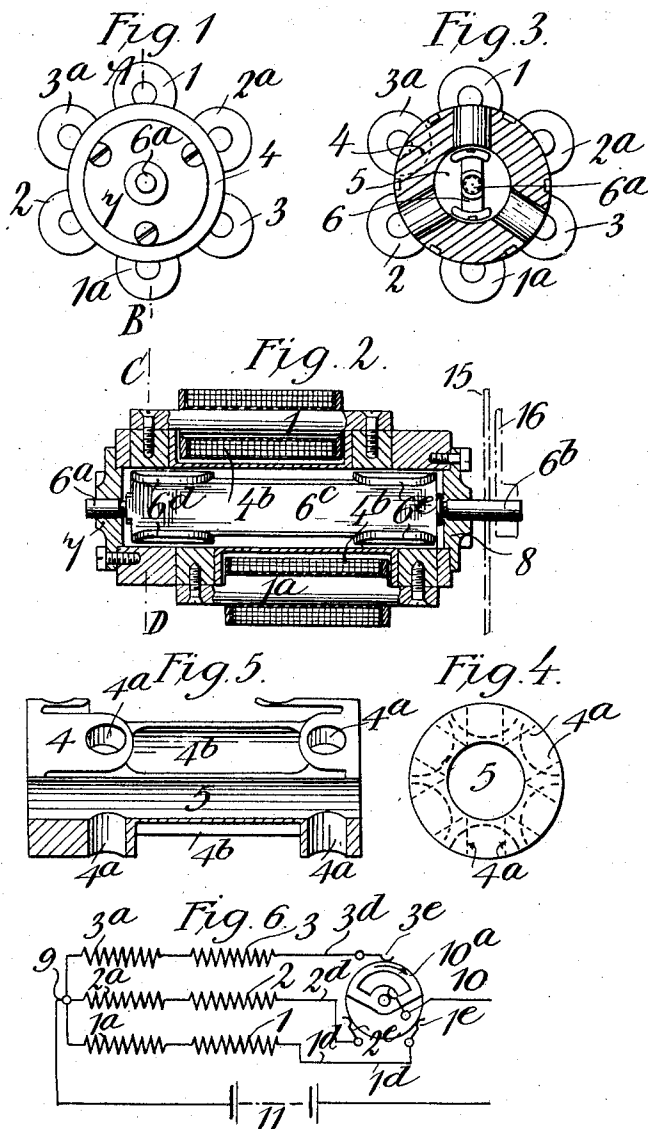


E. A. GRAHAM.
ELECTRICAL SIGNALING OR INDICATING APPARATUS ESPECIALLY APPLICABLE FOR SIGNALING
ORDERS AND NUMERICAL DATA.
APPLICATION FILED MAY 16, 1919.

1,843,362.

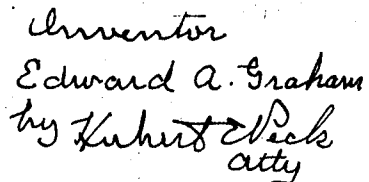
Patented June 15, 1920.
3 SHEETS—SHEET 1.



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attys

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3 SHEETS—SHEET 2.



REISSUED

AS NO. 162687

FEB. 16 1926

E. A. GRAHAM.

ELECTRICAL SIGNALING OR INDICATING APPARATUS ESPECIALLY APPLICABLE FOR SIGNALING
ORDERS AND NUMERICAL DATA.

APPLICATION FILED MAY 16, 1919.

1,343,362.

Patented June 15, 1920.

3 SHEETS—SHEET 3.

Fig. 17.

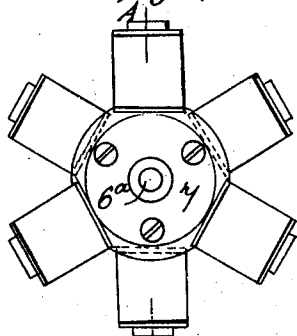


Fig. 18.

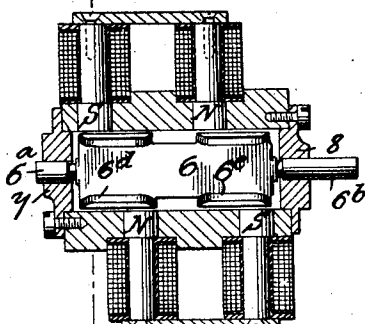


Fig. 19.

