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(54) FLEXOGRAPHIC PRINTER INCLUDING PRINTING UNITS WITH IMPROVED STABILITY

(57) The invention relates to a flexographic printer including printing units with improved stability, containing a print drum (1) having several printing units (3) disposed therearound, each of said units consisting of a plate-holding roller (5) rotatably supported on moving supports (7) driven along the length of linear guide elements (9) by linear electric motors (11, 12). Control means are provided to control one or more control parameters for the predetermined alteration of the conditions relating to the response offered by the linear motors (11, 12) to variations in the position of the plate-holding roller (5) during operation, with the plate-holding roller (5) being returned to the printing position, thereby preventing the system from vibrating at frequencies that can be in resonance.

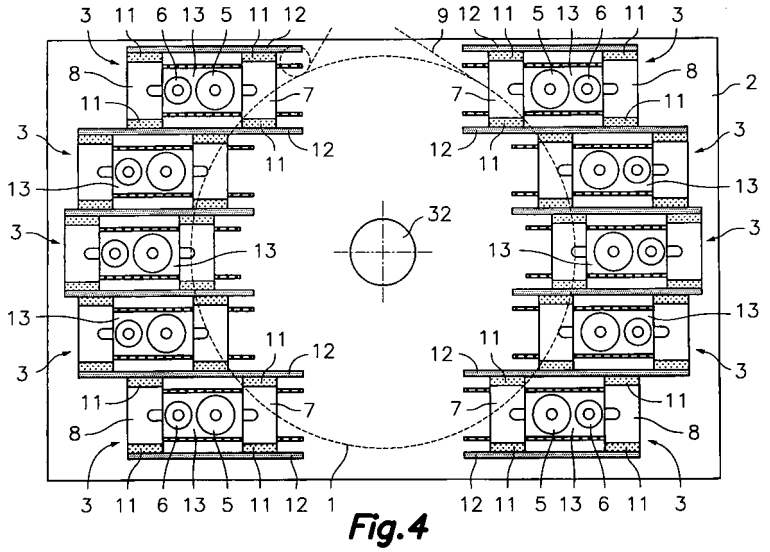

Fig.4

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Description

Technical Field

[0001] The present invention relates to a flexographic printer including printing units with improved stability, and more particularly to a flexographic printer provided with printing units driven by linear electric motors, in which a control strategy makes use of some of the features of said linear electric motors to prove greater positional stability to the rollers of the printing units and particularly to prevent the mentioned rollers from being in resonance at certain times or in certain printing conditions. The principles of the invention also allow minimizing the tapping effect when the plate-holding roller/rollers rotate during operation of the printer, resulting from irregularities imposed by the printing plates, on the plate itself or in relation to the surface of the roller.

Background of the Invention

[0002] The flexographic printers comprise one or more printing units in which a plate-holding roller has one or more plates assembled on its surface in order to contact against a material web to be printed supported on a support roller. The plates cause level differences or breaks in the surface of the plate-holding roller. When the plate-holding roller rotates in a printing position, the mentioned level differences cause cyclic blows against the material web to be printed supported on a support roller. At certain rotation speeds, these cyclic blows constitute an excitation frequency which is in resonance with the natural frequency of a system formed by the plate-holding roller, its supports, etc. An inking roller is similarly arranged in order to contact with the plate-holding roller in an inking position, and the cyclic blows experienced by the plate-holding roller are transmitted to the inking roller, which is part of a corresponding system provided with a natural frequency which can also be in resonance. When one, the other or both rollers are in resonance, the quality of the printing experiences serious deterioration and the mechanisms driving the rollers can end up being damaged.

[0003] It is therefore necessary to have means to prevent the plate-holding and/or inking rollers from being in resonance.

[0004] Patent US-A-6494138 describes a printing unit for a printing machine for printing a laminar material web. The unit has at least two rollers, the position of at least one of which is adjustable with regard to that of the other one. The rotation of each roller is driven by a corresponding rotating electric motor and the linear movements for the position setting are driven, in one embodiment, by linear electric motors (see Figure 5), each of which is made up of a primary element fixed to a carriage integral with a slide coupled to guide elements and a secondary element fixed to a frame or bedplate of the printing machine.

[0005] Patent application EP-A2-1634701 discloses a flexographic printer comprising a central drum to support the laminar material web to be printed and a plurality of printing units, each with a plate-holding roller and an inking roller rotatably supported at their ends in corresponding moving supports arranged to move along the length of respective first linear guide elements attached to said side bedplates. The rotation of each roller is driven by a corresponding rotating electric motor. The mentioned moving supports are driven by drive means to perform linear movements for the position setting of the plate-holding roller in relation to the central drum and of the inking roller in relation to the plate-holding roller. In one embodiment, the mentioned drive means comprise a linear electric motor for each moving support, with the particularity that the primary element is the one that is fixed to the bedplate and the secondary element is the one that is fixed to the moving support, such that the cables for the supply and control of the primary element are not moved together with the moving support.

[0006] None of these patents relates to the problem of resonances in the plate-holding and/or inking rollers nor do they face the tapping problem. Nor are any particular arrangements of the linear motors used to counteract or solve the problem described or suggested in said background documents.

Summary of the Invention

[0007] The invention provides a flexographic printer including printing units with improved stability.

[0008] The printer in question is of the type comprising at least one print drum arranged to rotate about a shaft supported between two side bedplates and adapted to support a web of a laminar material to be printed, and one or more printing units each comprising:

a plate-holding roller arranged to rotate about a shaft parallel to said shaft of the print drum and supported at its two ends in respective first moving supports arranged to move along the length of respective first linear guide elements attached to said side bedplates, said plate-holding roller having one or more plates assembled on the surface thereof, the relief of which causes level variations or break in its surface when it rotates; and

first drive means driven by linear electric motors arranged to move the first moving supports (along the length of their respective first guide elements for the purpose of changing said plate-holding roller between a printing position, in which a surface of one or more plates assembled on the plate-holding roller is in contact with said laminar material web on said print drum (1), and under a pressure determined according to the relief of said plate and a non-printing position, in which the plate-holding roller is not in contact with the print drum and the pressure is nil.

[0009] The printer incorporates control means applied to control the operation of said linear motors by means of a detection of the position of moving parts of the linear motors for the purpose of the plate-holding roller being returned to said printing position in response to variations in the position detected during operation and caused by said level variations, differences or breaks.

[0010] The proposal of the invention is based on adapting the mentioned control means to control one or more control parameters for the pre-determined alteration of the conditions of the response offered by the linear motors to said variations in the position with the plate-holding roller being returned to the printing position.

[0011] The principles of the invention also apply to the inking roller of the printer.

[0012] Particularly, when the variations in the position are cyclic and occur at a frequency within a range including at least one natural vibration frequency of a system formed by the plate-holding roller or inking roller, the first moving supports and said moving parts of the linear motors attached thereto, the mentioned control means of the linear motors act to at least partially disable their response and to thus counteract a possible resonance effect of said system.

[0013] The mentioned control means in one embodiment of the invention comprise:

a linear encoder or other functionally equivalent device, arranged to generate a position signal representative of the position of the moving part of each of the linear motors in relation to its respective fixed part;

an electric and/or electronic circuitry adapted to repeatedly compare said position signal generated by said linear encoder and a pre-established working position and generate a control signal for the linear motor with the moving part being returned to said pre-established working position in response to any variation between the position signal generated by said linear encoder and the pre-established working position, said electric and/or electronic circuitry including a frequency filter adapted to apply said control signal to determined application frequencies and with the exception of a frequency range which is around a natural frequency of the mentioned system formed by the plate-holding roller or inking roller, the first moving supports and said moving parts of the corresponding linear motors attached thereto, and

the mentioned electronic circuitry can include a position control module adapted to generate a position error signal from the comparison between the position signal generated by the linear encoder and the pre-established working position and according to the gain and/or the integral time and/or the derivative time.

