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(54) PRINTER COMPRISING A PRINTING HEAD WHOSE POSITION IS CONTROLLED BY A SENSOR

(71) We N.V. PHILIPS' GLOEILAMPENFABRIEKEN, a limited liability Company, organised and established under the laws of the Kingdom of the Netherlands, of Emmasingel 29, Eindhoven, the Netherlands do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The invention relates to a printer comprising a carriage which is displaceable in the printing-line direction along a record carrier, a printing head mounted on said carriage for movement therewith in the printing-line direction and which is movable relative to the carriage in a direction extending transversely of the printing-line direction, a sensor which moves with the carriage in the printing-line direction and which is displaceable relative to the carrier to sense the thickness of the record carrier, and a transducer whereby such displacement of the sensor produces an output signal which is proportional to the thickness of the record carrier and is supplied to an electric motor arranged in a mechanical drive for the printing head to effect a displacement of the printing head relative to the carriage which is equal to the sensed thickness of the record carrier in order to maintain a constant, predetermined distance between printing head and record carrier.

The "printing-line direction" is to be understood herein to mean the direction of a line of characters being printed on a record carrier.

United States Patent Specification No. 3,750,792, discloses a printer having a sensor which is mounted stationarily on the printing head, which is displaceable transversely of the carriage. The printing head is biased against the record carrier by means of a spring connected to the carriage. The necessary constant distance between printing head and record carrier is maintained in that the sensor occupies a fixed position with respect to the printing head. To protect the printing head against the effect of reaction forces during printing, the bias of said spring is chosen to be so large that the sensor remains in pressure contact with the record carrier in all circumstances. The required bias is comparatively large and may cause undesired imprints of the sensor on the record carrier. Moreover, the mode of transport of the record carrier is actually limited to intermittent transport, because continuous transport is impeded by the sensor which is subjected to a comparatively large bias.

According to the invention there is provided a printer comprising a carriage which is displaceable in the printing-line direction along a record carrier, a printing head mounted on said carriage for movement therewith in the printing-line direction and which is movable relative to the carriage in a direction extending transversely of the printing-line direction, a sensor which moves with the carriage in the printing-line direction and which is displaceable relative to the carriage to sense the thickness of the record carrier, and a transducer whereby such displacement of the sensor produces an output signal which is proportional to the thickness of the record carrier and is supplied to an electric motor arranged in a mechanical drive for the printing head to effect a displacement of the printing head relative to the carriage which is equal to the sensed thickness of the record carrier in order to maintain a constant, predetermined distance between printing head and record carrier, wherein the sensor comprises a first feeler which is biased against the record carrier and which is displaceable relative to the carriage, and a second feeler which is biased against the record carrier and which is displaceable relative to the first feeler, the transducer comprising a mechanical part which is coupled to the one feeler and an electrical part which is coupled to the other feeler.

An embodiment of the invention will be described in detail hereinafter with reference to the accompanying diagrammatic drawings, in which

Figure 1 is a side elevation, partly in section, of an embodiment of a printer in accordance with the invention during printing on a record carrier having a thickness d_1,

Figure 2 shows a part of the printer shown in Figure 1 during printing on a combination of a record carrier having the thickness d_1 and a record carrier having a thickness d_2,

Figure 3 shows a part of the printer of Figure 1 during printing on a comparatively rigid record carrier having a thickness d_3,

Figure 4 is a plan view of a part of the printer shown in Figure 1, and

Figure 5 is a block diagram of a control circuit for the electric motor, which circuit includes the transducer.

The printer shown in Figure 1 comprises a printing head 1 of a known kind, namely, a matrix printing head comprising printing styli which are actuated by electromagnets. Therefore, the printing head 1 is only diagrammatically shown. However, the invention is by no means restricted to printers comprising matrix printing heads. Generally, the invention can be used in printers where a constant distance must be maintained between printing head and record carrier, and also in printers where it must be possible to adapt the impact of the printing elements to the thickness or overall thickness, of the record carrier, or carriers. Examples of this are printers comprising electrostatic printing heads and printers comprising printing elements which comprise the entire character to be printed (type printers).