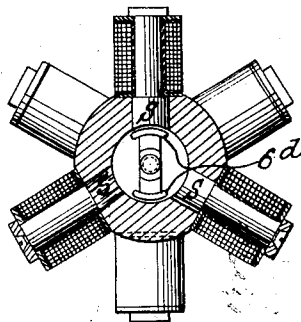


Fig. 20.

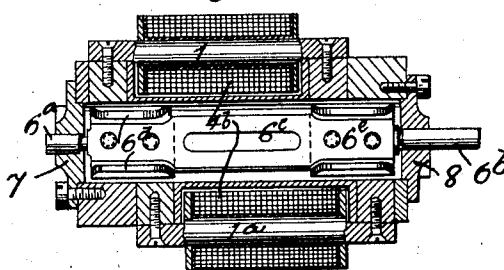


Fig. 21.

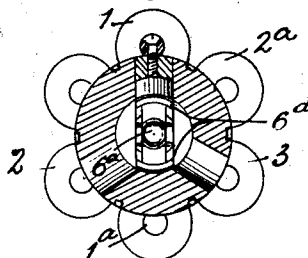


Fig. 22.

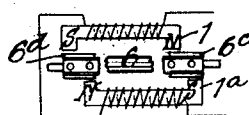


Fig. 23.

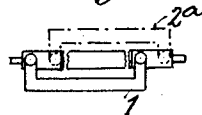


Fig. 24.

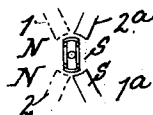
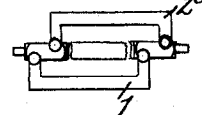


Fig. 25.



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UNITED STATES PATENT OFFICE.

EDWARD ALFRED GRAHAM, OF BROCKLEY, LONDON, ENGLAND.

ELECTRICAL SIGNALING OR INDICATING APPARATUS ESPECIALLY APPLICABLE FOR SIGNALING ORDERS AND NUMERICAL DATA.

1,343,362.

Specification of Letters Patent. Patented June 15, 1920.

Application filed May 16, 1919. Serial No. 297,582.

To all whom it may concern:

Be it known that I, EDWARD ALFRED GRAHAM, a subject of the King of Great Britain and Ireland, residing at Brockley, in the county of London, England, have invented Improvements in or Relating to Electrical Signaling or Indicating Apparatus Especially Applicable for Signaling Orders and Numerical Data, of which the following is a specification.

This invention relates to electrical signaling or indicating apparatus of the kind comprising an electrical receiving device wherein an armature secured to a spindle or shaft is influenced by a series of electro-magnets controlled by appropriate local or remotely situated switchgear, in such manner that, consequent upon actuation of the controlling switch, rotary motion is imparted in a step by step manner to the armature which assumes certain predetermined positions in the course of each revolution and, in conjunction with a suitable dial, or a pointer, according to the purpose for which the device is to be applied, affords various specific indications.

The object of the present invention is to provide electrical order receiving devices of the type referred to (hereinafter referred to as electrical receiving devices) possessing *inter alia* the important practical advantages over known types of being consistent and exact in operation within a wide range of variation of applied electrical pressure and of having an increased armature torque for a given dissipation of electrical energy.

To this end in an electrical receiving device according to the invention, a series of diametrically situated pairs of bipolar electro-magnets are so arranged that both polar extensions of one electromagnet of a pair are adapted when excited to magnetically influence radial polar projections of a rotary armature while the polar extensions of the other electro-magnet of the pair are adapted, when excited, to simultaneously magnetically influence other correspondingly projecting polar projections of the armature but in regions that will not in turn be influenced by the polar extensions of the first named electro-magnet. Furthermore, the arrangement is such that each polar projection of the armature can be influenced simultaneously in regions that are displaced axially of the armature, by the polar pro-

jections of the adjacent electro-magnets of two diametrically situated pairs of electro-magnets so that a series magnetic circuit is formed including the cores of such adjacent pairs of electro-magnets and the armature polar projections.

For these purposes the polar projections of the several pairs of electro-magnets are at each end portion of the receiving device, arranged in staggered relationship in successive planes transverse to the axis of the armature and each polar projection of the armature is made of such axial length and circumferential width as to bridge the adjacent polar projections of an adjacent pair of electro-magnets.

The arrangement is such that accurate registration is obtained when the armature is influenced by more than one pair of electro-magnets and the design and construction is such that the process of manufacture of the receiving device is facilitated.

