time the foot register relay FRC has closed its alternate contact 41 to establish an obvious energizing circuit for the foot release magnet FRM which magnet restores the foot indicator arm FIA to its normal position thereby opening the energizing circuit for the foot release magnet FRM at off-normal contact 42 which also opens the holding circuit for the foot register relay FRC. The original energizing circuit for the relay FRC is opened at past-normal contact PNF. The restoration to normal of the contact 25 of relay FRC again closes the operating circuits for the foot motor magnets FMM and FCM which will step their associated wipers until the foot finder wiper FFW makes connection with the thirty foot bank contact 73 which is connected to the thirty foot contact in the bank FC, then engaged by the lagging wiper

FCB which wiper is connected to ground G through conductor 12 and commutator CF, which is rotated with the inch contactor shaft IS so that the insulated segment 14 has passed the position of the brush 16. The indication on the register is now thirty feet eleven and three-quarter inches.

The level rises one-quarter inch from thirty feet eleven and three-quarter inch registration

When the level in the contents of the storage tank ST rises one-quarter of an inch from the thirty feet eleven and three-quarter inch mark, the inch switch contact wiper breaks the ground connection from the eleven and three-quarter inch bank contact and steps ahead to the 0 position which is then grounded by the wiper ICW in the regular manner as already described. The inch magnets IMM and ICM will step their wipers in unison until the wiper IFW engages the 0 contact 65 at which time the shunt circuit will again be closed and the indicator arm IIA will indicate no inches on the master register.

At the same instant that the inch contact wiper ICW breaks connection with the eleven and three-quarter inch bank contact the commutator CF breaks the ground connection from the brush 16 to the lagging foot contact wiper FCB in the bank contact 30. This removes the stopping shunt from the foot wiper switch motor magnet FCM and the master foot magnet FMM and these magnets step their associated wiper arm FFW and indicator arm IIA to the thirty-one foot position where the foot finder wiper FFW engages contact 57 which makes a ground connection through conductor 58, contact 59, and overlapping wiper FCA, conductor 11, brush 15, commutator CE and inch shaft IS to ground G. The master register again registers thirty-one feet which is the level of the contents of the tank as shown.

When the level of the contents of the storage tank ST rises at any point within the same foot from the one-quarter inch to eleven and three-quarter inches, the inch indicator arm IIA follows in the one-quarter inch steps while the foot reading remains constant.

Means for preventing error

As the foot contactor brush moves over but a single contact while the inch contactor brush moves through a complete revolution it is exceedingly difficult to so mechanically arrange the contact bank and relation between the brushes that the foot contactor brush will move from one of its contacts to the next at the very instant that the inch contactor brush moves from its eleven and three-quarter inch contact to its zero contact or vice versa. This difficulty is magnified by the fact that it is exceedingly difficult to create a contact bank the contacts of which are exactly spaced throughout the whole range, particularly as the dimensions of the bank vary slightly due to changes in temperature and humidity. It is to prevent an error arising on account of this variation that the foot contactor is provided with two brushes which are arranged to be normally grounded but which have their grounds removed as the inch contactor brush passes from its eleven and three-quarter inch contact to its zero contact or from its zero contact to its eleven and three-quarter inch contact. It will be understood that the two brushes FCA and FCB of the foot contactor are very close together and during most of the time rest upon

the same contact in the bank. It is only during the period when the level of the tank is changing to the next succeeding foot level position that these two brushes occupy adjacent contacts. Thus the interrupted segment 14 is adapted to remove ground for a short time from the brush FCB when the inch contactor brush moves to a position slightly beyond the eleven and three-quarter inch position and if the tank is being emptied the commutator segment 13 acts to remove ground from the brush FCA for a short time when the level falls below the exact foot.

Thus if the tank is being filled when a reading is taken and the inch contactor brush is in a position where it is about to move onto its zero contact the interrupted segment 14 is so arranged that it will break the circuit to the foot contactor brush FCB at the instant the inch contactor brush ICW passes from eleven and three-quarter inches to zero which will prevent the possibility of obtaining a reading of five feet no inches when the reading should be six feet no inches.