The printing head 1 is mounted on a transverse carriage 3 which, by means of a guide rod 5, can be displaced with respect to a longitudinal carriage 7. The longitudinal carrier 7 it displaceable on two parallel guide rods 9 and 11. The motor drive required for this purpose is of a commonly used type (not shown). The guide rods 9 and 11 are parallel to a cylindrical anvil 13 which extends horizontally in the printing-line direction, i.e., the direction of a line of characters being printed on a record carrier 15. The flexible record carrier 15 is partly bent around the anvil 13, which has a circular cross-section, and is further guided in a transport device of a commonly used type which is not shown. Because the printing head 1 is displaceable with respect to the longitudinal carriage 7 in a horizontal plane, perpendicularly to the direction of the guide rods 9 and 11, the movement direction of the printing head 1 extends perpendicularly to a plane tangential to the anvil 13 or the record carrier 15 at the area of printing, referred to hereinafter as "the tangent plane". The printing area is diagrammatically denoted by a reference numeral 17. On the longitudinal carriage 7 there is provided an electric motor 19 comprising a driven pinion 21 which cooperates *via* a gearwheel 23 with a toothed rack 25 provided on the transverse carriage 3. The direction of rotation of the motor 19 can be reversed. The motor 19 is controlled by a signal which originates from a sensor to be described hereinafter. This sensor supplies a signal which is proportional to the thickness d_1 of the record carrier 15, so that the motor 19 can effect a transverse displacement of the printing head 1 with respect to the longitudinal carriage 7 which is equal to d_1. Assuming that the distance in Figure 1 between the right-hand end of the printing head 1 and the tangent plane to the anvil 13 at the printing area 17 is the required printing distance, to maintain this distance when a record carrier is inserted the printing head 1 must be displaced to the left over the distance d_1 (see arrow). The printing distance is to be understood herein to mean the distance between a given reference point on the printing head, for example, the ends of the printing styli, and the record carrier which results in optimum printing quality. In practice, this distance is invariable for each type of printing head.

