

July 5, 1949.

G. M. GIANNINI
TELEMETRIC SYSTEM

2,475,232

Original Filed June 4, 1945

2 Sheets-Sheet 1

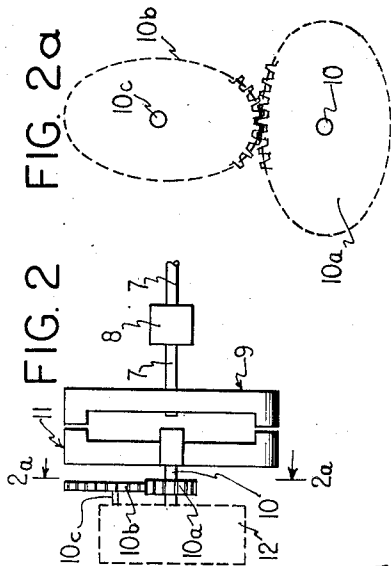


FIG. 1

FIG. 2a

FIG. 3

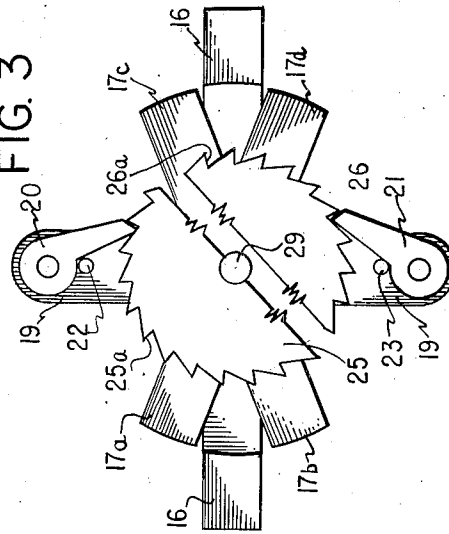
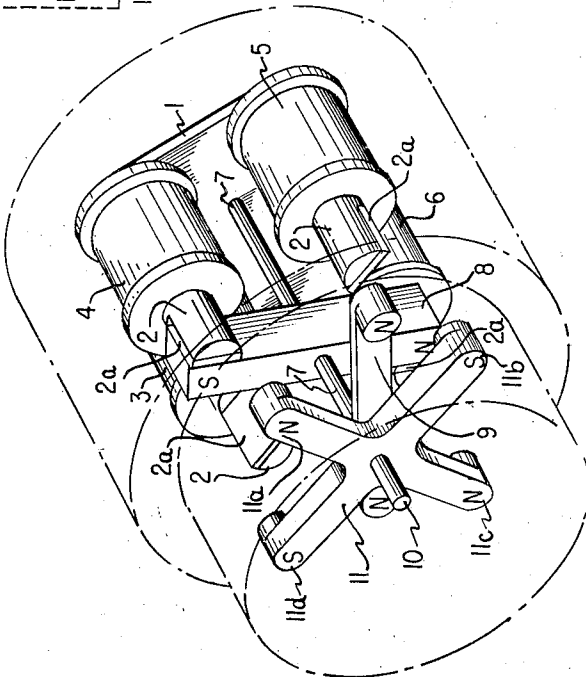


