Aug. 14, 1945. R. C. MATHES 2,381,978

IMPULSE TRANSMITTER

Filed Aug. 5, 1943 2 Sheets-Sheet 1

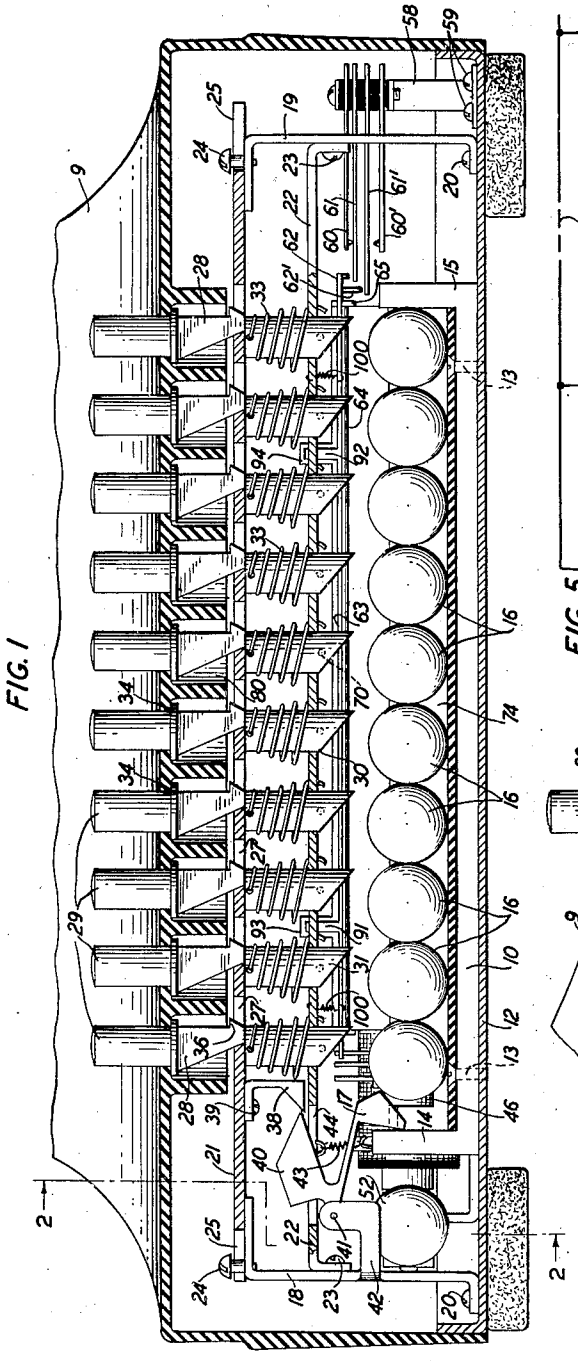


FIG. 1

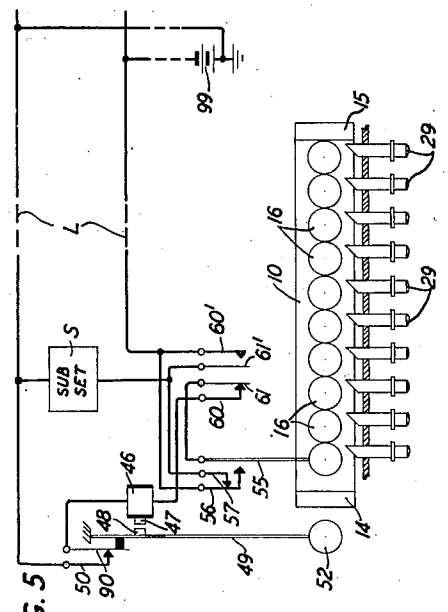



FIG. 5

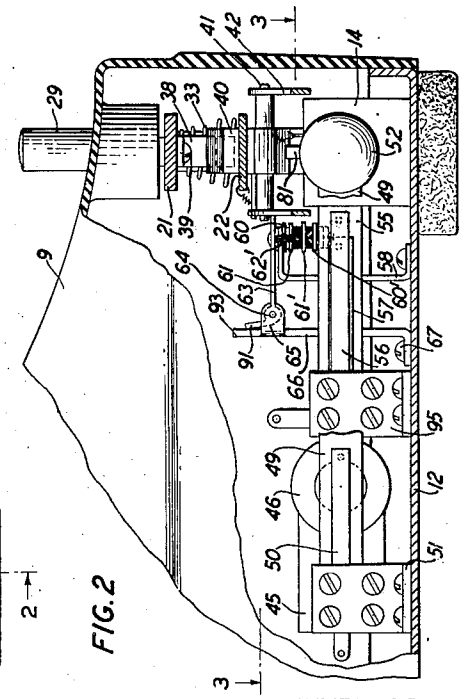


FIG. 2

INVENTOR
R. C. MATHES
BY
A. F. Kane
ATTORNEY

Aug. 14, 1945. R. C. MATHES 2,381,978

IMPULSE TRANSMITTER

Filed Aug. 5, 1943 2 Sheets-Sheet 2

FIG. 3

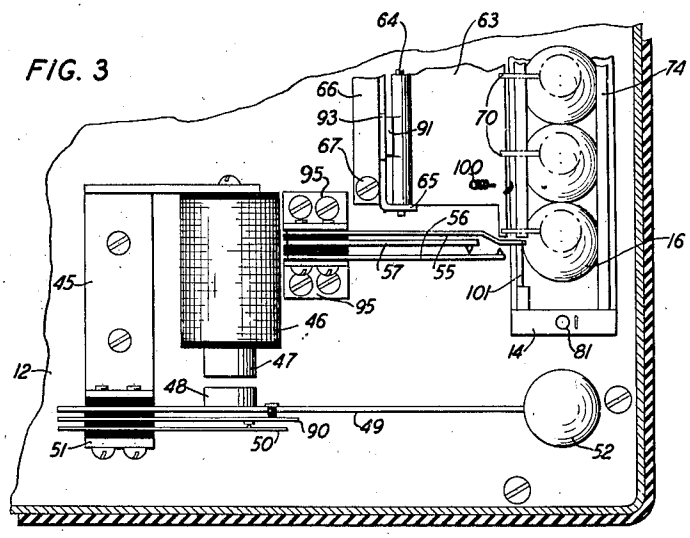
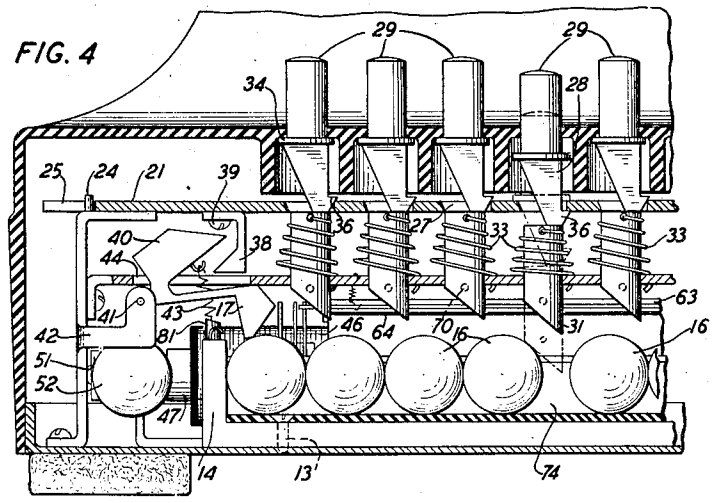



FIG. 4




INVENTOR
R. C. MATHES
BY
A. F. Kane
ATTORNEY

Patented Aug. 14, 1945 2,381,978

# UNITED STATES PATENT OFFICE

2,381,978

## IMPULSE TRANSMITTER

Robert C. Mathes, Maplewood, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application August 5, 1943, Serial No. 497,538

4 Claims. (Cl. 177—380)

This invention relates to impulse transmitting devices and more particularly to telephone call transmitters of the key-operated type.

It is the object of this invention to provide an impulse transmitter of the key-operated type which embodies characteristics that are particularly desirable from the user's standpoint and which functions to transmit series of correctly timed impulses without imposing any undue requirements on the operator.

This object is attained in accordance with a feature of the invention by combining in an impulse transmitter manually operable means for selectively predetermining the number of impulses to be transmitted, with means which functions automatically to transmit the predetermined number of impulses at a predetermined desirable speed or frequency independently of any control by the manually operable means. More particularly, the transmitter of this invention embodies an impulse counter comprising a plurality of manually displaceable resilient balls which may be selectively divided into groups containing one to ten balls to correspondingly predetermine the number of impulses to be transmitted, and electromagnetically controlled, mechanically tuned means for individually restoring the balls of a selectively displaced group of balls and for simultaneously operating a set of pulsing contacts once for each ball individually restored.