The sensor 27 shown in the Figures 1 and 4 comprises a first feeler, constructed as a sliding shoe 31, which is biased against the record carrier 15 by a helical spring 29, and a second feeler, also constructed as a sliding shoe 35, which is biased against the record carrier by a helical spring 33. The sliding shoe 31 is connected to a shaft 37 by a bracket 39, and the sliding shoe 35 is connected to a shaft 41 by a bracket 43. A pivotable arm 47, having a U-shaped cross-section, is mounted on the transverse carriage 3 to be rotatable about a vertical shaft 45 (Figure 4). The pivotable arm 47 serves as a support for the shafts 37 and 41. To this end, the downwardly projecting flanges 49 and 51 of the pivotable arm 47 are provided with openings in which the shaft 37 is slidably guided whilst on the upper side of the pivotable arm 47 a sleeve 53 is mounted for guiding the shaft 41. The shaft 37 as well as the shaft 41, and hence also the sliding shoes 31 and 35, are thus supported by the arm 47. The pivotable arm 47 is rotatable counter-clockwise against the force of a tension spring 55, the coils of which contact one another in the position of the arm 47 shown in Figure 4. On the shaft 37 there is provided an annular collar 57 which bears against a shoulder on the shaft. Between the collar 57 and another annular collar 59 a compression spring 61 is arranged around the shaft 37. The spring 61 presses the collar 59 against an adjustable threaded bush 63 which is screwed onto the shaft 37 and which is slidable in an opening in the flange 49 of the pivotable arm 47. The distance between the collar 59 and the flange 49 can be adjusted by the turning the threaded bush 63. On the first pivotable arm 47 there is provided a second pivotable arm 67 which is rotatable about a shaft 65 (Figure 4). The pivotable arm 67 is rotatable clockwise against the force of a tension spring 69, one end of which is connected to the second pivotable arm 67, its other end being connected to the bracket 43. The second pivotable arm 67 is provided at one end with an upwardly bent portion formed with a lug 73 which is bent over at right angles from the portion 71. The lug 73 is guided in a slot 75 (see Figure 1) provided in the bush 53. The tension spring 69 always keeps the lug 73 pressed against a shoulder 77 on the shaft 41, which shoulder acts as an abutment (diagrammatically denoted in Figure 4 by a broken line) for the lug 73. On the end which is remote from the portion 71, the second pivotable arm 67 carries a mechanical part of a transducer for converting mechanical movement into an electrical signal. In the present case, this mechanical part of the transducer consists of a piece of soft iron 79. The electrical part of the transducer comprises a magnetoresistor 81 (that is to say, a resistor whose resistance is dependent of the magnitude and the direction of a magnetic control field), which is connected to the first pivotable arm 47. The magnetoresistor 81 is of a known type comprising two resistance plates of semiconductor material which are magnetically biased by a common permanent magnet and which are electrically connected in series. The intensity of the magnetic control field is linearly dependent on the position of the piece of soft iron 79 with respect to the magnetoresistor 81. The disk-shaped magnetoresistor 81 is clamped between the legs 83 and 85 of a U-shaped clamp 87 provided on the first pivotable arm 47. The legs 83 and 85 are pulled towards each other by means of a tension bolt 89 which is inserted through holes in the legs and which is tensioned by a nut 91 (see Figure 4). On the transverse carriage 3 there is provided an adjustable stop in the form of a screw 93 for the first pivotable arm 47. For each relative displacement of the piece of soft iron 79 with respect to the magnetoresistor 81, a signal which is proportional to this displacement is generated in the magnetoresistor. This signal is processed in the known control circuit which is shown in the form of a block diagram in Figure 5 and which comprises a Wheatstone bridge 95 which includes the two resistance plates present in the magnetoresistor 81. These resistance plates are denoted by the reference numerals 97 and 99 in Figure 5. The difference signal originating from the Wheatstone bridge is supplied to a known differential amplifier 101 and subsequently to an amplifier 103. The signal supplied by the amplifier 103 is used for controlling the electric motor 19. The displacement of the printing head 1 by the motor 19 through the transverse carriage 3 is equal to the change in the thickness of the record carrier sensed by the sliding shoes 31 and 35, for example, the thickness variation of the record carrier 15 itself. The operation of the sensor 27 will be described in detail hereinafter, notably with reference to the Figures 1, 2 and 3 which show different situations which occur during printing on a record carrier or a number of record carriers.

In the case shown in Figure 1, a record carrier 15, having a thickness d_1, is bent around the anvil 13. Usually, the longitudinal carriage, with the guide rods 9 and 11, is arranged to be tiltable (not shown) so that the record carrier 15 can be easily inserted. It is assumed that the horizontal distance between corresponding points on the sliding shoes 31 and 35 equals a, as shown in Figure 1, due to the curvature of the anvil 13. The distance a is measured in the plane of the drawing. Actually, the distance between corresponding points on the sliding shoes 31 and 35 is negligibly smaller than a when the record carrier 15 is inserted. This is because the curvature at the area of the sliding shoes 31 and 35 is slightly smaller, i.e., has a greater radius, when the record carrier is present than when the sliding shoes contact a bare anvil. It is also assumed that, with the shoes in contact with the bare anvil, the distance between the flange 49 of the pivotable arm 47 and the collar 59 was adjusted, by means of the adjusting screw 63, so that it amounted to a prior to the insertion of the record carrier. After insertion of the record carrier, said distance amounts to $a-d_1$, as is shown in Figure 1 ($a > d_1$). The springs 29 and 33 are compressed over a length d_1 by the insertion of the record carrier, because the stiffness of the spring 55 (Figure 4) and the stiffness of the spring 61 (Figure 1) are chosen to be so high that only a relative displacement equal to d_1 occurs between the shaft 37 and the pivotable arm 47. Consequently, the position of the pivotable arm 47 is not changed by the insertion of the record carrier. Because the shaft 41 also has been displaced to the left relative to the pivotable arm 47 over a distance d_1 by the insertion of the record carrier, the piece of soft iron 79 has been displaced over a distance d_1 with respect to the magnetoresistor mounted on the stationary pivotable arm 47. To this end, the shortest distance between the soft iron 79 and the pivot shaft 65 has been chosen to be equal to the shortest distance between the shaft 41 and the pivot shaft 65. The resistance variation in the magnetoresistor 81 caused by the relative displacement over d_1 of the piece of soft iron 79, is converted in the described manner to form a control signal for the motor 19. During the resulting movement of the printing head 1 to the left (see arrow d_1 in Figure 1), the relative displacement between the second pivotable arm 67 and the first pivotable arm 47 gradually decreases to zero, so that the printing head 1 is ultimately displaced to the left over a distance d_1. Obviously, it is assumed that the distance between the printing head 1 and the anvil 13 in Figure 1 is the desired printing distance, so that the correct printing distance is obtained again after the displacement to the left over the distance d_1. The operation of the sensor 27 is identical to the operation described above in a situation where the printing head - travelling from left to right along the anvil (perpendicularly to the plane of the drawing) - must suddenly cope with a thickness d_1 of a record carrier which has a substantially smaller width than the anvil in the printing-line direction, after having initially travelled along a bare anvil. Thickness variations in the record carrier itself are also compensated for by means of the described servo system.