FIG. 2



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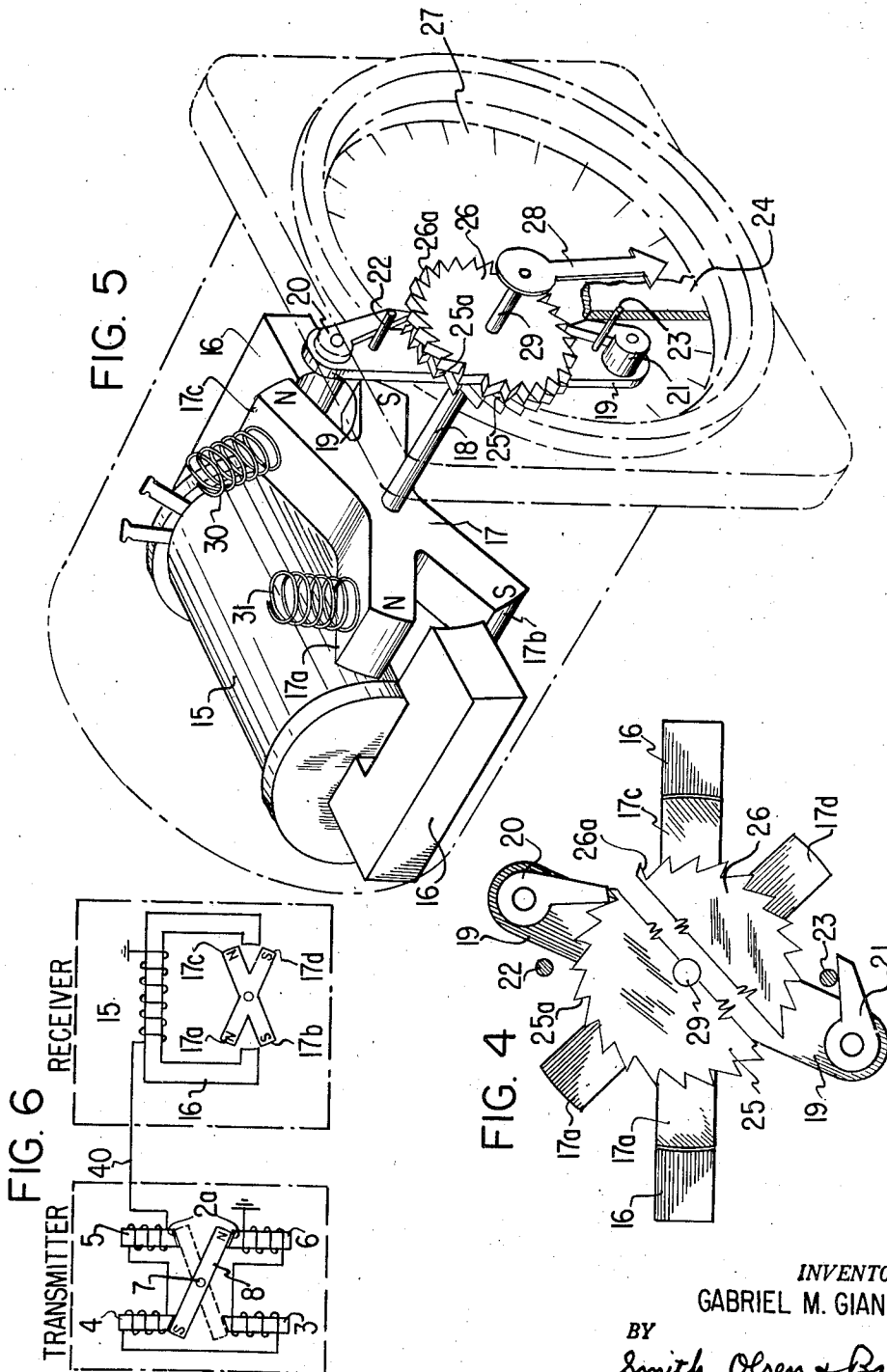
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UNITED STATES PATENT OFFICE

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TELEMETRIC SYSTEM

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Original application June 4, 1945, Serial No.
597,459. Divided and this application Septem-
ber 5, 1947, Serial No. 772,441

2 Claims. (Cl. 318—21)

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This invention relates generally to telemetric systems; that is, to systems of the follow-up type, including systems which are designed to perform the function of remote indication or of transmission of intelligence, and systems which perform the function of remote operation or remote control. The invention has useful applications and utilities in connection with all such operations; being generally useful in a great many if not all situations in which it is desired to perform any such functions and the present application is a division of a copending original application Serial No. 597,459, filed June 4, 1945, now Patent No. 2,471,947, May 31, 1949.

Without implying any limitations, but merely for example, telemetering systems of the type herein described are especially useful in aircraft operation, for the purpose of transmitting information concerned with landing gear position, oil pressure, gasoline pressure, engine temperature; and likewise the system is importantly useful in the remote control and operation of such conditions and of such devices. Other fields of utility are, for example, in automatic telephony, signalling and switching operations, and in computing machines of various kinds and types. The general function performed by the system in all such applications and uses, is the stepped operation or actuation of a follow-up device or receiver in consonance with the operation or movement of the initial operator or transmitter in either of two opposite directions. The system performs algebraically in the sense that it actuates the receiver selectively in both plus and minus directions, to add or subtract.