[0014] In a variant of the invention, the mentioned electric and/or electronic circuitry includes a speed control module to generate a speed control signal from said position error signal generated by said position control module.

[0015] The invention also provides that said electric and/or electronic circuitry includes a force control module to control a supply current intensity of the linear motor (11, 12) from said speed control signal generated by said speed control module, and according to the gain and/or the integral time and/or the derivative time.

[0016] Said electronic circuitry can include two or more modules of those mentioned functionally combined.

Brief Description of the Drawings

[0017] The foregoing and other features and advantages will be more fully understood from the following detailed description of several embodiments in relation to the attached drawings, in which:

Figure 1 is a diagram which schematically shows the dynamic performance of a plate-holding roller in a printing unit equipped with nut and spindle drives;

Figure 2 is a diagram which schematically shows the dynamic performance of a plate-holding roller in a printing unit equipped with linear motor drives;

Figure 3 is a diagram which schematically shows control means applied to control the operation of linear motors in a flexographic printer including printing units with improved stability according to the present invention;

Figure 4 is a side elevational schematic view of a flexographic printer including printing units with improved stability according to a first embodiment of the present invention;

Figure 5 is a profile schematic view showing a plate-holding roller in contact with a print drum and an inking roller;

Figure 6 is an enlarged detail showing a printing unit of the printer of Figure 4;

Figure 7 is a cross-section view of the printing unit of Figure 6;

Figure 8 is a side elevational schematic view of a flexographic printer including printing units with improved stability according to a second embodiment of the present invention;

Figure 9 is an enlarged detail showing a printing unit of the printer of Figure 8;

Figure 10 is a cross-section view of the printing unit of Figure 9;

Figure 11 is a cross-section view of a printing unit according to a variant of the second embodiment;

Figure 12 is a side elevational schematic view of a flexographic printer including printing units with improved stability according to a third embodiment of the present invention;

Figure 13 is an enlarged detail showing a printing unit of the printer of Figure 12;

Figure 14 is a cross-section view of the printing unit

of Figure 13;

Figure 15 is a side elevational schematic view of a flexographic printer including printing units with improved stability according to a fourth embodiment of the present invention;

Figure 16 is an enlarged detail showing a printing unit of the printer of Figure 15;

Figure 17 is a cross-section view of the printing unit of Figure 16;

Detailed Description of Several Embodiments

[0018] The differences with regard to a dynamic performance of a plate-holding roller in a printing unit of a flexographic printer according to whether it is equipped with nut and spindle drives or with linear motor drives is described below first in reference to Figures 1 and 2.

[0019] As shown in Figure 5, a flexographic printer generally comprises a rotating support roller 1 supporting a laminar material web 9 to be printed supported thereon, and one or more printing units each provided with a plate-holding roller 5 arranged to contact against the laminar material 9 on the support roller 1 in a printing position and an inking roller 6 arranged to contact the plate-holding roller 5 in an inking position. The plate-holding roller 5 is made up of a core 30 on which there is assembled a removable sleeve 31, which has one or more plates 4 assembled thereon. The mentioned plates 4 have a thickness which causes level differences in the surface of the plate-holding roller 5, and the surface of the plates 4 themselves also includes irregularities.

[0020] Figure 1 schematically shows the dynamic performance of the plate-holding roller 5 in a printing unit equipped with nut and spindle drives. The plate-holding roller 5 has a mass Mrp and is rotatably supported at its ends on moving supports linearly guided in corresponding side bedplates 2 of the printer. Each of said moving supports is connected by means of one or more nuts to one or more spindles driven by rotating electric motors. A rotation of said rotating motors causes the plate-holding roller 5 to move between printing and servicing positions, and this movement capability is also used to control the pressure exerted by the plate-holding roller 5 against a support roller 1 in the servicing position. When the plate-holding roller has been arranged in the desired printing position, the rotating motors driving the spindles are stopped and the supports of the plate-holding roller remain in fixed positions with regard to the side bedplates 2. A printing force Fi applied by the support roller 1 on the mass of the plate-holding roller Mrp is withstood by the supports anchored to the bedplates 2 by means of the nut and spindle drives. A certain elasticity inherent to the plate-holding roller 5 and to said supports, nuts, spindles, etc., makes the system act like a spring K1 against said printing force Fi and the mass of the plate-holding roller Mrp can oscillate with amplitude A1.

[0021] When the plate-holding roller 5, arranged in the printing position shown in Figure 5, rotates in contact with the laminar material 9 on the support roller 1, the mentioned level differences and irregularities on the surface of the plate-holding roller 5 cause cyclic blows. At certain rotation speeds, these cyclic blows constitute an excitation frequency which can be in resonance with the natural frequency of the mentioned system formed by the plate-holding roller 5, its supports, spindles, nuts, etc., and the oscillation amplitude A1 can increase up to values which damage the quality of the printing and/or which can cause damages to the printing unit. In this construction there is no device acting to dampen said resonance.

[0022] The diagram of Figure 2 schematically shows the dynamic performance of the plate-holding roller 5 in a printing unit equipped with linear motor drives. The plate-holding roller 5 herein also has a mass Mrp and is rotatably supported at its ends on moving supports linearly guided in corresponding side bedplates 2 of the printer, but each of said moving supports is fixed to a moving part of a linear motor, which exerts a thrust force Fm against the mass of the moving part of the linear motor Mm. The thrust force Fm opposes the printing force Fi applied by the printing roller 1 on the mass of the plate-holding roller Mrp. Every time there is a difference or irregularity in the surface of the plate-holding roller 5, the moving parts of the linear motors can move back a movement Dm with regard to the side bedplate 2, overcoming the thrust force Fm, and they are controlled in order to try to return the plate-holding roller 5 to its printing position. Here, a certain elasticity inherent to the plate-holding roller 5 and to its supports etc., combined with the thrust force Fm of the linear motors, make the system act like a spring K2 against said printing force Fi.

[0023] The essential feature of the present invention comprises using control means to affect how the linear motors respond to the movements Dm of the masses of the moving parts of the linear motors Mm in order to make the linear motors act like a damper Am to prevent the system from being in resonance.

[0024] A composition and a method for the operation of said control means are described below in relation to Figure 3.

[0025] As indicated, the control means can integrate a position control module 50, a speed control module 51 and a force control module 52 which can act in combination as shown in Figure 3 or individually or associated in pairs. Depending on the values treated by said modules action on the linear motor will be taken to control its response curve given any position alteration of the plate-holding or inking roller, in accordance with what has been explained. Reference number 35 refers to an encoder associated to the linear motor 10, 11 and in the left margin there is a pre-established (set) base parameter control block.

[0026] Several embodiments of a flexographic printer including printing units 3 with improved stability according to the present invention are described below in relation to Figures 4 to 17, including an arrangement of linear guide elements and linear motors for performing the

movements of the plate-holding and inking rollers 5, 6, in which the control device described above can be applied.

[0027] All the embodiments described herein have in common a single support roller in the form of a large, central print drum 1 arranged to rotate about a shaft 32 supported at its ends by bearings assembled in two side bedplates 2 (only one of which is seen in the drawings), such that the print drum 1 is arranged between said two side bedplates 2. The print drum 1 is adapted to support, while rotating at the same time, a laminar material web 9 to be printed, which moves without any relative movement between the print drum 1 and the laminar material web 9. Several printing units 3 are arranged around the print drum 1 and on both sides thereof for successively printing the laminar material web 9 with different ink colors.

