Jan. 12, 1943.

G. R. STIBITZ

2,307,868

BINARY COUNTER

Filed Nov. 26, 1941

FIG. 3

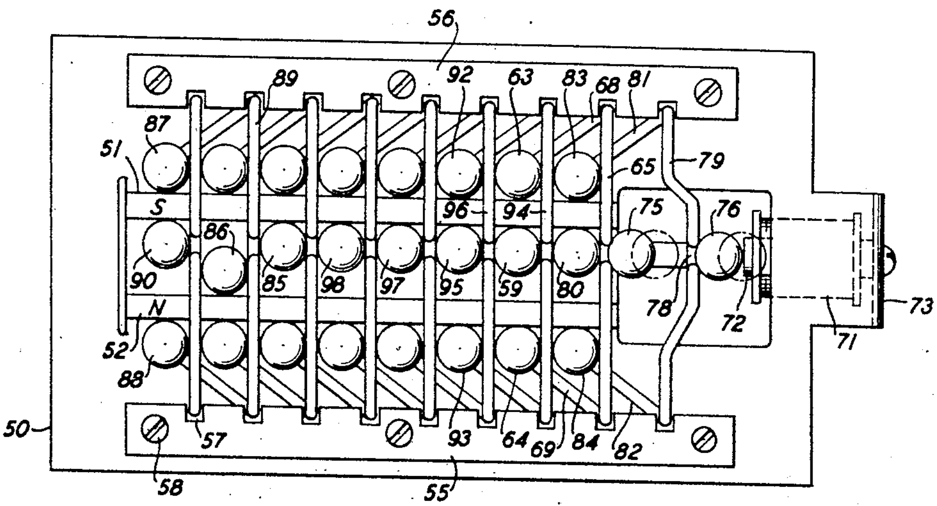


FIG. 4

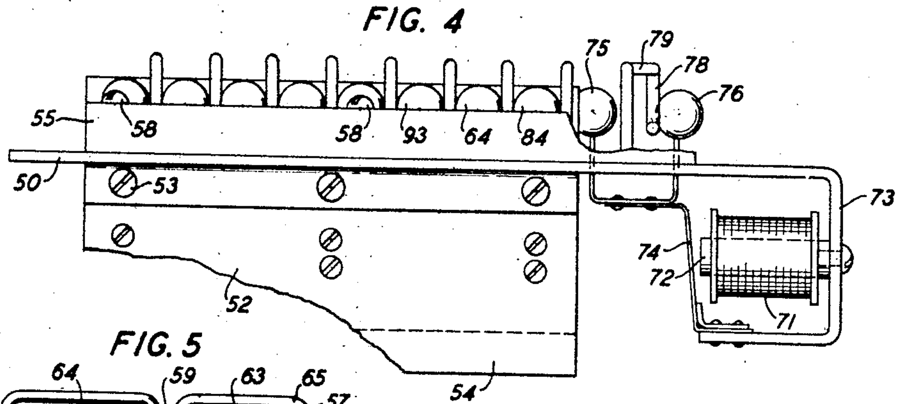


FIG. 5

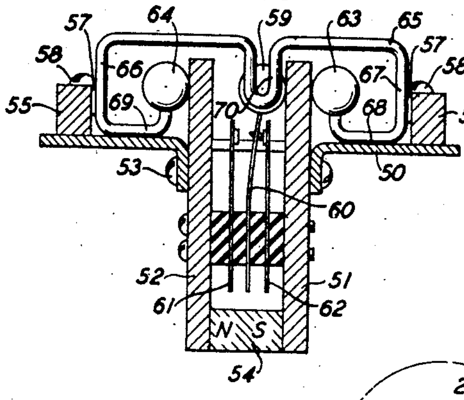


FIG. 1

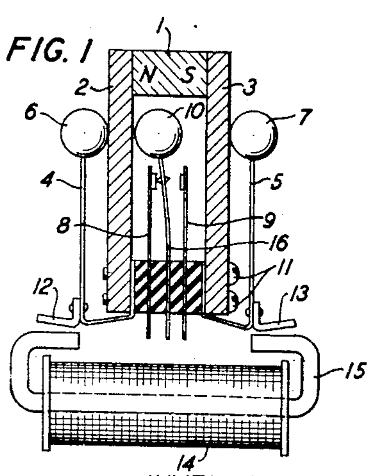
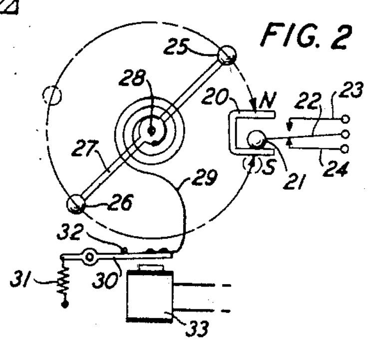


FIG. 2



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UNITED STATES PATENT OFFICE

2,307,868

BINARY COUNTER

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Application November 26, 1941, Serial No. 420,537

10 Claims. (Cl. 177—353)

This invention relates to timing mechanisms and has for its object to provide accurate and economical means for measuring time intervals of various durations.

In U. S. Patent No. 2,292,489, granted August 11, 1942, the present inventor has disclosed a counting arrangement in which a series of resilient balls, mounted within the arms of a magnet and in contact with one arm thereof may be moved one at a time into contact with the other arm by the impact of a similar ball on the arm of the magnet along the axis of contact of the balls.

In accordance with the present invention a binary counting means is provided, wherein a single ball, mounted within a magnet and normally resting against one arm of the magnet, is driven from side to side in response to successive impacts delivered by two simultaneously actuated balls, the driven ball controlling a pair of contacts.

A feature of the invention lies in a unitary structure for binary counting in which a plurality of units of the above type are arranged in a series, with the individual driving balls so mounted that the impact of a common driving member is transmitted through the driven balls to a particular pair of individual driving balls.

According to a further feature of the invention, individual impact devices may be made slow acting by interposing a link comprising a comparatively weak spring between the actuating electromagnet and the driving member.

These and other features of the invention will be more apparent from a consideration of the following description in connection with the drawing in which:

