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(54) **GUN REPLICA WITH PISTON POSITION DETECTION SYSTEM**

(57) At least two light sources D (10 and 11) are located on at least one printed circuit board (9) and at least two light detectors Q (12 and 13) are located on at least one printed circuit board (9"), with the boards (9 and 9") located on opposite inner walls of the replica's skeleton in such a way, that the active surface of each light source D faces the reciprocating gear (1) and the active surface of one light detector Q, and the geometric centers of the light sources D and the corresponding light detectors Q, are located on lines I parallel to each other that intersect the two printed circuit boards (9, 9") perpendicularly. The distance between adjacent light sources D (10 and 11) and the distance between adjacent light detectors Q (12 and 13) is equal to half of the distance between the vertical axes A of the teeth of the outer mesh of the reciprocating gear (1) or an odd multiple thereof, so that while one tooth constitutes an aperture for the light emitted by light source D, a light signal flows through the free space between that tooth and an adjacent tooth from the light source D to the corresponding light detector Q, with the light sources D (10 and 11) connected to a microcontroller pin and the light detectors Q (12 and 13) connected to microcontroller pins equipped with an analog-to-digital converter U or to external analog-to-digital converters U.

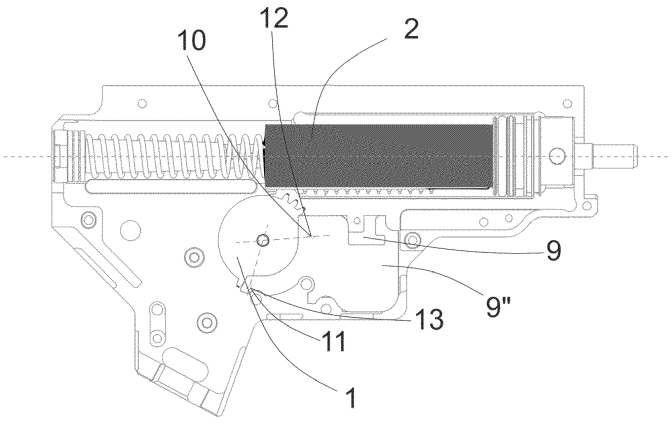

Fig. 5

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Description

[0001] The subject of the invention is a gun replica with a piston position detection system.

[0002] Air Soft Gun or ASGs are usually faithful copies of original firearms made in 1:1 scale, which fire balls using compressed gas.

ASG weapons are used for airsoft games, training, military simulations, and their users pay attention not only to the faithful reproduction of the external appearance, but also expect it to work in a way that best imitates the operation of a real firearm.

Automatic Electric Gun (AEG) is a variation of ASG replicas in which an electric motor, via a geared gear, moves a piston and compresses a spring. The piston moves inside a cylinder, which is terminated by a discharge nozzle. Moving the piston compresses the piston spring and draws air into the cylinder. The piston gear has an outer mesh and an inner mesh. The teeth of the outer mesh of the piston gear are located only on part of its circumference. The piston has a toothed bar in its design, which works directly with the outer mesh of the piston gear. In the factory models of AEG replicas there is no system to control the position of the piston. Pressing the trigger tongue activates an electric motor, which sets the gears of the transmission in motion. When the rotating piston gear meshes with the piston toothed bar, the rotary motion is converted to a reciprocating motion, thereby moving the piston along the cylinder axis in the direction that causes the piston spring to compress. When the piston gear is in a position where there are no teeth on its circumference, the piston is released and the piston spring is decompressed. The air sucked into the cylinder is then ejected through the cylinder's nozzle into the replica's barrel. Releasing the trigger tongue disengages the electric motor. The process of stopping the pinion gear, which is not controlled in any way, then begins. The stopping of the piston gear depends in factory replica models on the type of motor used, the type of gear transmission and the piston spring used.

[0003] The disadvantage of this solution is that the user has no control over the position of the piston. The optimal case is when, after releasing the trigger tongue, the piston is in such a position that the piston spring is expanded and there is no air in the cylinder. Then there are practically no forces acting on all mechanical parts of the replica's gearbox. In factory models of AEG replicas, the piston may be in a different position each time the trigger tongue is released. This results in a reduction in the life of the mechanical parts of the replica gearbox, and in special cases, firing two shots when the selected fire mode should result in firing only one shot when the trigger is pressed.

[0004] There have been attempts to solve this problem, and so, for example, from the application US200602243263 (A) is known an air pistol electronically controlled in such a way that after any firing operation the rotating gear wheel returns to the position where it does not mesh with the gearbox, which improves the reliability of the pistol mechanism, prevents the degradation of the spring, and also makes it possible to open the interior of the pistol and carry out maintenance easily. The air gun consists of: a pinion that is integrated into the piston, a piston wheel with a toothed section on part of the circumference that meshes with the pinion, and a toothless section that does not mesh with the pinion, a motor that drives the piston gear by means of a gear release mechanism; a rotation reference position (40) that is located on the piston wheel, in which a hole is made, and a sensor that detects the position of this hole. When the sensor detects the position of the pivot reference point, the power supply to the motor is turned off and the piston gear stops in a position where the toothless section of the piston gear faces the piston gear bar, with the piston returning to the starting position.