One characteristic feature, and object, of my invention in one of its preferred forms, resides in its creation and utilization of succeeding electrical impulses of positive or negative sign, depending upon the direction of motion of the transmitter. The motion of both transmitter and receiver, in the practical and preferred form of the system which I shall describe here, is preferably rotary; and so I shall refer to the motions as rotation, but without implying necessary limitation thereto. Assuming rotational movement, the transmitter delivers a measured series of integer impulses of one sign on rotation in one direction, one impulse for each angular unit of movement; and on rotation in the opposite direction delivers a similarly measured series of integer impulses of the opposite sign. The two series of impulses of opposite signs cause the receiver to rotate selectively in one direction or the opposite direction, depending upon the sign of the received

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impulses. Consequently, if both the transmitter and receiver are initially set in corresponding positions, the operation of the system will cause the two mechanisms to move in consonance with each other, the accuracy of consonance being only limited by the size of the angular movement which is adopted as a unit or step. That unit or step, as will hereinafter appear, may be made as large or as small as may be desired or necessary in any particular installation. And, in any given installation the angular measure of the unit or step of movement may be varied over the range of operation to make the system more accurate in its following functions throughout some predetermined part of the range.

Another feature of the invention is that the system is self-energized, not depending upon a separate or external source of electrical energy such as a battery. Another feature of the invention is that the system constitutes a continuous non-interrupted circuit employing no contacts and requiring the actuation of no switches.

The preferred form of transmitter, as will be described, is one which generates distinctly separated electrical pulses of relatively high amplitude which amplitude does not depend materially upon the speed of operation of the initial driver or transmitter. The transmitter is, in effect, a mechanism in which energy from the original driver is stored and periodically released, the released energy being expended through a relatively short period of time to create each time a high amplitude pulse. The mechanism for performing those functions is preferably of a magnetic ratchet nature, involving no relatively moving parts in mechanical engagement with each other and thus involving no wear. The ratchet mechanism which I prefer is in the nature of a magnetic mechanism which operates an oscillatory generating magnet slowly in one direction and at high speed in the opposite direction of oscillation, the orientation of those directions being fixed with reference to the direction of rotation of the initial driver and the ratchet mechanism so that, on initial rotation of the driver in one direction the fast oscillatory movement of the generating magnet will be in one direction, and on initial rotation in the opposite direction the direction of fast oscillatory movement of the generating magnet will be reversed.

The receiver of the system functions to actuate a driven member step-by-step in either of two opposite directions, in accordance with the sign of the received impulse or impulses. Its characteristics and features and its preferred struc-

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ture and mode of operation will be later described in detail.

One of the outstanding operational characteristics of my system is its continued positiveness and accuracy of operation throughout long use, and its very small liability to derangement from any external or internal cause. The actuating pulses are sharp and definite and of relatively high amplitude, and since they are generated internally in the system, the system as a whole is free from liabilities of being disabled by such causes as the failure of an energizing battery or generator, the blowing-out of protective fuses or the inadvertent or malicious operation of switches.

Other accomplishments, characteristics and corresponding objects of the invention will appear from the following description wherein reference is had to the accompanying drawings in which

Fig. 1 is a perspective showing one preferred form of my transmitter;

Fig. 2 is a fragmentary diagrammatic side view of portions of the transmitter of Fig. 1, showing the driving and driven magnets of the magnetic ratchet mechanism, and also the generating magnet, and also showing a primary driver;

Fig. 2a is a view in elevation taken as indicated by line 2a—2a on Fig. 2;

Figs. 3 and 4 are fragmentary front elevations of a preferred form of receiver, in different operating positions;

Fig. 5 is a perspective of the preferred form of receiver; and

Fig. 6 is a schematic circuit diagram of the telemetric system utilizing the illustrated preferred forms of transmitter and receiver.