In the particular embodiment of the invention disclosed in the drawings a row of ten balls is normally confined between two oppositely disposed poles of a permanent magnet. The balls are arranged in consecutive contiguity in such a manner that the last ball of the row abuts one of the permanent magnet poles and the first ball of the row is spaced from the other permanent magnet pole. A group of ten individually manually operable keys is arranged in superposed relation to the row of balls, each key being so contoured as to function, when depressed, as a camming device for displacing one or more balls from their normal positions and for moving the said balls in such a direction that the first ball of the selectively displaced group of balls contacts the other permanent magnet pole. The number of balls thus displaced is determined by the particular key actuated and predetermines the number of impulses to be transmitted. An electromagnetic interrupter is rendered effective at a particular stage in the operation of a key and functions through a mechanically tuned striker or hammer to repeatedly strike the permanent magnet pole against which the selected group of balls has been moved to cause one ball of the selected group of balls to be returned to its normal position for each impact of the striker against the permanent magnet pole. The striker functions simultaneously to operate a set of pulsing contacts which, in reality, constitute the interrupter contacts of the electromagnet. When the last ball of the selected group is restored to its normal position the circuit of the electromagnetic interrupter is opened and operation of its pulsing contacts is discontinued. Thus the number of balls displaced incident to the actuation of a key predetermines the number of impulses to be transmitted and the tuned striker functions to count off the predetermined number of impulses at a speed or frequency corresponding to the frequency of vibration of the striker.

A feature of the invention resides in the use of manually operable keys for selectively displacing the balls which have normal, fully depressed and intermediate positions whereby the ball camming portion of the key after having been fully depressed to displace a particular group of balls is returned to its intermediate position in which it clears the balls and thereby allows freedom of movement of the balls in their return to normal positions under control of the tuned striker.

Another feature of the invention contemplates the use of switching means which function when a key is fully depressed for preparing the electromagnetic interrupter for inclusion in the pulsing circuit and which complete the effective inclusion of the interrupter in the pulsing circuit only when the key has attained its intermediate position. This feature precludes the premature operation of the pulsing contacts and precludes the functioning of the interrupter until the ball moving cam portion of the key has been removed from the line of travel of the balls. This feature also precludes the false operation of the transmitter should the operating subscriber hold a key in its fully depressed position for an abnormal interval of time.

In accordance with another feature of the invention latching means is provided which func-

tions to lock an actuated key in its intermediate position. An ancillary feature provides means whereby the last ball restored to normal position under the influence of the tuned striker serves to operate the latching means and to effect the restoration of the actuated key.

These and other features of the invention will be better understood from the following detailed description when read in connection with the accompanying drawings, in which:

Fig. 1 is a front elevation of the impulse transmitter of this invention mounted within the base of a telephone set;

Fig. 2 is a view of the impulse transmitter taken along the line 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a view of a portion of the impulse transmitter taken along the line 3—3 of Fig. 2, looking in the direction of the arrows;

Fig. 4 is a view similar in part to that shown in Fig. 1 and shows the transmitter with one of the manually operable keys in its operated position; and

Fig. 5 is a combined circuit and structural schematic illustrating the various switching elements controlled by the transmitter and their locations in the line circuit of a telephone subscriber's station.

A permanent magnet consisting of an elongated flat piece 10 and two oppositely disposed integrally formed pole-pieces 14 and 15 is secured to the base 12 of the telephone set 9 by means of screws 13. Fixed to the piece 10 also by the screws 13 is an insulating trough-like member 74. This member 74 is made up of a base piece which rests upon the magnet piece 10 and two integrally formed sides which extend the entire length of the permanent magnet. The upper ends of the member 74 are turned in to partially enclose the area defined by the insulating base piece, its two sides and the permanent magnet poles 14 and 15. This insulating structure forms a race or receptacle for ten balls 16 of resilient magnetic material. The receptacle 74 is slightly longer than the space occupied by the ten balls when in contact one with another and the partial enclosure effected by the inturned upper edges of the sides precludes the possibility of the balls falling out of the receptacle while permitting them freedom of motion therein.