[0005] A gun replica equipped with a piston with a toothed bar pressing on a spring moving inside a cylinder terminated by an exhaust nozzle, a piston gear wheel with an outer mesh on part of the circumference and an inner mesh driven by a motor, and at least one light source and at least one detector converting a light signal into an electrical signal, the light source and the light detector receiving the signal from it being placed on separate circuit boards. The essence of the solution according to the invention is that at least two light sources are located on at least one printed circuit board and at least two light detectors are located on at least one printed circuit board, with the printed circuit boards located on opposite inner walls of the replica skeleton in such a way that the active surface of each light source faces the plunger gear and the active surface of one light detector, and the geometric centers of the light sources and the corresponding light detectors are located on lines parallel to each other that intersect the printed circuit boards perpendicularly. The distance between adjacent light sources and the distance between adjacent light detectors is equal to half the distance between the vertical axes of the teeth of the outer mesh of the reciprocating gear, or an odd multiple thereof, so that while one tooth is an aperture for the light emitted by the light source, a light signal flows through the free space between the two teeth from the light source to the corresponding light detector. The light source is connected to microcontroller pins, and the light detectors are connected to microcontroller pins equipped with an analog-to-digital converter or to external analog-to-digital converters. Advantageously, the light source is a light-emitting diode, Advantageously, the light source is a laser diode.

[0006] Advantageously the light detector is a phototransistor.

[0007] Advantageously the light detector is a photodiode.

[0008] Advantageously, the light detector is a photoresistor.

[0009] Advantageously, the light detector is a CCD detector.

[0010] In an advantageous embodiment, the angle between the surface on which the straight lines passing through the geometric centers of the light sources and light detectors are located and the axis of the reciprocating gear is no greater than 180o.

[0011] Preferably, the angle between the surface on which the straight lines passing through the geometric centers of the light sources and light detectors are located and the axis of the reciprocating gear is 111o. Advantageously, each light source is located on a separate circuit board.

[0012] Advantageously, each light detector is located on a separate circuit board.

[0013] The main advantage of the solution according to the invention is the use and suitable foundation of the sensor in the form of a set of two printed circuit boards, one with the light sources and the other with the light detectors, which is not destroyed by ordinary operation, is trouble-free and maintenance-free. The user does not interfere in any way with the replica's gear mechanism, for example by drilling a hole in the piston gear as described in application US200602243263 (A). The sensor is connected to the inputs of an analog-to-digital converter, the processing result of which is analyzed by a microcontroller, which makes it possible to precisely analyze the received signal and accurately determine in which position the piston gear and indirectly the replica piston are located. The sensor allows full control of the piston position, so that the cycle of piston movement after releasing the trigger is always the same. This is made possible by fine-tuning the shutdown time of the electric motor taking into account the data from the piston position sensor. In addition, the user can determine himself, using the GCS app, in which position the piston should stop after releasing the trigger. The use of the sensor also makes it possible to recognize the direction of the piston gear, which is especially important when the replica does not have an anti-reverse pawl.

[0014] Thanks to the miniature dimensions, it is possible to use more light sources and detectors as needed, and thus control the position of the piston even more precisely.

[0015] The electronic photoelements used in the sensor system, due to their design, are resistant to a wide range of temperatures, moisture, vibration, shock and electromagnetic interference.

[0016] Fig. 1 shows the standard solution in AEG replicas, which is described for comparison in Example I, while the solution according to the invention is illustrated by the manufacturing example shown in the figure, where Fig. 2 is a schematic diagram of the arrangement of the sensor elements on the first PCB in front view, Fig. 3 is a schematic of the arrangement of the sensor elements on the second PCB in front view, Fig. 4 is a schematic of the arrangement of the sensor elements on the first PCB relative to the piston gear in front view, Fig. 5 is a schematic of the arrangement of the sensor elements of both PCBs relative to the piston gear in front view, Fig. 6 - schematic diagram of the sensor components of the first PCB relative to the reciprocating gear in approximate front view, Fig. 7 - schematic diagram of the sensor components of both PCBs relative to the reciprocating gear in left view, Fig. 8 - electronic schematic of the optical piston position sensor, where the microcontroller is equipped with an analog-to-digital converter, Fig. 9 - electronic schematic of the optical sensor, where the microcontroller is coupled with analog-to-digital converters, Fig. 10 - waveform of signals analyzed by the microcontroller, Fig. 11 - view of the piston gear with the axes marked.

Example I

[0017] Fig. 1 shows the standard solution used in AEG replicas. Pressing the trigger tongue 8 starts the electric motor 5, which sets the gear wheels in motion. When the rotating piston gear 1 meshes with the toothed bar 3 of the piston 2, the rotary motion is converted to a reciprocating motion and thus the piston 2 is moved along the axis of the cylinder 6, in a direction that causes the spring 14 of the piston 2 to compress. When the piston gear 1 is in a position where there are no teeth on its circumference, the piston 2 is released and the spring 3 of the piston 2 is decompressed. The air sucked into the cylinder is then ejected through the nozzle 7 of the cylinder 6 into the barrel of the replica. Releasing the trigger tongue 8 causes the electric motor 5 to shut down. The process of stopping the pinion gear then begins, which is not controlled in any way. The stopping of the piston gear 1 depends in factory replica models on the type of motor 5 used, the type of gear transmission and the spring 3 of piston 2 used.