In connection with an electric receiving device constructed and operating in accordance with the invention a switching device is provided for controlling the several electric circuits, and also conductors between the switching device and the said receiving device. The conductors may conveniently be four in number and one of them may serve as a common return in which case the battery or other source of electrical energy employed, may be included therein, each of the remaining conductors serving to connect the windings of one pair or group of electro-magnets, to a given element of the controlling switch. Additional conductors may be employed in instances where it is advantageous to provide more than three pairs or groups of electro-magnets, but, as in practice it is desirable to maintain the number of conductors within reasonable limits, reference will be made to the use of only four conductors in the following description of the accompanying illustrative drawings which show various constructions of receiving devices according to the invention.

In these drawings, Figure 1 shows in end view, Fig. 2 in central section on the line A B of Fig. 1 and Fig. 3 partly in end elevation and partly in cross section on the line C D of Fig. 2 one form of step by step receiving device according to the invention.

Fig. 4 shows the stationary body or cen-

tral casting of the device in end view and Fig. 5 shows it partly in side elevation and partly in central section.

Fig. 6 shows the preferred connections of the three pairs of electro-magnets used in the said receiving device and the controlling switch therefor.

Fig. 7 is a development of the cylindrical pole-face of the said body or casting.

Fig. 8 shows, semi-diagrammatically, the relative position of the armature and one pair of electro-magnets influencing it.

Fig. 9 is a semi-diagrammatic plan view showing the same elements.

Fig. 10 is a semi-diagrammatic end view of the armature and two pairs of influencing electro-magnets and Fig. 11 is a semi-diagrammatic plan of the same.

Figs. 12, 13, 14, 15 and 16 are similar views to Figs. 1, 2, 3, 6 and 7 respectively, showing a modified construction in which twelve electromagnets influence an armature having four pairs of polar projections, the section shown in Fig. 13 being taken in the line X—Y Fig. 12.

Fig. 17 is an end view of a step by step device similar to that of Fig. 1 but so arranged that each bipolar electromagnet has two exciting coils.

Fig. 18 is a central section of the device taken on the line A B of Fig. 17 and

Fig. 19 is a cross section taken on the line C D of Fig. 18.

Figs. 20, 21, 22, 23, 24, and 25 are similar views to Figs. 2, 3, 8, 9, 10 and 11 respectively showing a further modified construction.

Referring to the construction shown in Figs. 1 to 11 inclusive, it will be seen that the step by step receiving device comprises three pairs of bipolar electromagnets 1, 1^a, 2, 2^a and 3, 3^a, carried by and arranged around a stationary cylindrical body 4 having a central cylindrical bore 5 in which is disposed an armature 6. This armature is provided with journals 6^a and 6^b mounted to rotate in end caps 7 and 8 parts of which are adapted as shown, to fit within the bore 5 and thus accurately centralize the armature.

The polar ends or projections of each electromagnet extend radially through and are fixed in holes 4^a in the body 4 and have their free ends flush with the inner cylindrical surface of the bore 5, the polar ends of adjacent electromagnets being staggered relatively to one another at each end of the body as shown in Fig. 7.

By this arrangement of the poles, if the number of electromagnets be p , each pole piece may subtend an arc equal to $\frac{1}{p}$ of the entire circumference of the armature bore without undue magnetic leakage being set

up. The pole pieces being of this breadth, for a given diameter of armature the maximum torque is obtained combined with definite indexing of the armature.

The body is recessed at 4^b to accommodate the windings of the electromagnets.

The armature 6 comprises a core 6^c of approximately rectangular cross section provided at its opposite end portions with two radially projecting pairs of elongated polar projections 6^a and 6^b the polar projections in each pair being diametrically arranged. These polar projections are each preferably so dimensioned as to be twice the polar diameter of the pole piece of the electromagnet in an axial direction and equal to the diameter of each pole piece of the electromagnet in a circumferential direction, its outer surface being of part cylindrical shape and disposed near to the inner periphery of the bore 5.

It will be seen by reference to Figs. 2, 3, 8, and 9, that the two diametrically opposed electromagnets connected in one electrical circuit and constituting a pair, say 1 and 1^a are staggered with regard to each other and act upon alternate or relatively displaced portions of the armature polar projections 6^a and 6^b. Also, that each adjacent neighboring pair of electromagnets are relatively staggered and also act upon alternate portions of the polar faces of the armature in such a manner that in passing from under one pair of poles say those of electromagnet 2^a, the polar projections 6^a and 6^b respectively bridge the neighboring poles of these two magnets as shown in Figs. 10 and 11.

In Figs. 6 and 7 it will be seen that each of the pairs of electromagnets 1 and 1^a, 2 and 2^a, 3 and 3^a is connected to a common junction 9 and by a separate line wire 1^a, 2^a or 3^a to a controlling switch marked collectively 10. One pole of the source of electric supply 11 is connected to a rotary member 10^a of the switch and the opposite pole to the common junction 9. By the rotation of the switch element 10^a the electric contacts 1^c, 2^c and 3^c are successively energized and with them the associated electromagnets.