The preferred form of the transmitter shown in Figs. 1 and 2 comprises a system of four coils 3, 4, 5, 6, preferably wound on cores 2 which are mounted on a base 1. Both cores and base are preferably of soft iron. The cores and coils are symmetrically arranged about the axis of a central rotatable shaft 7 which carries the oscillating generator 8 which, in this case, is preferably a highly magnetized bar. In operation, the generating magnet 8 oscillates between the two positions shown in full and dotted lines in Fig. 6; that is, between a position in which it closes the magnetic circuit between the cores of coils 4 and 6 (the position shown in Fig. 1) and a position in which it closes the magnetic circuit between the cores of coils 3 and 5 (the position shown in dotted lines in Fig. 6). Preferably the generating magnet 8 is positively stopped in both its terminal positions and, although the stop may be of any suitable physical kind, I prefer to use a simple arrangement in which generating magnet 8 brings up directly against non-magnetic inserts 2a in the ends of cores 2.

As will appear, it is not necessary that the member 8 itself be magnetized. It is sufficient for the operation of the system that any one or more of the magnetic circuit elements be magnetized, either permanently or by an electrically energized coil. Thus, in the following description of operation it may be assumed either that member 8 is magnetized and that cores 2 and base 1 are of soft iron (the preferred arrangement) or that member 8 is of soft iron and cores 2 or base 1 are magnetized. In either case, upon oscillatory movement of member 8 from the position shown in full lines in Figs. 1 and 6 to the position shown in dotted lines in Fig. 6, the magnetic flux in the magnetic circuit of coils 3 and 5

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will be increased, while the flux in the magnetic circuit of coils 4 and 6 will be decreased. On opposite movement of 8, opposite changes in the fluxes will occur.

The four coils may be connected in series (preferably so) or in multiple, or in series multiple; but in any event the connections are such that the current induced in the several coils by the changes of magnetic flux are in additive relation. Thus, considering a series circuit such as shown in Fig. 6 and tracing that circuit through from one end to the other, the windings of coils 3 and 6 will be in one and the same direction and the windings of coils 4 and 5 in the opposite direction. Consequently, on movement of member 8 from the full line to the dotted line position of Fig. 6 an additive current or voltage pulse will be generated in the four coils and, for simplicity of description, it may be assumed that on that movement a positive pulse voltage is generated in conductor 40 leading from the transmitter. On opposite oscillatory movement of generating member 8, from the dotted line to the full line position of Fig. 6, a pulse of opposite or negative signs will be generated in conductor 40.

It is to be observed that the same pulse generations will take place in circuit 40 without the necessity of four coils. For instance, considering only one coil, say coil 5, the oscillatory movement of generator 8 to and from the vicinity of that coil or its core will generate pulses of opposite signs on opposite movements. The same is true if pairs of coils are used; for instance, the pair 5, 6, the pair 5, 3, or the pair 5, 4. However, the arrangement illustrated is preferred, both for efficiency of pulse generation and for static and dynamic balance in the instrument; the latter being particularly important where the system is subject to vibrations and to accelerating forces, as in aircraft.

It is the general function of the magnetic ratchet mechanism to move generating member 8 from one of its positions to the other position relatively slowly so as to cause a slow change of magnetic flux during that movement, and then to move the generating member from its last mentioned position to its initial position at high velocity so as to cause relatively rapid change of magnetic flux during that movement; and also to cause the orientations of the slow and fast movements to reverse whenever the rotational direction of the initial driver reverses. A preferred illustrative form of magnetic ratchet mechanism is shown in Figs. 1 and 2.

As shown in those figures the ratchet mechanism comprises six bar magnets, two driven magnets 9 solidly connected to rotate with generating magnet 8, and four driver magnets 11 which are rotatable as a whole, independently of the driven magnets 9, without any necessary limit in either direction. As illustrated in the drawings, driven magnet system 9 is rigidly mounted on the shaft 7 on which generating magnet 8 is also rigidly mounted, so that the two magnetic systems oscillate together. And driving magnet system 11 is shown as rigidly mounted on a shaft 10 concentric with but free of shaft 7. Shaft 10 is rotatively driven by or from the element which I here call the primary driver, indicated diagrammatically at 12 in Fig. 2, and which may be any movable or rotatable element. For instance in a system of remote control or remote actuation, element 12 may be nothing more than a manually movable handle or dial. Or, in systems where

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it is desired to give a remote indication of an existing variable condition, element 12 will itself be, or be connected to, the member, device or mechanism whose position or condition is to be remotely indicated. For explanatory purposes, but without limitation, I will assume that element 12 is, for example, a pressure gauge and that shaft 10 is so connected to the gauge that it rotates back and forth as pressure rises and falls. In consonance with this assumption, the receiver (hereinafter described) will operate an indicator of pressure, such as an indicator pointer travelling over a calibrated dial. However, as has been indicated herein, the receiver is capable of actuating any suitable indicator, device or mechanism, depending upon the use to which the system is put.