[0028] Each printing unit 3 comprises a plate-holding roller 5 arranged to rotate about a shaft parallel to said shaft 32 of the print drum 1 and supported at its two ends in bearings assembled in respective first moving supports 7 arranged to move along the length of respective first linear guide elements attached to said side bedplates 2. As described above in relation to Figure 5, the plate-holding roller 5 comprises a core 30 and a removable sleeve 31 which has one or more plates 4 assembled thereon. The mentioned first moving supports 7 are operatively connected to first drive means driven by linear electric motors 11, 12 arranged to move the first moving supports 7 along the length of their respective first linear guide elements for the purpose of changing said plate-holding roller 5 between a printing position, in which a surface of the plate or of the plates 4 assembled on the plate-holding roller 5 is in contact with the laminar material web 9 on the print drum 1, and a servicing position, in which the plate-holding roller 5 is separated from the print drum. A rotating electric motor (not shown) operatively connected to rotate the plate-holding roller 5 with a tangential speed in its surface equal to the tangential speed of the laminar material 9 on the print drum 1 is arranged in one of the first moving supports 7 located on one of the side bedplates 2. The bearing associated to the other one of the first moving supports 7 located in the opposite side bedplate 2 can be open in order to release the corresponding end of the shaft of the plate-holding roller 5 while the shaft is supported in a projecting manner at the opposite end, and the moving support 7 can be separated such that the sleeve 31 with the plates 4 can be removed and/or replaced.

[0029] Each printing unit 3 further comprises an inking roller 6 arranged to rotate about a shaft parallel to the shaft 32 of the print drum 1 and supported at its two ends in bearings assembled in respective second moving supports 8 arranged to move along the length of respective second linear guide elements attached to the side bedplates 2. As shown in Figure 5, the inking roller 6 comprises a core 33 and a removable sleeve 34, which has a honeycombed, also called "anilox", surface in permanent contact with an ink applicator device (not shown). The mentioned second moving supports 8 are operatively connected to second drive means driven by linear electric motors 11, 12 arranged to move said second moving supports 8 along the length of their respective second linear guide elements for the purpose of changing said inking roller 6 between an inking position, in which the inking roller 6 is in contact with said plate-holding roller 5, and a servicing position, in which the inking roller is separated from the plate-holding roller 5. A rotating electric motor (not shown) operatively connected to rotate the inking roller 6 with a tangential speed in its surface equal to the tangential speed of the surface of the plates 4 in the plate-holding roller 5 is arranged in one of the second moving supports 8 located on one of the side bedplates 2. The bearing associated to the other one of the second moving supports 8 located in the opposite side bedplate 2 can be open in order to release the corresponding end of the shaft of the inking roller 6 while the shaft is supported in a projecting manner at the opposite end, and the moving support 8 can be removed such that the sleeve 33 with the anilox surface can be removed and/or replaced.

[0030] The side bedplates 2 comprise openings 13 associated to the printing units 3 and sized to allow the movements of the plate-holding and inking rollers 5, 6 as well as the extraction and placement therethrough of the sleeves 31, 33 of the plate-holding and inking rollers 5, 6. Therefore, the first and second linear guide elements of each printing unit 3 are arranged to guide the movements of the first and second moving supports 7, 8 opposite said openings 13 and along the length thereof. Figures 4, 6, 8, 9, 12, 13, 15 and 16 show the first and second moving supports 7, 8 of each printing unit 3 in their separated positions to allow the placement and extraction of the sleeves 31, 33 of the plate-holding and inking rollers 5, 6.

[0031] As is conventional, each linear motor 11, 12 is formed by a moving part 11 attached to one of the first or second moving supports 7, 8 and a fixed part 12 attached to the corresponding bedplate 2. In all the embodiments of the present invention, the mentioned moving part 11 of the linear motor is a primary element 11 including at least one winding and the fixed part 12 is in the form of a secondary element 12 including one or more rows of permanent magnets arranged along the length of an elongated plane. Therefore, the primary element 11 including the winding of the linear motor is fixed to the corresponding first or second moving support 7, 8 whereas the secondary element 12 including the permanent magnets is fixed to the corresponding bedplate 2. The first and second linear guide elements are arranged for the purpose of guiding the movements of the first and second moving supports 7, 8 such that the primary elements 11 fixed thereto move opposite the mentioned elongated plane defined by their corresponding secondary element 12, and along the length thereof.

[0032] Figures 4, 6 and 7 show a flexographic printer

according to a first embodiment of the present invention, which comprises several printing units 3 arranged around the central print drum 1, including the common elements described above. In each printing unit 3 (shown separately in Figures 6 and 7) each of the first and second moving supports 7, 8 has fixed thereto two primary elements 11, one of them opposite a secondary element 12 fixed to the bedplate 2 above the corresponding opening 13 and the other one opposite another secondary element 12 fixed to the bedplate 2 under the opening 13. It will be observed that in all the printing units 3 located on each side of the central drum 1, the mentioned first and second linear guide elements (which will be described in greater detail below) are parallel to one another. A single secondary element 12 is arranged between every two of said adjacent openings 13 which defines two parallel elongated planes on opposite sides thereof. As is best shown in Figure 7, these secondary elements 12 of the linear motors are arranged projecting out from the side frame 2, with the mentioned two elongated planes oriented in a position parallel to a plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6, therefore one of the two parallel elongated planes located on an upper side of the secondary element 12 and the other one on its lower side. Thus, each of the secondary elements 12 located between two adjacent openings 13 is common for four primary elements 11, two of them attached respectively to the first and second moving supports 7, 8 of the printing unit 3 located on the upper side with regard to the secondary element 12 and the other two attached respectively to the first and second moving supports 7, 8 of the printing unit 3 located on the lower side with regard to the secondary element 12. With this construction, the resulting vectors of the forces provided by the linear motors 11, 12 are suitably aligned with the plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6.

[0033] In each printing unit 3 of this first embodiment, the first and second linear guide elements comprise an upper rail 14 fixed to the corresponding side bedplate 2 between the opening 13 and the secondary element 12 located above the opening 13 and a lower rail 15 fixed to the corresponding side bedplate 2 between the opening 13 and the secondary element 12 located under the opening 13. Each of the first and second moving supports 7, 8 has fixed thereto an upper slide 16 coupled to said upper rail 14 and a lower slide 17 coupled to said lower rail 15. Therefore, said upper rail 14 is common for at least two of said upper slides 16, one of them attached to the first moving support 7 and the other one attached to the second moving support 8, and said lower rail 15 is common for two of said lower slides 17, one of them attached to the first moving support 7 and the other one attached to the second moving support 8. Although Figure 7 shows only the first moving supports 7, the arrangement of the primary elements 11 and upper and lower slides 16, 17 is similar for the second moving supports 8. Obviously, each of the first and second moving supports 7, 8 could have more than one upper slide 16 and/or more than one lower slide 17, or the upper and lower rails 14, 15 could be independent for each of the first and second moving supports 7, 8 without departing from the scope of the present invention.