The situation shown in Figure 2, which often occurs in practice, is characterized by the presence of a record carrier 15 having a thickness d_1 and a record carrier 105 having a thickness d_2. The width of the record carriers 15 and 105 differs and they partly overlap in the printing-line direction. Assuming that during its movement from left to right along the anvil 13 (perpendicularly to the plane of the drawing), the printing head must first print on the record carrier 15 having the thickness d_1, and subsequently on the record carrier 105 having the thickness d_2, the sensor 27 will have to deal with a jump equal to d_2 during printing. This jump d_2 is dealt with in the same way as the jump d_1 of the preceding case, if the relation $a > d_1 + d_2$ is satisfied. The distance *a* may also be considered as the free stroke of the shaft 37 with respect to the pivotable arm 47. During printing on the record carrier 105, the printing head has thus being displaced to the left over the distance $d_1 + d_2$. The sliding shoes 31 and 35 are each preferably shaped as a truncated V in plan view (see Figure 4) in order to enable printing on the record carrier 15 as far as the vicinity of the jump to the record carrier 105.

A very special case of sensing occurs in the situation shown in Figure 3. In practice, printing on comparatively rigid record carriers, such as account cards, occurs quite frequently. Assuming that the total spring pressure exerted by the sensor 27 on a rigid record carier 107, having a thickness d_3, is comparatively small, the situation shown in Figure 3 arises. In this case, the rear of the record carrier 107 is situated in the vertical tangent plane to the anvil at the printing area. If necessary, an additional anvil may be arranged between the record carrier 107 and the anvil 13. Actually, in that case the same situation arises as in the case of printing on flexible and/or rigid record carriers which are passed over a flat (non-curved) anvil. The total absolute displacement of the sliding shoe 31 amounts to $a + b + d_3$, the distance *a* also being the maximum free displacement of the shaft 37 with respect to the pivotable arm 47 (see Figure 1). The total absolute displacement of the sliding shoe 35 amounts to $b + d_3$. The distance *b* is the shortest distance between the vertical tangent plane to the anvil and the vertical plane through the point of contact of the sliding shoe 35 with the bare anvil. When the sliding shoe 31, and hence the shaft 37, has been displaced over a distance *a* with respect to the first pivotable arm 47, the collar 59 abuts against the flange 49 of the first pivotable arm 47. The part *b* of the total displacements of the sliding shoes 31 and 35 causes rotation of the pivotable arm 47 over a distance X (Figure 4) which satisfies the relation $X = l_1/(l_2) \cdot b$. The distance X is adjusted by means of the adjusting screw 93 for this purpose. Therefore, during the displacement over the distance *b* no control signal is generated for the motor. The part d_3 of the total displacements of the sliding shoes takes place while the stationary pivotable arm 47 bears against the adjusting screw 93. The spring 61 is then slightly compressed. The second pivotable arm 67, however, performs a relative displacement with respect to the first pivotable arm 47 at the area of the shaft 41, said displacement being equal to the thickness d_3 of the record carrier 107. Because the piece of soft iron then also performs a displacement d_3 with respect to the magnetoresistor 81, a control signal proportional to d_3 is applied to the motor 19. Consequently, the printing head 1 is moved to the left over a distance d_3.