Fig. 1 shows a single binary counting device,

Fig. 2 shows a slow-operating binary counting device,

Fig. 3 shows the top view of a multiple counting device,

Fig. 4 shows a side view of the device of Fig. 3; and

Fig. 5 shows one element of the device of Fig. 3.

In Fig. 1 the contact unit comprises a permanent magnet 1 to which are fastened two pole-pieces 2 and 3 forming a U-shaped magnetic circuit. Between the ends of the pole-pieces 2 and 3 is clamped a spring pile-up comprising two J-shaped springs 4 and 5 carrying balls 6 and 7, two contact carrying springs 8 and 9 and a spring 16 carrying ball 10 and contacts cooperating with those on springs 8 and 9, all separated by suitable insulating material and held in place by screws 11. Ball 10 is of resilient magnetic material such as steel and therefore remains in contact with one or the other of the pole-pieces 2 or 3. Balls 6 and 7, although conveniently the same as ball 10, need not be of magnetic material. Fastened to springs 4 and 5 in any suitable manner are two armatures 12 and 13. A magnet coil 14 with a C-shaped core 15 is mounted in operative relation to the armatures 12 and 13.

When coil 14 is energized and armatures 12 and 13 are drawn toward the pole-pieces of core 15, balls 6 and 7 are swung away from pole-pieces 2 and 3. Deenergization of coil 14 as by a dial pulse permits balls 6 and 7 to strike against pole-pieces 2 and 3. If ball 10 is in the position shown, the impact by ball 7 is ineffective, but the impact by ball 6 is communicated to ball 10 which moves toward pole-piece 3 where it is held by the magnetic attraction. As ball 10 moves, it opens the contact between springs 16 and 8 and closes one between springs 16 and 9.

The device of Fig. 1 therefore forms a compact form of pulse halver such as is used in telephone control circuits for reducing the number of relays necessary for counting dial pulses. A series of such devices controlled by timed pulses might also be used in such circuits for trouble timing operations.