[0034] A second embodiment of the flexographic printer of the invention is now described in relation to Figures 8, 9 and 10, comprising several printing units 3 arranged around the central print drum 1, including the common elements described above. In each printing unit 3 (shown separately in Figures 9 and 10) each of the first and second moving supports 7, 8 has fixed thereto a primary element 11 opposite a secondary element 12 fixed to the bedplate 2 within the opening 13. The secondary element 12 is arranged with its elongated plane oriented in a position parallel to a plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6. In this second embodiment, the secondary element 12 is common for both the primary element 11 attached to the first moving support 7 and for the primary element 11 attached to the second moving support 8. As shown in Figure 10, in each printing unit 3 the first and second linear guide elements comprise at least one pair of rails 18 fixed to the corresponding side bedplate 2 on both sides of the secondary element 12 within the opening 13, and each of the first and second moving supports 7, 8 has fixed thereto at least one pair of slides 19, each coupled to a respective rail of said pair of rails 18. Thus, each rail of the pair of rails 18 is common for at least two of said slides 19, one of them attached to the first moving support 7 and the other one attached to the second moving support 8. Although Figure 10 shows only the first moving support 7, the arrangement of the primary element 11 and of the slides 19 is similar for the second moving supports 8. Obviously, each of the first and second moving supports 7, 8 could have more than two slides 19, or the rails 18 could be independent for each of the first and second moving supports 7, 8 without departing from the scope of the present invention.

[0035] Figure 11 shows a variant of the second embodiment described above in relation to Figures 8 to 10. In this variant, each of the first and second moving supports 7, 8 of each printing unit 3 has fixed thereto a primary element 11 opposite a secondary element 12 arranged with its elongated plane oriented in a position perpendicular to a plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6. This secondary element 12 is fixed to the bedplate 2 under the opening 13, although it could alternatively be fixed above the opening 13 with an equivalent result. The secondary element 12 herein also is common for both primary elements 11 attached to the first moving support 7 and to the second moving support 8, respectively. The first and second linear guide elements comprise a single rail 20 fixed to the corresponding side bedplate 2 within the opening 13, in a plane parallel to the plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6, and each of the first and second moving supports 7, 8 has

fixed thereto a slide 21 coupled to said rail 20. Thus, the rail 20 is common for two of said slides 21, one of them attached to the first moving support 7 and the other one attached to the second moving support 8. Although Figure 11 shows only the first moving support 7, the arrangement of the primary element 11 and of the slide 21 is similar for the second moving supports 8. Obviously, each of the first and second moving supports 7, 8 could have more than a slide 21, or there could be independent rails 20 for each of the first and second moving supports 7, 8 without departing from the scope of the present invention.

[0036] A third embodiment of the flexographic printer of the invention is now described with reference to Figures 12, 13 and 14, comprising several printing units 3 arranged around the central print drum 1, including the common elements described above. In each printing unit 3 (shown separately in Figures 13 and 14), each of the first and second moving supports 7, 8 has fixed thereto a primary element 11 opposite a respective secondary element 12 arranged with its elongated plane oriented in a position perpendicular to a plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6. Each secondary element 12 extends in relation to an imaginary central longitudinal line Lc. The two secondary elements 12 are fixed to the bedplate 2 on both sides of the opening 13 with their respective central longitudinal lines Lc aligned with one another and aligned with said plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6. With this construction, the vectors of the forces provided by the linear motors 11, 12 are suitably aligned with the plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6. Here, the first and second linear guide elements comprise at least one upper rail 22 fixed to the corresponding side frame 2 above the secondary elements 12 and above the opening 13 and at least one lower rail 23 fixed to the corresponding side frame 2 under the secondary elements 12 and under the opening 13.

[0037] In this third embodiment, each of the first and second moving supports 7, 8 has fixed thereto at least one upper slide 24 coupled to said upper rail 22 and at least one lower slide 25 coupled to said lower rail 23. Thus, the mentioned upper rail 22 is common for two of said upper slides 24, one of them attached to the first moving support 7 and the other one attached to the second moving support 8, and said lower rail 23 is common for at least two of said lower slides 25, one of them attached to the first moving support 7 and the other one attached to the second moving support 8. Although Figure 14 shows only the first moving support 7, the arrangement of the primary element 11 and of the upper and lower slides 24, 25 is similar for the second moving supports 8. Obviously, each of the first and second moving supports 7, 8 could have more than one upper slide 24 and/or more than one lower slide 25, or the upper and lower rails 22, 23 could be independent for each of the first and second moving supports 7, 8 without departing from the scope of the present invention.

[0038] Finally, Figures 15, 16 and 17 show a flexographic printer according to a fourth embodiment of the present invention, which comprises several printing units 3 located around the central print drum 1, including the common elements described above. In each printing unit 3 (best shown in Figures 16 and 17) each of the first and second moving supports 7, 8 has fixed thereto two primary elements 11, one of them opposite a secondary element 12 fixed to the bedplate 2 above the corresponding opening 13 and the other one opposite another secondary element 12 fixed to the bedplate 2 under the opening 13. Therefore, each of the secondary elements 12 is common for at least two primary elements 11, one of them attached to the first moving support 7 and the other one attached to the second moving support 8. Each of the secondary elements 12 is arranged with its elongated plane oriented in a position perpendicular to a plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6. With this construction, the resulting vectors of the forces provided by the linear motors 11, 12 are suitably aligned with the plane Pr defined by the shafts of the plate-holding and inking rollers 5, 6.

[0039] In each printing unit 3, the first and second linear guide elements comprise an upper rail 26 fixed to the corresponding side bedplate 2 above the secondary element 12 located above the opening 13 and a lower rail 27 fixed to the corresponding side bedplate 2 under the secondary element 12 located under the opening 13. Each of the first and second moving supports 7, 8 has fixed thereto an upper slide 28 coupled to said upper rail 26 and a lower slide 29 coupled to said lower rail 27, such that said upper rail 26 is common for two of said upper slides 28, one of them attached to the first moving support 7 and the other one attached to the second moving support 8, and said lower rail 27 is common for two of said lower slides 29, one of them attached to the first moving support 7 and the other one attached to the second moving support 8. Obviously, each of the first and second moving supports 7, 8 could have more than one upper slide 28 and/or more than one lower slide 29, or the upper and lower rails 26, 27 could be independent for each of the first and second moving supports 7, 8 without departing from the scope of the present invention. Although Figure 17 shows only the first moving support 7, the arrangement of the primary elements 11 and upper and lower slides 28, 29 is similar for the second moving supports 8. Obviously, each of the first and second moving supports 7, 8 could have more than one upper slide 28 and/or more than one lower slide 29, or the upper and lower rails 26, 27 could be independent for each of the first and second moving supports 7, 8 without departing from the scope of the present invention.

[0040] A person skilled in the art will be able to make modifications and variations based on the embodiments shown and described without departing from the scope of the present invention as it is defined in the attached claims.

Claims

1. A flexographic printer including printing units with improved stability, of the type comprising at least one print drum (1) arranged to rotate about a shaft supported between two side bedplates (2) and adapted to support a web of a laminar material to be printed, and one or more printing units (3) each comprising:

   a plate-holding roller (5) arranged to rotate about a shaft parallel to said shaft of the print drum (1) and supported at its two ends in respective first moving supports (7) arranged to move along the length of respective first linear guide elements (9) attached to said side bedplates (2), said plate-holding roller (5) having one or more plates (4) assembled on the surface thereof, the relief of which produces level variations, differences or breaks in its surface when it rotates; and
   first drive means driven by linear electric motors (11, 12) arranged to move the first moving supports (7) along the length of their respective first guide elements (9) for the purpose of changing said plate-holding roller (5) between a printing position, in which a surface of one or more plates (4) assembled on the plate-holding roller (5) is in contact with said laminar material web on said print drum (1), and under a pressure determined according to the relief of said plate and a non-printing position, in which the plate-holding roller (5) is not in contact with the print drum and the pressure is nil;
   there being arranged control means applied to control the operation of said linear motors (11, 12) by means of a detection of the position of moving parts (11) of the linear motors (11, 12) for the plate-holding roller (5) to at least be returned to said printing position in response to variations in the position detected during operation and caused by said level variations or differences,
   characterized in that said control means are provided to control one or more control parameters for the pre-determined alteration of the conditions of the response offered by the linear motors (11, 12) to said variations in the position with the plate-holding roller being returned (5) to the printing position.