The U-shaped permanent magnet serves to hold the balls in the normal position illustrated in Fig. 1 and also in whatever positions the balls are moved to incident to the actuation of the keys 29. The balls 16 are so normally positioned in the receptacle 74 that the ball on the extreme right of the row, viewing Fig. 1, touches the permanent magnet pole 15 and the ball on the extreme left is spaced from the pole 14. As above indicated, the ten balls are held in this position by the action of the permanent magnet.

Brackets 18 and 19 are fixed to the base 12 by screws 20. These brackets, located one at either end of the base, provide means for mounting a slidable latch plate 21, a fixed plate 22 and a stop member comprising two angularly disposed integrally formed portions 40 and 17.

The latch plate 21 is provided at each end with a slot 25 and is slidably held on the upper flanges of the brackets 18 and 19 by screws 24 which screw into the bracket flanges in such a manner that the shank portions of the screws constitute guides which pass through the slots 25 and allow the plate 21 to move freely longitudinally. The plate 21 is provided with ten spaced apertures or orifices 27 for a purpose to be set forth hereinafter.

The plate 22 is stationary and is fixed to the brackets 18 and 19 by screws 23. This plate 22 is located below the slidable latch plate 21 and is provided with ten circular openings 30 and a larger substantially rectangular aperture 44 located near the left end of the plate.

The stop member comprising a weighted portion 40 and a stop portion 17 is pivotally mounted on a rod 41 which is supported by two integrally formed arms 42 of the bracket 18. The hole or aperture 44 in plate 22 permits freedom of movement of the stop member when pivoting on the rod 41. A spring 43 having one end fixed to the underside of the weighted portion 40 and its other end fixed to a pin mounted on the upper edge of permanent magnet pole 14 assists in restoring the stop member to its normal position, illustrated in Fig. 1. In this position the stop portion 17 is located between the inner face of pole 14 and the ball 16 on the extreme left of the row.

The ten balls 16 are displaceable from normal to alternate positions in groups of one to ten balls by means of the keys 29. Each key 29 consists of a shank portion 31, a camming portion 28 and a button, designated 29, all of which are formed integrally, or associated in such a manner as to constitute a unitary structure. The shank portion 31 of each key is located immediately over one of the balls 16 and has its end beveled for engaging its respective ball and camming it to the left when the key is manually depressed. A coil spring 33 is wound around the shank portion 31 of each key and has one end embedded in the shank and the other end fixed to the stationary plate 22. These springs serve to restore the keys after manual actuation and automatic release by the latch plate 21, as will appear from a later description.

The cam section 28 of each key, interposed between the shank and button, has one edge beveled and is provided with a detent or catch 36 projecting from the lower opposite edge. When a key is depressed, the beveled edge of the cam portion 28 acts upon the edge of a corresponding aperture 27 in plate 21 and cams the plate to the left. As indicated more clearly in Fig. 4, the keys 29 have normal, intermediate and fully depressed positions. As the key is depressed, the beveled end of its shank portion 31 engages the ball 16 directly below it and cams the ball, and all other balls to the left in the row, so as to move it, or them to their alternate positions, in which the first ball on the left of the row contacts the permanent magnet pole 14. This alternate position of the balls is attained when the actuated key is fully depressed. It will be observed that when a key is fully depressed the catch 36 has moved considerably below the under surface of the latch plate 21 so that when the finger is removed from the depressed key the spring 33 associated therewith functions to restore the key to its intermediate position, in which the catch 36 engages the under surface of the plate 21 causing the key to be locked.

A cam bracket 38 is fixed to the under-side of the latch plate 21 by means of screw 39 and, as shown in Fig. 1, normally is in contact with the end of the weighted portion 40 of the stop member. When the plate 21 moves to the left, incident to the operation of a key, the stop is caused to rotate on its rod 41 in a counter-clockwise direction. In this manner the stop portion 17 is raised from its normal position to permit free movement of the balls 16 to the left. It will be observed,

by referring to Fig. 4, that the first ball in the row serves to further raise the stop and when the first ball contacts the pole 14 the stop portion 17 rests thereon and is held thereby in the position illustrated. When any group of balls is moved to the left so as to occupy their alternate positions they are held by the action of the permanent magnet.

The purpose of providing three positions for the keys 29 is to remove the shank portions thereof from the path of the balls 16 after actuating them to their alternate positions and thereby allow the balls to be returned to their normal positions without interference from the key shanks. In their intermediate positions the key shanks are lifted clear of the balls as shown in Fig. 4 and do not hinder the balls in their return movement. It is obvious from Figs. 1 and 4 that the first key 29 to the left functions, when depressed, to move the first ball 16 to the left of the row into engagement with pole 14; the second key functions to move the first two balls; the third key moves the first three balls, and so on.