The modified form of impact relay shown in Fig. 2 employs a contact controlling member comprising a magnet 20, a resilient magnetic ball 21 mounted on a contact bearing spring 22 and two contact springs 23 and 24. These have been shown schematically and may be assembled as are the corresponding members of Fig. 1. The driving balls 25 and 26 are mounted at opposite ends of rod 27 which is enlarged at the center to afford a pivotal mounting 28 and a fastening point for one end of coiled spring 29. The opposite end of spring 29 is fastened to the armature 30 of magnet 33. Armature 30 is biased away from magnet 33 by spring 31 and normally rests against backstop 32.

When magnet 33 is energized, the motion of armature 30 is communicated to spring 29 which in turn causes bar 27 to rotate about pivot 28 and, after a time interval determined by the strength of spring 29 and length of path travelled by ball 26, causes ball 26 to strike against the lower leg of magnet 20 and drive ball 21 to its alternate position. As this occurs in response to the first blow by ball 26, any further impacts due to the resilience of ball 26 and magnet 20 will be ineffective. On the release of magnet 33, spring 29 requires a similar time interval to transmit the motion of armature 30 to bar 27 which, due to the inertia of balls 25 and 26, rotates beyond the normal position shown and causes ball 25 to impart a blow to the ball 21 through the upper leg of magnet 20, restoring ball 21 to its lower position.

The time of operation of such a device depends upon the ratio of force applied to the driving balls to their mass, and upon the distance travelled. Assuming a constant force rg where g is the gravitational constant, the time of operation is

$$t=\sqrt{\frac{2S}{rg}}$$

where S is the distance thru which the ball travels. A value of $\frac{1}{10}$ for r seems practicable, so that if S is 4 cm.,

$$t=\sqrt{\frac{2\times4}{.1\times980}}$$

$$\doteq\sqrt{0.08}$$

$$\doteq .3 \text{ second}$$

The energy stored in two 10 gram balls, in this example is

$$2\times.1\times10\times4=8 \text{ gm. cm.}$$

or about 10^{-3} watt-seconds. This is approximately the energy stored by 1 microfarad at 50 volts, and is sufficient, in the present model, to break about 200 grams of contact pressure and produce about 20 mils of contact travel.

Since the time of operation depends only on masses, dimensions and spring stiffness, time could be measured very accurately with such a relay.

The mechanism of Figs. 3, 4 and 5 is designed to operate a series of binary counters, such as the device of Fig. 1, by means of a single pulsing magnet, the transfer between counters being performed on the impact principle. A counting arrangement, employing relays, for which the mechanism of Figs. 3, 4 and 5 might be substituted, is shown in Patent No. 1,970,455, granted to H. E. Humphries, August 14, 1934.

The mechanism comprises a plate 50 having a central rectangular opening, the edges of which are bent downward to provide brackets to which the magnetic pole-pieces 51 and 52 of permanent magnet 54 are fastened by screws 53. On the upper face of plate 50 and parallel with the pole-pieces 51 and 52 are arranged two elongated blocks of material 55 and 56 having spaced slots 57 in their inner faces. These blocks are held in place by screws 58. Between pole-pieces 51 and 52 are arranged a series of balls such as ball 59 each with its mounting spring 60 and associated contact springs 61 and 62, similar to the individual ball and contact arrangement of Fig. 1. The driving balls 63 and 64 in this case are mounted on a flexible wire or band 65, bent as shown to provide a horizontal section connecting two vertical arms 66 and 67 which rest in corresponding slots 57 in blocks 55 and 56, and two lever arms 68 and 69 which carry the balls 63 and 64. At one side of the center of the horizontal section is formed a loop 70. The driving units may be slipped in place and when so assembled loops 70 are aligned with the driven balls when they are in their upper position. The lever arms 68 and 69 are of such length and angular displacement that the balls which they carry rest against the pole-pieces 51 and 52 opposite the first driven ball beyond the one against which the loop 70 rests.