As illustratively shown in the drawing the driven magnetic system 9 is composed of two magnetized bars extending on opposite sides of shaft 7 and having their two outer ends magnetized to the same polarity, say north. Also as illustratively shown, driver magnetic system 11 comprises four radial magnets 11a, 11b, 11c, 11d, magnetized to alternate terminal polarities. The radial lengths of all the magnets are substantially equal, and the magnetic system 11 rotates in a plane close to the plane of oscillation of the driven magnetic system 9, so that during rotation the poles of magnets 11 will approach closely to the poles of magnets 9.

In explaining the operation of the ratchet mechanism I will assume that the parts initially stand in the relative positions shown in Fig. 1 and that shaft 10 and the driving magnet system 11 are being rotated counter-clockwise. In that counter-clockwise movement the south pole of magnet 11b is approaching the upper north pole of driven magnet 9. As these two poles approach each other the attraction of 11b for 9 increases, but driven magnet 9 cannot move toward magnet 11b because it and generating magnet 8 are at the limit of their movement in that direction (clockwise). Driving magnet 11b approaches driven magnet 9, finally reaching a position in opposition to it, and then starts to move away from it. The magnetic strength of the magnets in the ratchet system is much greater than the magnetic strength of generating magnet 8 or of the magnetic circuit of which it forms a part. Consequently, as driving magnet 11b begins to move away from driven magnet 9, exerting an intense attractive force on the latter, that driven magnet immediately begins to follow driving magnet 11b. The attractive force of generating magnet 8 for the cores 2 is overcome by the much larger attractive force of magnet 11b for magnet 9; so that magnet 9 follows magnet 11b closely, travelling at substantially the same speed as the latter, until generating magnet 8 is moved from the position shown in Fig. 1 and in full lines in Fig. 6, to the position shown in dotted lines in Fig. 6 where it brings up against cores 2 of coils 3 and 5. This movement of the generating magnet is comparatively slow and only causes the generation of a small or negligible pulse amplitude in the coils.

In the continued counter-clockwise rotation of the magnetic driving system 11 the north pole of magnet 11c next approaches the upper north pole of magnet 9. That magnet 9, and generating magnet 8, being now at the limit of their counter-clockwise movement, the repulsive action of 11c on 9 has no effect until 11c has just passed 9. When that occurs the attractive hold of generating magnet 8 on cores 2 of coils 3 and

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5 is broken by the much larger repulsive force between the like poles of 11c and 9, and driven magnet 9 is consequently repelled in a clockwise direction at high velocity, to its initial position shown in Fig. 1. During this high velocity snap action the magnetic flux in the magnetic circuits of coils 4 and 6 is rapidly increased, and in those of coils 3 and 5 is rapidly decreased, resulting in a high amplitude pulse of short duration. According to the descriptive convention here adopted, that pulse would be negative.

With the parts back in the position of Fig. 1, the next driving pole to approach the upper north pole of driven magnet 9 will be the south pole of driving magnet 11d. As it comes opposite and begins to pass the north pole of magnet 9, the latter will follow it slowly just as it previously followed the south pole of magnet 11b; and the driven magnet and generating magnet 8 will thus again be moved slowly to the limit of their counter-clockwise movement. And then when the north pole of driving magnet 11a next approaches and passes the upper north pole of driven magnet 9, the high velocity snap action of the driven magnet and the generating magnet in a clockwise direction will be repeated, accompanied by a second high amplitude negative pulse in the coil circuit. On successive counter-clockwise passages of the alternating poles of the driving magnets, the driven magnet and the generating magnet will be alternately moved slowly in a counter-clockwise direction and then driven in high velocity snap action in clockwise direction.