Example II

[0018] A gun replica of standard design is equipped with a sensor built from two light sources D1 10 and D2 11, which are a light-emitting diode or laser diode, and two detectors Q1 12 and Q2 13 converting the light signal into an electrical signal, which are a phototransistor or photodiode or photoresistor or CCD detector, whereby the light sources D1 10 and D2 11 are placed on a printed circuit board 9 fixed on the inner surface of one half 14 of the replica frame and the light detectors Q1 12 and Q2 13 are placed on a printed circuit board 9" located at the inner surface of the other half 15 of the replica frame. The distance between the light sources D1 10 and D2 11 and between the light detectors Q1 12 and Q2 13 is equal to half the distance between the vertical axes of the adjacent teeth of the piston gear 1 or an odd multiple thereof. The active surfaces of the light sources D1 10 and D2 11 face the piston gear 1 and the light receivers Q1 12 and Q2 13, so that the light emitted by one light source is received by one light detector, and one of the teeth of the outer mesh of the piston gear 1 prevents the flow of the light signal from one light source to the corre-

sponding light detector. The positions of the light sources D1 10 and D2 11 and of the light detectors Q1 12 and Q2 13 are strictly determined with respect to the position of the replica's piston gear 1. The geometric center of the light source D1 10 and the light receiver Q1 12, is located on one straight line crossing perpendicularly both printed circuit boards 9 and 9", and the geometric center of the light source D2 11 and the light receiver Q2 13, is located on the other straight line crossing perpendicularly both printed circuit boards 9 and 9". The surface on which the straight line passing through the geometric center of the light source D1 10 and the light receiver Q1 12 and the axis of the reciprocating gear are located, and the surface on which the straight line passing through the geometric center of the light source D2 11 and the light receiver Q2 13 and the axis of the reciprocating gear are located, form an angle as shown in Fig. 11, with a value of 111o.

[0019] Light sources D1 10 and D2 11 are connected to the microcontroller pin. Light receivers Q1 12 and Q2 13 are connected to the analog pins of the microcontroller, equipped with an analog-to-digital converter as shown in Fig. 8, or to analog-to-digital converters U1 and U2, which are coupled to the microcontroller as shown in Fig. 9.

[0020] The light source D1 10 and D2 11 is a light-emitting diode or laser diode. The light receiver Q1 12 and Q2 13 is a phototransistor or photodiode or photoresistor or CCD detector. The rotating reciprocating gear wheel 1 generates pulses at the output of the light detectors Q1 12 and Q2 13, the number of which corresponds to the number of teeth of the outer mesh of the reciprocating gear wheel 1. When the tooth of the outer mesh of the reciprocating gear wheel 1 is, for example, between the light source D1 10 and the light receiver Q1 12, it causes the light emitted by the light source D1 10 to be obscured and the value of the current flowing through the resistor R3 to decrease, which causes a smaller voltage drop across the resistor R3. At the same time, the current flowing through resistor R4 connected to the second light detector Q2 13 induces a voltage drop across resistor R4 that is shifted in phase by 90o with respect to the voltage drop across resistor R3. The waveform of signals analyzed by the microcontroller is shown in Fig 10.

Claims

1. A gun replica with a piston position detection system equipped with a piston (2) moving inside a cylinder (6) terminated by an outlet nozzle (7) with a toothed bar (3) pressing on a spring (14), a reciprocating gear wheel(1) with an outer mesh on part of the circumference and an inner mesh driven by a motor (5), and in at least one light source D and at least one light detector Q converting the light signal into an electrical signal, whereby the light source D and the light detector Q receiving the light signal from it are placed on separate printed circuit boards, **characterized by** the following, that on at least one printed circuit board (9) there are at least two light sources D (10 and 11) and on at least one printed circuit board (9") there are at least two light detectors Q (12 and 13), with the boards (9' and 9") located on opposite inner walls of the replica skeleton in such a way that the active surface of each light source D faces the piston gear (1) and the active surface of one light detector Q, and the geometric centers of the light sources D and the corresponding light detectors Q, are located on lines I parallel to each other that intersect perpendicularly the two circuit boards (9, 9"), and the distance between adjacent light sources D (10 and 11) and the distance between adjacent light detectors Q (12 and 13) is equal to half the distance between the vertical axes A of the teeth of the outer mesh of the piston gear (1) or an odd multiple thereof, so, that while one tooth constitutes an aperture for the light emitted by the light source D, a light signal flows through the free space between this tooth and the tooth adjacent to it from the light source D to the corresponding light detector Q, with the light sources D (10 and 11) connected to a microcontroller pin and the light detectors Q (12 and 13) connected to microcontroller pins equipped with an analog-to-digital converter U or to external analog-to-digital converters U.

2. The gun replica according to claim. 1 **characterized in that** the light source D is a light-emitting diode,

3. The gun replica according to claim. 1 **characterized in that** the light source D is a laser diode.

4. The gun replica according to claim. 1 **characterized in that** the light detector Q is a phototransistor.

5. The gun replica according to claim. 1 **characterized in that** the light detector Q is a photodiode.

6. The gun replica according to claim 1, **characterized in that** the light detector Q is a photodiode. 1 **characterized in that** the light detector Q is a photoresistor.

7. The gun replica according to claim. 1 **characterized in that** the Q light detector is a CCD detector.

8. The gun replica according to claim. 1, **characterized in that** the angle between the surface on which the straight lines passing through the geometric centers of the light sources D (10 and 11) and the light detectors Q (12 and 13) are located and the axis B of the piston gear (1) is no more than 180°.

9. The gun replica according to claim. 8, **characterized**

in that the angle between the surface on which there are straight lines passing through the geometric centers of the light sources D (10 and 11) and light detectors Q (12 and 13) and the axis B of the piston gear (1) is 111o.

10. The gun replica according to claim. 1 **characterized in that** each light source D (10 and 11) is located on a separate circuit board.

11. The gun replica according to claim. 1 **characterized in that** each light detector Q (12 and 13) is located on a separate circuit board.