The master driving mechanism comprises a coil 71 surrounding a core 72 which is screwed to a C-shaped bracket 73 formed at one end of frame 50. Coil 71 controls an armature 74 on which are mounted two spaced balls 75 and 76. Ball 75 acts on the loop 70 of the first mounting wire 65 while ball 76 acts on the loop 78 of a mounting wire 79 which is bent as shown, so that each pulse received by coil 71 causes two impact operations, one under the control of wire 79 on ball 80 and one along the row of balls 80, 59, etc.

The effect of the impact of ball 76 against loop 78 presses forward the horizontal section of wire 79 so that the lever arms 81 and 82 formed thereon rotate around the vertical sections which are pivoted in slots 57, moving balls 83 and 84 away from the pole-pieces 51 and 52. At the end of the impact, the elasticity of the wire 79 causes balls 83 and 84 to snap back against the pole-piece and thereby drive ball 80 from one pole-piece to the other. Thus ball 80 moves from one position to the other in response to each pulse received.

Assuming that the balls 80, 59, etc. are in the position shown, the effect of the impact of ball 75 against the first loop 70 is to transmit the impact through all of the balls in the upper position and the intervening loops 70 as far as ball 85. Since ball 86 is in its lower position ball 85 attempts to move toward the left and in so doing presses against the loop 70 of wire 89, moving balls 87 and 88 away from the pole-pieces. When the impact ceases balls 87 and 88 strike against the pole-pieces driving ball 90 to its lower position.

When the next impulse is received, ball 80 is in its lower position and the impact of ball 75 against wire 65 causes driving balls 63 and 64 to act on ball 59 to move it to its lower position. This same impulse restores ball 80 to its upper position.

Therefore a third pulse will act through ball 59 on wire 94 driving ball 95 to its lower position while ball 80 is also moved downward.

The fourth pulse restores ball 59 and ball 80 while the fifth pulse acts through balls 80 and 59 on wire 96 to move ball 97.

If at the first pulse all of the balls are in their upper positions and the operation of ball 80 is disregarded, the first pulse moves ball 59 and pulse 2 moves ball 95. However it requires 4 pulses to move ball 97 to its alternate position, 8 pulses to move ball 98, 16 pulses for ball 85, 32 pulses for ball 86 and 64 pulses for ball 90.

A clearer idea of the position of the balls after each pulse will be obtained if the set of balls is represented by a number having a similar number of digits, each of which may have one of two arbitrary values, for example 0 and 1. If the upper position is called 0 and the lower position, 1, then the setting of the counter of Fig. 3 may be read from left to right as 0,100,000.

Following is a translation of the number of pulses received into this form of binary notation for the first sixteen pulses as received on the first five balls.

Pulse number:	Binary notation
0	00000
1	00001
2	00011
3	00010
4	00110
5	00111
6	00101
7	00100
8	01100
9	01101
10	01111
11	01110
12	01010
13	01011
14	01001
15	01000
16	11000

What is claimed is:

1. In an impulsing device, a pulse receiving

magnet, a pair of contacts and means for closing said contacts alternately under the control of said magnet, comprising a spring mounted ball having two positions of rest, means controlled by said ball for closing one of said contacts in each of said positions and means controlled by said magnet for delivering an impact to said ball in either position to drive it into its alternate position.

2. In an impulsing device, a pulse receiving coil, a pair of contacts and means for closing said contacts alternately under the control of said coil, comprising a spring mounted ball of resilient magnetic material, magnetic means for holding said ball in either of two positions of rest to close one of said contacts in each of said positions and means controlled by said coil for delivering an impact to said ball in either position to drive it into its alternate position to close the other of said contacts.

3. A pulse divider comprising a pulse receiving magnet, a pair of contacts and means for closing said contacts alternately in response to the energization of said magnet by successive pulses comprising a spring mounted ball having two positions of rest, means controlled by said ball for closing one of said contacts in each of said positions and means controlled by said magnet for delivering an impact to said ball in either position to drive it into its alternate position.