2. The printer according to claim 1, **characterized in that** said printing unit (3) further comprises an inking roller (6) arranged to rotate about a shaft parallel to the shaft of the print drum (1) and supported at its two ends in respective second moving supports (8) arranged to move along the length of respective second linear guide elements (10) attached to the side bedplates (2), and second drive means driven by linear electric motors (11, 12) arranged to move said second moving supports (8) along the length of their respective second guide elements (10) for the purpose of changing said inking roller (6) between an inking position, in which the inking roller (6) is in contact with said plate-holding roller (5), and a servicing position, in which the inking roller is separated from the plate-holding roller (5), said control means being applied to furthermore control the operation of said linear motors (11, 12) by means of a detection of the position of moving parts of said linear motors (11, 12) for, among other functions, the inking roller (6) to be returned to said inking position in response to variations in the position detected during operation caused by level changes in the surface of the plate-holding roller (5), said control means furthermore being adapted to control one or more control parameters for the pre-determined alteration of the conditions relating to the response offered by the linear motors (11, 12) to said variations in the position, with the inking roller (6) being returned to the inking position,.

3. The printer according to claim 1 or 2, **characterized in that** when the variations in the position are cyclic and occur at a frequency within a range including at least one natural vibration frequency of a system formed by the plate-holding roller (5) or inking roller (6), the first moving supports (7, 8) and said moving parts (11) of the linear motors (11, 12) attached thereto, the mentioned control means of said linear motors (11, 12) act to at least partially disable their response and to thus counteract a possible resonance effect of said system.

4. The printer according to any one of claims 1 to 3, **characterized in that** each linear motor (11, 12) is formed by said moving part (11) attached to one of the first or second moving supports (7, 8) and a fixed part (12) attached to the corresponding bedplate (2), and the control means comprise:

   a linear encoder (35) arranged to generate a position signal representative of the position of the moving part (11) of each of the linear motors (11, 12) in relation to its respective fixed part (12);
   an electric and/or electronic circuitry adapted to repeatedly compare said position signal generated by said linear encoder (35) and a pre-established working position and generate a control signal for the linear motor (11, 12) with the moving part (11) being returned to said pre-established working position in response to any variation between the position signal generated by said linear encoder (35) and the pre-established working position, said electric and/or electronic circuitry including a frequency filter adapted to apply said control signal to determined ap-

plication frequencies and with the exception of a frequency range which is around a natural frequency of the mentioned system formed by the plate-holding roller (5) or inking roller (6), the first moving supports (7, 8) and said moving parts (11) of the linear motors (11, 12) attached thereto.

5. The printer according to claim 4, **characterized in that** the electric and/or electronic circuitry includes:

a position control module adapted to generate a position error signal from the comparison between the position signal generated by the linear encoder (35) and the pre-established working position and/or according to the gain and/or the integral time and/or the derivative time.

6. The printer according to claim 4, **characterized in that** the electric and/or electronic circuitry includes:

a speed control module to generate a speed control signal from said position error signal generated by said position control module.

7. The printer according to claim 4, **characterized in that** the electric and/or electronic circuitry includes:

a force control module to control a supply current intensity of the linear motor (11, 12) from said speed control signal generated by said speed control module, and according to the gain and/or the integral time and/or the derivative time.

8. The printer according to claim 4, **characterized in that** the electric and/or electronic circuitry includes:

two or more modules according to claims 5 to 7 functionally combined.

9. The printer according to claim 1, 2 or 3, **characterized in that** said print drum (1) is a central drum and several of said printing units (3) are located on both sides of the print drum (1).

10. The printer according to claim 9, **characterized in that** said moving part (11) of each linear motor (11, 12), to which the corresponding first or second moving support (7, 8) is attached, is a primary element (11) including at least one winding, and each linear motor (11, 12) comprises a fixed part (12) attached to the corresponding side bedplate (2) in the form of a secondary element (12) including one or more rows of magnets arranged along the length of an elongated plane, the first and second linear guide elements (9, 10) being arranged to guide the movements of the first and second moving supports (7, 8) for the purpose of said primary elements (11) moving opposite said elongated plane defined by their corresponding secondary element (12) and along the length thereof.

11. The printer according to claim 9, **characterized in that** at least one of the side bedplates (2) comprises an opening (13) associated to each printing unit (3) and sized to allow the extraction and placement therethrough of sleeves on the plate-holding and inking rollers (5, 6), and the first and second linear guide elements (9, 10) of each printing unit (3) are arranged to guide movements of the first and second moving supports (7, 8) opposite said opening (13) and along the length thereof.

12. The printer according to claim 11, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto two primary elements (11), one of them opposite a secondary element (12) fixed to the bedplate (2) above the opening (13) and the other one opposite another secondary element (12) fixed to the bedplate (2) under the opening (13), each of said secondary elements (12) being common for at least two primary elements (11), one of them attached to the first moving support (7) and the other one attached to the second moving support (8).

13. The printer according to claim 12, **characterized in that** each of the secondary elements (12) is arranged with its elongated plane oriented in a position parallel to a plane defined by the shafts of the plate-holding and inking rollers (5, 6).

14. The printer according to claim 13, **characterized in that** said first and second linear guide elements (9) of all the printing units (3) on each side of the central drum (1) are parallel to one another, and a single secondary element is arranged (12) between every two of said adjacent openings (13) which defines two elongated planes on opposite sides thereof and arranged projecting out from the side frame (2), with said two elongated planes oriented in a position parallel to a plane defined by the shafts of the plate-holding and inking rollers (5, 6) and one located on its upper side and the other one on its lower side, each of said secondary elements (12) being located between two adjacent openings (13) common for four primary elements (11), two of them attached respectively to the first and second moving supports (7, 8) of the printing unit (3) located on the upper side with regard to the secondary element (12) and the other two attached respectively to the first and second moving supports (7, 8) of the printing unit (3) located on the lower side with regard to the secondary element (12).

15. The printer according to claim 12, 13 or 14, **charac-**

terized in that for each printing unit (3), the first and second linear guide elements (9, 10) comprise at least one upper rail (14) located between the opening (13) and the secondary element (12) located above the opening (13) and a lower rail (15) located between the opening (13) and the secondary element (12) located under the opening (13).

16. The printer according to claim 15, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto at least one upper slide (16) coupled to said upper rail (14) and at least one lower slide (17) coupled to said lower rail (15), said upper rail (14) being common for at least two of said upper slides (16), one of them attached to the first moving support (7) and the other one attached to the second moving support (8), and said lower rail (15) being common for at least two of said lower slides (17), one of them attached to the first moving support (7) and the other one attached to the second moving support (8).

17. The printer according to claim 11, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto a primary element (11) opposite a secondary element (12) arranged with its elongated plane oriented in a position parallel to a plane defined by the shafts of the plate-holding and inking rollers (5, 6) and fixed to the bedplate (2) within the opening (13), said secondary element (12) being common for both primary elements (11) attached to the first moving support (7) and to the second moving support (8), respectively.

18. The printer according to claim 17, **characterized in that** for each printing unit (3), the first and second linear guide elements (9, 10) comprise at least one pair of rails (18) located on both sides of the secondary element (12).