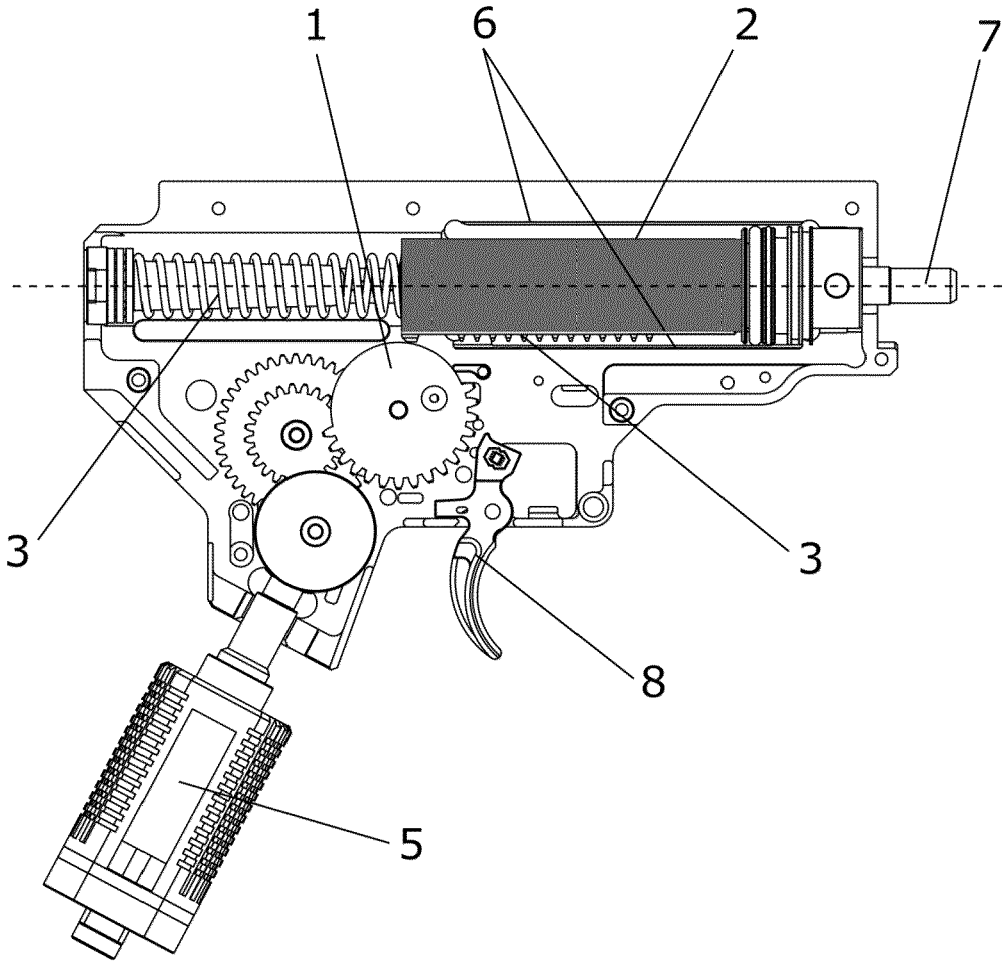


Fig. 1

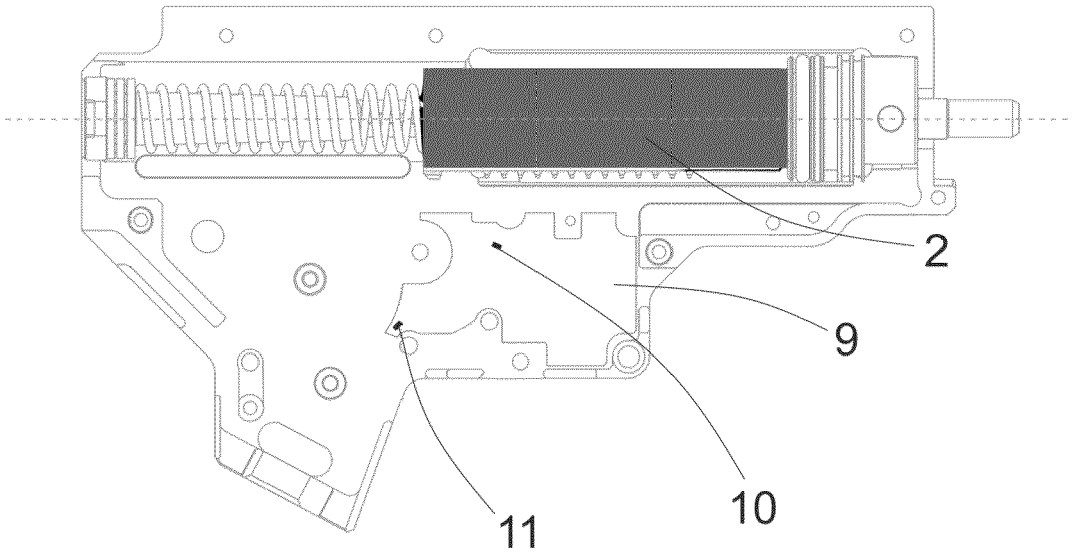


Fig. 2

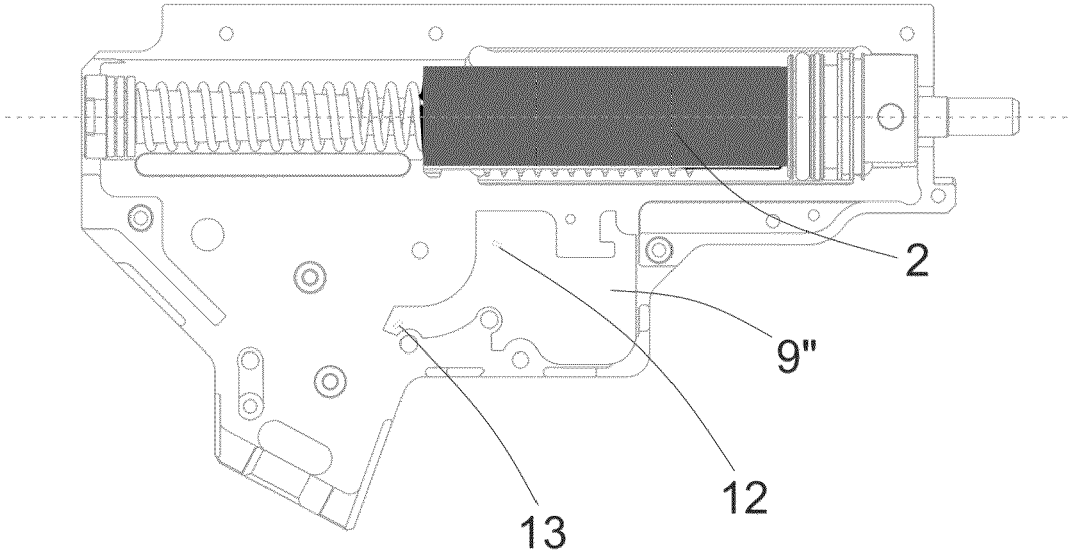