4. A pulse divider comprising a pulse receiving coil, a pair of contacts and means for closing said contacts alternately in response to the energization of said coil by successive pulses comprising a spring mounted ball of resilient magnetic material, magnetic means for holding said ball in either of two positions of rest to close one of said contacts in each of said positions and means controlled by said coil for delivering an impact to said ball in either position to drive it into its alternate position to close the other of said contacts.

5. A pulse divider comprising a pulse receiving coil, a pair of contacts and means for closing said contacts alternately in response to the energizations of said coil by successive pulses, comprising a U-shaped magnet, a plurality of contact carrying springs held between the arms of said magnet, a driven ball of resilient magnetic material mounted on one of said springs, said ball normally resting in either one of two positions of rest against either arm of said magnet to cause said one spring to close a corresponding contact, a pair of driving balls, springs for holding said balls outside said magnet arms and in alignment with said driven ball, and armatures attached to said last-mentioned springs, controlled by said coil to cause said drving balls to simultaneously impact said magnet arms and move said driven ball to its other position of rest to close another of said contacts.

6. In an impulsing device, a pulse receiving magnet, a pair of contacts and means for closing said contacts alternately under the control of said magnet, comprising a spring mounted ball having two positions of rest, means controlled by said ball for closing one of said contacts in each of said positions and means controlled by said magnet for delivering an impact to said ball in either position to drive it into its alternate position, said controlled means comprising a balanced hammer and mechanical means for rendering said hammer slow to respond to said magnet.

7. In an impulsing device, a pulse receiving magnet, a pair of contacts and means for closing said contacts alternately under the control of said magnet, comprising a spring mounted ball having two positions of rest, means controlled by said ball for closing one of said contacts in each of said positions and means controlled by said magnet for delivering an impact to said ball in either position to drive it into its alternate position, said controlled means comprising an armature for said magnet, a balanced hammer and a weak spiral spring connecting said armature and said hammer for rendering said hammer slow to respond to said magnet.

8. In an impulsing device, a pulse receiving magnet, a plurality of pairs of contacts, means for closing said contacts under the control of said magnet, comprising a row of spring mounted balls each having two positions of rest, means controlled by each ball for closing one of said contacts in each of said positions and means controlled by said magnet for delivering an impact to any one of said balls in either position to drive it into its alternate position, said controlled means comprising pairs of hammers held in transverse impacting relation with each ball, means for delivering an impact longitudinally of said row of balls and means for transforming said longitudinal impact into a transverse impact by one of said pairs of hammers.

9. In an impulsing device, a pulse receiving magnet, a plurality of pairs of contacts, means for closing said contacts under the control of said magnet, comprising a row of spring mounted balls each having two positions of rest, means controlled by each ball for closing one of said contacts in each of said positions and means controlled by said magnet for delivering an impact to any one of said balls in either position to drive it into its alternate position, said controlled means comprising pairs of hammers held in transverse impacting relation with each ball, means for delivering an impact longitudinally of said row of balls, spring mounting means for each of said pairs of hammers for transforming said longitudinal impact into a transverse impact by one of said pairs of hammers, said balls effective in one position of rest to transmit said impact longitudinally and in the other position of rest to select a pair of hammers.

10. In an impulsing device, a pulse receiving magnet, a plurality of pairs of contacts, means for closing said contacts under the control of said magnet, comprising a row of spring mounted balls each having two positions of rest, means controlled by each ball for closing one of said contacts in each of said positions and means controlled by said magnet for delivering an impact to any one of said balls in either position to drive it into its alternate position, said controlled means comprising pairs of hammers held in transverse impacting relation with each ball, means for delivering an impact longitudinally of said row of balls, spring mounting means for each of said pairs of hammers for transforming said longitudinal impact into a transverse impact by one of said pairs of hammers, said balls effective in one position of rest to transmit said impact longitudinally and in the other position of rest to determine at which pair of hammers said longitudinal impact shall be transformed into said transverse impact.

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