Assuming on the other hand that the driving magnetic system is rotated in a clockwise direction it will be seen without the necessity of detailed explanation that on the alternate clockwise passage of the south and north poles of the driving system, the north pole of driven magnet 9 will be alternately moved slowly in a clockwise direction and driven in high velocity snap action in a counter-clockwise direction. In the slow clockwise movement the pulse generated in the coils has low or negligible amplitude, while in the fast counter-clockwise movement of the generating magnet a pulse of short duration and high amplitude is generated, of positive sign according to the descriptive convention.

It is assumed that the angular velocity of the driving magnetic system 11 is considerably less than the angular velocity of the snap action which generates the high amplitude pulse. Or, putting the matter in another way the constants of the transmitter will be designed in any particular case so that the angular velocity of the snap action is definitely greater than the maximum angular velocity with which the driving magnetic system 11 is rotated; so that in every case the amplitude of the pulse generated by the snap action will be materially greater than the amplitude of the pulse of opposite sign generated by what may be called the setting action of the ratchet mechanism. In fact, in a great variety of uses and installations, the angular velocity of driving magnet 11 is relatively so slow that the pulse generated during the setting movement is of substantially zero or negligible amplitude. In any case, the pulse amplitude generated by the snap action should be at least, say, three times the maximum pulse amplitude generated during the setting action.

The relation of the angular velocity of the snap action to that of the driving magnet is also a factor which enters into the determination of the ratio of the pulse time-period to that of a complete

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cycle. Speaking generally, it is desirable that the cycle period be, say, two or more times the pulse period so as to keep successive pulses distinctly separated and allow the receiver ample time to return to normal position after each pulse actuation. For instance if the driving magnetic system operates at one hundred cycles per second, the pulse period should be limited to, say, five thousandths of a second or less.

The description so far has assumed that there is only one driven magnet 9, presenting one terminal pole. In such an arrangement, the number of complete cycles per revolution of the driving magnets will be equal to the number of pairs of alternating north and south poles in the driving magnetic system. With the driver design as shown in Fig. 1 there are two complete cycles per revolution of the driving magnets. The transmitter will generate two successive (positive) pulses per revolution of shaft 10 clockwise, and two opposite (negative) pulses per revolution counterclockwise. The number of cycles per revolution may be increased by increasing the pairs of poles in the driving system; the only limitation on that being that the angle between adjacent north and south poles in the driver should be greater than the angle through which the driven magnet is oscillated. If the number of pairs of driven poles is even (as in Fig. 1) the driver will have like poles in diametric opposition; and consequently the driven magnet can be double as shown, with two like poles diametrically opposed. If the number of pole pairs in the driver is odd it will have unlike poles in diametric opposition; and the double driven magnet will then have unlike poles in diametric opposition. Although the system will operate with a driven magnet having only one pole, it is desirable that it as well as the driving magnet be multiple poled. Such an arrangement conduces to static and dynamic balance and also increases the number of cycles and the number of high amplitude pulses which are generated for each revolution of shaft 10 and the driving magnet. In the arrangement illustratively shown, there will be two such pulses per revolution.

From what has been said it will readily be gathered that the operation of the ratchet mechanism involves the relative approach and passage successively of a pair of unlike poles, one in the driver and the other in the driven system, and then of a pair of like poles. Any polar distribution in the driver and driven system which will accomplish that alternating succession of polar passage will operate in the manner that I intend. As an illustration, in Fig. 1 the driven magnet 9 could be the driving magnet, and the driving magnets 11 could be the driven. That can readily be seen by considering that the ratcheting operation depends solely on the relative movements of the two magnet systems and that the reactions between any two approaching and passing poles are necessarily equal and opposite.

On the basis of the functional descriptions which have been given, I make certain further generalizations which will now be readily understood. It is of course not necessary that the several coils be equipped with cores, their presence merely increasing the efficiency of pulse generation. But, without cores, the oscillations of generating magnet 8 between such relative positions as have been indicated will generate pulses as described.