Fig. 3

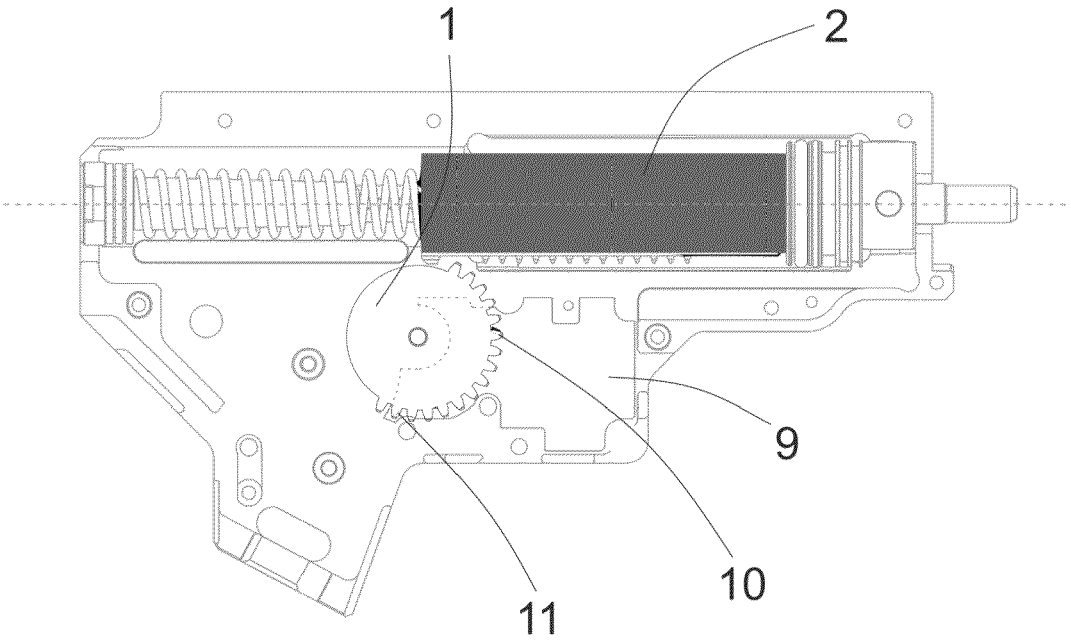


Fig. 4

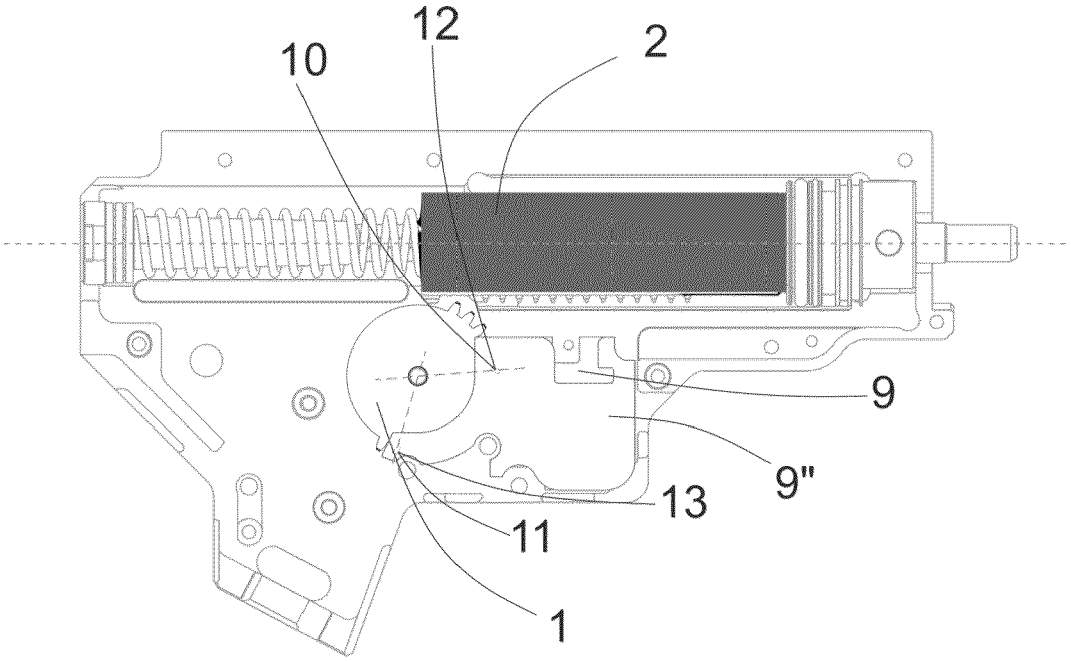


Fig. 5