19. The printer according to claim 15, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto at least one pair of slides (19) coupled respectively to said pair of rails (18), each rail of the pair of rails (18) being common for at least two of said slides (19), one of them attached to the first moving support (7) and the other one attached to the second moving support (8).

20. The printer according to claim 11, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto a primary element (11) opposite a secondary element (12) arranged with its elongated plane oriented in a position perpendicular to a plane defined by the shafts of the plate-holding and inking rollers (5, 6) and fixed to the bedplate (2) under the opening (13), said secondary element (12) being common for both primary elements (11) attached to the first moving support (7) and to the second moving support (8), respectively.

21. The printer according to claim 20, **characterized in that** for each printing unit (3), the first and second linear guide elements (9, 10) comprise at least one rail (20) located in a plane parallel to a plane defined by the shafts of the plate-holding and inking rollers (5, 6) within the opening (13).

22. The printer according to claim 21, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto at least one slide (21) coupled to said rail (20), which is common for at least two of said slides (21), one of them attached to the first moving support (7) and the other one attached to the second moving support (8).

23. The printer according to claim 11, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto a primary element (11) opposite a respective secondary element (12) arranged with its elongated plane oriented in a position perpendicular to a plane defined by the shafts of the plate-holding and inking rollers (5, 6), the two secondary elements (12) being fixed to the bedplate (2) on both sides of the opening (13), with central longitudinal lines of the secondary elements (12) aligned with one another and aligned with the shafts of the plate-holding and inking rollers (5, 6).

24. The printer according to claim 23, **characterized in that** for each printing unit (3), the first and second linear guide elements (9, 10) comprise at least one upper rail (22) fixed to the corresponding side frame (2) on one side of the secondary elements (12) and above the opening (13) and at least one lower rail (23) fixed to the corresponding side frame (2) on the other side of the secondary elements (12) and under the opening (13).

25. The printer according to claim 24, **characterized in that** in each printing unit (3), each of the first and second moving supports (7, 8) has fixed thereto at least one upper slide (24) coupled to said upper rail (22) and at least one lower slide (25) coupled to said lower rail (23), said upper rail (22) being common for at least two of said upper slides (24), one of them attached to the first moving support (7) and the other one attached to the second moving support (8), and said lower rail (23) being common for at least two of said lower slides (25), one of them attached to the first moving support (7) and the other one attached to the second moving support (8).