As previously indicated, it is not necessary that element 8 be magnetized; it can be of any mag-

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netic material and magnetic flux may be provided at any place in the magnetic circuit through the cores. For instance, the cores themselves may be magnetized; or base plate 1 may be suitably magnetized to provide the magnetic flux whether cores 2 are used or not.

If generating element 8 is a magnet (as it is preferably) then it is not necessary that magnet 8 and the driven magnets 9 of the ratchet mechanism be separate magnets. As will be readily seen, the particular angular relationship between magnet 9 and 8 as shown in Fig. 1 is no necessary part of the system. Magnet 9 could just as well be parallel to magnet 8 and, insofar as its flux changing functions are concerned, magnet 8 could just as well have like poles at its terminal ends. And in that case magnet 9, parallel to magnet 8 could be placed close to or against it, so that the two would not only virtually but in fact be but a single magnet. The operation of the system with such changes would still be exactly as hereinbefore described.

It is not necessary that the driven magnet 9 and the driving magnet 11 be co-axial, except in such a multiple arm arrangement as shown. For instance, if driven magnet 9 has only one arm and pole, the axis of driving magnet 11 can be located in any position where its poles move through an arc which is in approximate parallelism with the limited arcuate movement of the pole of driven magnet 9.

The velocity of the snap action and the amplitude of the generated pulse is substantially independent of the speed at which the driving magnet 11 is rotated, as long as that speed is relatively low as hereinbefore stated. This is a distinct advantage in systems where the initial driver may operate at various speeds—a pressure gauge for instance. Regardless of the rapidity of movement of the pressure gauge, each generated pulse is strong and distinct and capable of positively and reliably actuating the receiver of the system.

The number of impulses generated by the transmitter for each revolution or other unit of movement of the primary driver—that is, the angular spacing of the generated impulses with relation to the angular rotation of the primary driver—will depend not only on the number of poles in the two ratchet magnetic systems 9 and 11, but also on the ratio of gearing which may be inserted between the primary driver and the driving magnet system 11. And in any situation in which gearing is thus interposed, the gearing may either have a constant ratio or a variable ratio. Thus, again to take the illustrative case of a pressure gauge, it may be desirable to have a more accurate indication of pressures throughout some limited portion of the pressure gauge range. For that purpose gears of variable ratio, such as elliptical gearing, may be used, and arranged so that the driving magnet 11 rotates relatively faster through the critical range, and the transmitter consequently delivers a larger number of generated pulses per unit of movement of the primary driving pressure gauge. In any such arrangement the final indicator at the receiver will be correspondingly calibrated. Figs. 2 and 2a show, by way of example, a pair of intermeshing elliptical gears 10a and 10b, between the shaft 10 and the shaft 10c of the primary driver 12.

The receiver, as here shown in illustrative and preferred form, comprises a polarized magnetic system in combination with a physical ratchet, which acts to move an indicator (or other device

or mechanism) step by step selectively in either direction depending upon the sign of the pulse or pulses received. One preferred form of the receiver mechanism is shown in Figs. 3 to 5. In Fig. 5 the receiver as a whole is shown as being mounted in a suitable casing (dotted lines) arranged for panel mounting. The mechanism has a coil 15 on a soft iron U-shaped core 16, and an X-shaped armature magnet 17 rigidly mounted on a shaft 18 for oscillatory rotation in the gap between the free ends of the U-shaped core 16. To determine the direction of rotation of shaft 18 in accordance with the direction of current flow through coil 15, the four arms 17a, 17b, 17c, 17d of magnet 17 are magnetized alternately north and south, as indicated. The armature magnet 17 is biased by light springs 30 and 31 to normally take the neutral position shown in Figs. 3, 5 and 6 when coil 15 is de-energized. For descriptive purposes it will be assumed that coil 15 is connected in the circuit of Fig. 6 in such manner that upon a generation of a positive pulse in the transmitter, the end of core 16 which is adjacent arms 17a and 17b will be magnetized to north polarity, and the other end of the core to south polarity. Upon such energization, the X-shaped armature magnet will rotate in a clockwise direction until arms 17b and 17c are lined up with the free ends of core 16 (see Fig. 4). On the other hand if the received impulse is negative, it will be assumed that the armature magnet will be rotated in a counter-clockwise direction to line up its poles 17a and 17d with the core 16. To prevent the armature from materially over-travelling and oscillating about its final position a small damping effect may be applied to it if desired. Under ordinary conditions the friction of the various parts which move with the armature will provide sufficient damping. The velocity at which the armature goes through its magnetically induced movements depends mainly upon the magnetic constants involved in the design and upon the inertia of the moving parts. Generally speaking, it is desirable to design those controlling factors in such manner as to cause the movement to be fast; and restoring springs 30 and 31 may also be proportioned to restore the armature quickly to neutral position; which they do after the cessation of each successively received impulse.