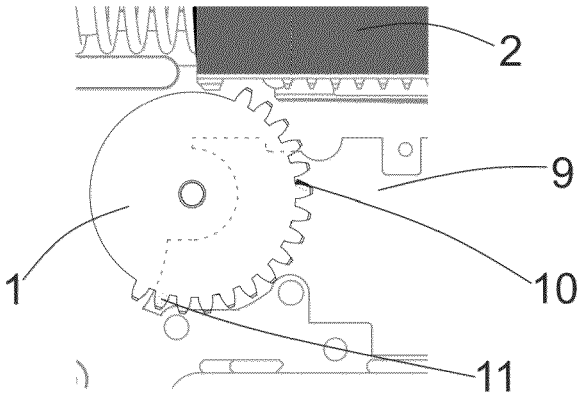


Fig. 6

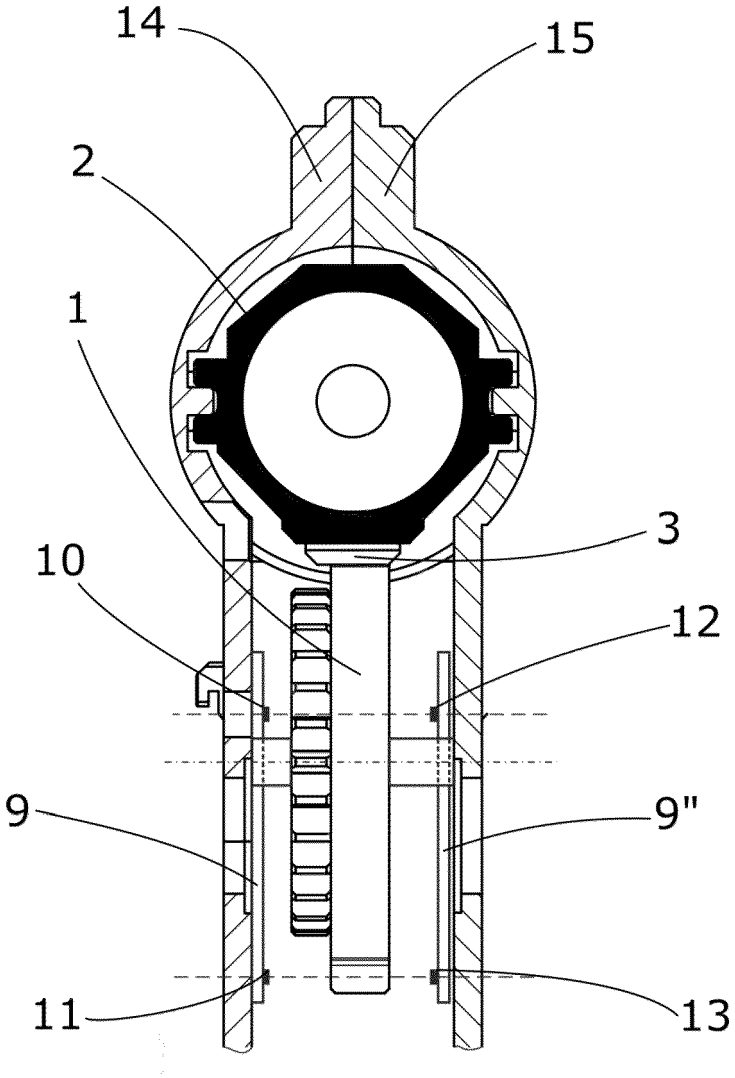
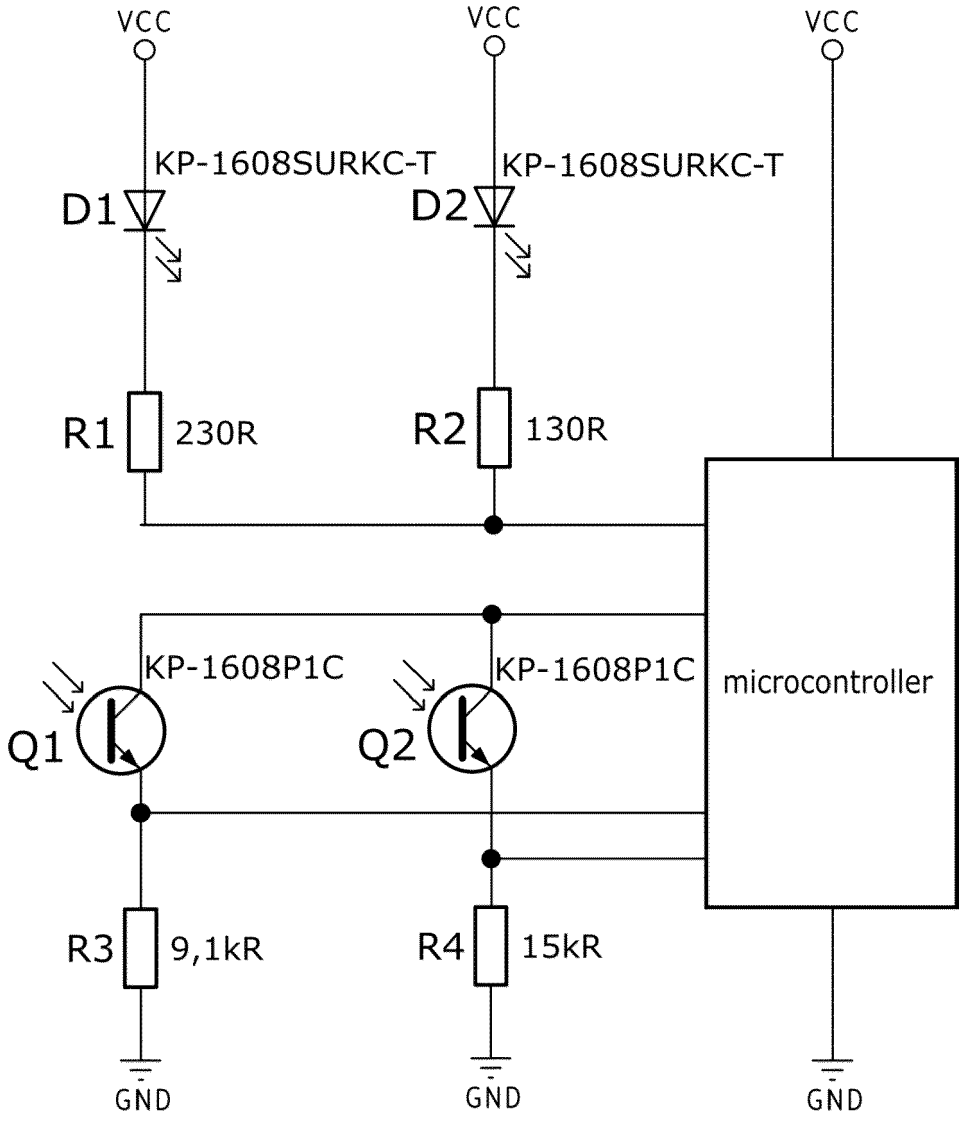