Even though the invention has been described with reference to a printer comprising a sensor which includes rotatable feelers (pivotable arms), translationally movable feelers can also be used. The sensor comprising two feelers which are relatively movable with respect to each other is particularly suitable for printing on account cards. However, if no account cards need be printed, it suffices to use only one rotatable or translationally movable feeler which is mounted on the transverse carriage and which can perform a relative movement with respect thereto.

For the mechanical/electrical transducer, use can actually be made of any transducer whereby a relative movement can be translated into a signal for controlling an electric motor.

The signal generated by the sensor may also be used for the automatic control of the impact of the printing styli which is *inter alia* dependent of the number of copies to be printed.

WHAT WE CLAIM IS:-

1. A printer comprising a carriage which is displaceable in the printing-line direction along a record carrier, a printing head mounted on said carriage for movement therewith in the printing-line direction and which is movable relative to the carriage in a direction extending transversely of the printing-line direction, a sensor which moves with the carriage in the printing-line direction and which is displaceable relative to the carriage to sense the thickness of the record carrier, and a transducer whereby such displacement of the sensor produces an output signal which is proportional to the thickness of the record carrier and is supplied to an electric motor arranged in a mechanical drive for the printing head to effect a displacement of the printing head relative to the carriage which is equal to the sensed thickness of the record carrier in order to maintain a constant, predetermined distance between printing head and record carrier, wherein the sensor comprises a first feeler which is biased against the record carrier and which is displaceable relative to the carriage, and a second feeler which is biased against the record carrier and which is displaceable relative to the first feeler, the transducer comprising a mechanical part which is coupled to the one feeler and an electrical part which is coupled to the other feeler.

2. A printer as claimed in Claim 1, wherein the first feeler is mounted on and is displaceable relative to a support which itself is displaceable relative to the carriage, the carriage being provided with an abutment for said support.

3. A printer as claimed in Claim 2, wherein the support for the first feeler consists of a first pivotable arm which is mounted on the carriage and which is rotatable against spring force, the second feeler being coupled to the first pivotable arm by means of a second pivotable arm which is rotatable with respect thereto against spring force.

4. A printer as claimed in Claim 3, wherein the first pivotable arm comprises an adjustable abutment for the first feeler.

5. A printer as claimed in Claim 3, wherein the second feeler is guided in the first pivotable arm.

6. A printer as claimed in Claim 3, wherein the mechanical part of the transducer comprises a magnetic conductor which is connected to the second pivotable arm, the electrical part of the converter comprising a magnetoresistor.

7. A printer substantially as herein described with reference to the accompanying drawings.

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1593740 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