If the tank is being emptied at the time a reading is taken the segment 13 is so arranged as to remove ground from the brush FCA at the instant the inch contactor brush ICW passes from its zero contact to its eleven and three-quarter inch contact. This expedient insures that the ground will be removed from one foot contact and placed on the adjacent foot contact at substantially the instant that the inch contactor passes from its eleven and three-quarter inch contact to its zero contact or vice versa, thus insuring a correct reading even though there may be a slight lost motion in the connection between the inch contactor brush and the foot contactor brush or slight inaccuracies in the contact bank.

While it will be obvious from the above that the interrupter segments 13 and 14 must be placed so as to occupy very nearly the same angular position, nevertheless it is necessary that they do not coincide in their position as in that case there would be a certain position where neither of the two foot contactor brushes would be connected to ground and if a reading was taken at this time it would result in the foot contactor running wild, that is, hunting and releasing repeatedly. Thus these interrupter segments are sufficiently angularly spaced apart so that one or the other of the foot contactor brushes is at all times connected to ground.

As the inch contact finder wiper and the foot contact finder wiper are arranged to step in their hunting movement at the same time, if the contents of the tank are low, say for instance five feet eleven and three-quarter inches, it is obvious that the foot contact finder will reach its stopping position before the inch contact finder does. If at the time a reading is being taken the contents of the tank are just below an exact foot level position it is conceivable that the level of the tank may pass from the eleven and three-quarter inch level to the zero inch level during the period of time in which the inch contact finder brush is in movement after the foot contact finder brush has stopped, in which case, were it not for applicant's expedient, there would be an error of one foot in the reading of the contents of the tank, as the reading would then appear five feet no inches.

However, as the inch contactor brush moves from the eleven and three-quarter inch position to its zero position the foot contactor brushes

will remove ground from the five foot contact and place ground on the six foot contact. This will remove ground from the contact occupied by the foot contact finder brush and the foot contact finder will start hunting and will step onto the next (sixth) contact where it will stop. The foot register arm will move in synchronism with the foot contact finder brush and will also step six times and the register will now indicate exactly six feet no inches.

If while the tank is being emptied the inch contactor moves from its zero to its eleven and three-quarter inch position during the period in which the inch contact finder brush is in movement after the foot contact finder brush has stopped the mechanism described will act to remove ground from the sixth contact of the foot finder bank and place it upon the fifth contact. This will remove the ground from the contact occupied by the foot contact finder brush and the foot contact finder will start hunting and will step to the end of its arc. The foot register arm will move in synchronism with the foot contact finder brush and will also step to the end of its arc closing the past normal contact PNF which will bring about the release of the foot contact finder and the foot contact register as previously described.

Upon restoration to zero the release magnets of the two switches will be deenergized and the foot contact finder wiper and the foot contact register arm will again start into motion, but this time will come to rest on their fifth contact indicating five feet, eleven and three-quarter inches.

While this occurrence may be comparatively infrequent, nevertheless were it not for the expedient provided by applicant, in these rare instances an error of one foot in the reading would be obtained.

While I have shown and described a preferred embodiment of my invention, it is to be understood that changes and modifications will suggest themselves to those skilled in the art. I, therefore, desire to be limited only by the scope and spirit of the appended claims.

Having described my invention, what I claim is new and desire to secure by United States Letters Patent is:

1. In a system of the character described, an object movable in opposite directions, a contact bank, a pair of wipers associated with said contact bank, means connecting said movable object and wipers to move said wipers over the contacts of said bank in a direction corresponding to the direction of movement of the movable object to cause one of said wipers, upon sufficient movement of the object, to engage a new contact corresponding to the changed position of the object while the other wiper may still engage the previous contact, and commutator means associated with said connecting means and having two individual contact controls, one of which has means for placing a potential on the wiper making a new contact and the other of which has means for at the same time removing the potential from the other wiper, when the two wipers engage different contacts.