Fig. 7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VCC
VCC
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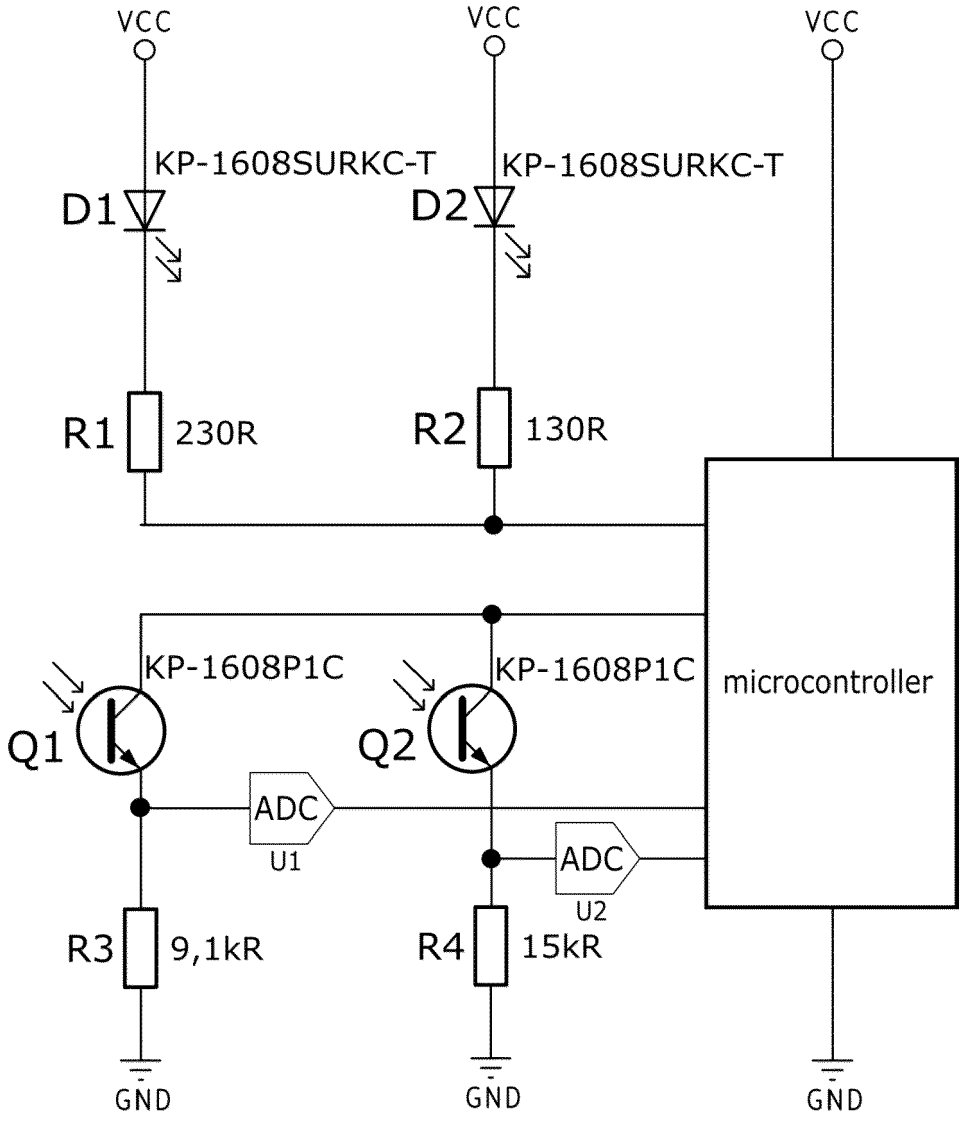
KP-1608SURKC-T
D1
D2
R1
230R
R2
130R
KP-1608P1C
KP-1608P1C
microcontroller
Q1
Q2
R3
9,1kR
R4
15kR
GND
GND
GND