The shank portion 31 of each key is provided with a projecting pin 70 which normally clears the upper edge of a pivotal member 63. This member is mounted on a rod 64 carried by the ear-like extensions 65 of a bracket 66. The bracket 66 is located to the rear of the permanent magnet and is secured to the base 12 by screws 67. This bracket is substantially of the same length as the pivoted member 63 and carries two integrally formed lugs 93 and 94 against which similarly formed lugs 91 and 92 on the pivoted member 63 rest when the member 63 is in its normal position. The member 63 is held in its normal position by the action of coil springs 100, one end of each of which is fixed to the member 63, the other ends being fastened to the stationary plate 22. The purpose of the pivotal member 63, which is common to all keys, is to operate springs 60, 60', 61 and 61' carried by bracket 58 and more specifically to move spring 61 out of engagement with spring 60 and spring 61' into engagement with spring 60' during the downstroke of the keys, and to permit the spring 61 to reengage spring 60 and spring 61' to disengage spring 60' when the key assumes its locked intermediate position. The actuation of springs 61 and 61' is effected by arms 62 and 62' respectively which extend from the right of the member 63. The functions of springs 60, 60', 61 and 61' will appear from a later description. Suffice it to say at this time that when a key assumes its intermediate position spring 61 reengages spring 60 before spring 61' moves out of engagement with spring 60'.

Secured to the left central portion of the base 12 is a bracket 45. Viewing Fig. 3, this bracket 45 is provided with a forwardly projecting extension to which the electromagnet 46 is secured by screws. The bracket 45 is contiguously associated with the core 47 of the magnet 46 and constitutes a portion of the magnetic circuit. The lower end of the bracket 45, still viewing Fig. 3, is provided with a vertical extension which cooperates with an L-shaped bracket 51 in supporting the armature 49 and contact springs 50 and 90. The bracket 51 is secured to the base 12 by screws. The springs 50 and 90 are insulated from the armature 49 and from each other, while the armature makes direct contact with the vertical extension of bracket 45. The armature 49 carries a pole-piece 48 in juxtaposition to the free end of magnet core 47. At its extreme outer end the armature carries a ball 52 which is similar in construction and dimensions to the balls 16. The armature 49, with its pole-piece 48 and ball 52, is designed to vibrate at a particular predetermined frequency, or speed which corresponds to the speed at which it is desired to transmit pulses. The spring 90 is associated with the magnet armature 49 in such a manner that it responds faithfully to any movement of the armature. Thus, when the armature is attracted by the magnet 46 the spring 90 is moved out of engagement with spring 50 and when the electromagnet is deenergized the armature releases and causes spring 90 to reengage spring 50. The purpose of these springs will be set forth in detail in connection with a description of Fig. 5 to be made hereinafter.

The first ball 16 to the left of the row of balls has fixed thereto a spring 55 which extends inwardly from the ball. This spring functions, when operated, to actuate the make-before-break springs 56 and 57. The springs 56 and 57 and the rear end of spring 55 are insulatively supported between two L-shaped brackets 95 fixed to the base 12 by screws. The insulating receptacle 74 is cut away at 101 to permit movement of the spring 56.

Referring now to Fig. 5, the subscriber's subset S is normally connected to the line L by way of contact springs 56 and 57. The circuit for the electromagnet 46 extends from one of the line conductors and includes contact springs 50 and 90, winding of magnet 46, normally closed contacts 60 and 61 and spring 55 which is normally disengaged from spring 56. Thus the winding of magnet 46 is normally excluded from the line circuit L. When a key 29 is depressed, one or more balls 16 are moved to the left so that the first ball to the left of the row engages the permanent magnet pole 14. As the first ball moves to its alternate position the spring 55 moves so as to cause spring 56 to disengage spring 57. It will be recalled that during the depression of any key 29 the pivoted member 63 is engaged by the pin 70 associated with the depressed key and moves so as to operate the spring pile-up comprising contact springs 60, 61, 60' and 61'. Since the member 63 functions during the downstroke of the key and spring 55 functions when the key is fully depressed, the springs 60, 61, 60' and 61' are operated before the contact springs 56, 57 and 55. The springs 60' and 61' accordingly close to maintain the subset S across the line pending the reconnection of magnet 46 to the line and thereby to preclude the possibility of a lost connection, it being understood that the contacts 56 and 57 open when the key is fully depressed and thus open one of the substation connections to the line. Thus when the key is fully depressed the subset S is still connected to the line and the circuit to magnet 46 is opened at springs 60 and 61. When the key is released and thereby assumes its intermediate locked position, contact spring 61 reengages spring 60 just prior to the separation of contact springs 60' and 61' so that the winding of magnet 46 is effectively included in the line circuit. The circuit for magnet 46 includes the contact springs 50 and 90, winding of magnet 46, closed springs 60 and 61, and springs 55 and 56. The purpose of springs 60 and 61 is to preclude the effective inclusion of magnet 46 in the line L until the depressed key has been released and has assumed its intermediate locked position. Unless such precaution is taken and the magnet is included in the line when the key is fully depressed it would immediately start to operate as an interrupter to actuate