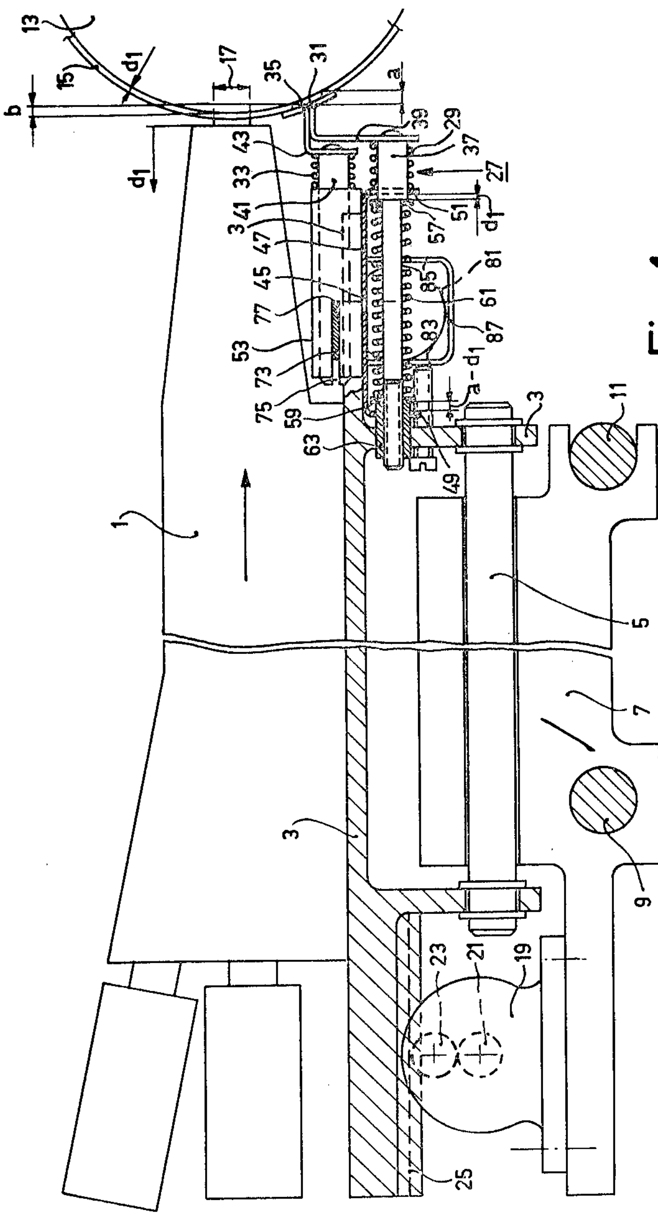
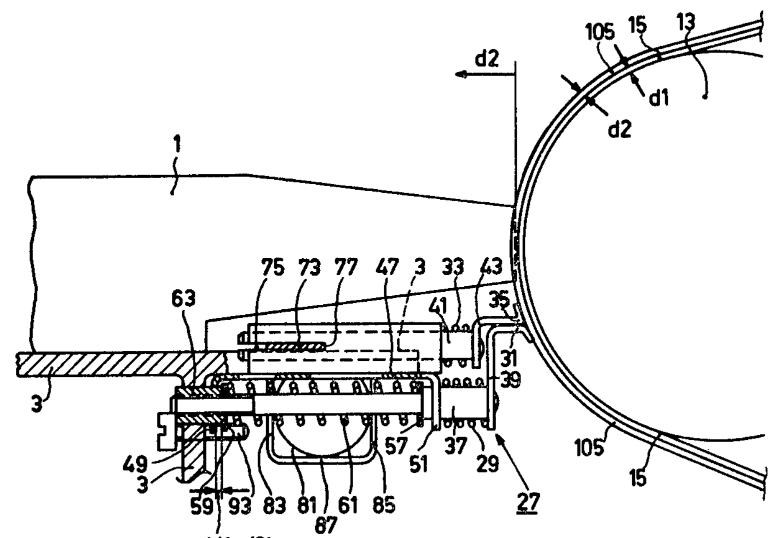


Fig.1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a-(d1+d2)