Fig. 8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U1
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U2
R3
9,1kR
R4
15kR
GND
GND
GND

Fig. 9

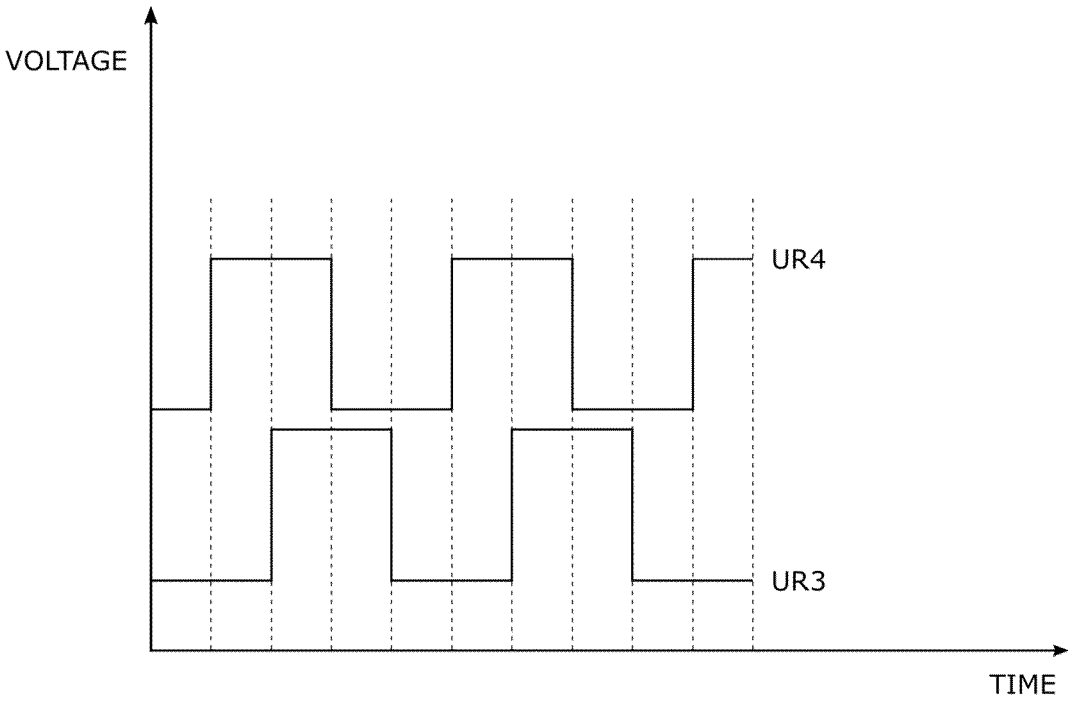

Fig. 10

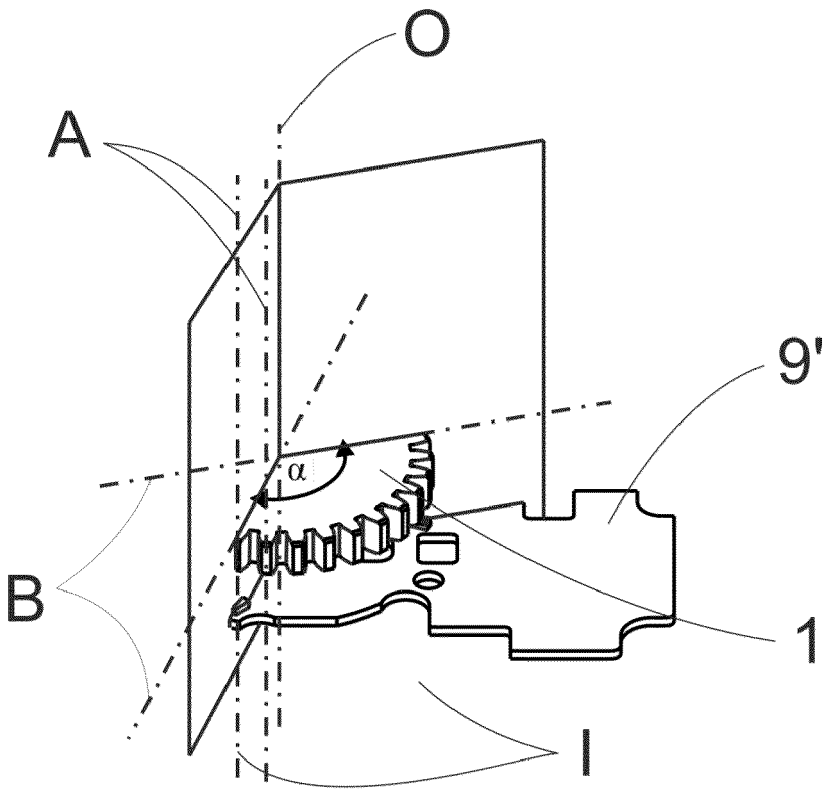

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 8937

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2006/231083 A1 (TSURUMOTO KOICHI [JP]) 19 October 2006 (2006-10-19) * claim 1; figures 1-6D *	1-11	INV. F41B11/642

TECHNICAL FIELDS SEARCHED (IPC)

F41B
F41A
F42B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 June 2024	Beaufumé, Cédric

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07-06-2024

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