the pulsing contacts 50—90 and this operation of the magnet would persist as long as the operator or subscriber maintained the key in its fully depressed position. The consequent operation of the pulsing contacts would result in false connections.

When the magnet 46 is effectively included in the line circuit it functions as an interrupter on current from the source 99 located at a central office. Obviously the magnet would function indefinitely as an interrupter to operate springs 50 and 90 and correspondingly effect the transmission of impulses since the springs 50 and 90 are connected in series with the line and the winding of the magnet. However, the number of times the armature 49 operates and therefore, the number of times the pulsing circuit is interrupted to transmit impulses is determined by the number of balls that have been moved to their alternate positions incident to the actuation of a key. For example, assuming the fourth key from the left is actuated, four balls 16 are moved to the left so that the first ball thereof contacts permanent magnet pole 14. When the magnet 46 starts to operate as an interrupter, the ball 52 fixed to the armature 49 of the magnet strikes pole 14 once for each energization of the magnet. Upon the first impact of ball 52 on pole 14 the fourth ball of the selected group is driven back to its normal position; the second impact causes the third ball to be returned to its normal position; the third impact causes the second ball to return to its normal position; and the fourth impact returns the first ball to its normal position. When the first ball is returned to its normal position, the spring 55 restores to normal causing spring 56 to reengage the spring 57. Thus the operating circuit for magnet 46 is opened at spring 57 and the subset S is reconnected to the line. The opening of the circuit to magnet 46 precludes any further operation of the armature 49 and any further operation of the pulsing springs 50, 90 and the electrical circuit assumes its normal unoperated condition. Thus, four pulses are transmitted incident to the actuation of the fourth key.

When the first ball in the row is returned to normal as described above, the stop 40—17 falls back to its normal position due to the action of gravity on the weighted portion 40 and to the action of spring 43. The weighted portion 40 thus engages the cam bracket 38 and cams the latch plate 21 to the right. This movement of the latch plate disengages the catch 36 and permits the depressed key 29 to restore to normal under the action of its spring 33. The member 63 thereupon returns to normal and the springs 60, 60' 61 and 61' restore. The transmitter is thus restored to normal.

In practice, each key of the impulse transmitter of this invention carries designation characters or symbols corresponding to those appearing on the number plate of the well-known fingerwheel dial. For example, the first key would bear the numeral "1"; the second key, the characters "ABC2"; the third key, the characters "DEF3"; etc.

The telephone set casing is provided with ten cylindrical compartments 80 in which the button end of the key 29 moves when depressed. The diameter of the compartments is slightly greater than that of the collar 34 associated with each key so as to permit free movement of the keys therein.

A stop 81 is provided on the pole 14 and provides a rest for the stop 40—17.

The transmitter of this invention functions to transmit a number of impulses corresponding to the number of balls selectively displaced by the manual operation of any of a plurality of keys, and the selected number of impulses is transmitted at a frequency or speed determined by the mechanical tuning of the electromagnet armature.

While the embodiment of the invention described in the specification involves the use of magnetic balls, it is readily apparent that the transmitter is not limited to the use of such balls and that it will function equally well with non-magnetic balls provided some simple expedient is resorted to in holding the balls in their normal and alternate positions. Such means may take the form of non-linear springs or toggles, the principle of operation of such mechanisms being well known.