Without detailed description, it will be understood that the electro-magnet and polarized armature need not be double poled. For instance, the same functions will be performed, although less efficiently, if the armature has only the poles 17a and 17b and the core 16 only one pole. The double symmetric arrangement has the advantage also of being balanced.

Upon receipt of each impulse from the transmitter the receiver armature is oscillated through a predetermined angle to one side or the other of its neutral position depending upon the sign of the impulse received. The general function of the physical ratchet mechanism is to advance the finally operated member of the system (in this illustrative case, a pointer) through a predetermined unit distance in either one direction or the other depending upon the direction in which the armature has been moved from its neutral position. Arm 19 carries two oppositely facing pawls 20 and 21 which, in their neutral positions (Fig. 3) just bear on two pins 22 and 23 which may conveniently be mounted on a plate 24 (see Fig. 5) which is a part of the instrument case. Pawls 20 and 21 act respectively on

ratchets 25 and 26 which have oppositely facing teeth 25a and 26a. Each pawl, cooperating with its pin, acts on its ratchet like an overriding pawl; when drawn back from its neutral position it is lifted by its pin but engages and drives its ratchet on forward movement from the neutral position. Thus, on movement of the armature clockwise to the position of Fig. 4, pawl 20 drives its ratchet 25 clockwise and pawl 21 lifts off its ratchet. On counter-clockwise movement of the armature pawl 20 rises and pawl 21 drives its ratchet 26 counter-clockwise.

The two ratchets are rigidly mounted on shaft 28 concentric with but free from armature shaft 18. Shaft 29, which may be conveniently journaled in the plate 24, carries the pointer 28 which moves over calibrated dial 27.

The direction of the stepped movement of the finally driven member, shaft 29, is fixed with relation to the direction of movement of armature 17 which is determined by the sign of the pulse or pulses received. The sign of the pulse or pulses is determined by the direction of movement of the initial driver, whatever that may be; and the number of pulses generated is determined by the extent of that movement. Consequently, step by step, the finally driven member is moved in consonance with the movements of the initial driver in each of two opposite directions.

I consider my invention to reside not only in the telemetric system as a whole, but also in the improved transmitter and the magnetic ratchet mechanism, and in the improved receiver. While I have disclosed what at present I consider the preferred embodiments of the several aspects of the invention, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention as defined by the following claims.

I claim:

1. In an impulse receiver, a U-shaped core member, an X-shaped magnetized armature pivotally mounted in the air gap formed by the opposite ends of said core member, one pair of adjacent arms of said armature cooperating with one end of said core member and the opposite pair of adjacent arms of said armature cooperating with the opposite end of said core member, the arms of one pair of adjacent arms and the diametrically opposite arms of said armature being oppositely poled, and a winding for said core for magnetizing the ends of said core to repel one arm and to attract the other arm of each pair of arms of said armature responsive to each received impulse, the polarity of the received impulses determining the direction of rotation of said armature.

2. In an impulse receiver, a core member, an X-shaped permanent magnet armature pivotally mounted in an air gap formed by opposite ends of said core member, said armature having a normal position and a first operated position and a second operated position, a winding for said core member adapted to be energized by received current impulses, an impulse of one polarity for polarizing said core member to attract one set of diametrically opposite legs of said armature to move said armature from said normal position to said first operated position and an impulse of another polarity for polarizing said core member to attract another set of diametrically opposite legs of said armature to move said armature from said normal position to said second operated position, and means responsive to the termination of each current impulse for restoring said arma-

ture from one of said operated positions to said normal position.

GABRIEL M. GIANNINI.

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