2. In a system of the character described, an object movable in opposite directions, a contact bank, a pair of wipers associated with said bank, means connecting said movable object and wipers to move said wipers over the contacts of said bank in a direction corresponding to the direction of movement of the movable object and to cause

one of said wipers, when the object moves sufficiently, to engage a new contact corresponding to the position of the said movable object, while the other wiper may still engage the previous contact, commutator means associated with said connecting means for placing a potential on the wiper and the contact engaged thereby corresponding to the position of the movable object, a second contact bank, means connecting the contacts of the second bank to the contacts of said first bank of contacts respectively, a third wiper adapted to step over the said second bank of contacts to locate the contact having the potential thereon, an indicator arm and means including an electro-magnet controlling said third wiper and an electro-magnet controlling said indicator for moving said indicator arm in unison with said third wiper.

3. In a system of the character described, an object movable in opposite directions, a contact bank, a wiper adapted to move over the contacts in said contact bank, a rotatable shaft supporting said wiper, another contact bank, a pair of wipers so spaced they may engage adjacent contacts adapted to move over the contacts of said second bank in a direction corresponding to the direction of movement of the movable object, a rotatable shaft supporting said pair of contact wipers, means connecting said two shafts whereby the pair of wipers move an aliquot part of a rotation of the single wiper carrying shaft, and commutator means on this shaft having two individual contact controls, one of which has means for placing a potential on one of the pair of wipers and a new contact and the other of which has means for, at the same time, removing the potential from the other wiper when the two wipers of the pair engage different contacts.

4. In a system of the character described, an object movable in opposite directions, a contact bank, a pair of wipers associated with said contact bank, means connecting said object and wipers to move said wipers in a direction corresponding to the direction of movement of the movable object to cause one of said wipers when the object moves sufficiently, to engage a new contact corresponding to the position of said object, while the other wiper may still engage the previous contact, commutator means associated with said connecting means for placing a potential on the wiper or wipers and contact engaged thereby corresponding to the position of the movable object, a second contact bank the contacts of which are electrically connected with the contacts of the first bank, respectively, a wiper adapted to move over the second contact bank to locate the contact having the potential thereon, an indicating arm and means including an electro-magnet controlling said third wiper and an electro-magnet controlling said indicator for moving said indicator arm in unison with said second contact bank wiper to indicate the position of the said object.

5. In a system of the character described, a contact bank, a wiper adapted to move over the contacts in said bank to place a potential thereon, a rotatable shaft supporting said wiper, a zero position for said shaft, another contact bank a pair of wipers adapted to move over the latter contacts and place a potential thereon, said wipers engaging adjacent contacts when said shaft is near its zero position, a rotatable shaft supporting said pair of wipers, means connecting said shafts whereby the pair of wipers move an aliquot fraction of a rotation for each revolution

of the single wiper carrying shaft, commutator means for placing a potential on one of said pair of wipers and the contact engaged thereby and for removing such potential from the other of said pair of wipers and the contact engaged thereby during the last movement of said single wiper carrying shaft to its zero position in one direction and for removing said potential from the first mentioned one of the wiper pair and the contact engaged thereby during the first movement of the single wiper carrying shaft from its zero position in the opposite direction.

6. A movement translating means comprising an object movable in opposite directions, an arm rotatable for any movement of said object, a contact bank co-operating with said arm, a pair of arms comprising a leading arm and a lagging arm and a contact bank therefor, the direction of rotation of all of said arms depending on the direction of movement of said object, means connecting said first arm and said pair of arms whereby the pair move only an aliquot fraction of a rotation for a complete revolution of the single arm, commutator means controlled by the move-

ment of the object normally placing an electrical potential on said leading and lagging arms, but which removes the potential from the lagging arm when the object moves sufficiently to cause the single arm to complete a revolution.

7. A movement translating means comprising an object movable in opposite directions, an arm rotatable for any movement of said object, a contact bank co-operating with said arm, a pair of arms comprising a leading arm and a lagging arm and a contact bank co-operating therewith, the direction of rotation of all of said arms depending on the direction of movement of said object, means connecting said first arm and said pair of arms whereby the pair move only a fraction of a rotation for a complete revolution of said single arm, commutator means controlled by the movement of the object normally placing an electrical potential on the leading and lagging arms but which removes the potential from the lagging arm when the object moves sufficiently in either direction to cause the single arm to complete a revolution.

BERT A. WALLACE.