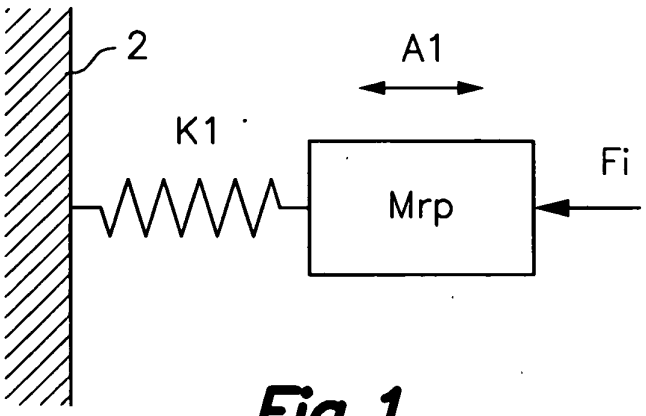

Fig. 1

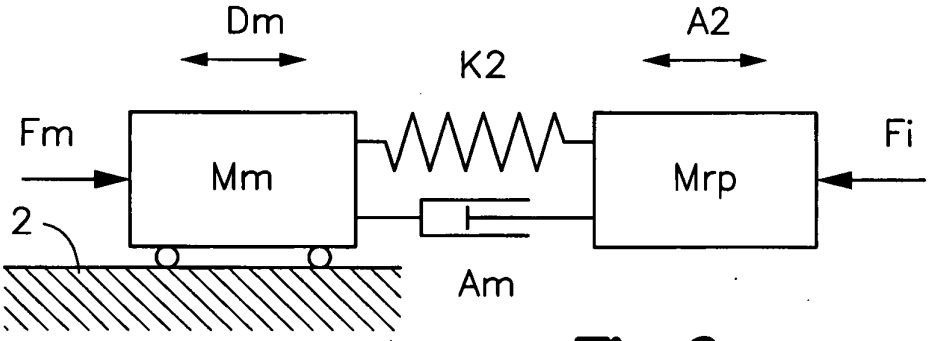

Fig.2

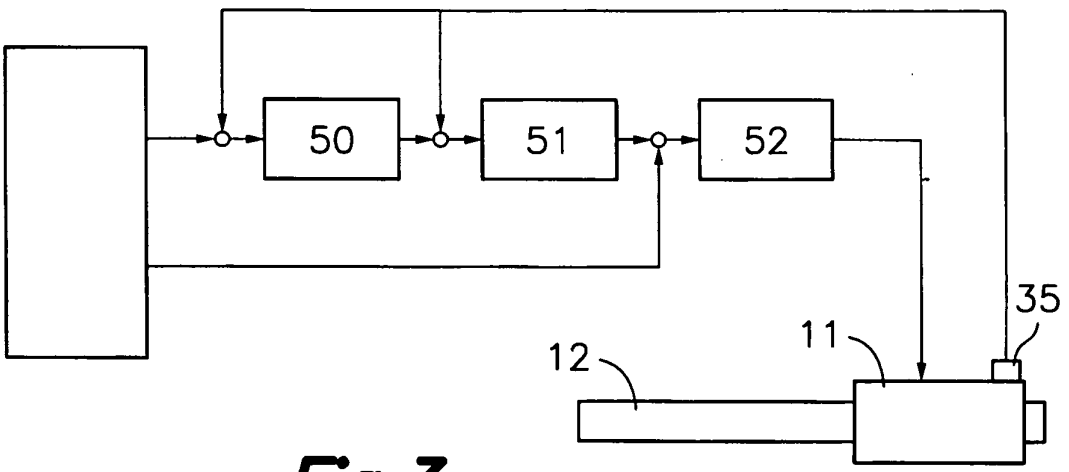

Fig.3

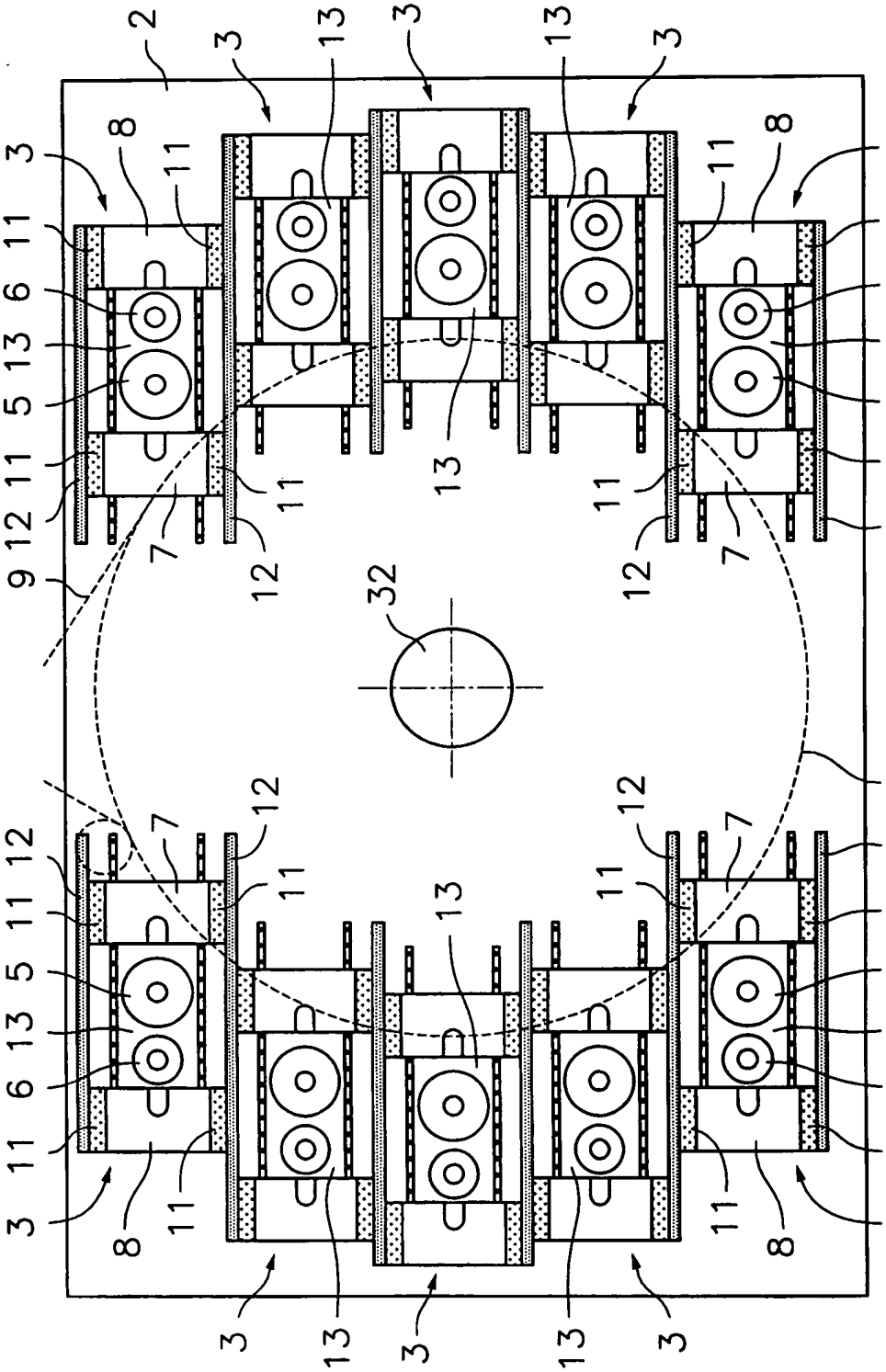
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Fig.4