Fig. 2

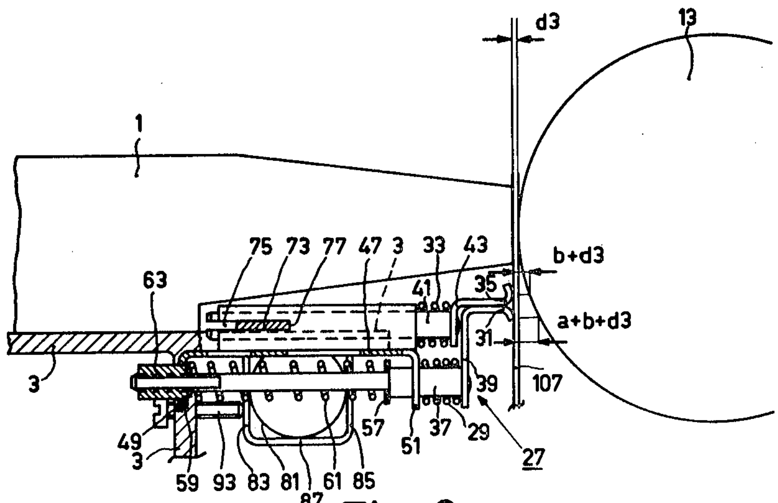
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Fig. 3

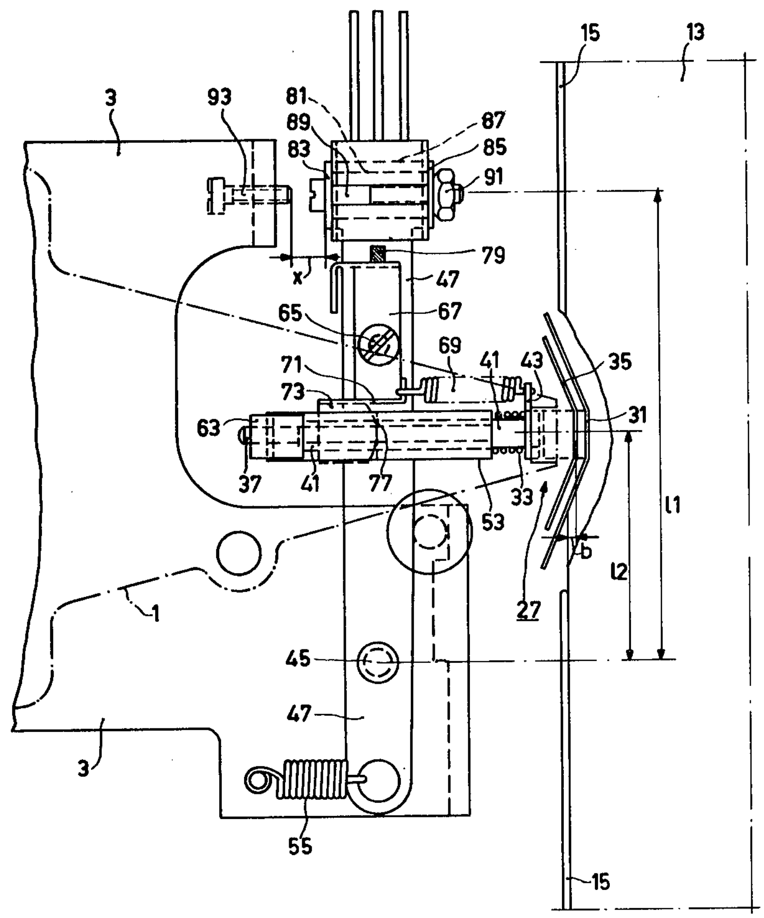
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Fig. 4

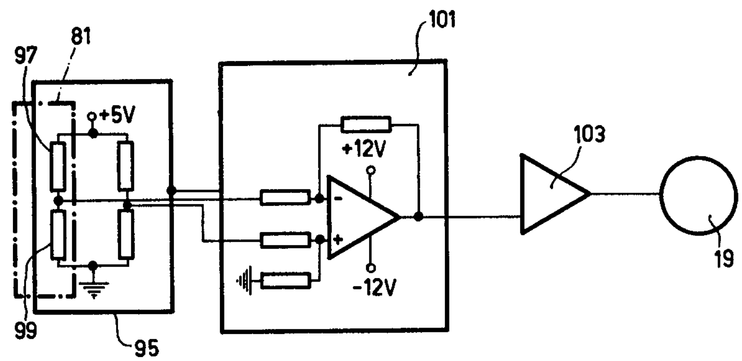

Fig. 5