What is claimed is:

1. The combination, in an impulse transmitter, of an electromagnet, an armature for said electromagnet, pulsing contacts controlled by said armature, and an impulse counter comprising a row of ten resilient magnetic balls, a magnetic circuit for holding said balls normally in contact with one another comprising a permanent magnet having two oppositely disposed poles against one of which the last ball of said row rests, manually operable key means having fully depressed and intermediate positions, means controlled by said key means when fully depressed for selectively dividing said row of balls into two groups containing one to ten balls and moving a selected group so that the first ball of the selected group is moved into engagement with the other pole of said permanent magnet, means controlled by the first ball of the selected group when thus moved for preparing an operating circuit for said electromagnet, means for locking said key means in its intermediate position, means controlled by said key means in its intermediate position for completing the operating circuit for said electromagnet whereupon said electromagnet causes said armature to vibrate and actuate said pulsing contacts, means controlled by said armature when vibrated for repeatedly striking the other pole of said permanent magnet to cause the balls of the selected group to be driven back individually to their normal positions, means controlled by the first ball of the selected group when driven back to its normal position for opening the operating circuit for said electromagnet, and other means controlled by said first ball for releasing said key means.

2. An impulse transmitter for use at a telephone subscriber's station for transmitting impulses suitable for actuating automatic switches employed in extending a call initiated at the said station, comprising, in a unitary structure, a normally positioned row of contiguously associated balls, a plurality of manually operable keys corresponding in number to the number of balls in said row and each key having normal, fully depressed and intermediate positions, pulsing contacts, an electromagnet having a vibratable armature for controlling said contacts, a normally open control circuit for said electromagnet, means integral with each of said keys and effective when its corresponding key is fully depressed for moving a predetermined number of the balls of said row from their normal positions, means for restoring the fully depressed key to its intermediate position, means effective only when said key has been fully depressed and then restored to its intermediate position for closing the con-

trol circuit of said electromagnet whereupon said electromagnet functions to vibrate its armature and said pulsing contacts are operated once for each vibration of said armature, means controlled by said armature for restoring one ball of said predetermined number of balls to its normal position for each vibration of said armature, and means controlled by the last ball restored for opening the control circuit of said electromagnet and for restoring said key to its normal position.

3. The combination, in an impulse transmitter, of pulsing contacts, a vibratable member for operating said pulsing contacts once for each vibration thereof, an electromagnet for vibrating said member, a plurality of balls normally contiguously associated so as to form a continuous row, a normally open operating circuit for said electromagnet, a plurality of manually operable keys each having a normal, a fully depressed and an intermediate position, means controlled by each of said keys when manually moved to its fully depressed position for separating a predetermined number of balls from the said continuous row of balls, means controlled by one of the balls of the separated predetermined number of balls for preparing the operating circuit for said electromagnet, means for initiating the return of a fully depressed key, means for arresting the return movement of the key so as to maintain it in its intermediate position, means controlled by the key when in its intermediate position for completing the operating circuit for said electromagnet whereupon said electromagnet functions to vibrate said member, means including said member for restoring a ball of said predetermined number of balls to normal position for each vibration of said member, and means controlled by the said one of said balls for opening the operating circuit to said electromagnet and for simultaneously restoring the key to its normal position.

4. The combination, in an impulse transmitter, of an electromagnet, an armature for said electromagnet, pulsing contacts controlled by said armature, and means for predetermining the number of operations of said pulsing contacts by said armature comprising a row of resilient magnetic balls, a magnetic circuit for holding said balls normally in contact with one another comprising a permanent magnet having two oppositely disposed poles against one of which the last ball of said row rests, a plurality of manually operable keys having normal, fully depressed and intermediate positions, means integral with each of said keys and effective upon the full depression of said keys for physically engaging said balls so as to separate said row into two sections and for moving one of said sections so that the first ball of said row engages the other pole of said permanent magnet, means controlled by the first ball when thus moved for preparing an operating circuit for said electromagnet, means for returning said keys from their fully depressed positions, means for arresting said keys in their intermediate positions, means controlled by said keys in their intermediate positions for completing the operating circuit for said electromagnet whereupon said electromagnet causes said armature to vibrate and actuate said pulsing contacts, means controlled by said armature when vibrated for driving the balls of the said moved section to their normal positions one at a time, means controlled by the said first ball of said row when driven back to its normal position for opening the operating circuit to said electromagnet, and other means controlled by the said first ball for restoring said keys to their normal positions.

ROBERT C. MATHES.