In Fig. 7 the relative arrangement of the pole pieces of the several electromagnets around the cylindrical bore 5 is set out in developed form.

As will be seen from Fig. 6, by rotation of the switch the pair of electromagnets 3, 3^a will be alone connected in circuit, then in parallel with the next pair of electromagnets 1, 1^a. This pair will afterward alone be connected in circuit, and subsequently in parallel with the pair of electromagnets 2, 2^a. These will afterward alone be connected in circuit and subsequently in parallel with the electromagnets 3, 3^a, and so on for each rotation of the switch.

In order that the arrangement of magnetic circuits may be readily followed, reference is made to Figs. 8 to 11 inclusive.

In Figs. 8 and 9 it will be seen that the upper and lower electro-magnets 1, 1^a equally influence corresponding limbs of the armature, which is thereby maintained in a state of equilibrium and consequently the armature shaft remains free from stress.

While the upper and lower magnetic circuits are each complete and parallel, a further, or secondary, magnetic circuit is formed, including the armature and both electromagnets.

When the second pair of electro-magnets are energized and the first pair of magnets remain energized, the armature assumes a position with the faces midway between the polar extensions of the influencing magnets, as shown in Figs. 10 and 11. In these conditions, series magnetic circuits are formed, including, in the first instance, the upper electro-magnet first energized, the upper limb of the armature and the upper electro-magnet secondly energized. Similarly, the corresponding lower electro-magnets and the lower limb of the armature, form a second series magnetic circuit. Subsidiary magnetic circuits exist, but the exact location of the armature at the intermediary position is due to the rapid building up of the series magnetic circuits, as referred to. The relative positions of the armature and arrangement of influencing electro-magnets are shown by Figs. 10 and 11.

In Figs. 12 to 16 inclusive, the arrangement of receiving device shown has twelve electro-magnets connected in three groups of four each. The armature 6 in this case is provided with four polar projections 6^a at one end, and four polar projections 6^b at the other end, each of the four pairs of polar projections 6^a, 6^b, thus formed being acted upon respectively by one of the four electro-magnets in a group or alternatively by two electro-magnets belonging to the two neighboring groups. As in the previously described arrangement, the construction comprises a body 4 drilled to carry at each end the twelve staggered pole pieces of the electro-magnets 1, 2, 3, 1^a, 2^a, 3^a, 1^b, 2^b, 3^b and 1^c, 2^c, 3^c (see Fig. 16). The connections employed in this modification are shown in Fig. 15 and it will be seen from the figure that the four electromagnet coils of each group are connected in series and that each group is connected to a controlling switch in a manner corresponding to that shown in Fig. 6. A developed view of the cylindrical bore showing the relative positions of the poles and coils of the electro-magnets is shown in Fig. 16. In this modification the armature pole projections are acted upon in a manner similar to that described with reference to the first described

arrangement of receiving device, that is to say, the electro-magnets of a pair or of a group thereof, have their poles so arranged that a complete series magnetic circuit or circuits is or are produced through the polar projections of the armature, or otherwise stated, the poles of one group are of alternate polarity.

In the modified construction shown in Figs. 17, 18 and 19 two exciting coils are employed for each bipolar electro-magnet in a pair or group, these coils being wound in the same sense, so as to coöperate in imparting to the electro-magnet the polarity indicated in Fig. 18 and to avoid consequent poles therein. From these figures it will be followed that the disposition and operation of the modified devices are similar to that of the device shown in Figs. 1 to 5 inclusive.

In the construction of electrical receiving devices shown in and described with reference to Figs. 1 to 11 inclusive and in Figs. 17, 18 and 19, the rotary armature takes up, during each revolution twelve definite positions as the various groups of electro-magnets are excited. In the construction shown in and described with reference to Figs. 12 to 16 inclusive twenty-four definite positions are taken up by the armature to afford a like number of indications for each revolution of the armature.

The indicating elements may, as shown in broken lines in Fig. 2, take the form of a stationary dial 15 and a pointer 16 fixed on the armature shaft. Or the motor armature may be connected to a counting or numbering train by suitable gearing in known manner.

Figs. 20 to 25 inclusive show a similar construction of receiving device to that shown in Figs. 2, 3, 8, 9, 10 and 11 except that the central or intermediate portion of the rotary armature is made of non-magnetic material, instead of being of magnetic material as it is in the first described construction, which is however that preferred. The magnetic circuits are in this construction completed through the magnetic end portions of the armature and their polar projections. Thus the magnetic circuit, in the position shown in Fig. 22 includes the cores of both magnets 1, 1^a, and the said end portions of the armature, while in the position shown in Fig. 24 the circuit of the magnets 1, 2^a is completed through the upper polar projection and the circuit of the magnets 2, 1^a through the lower polar projection.

I desire it to be understood that I am aware of various known ways or means by which step-by-step devices or indicating movements are obtainable and I make no broad claim to the use or employment of a minimum number of three electromagnetic circuits or groups, or four conductors be-

tween the controlling switch and the operated movement, which combination is common to many step-by-step mechanisms and is referred to, or may be applied to, the electric receiving devices or movements disclosed in the specifications of British Letters Patent of Hauss No. 22336 of 1902, of Ritchie No. 28254 of 1904, of Barr and Stroub No. 4422 of 1906, of Creffield No. 8,346 of 1908, and of Calten No. 28180 of 1910. The present invention however, differs from these known arrangements in various respects, the electromagnetic system being an important particular. Thus in an electric receiving device constructed according to the present invention as herein set forth the polar projections of the armature are simultaneously magnetically influenced at each position of rest and the said polar projections are alternately influenced on one or other of two portions of each pole face for each succeeding step, the polar prolongations of the influencing electromagnets being in staggered relationship.

What I claim is:—

1. An electrical step-by-step device comprising a rotary armature having at one side of its axis two radially disposed polar projections separated axially from each other along the armature, an electro-magnet having polar extensions which, measured in the direction of the axis of the armature, are of less length than the length of the corresponding armature polar extensions and influence certain portions only of the latter, and another similar electro-magnet the polar extensions whereof are displaced in the direction of the axis of the rotary armature compared with the polar extensions of the first named electro-magnet and are adapted also to influence the said armature polar projections but on alternative portions of the same.

2. An electrical step-by-step device, comprising a rotary armature having at one side of its axis two radially disposed polar projections separated from each other axially along the armature, an electro-magnet having core polar extensions which measured in the direction of the axis of the armature do not exceed half the corresponding length of the armature polar extensions with which latter the core polar extensions coöperate, the magnetic circuit at one position of rest of the armature being completed through the electro-magnet core and portions of such armature polar projections, and a second similar electro-magnet displaced axially in relation to the first named electro-magnet so that, corresponding to a following position of rest, a series magnetic circuit through both magnet cores is completed by way of the armature polar projections extending between the axially placed magnet polar extensions.

3. An electrical step-by-step device, comprising a rotary armature having a pair of radially disposed polar projections at one end, and a similar pair of polar projections at the other end, an electro-magnet having polar extensions adapted to influence the pair of armature polar projections at one side of the axis of the armature, and another electro-magnet displaced axially in relation to the first named magnet and having polar extensions adapted to influence the opposite pair of armature polar projections but at portions of the polar faces alternate to those of the portions influenced by the companion electro-magnet.

4. An electrical step-by-step device, comprising a series of electro-magnets having polar extensions arranged in staggered relationship and a rotary armature having polar projections the axial length and circumferential width of each of which is such that it can bridge an adjacent and staggered pair of the electro-magnet polar projections.

5. An electrical step-by-step device, comprising a rotary armature having a pair of radially disposed polar projections at one end, and a similar pair of polar projections separated axially along the armature from the first named pair, an electro-magnet having polar extensions adapted to influence the pair of armature polar projections at one side of the axis of the armature, and another electromagnet having polar extensions that are displaced axially in relation to the armature with reference to the first named pair of polar extensions and are adapted to influence the opposite pair of armature polar projections.

6. In combination, a rotary armature having a number of pairs of radially disposed polar projections and a number of pairs of electromagnets disposed around said armature and having polar extensions arranged in staggered relationship.

7. In combination, a rotary armature having a number of pairs of radially disposed polar projections and around said armature a number of pairs of electro-magnets having polar extensions arranged in staggered relationship, the axial length and circumferential width of each polar projection of the armature enabling it to bridge any adjacent staggered pair of polar extensions.

8. In an electrical step-by-step device, a stator comprising a body having firstly a central cylindrical bore, secondly radial holes arranged in pairs in staggered relationship proceeding circumferentially of the body and thirdly recesses extending longitudinally between each pair of holes, substantially as described.

Signed at London, Eng., this sixteenth day of April, 1919.

EDWARD ALFRED GRAHAM.