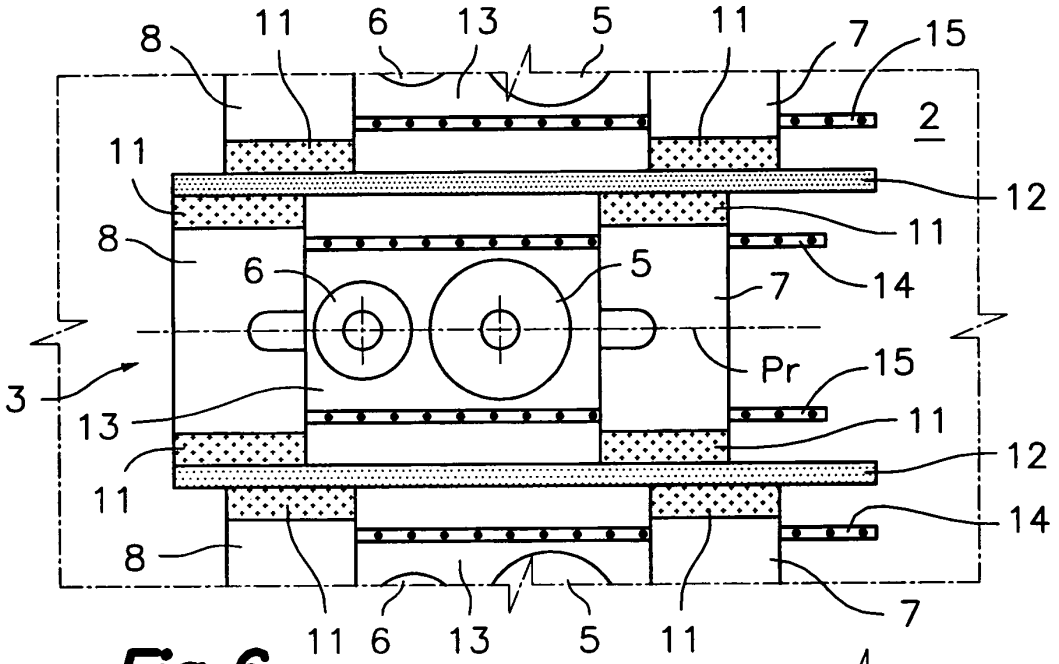

Fig.6

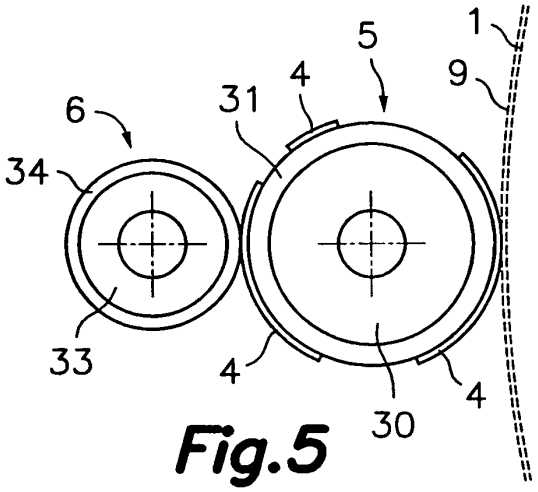

Fig.5

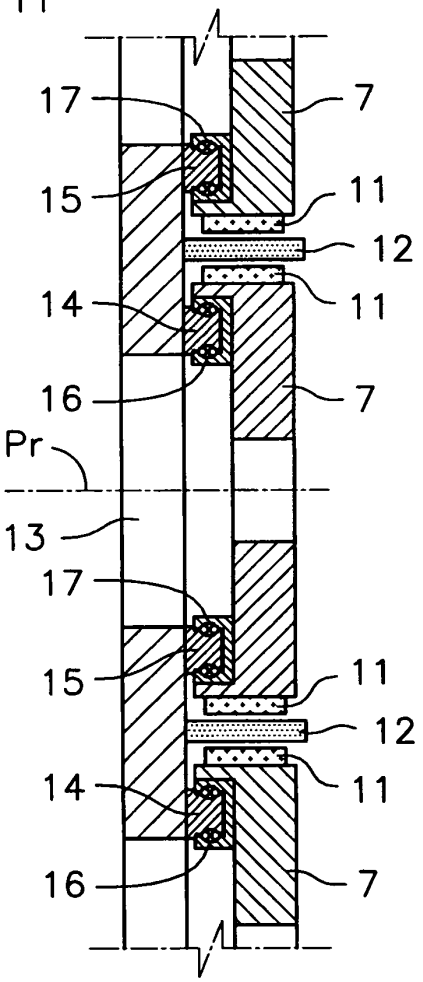

Fig.7

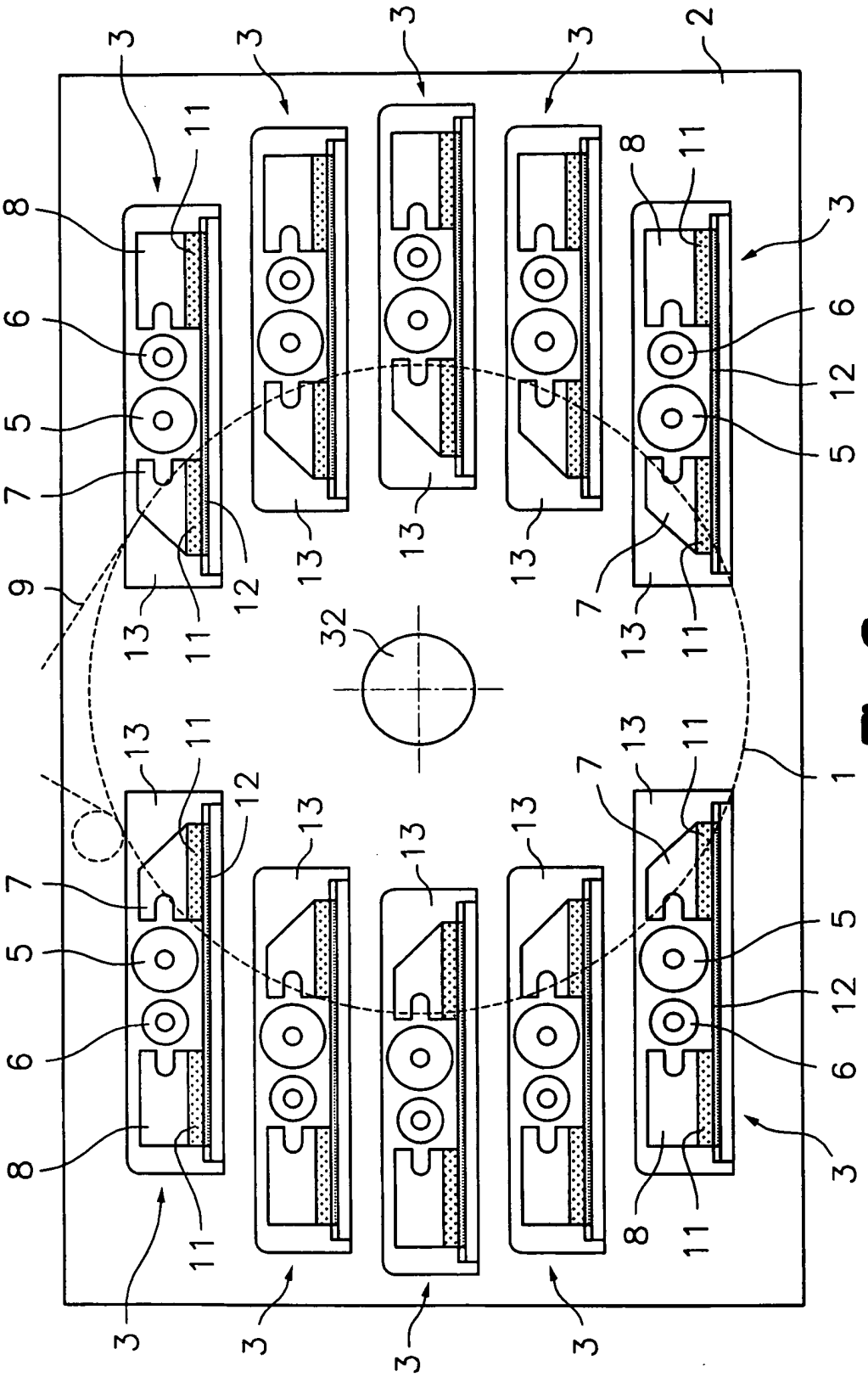

Fig.8

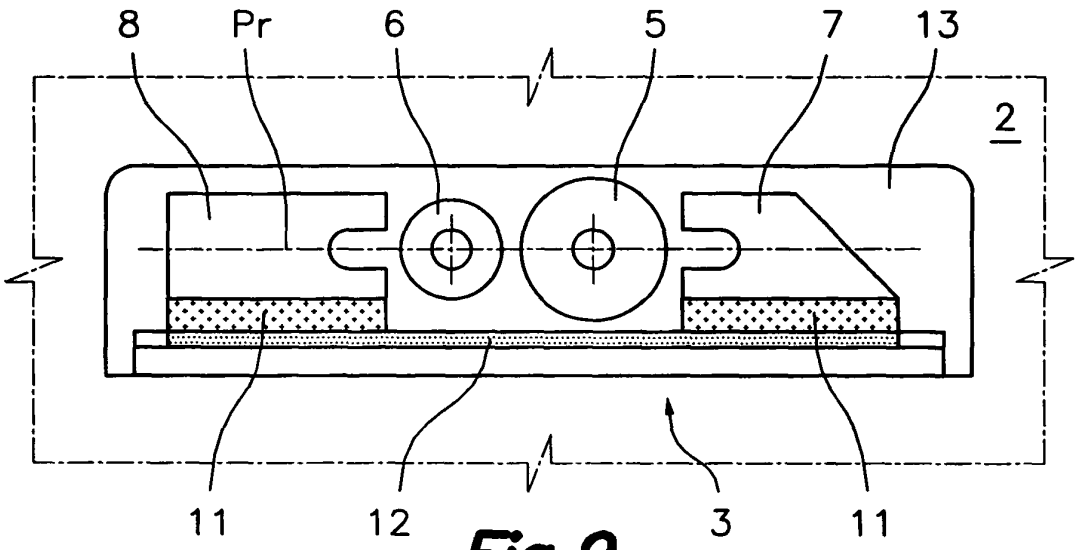

Fig.9

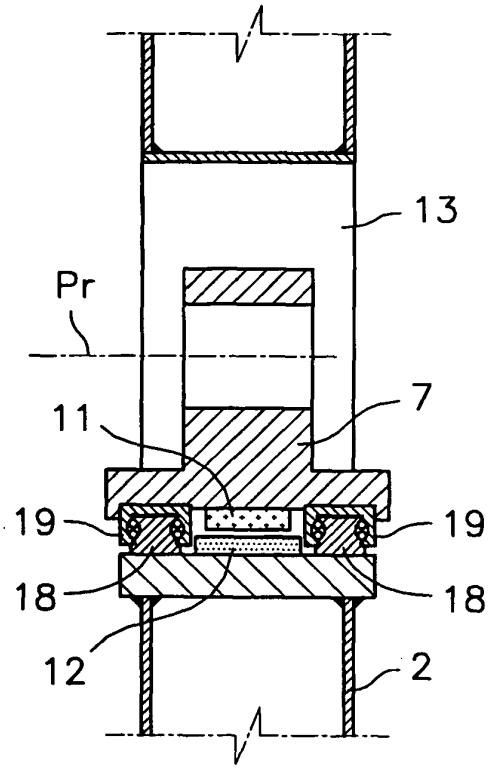

Fig.10

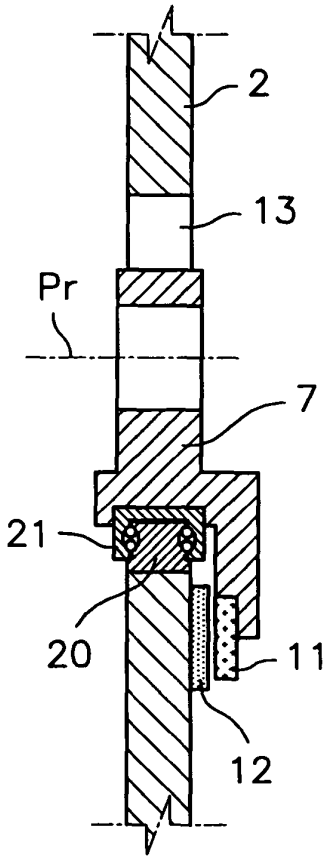

Fig.11

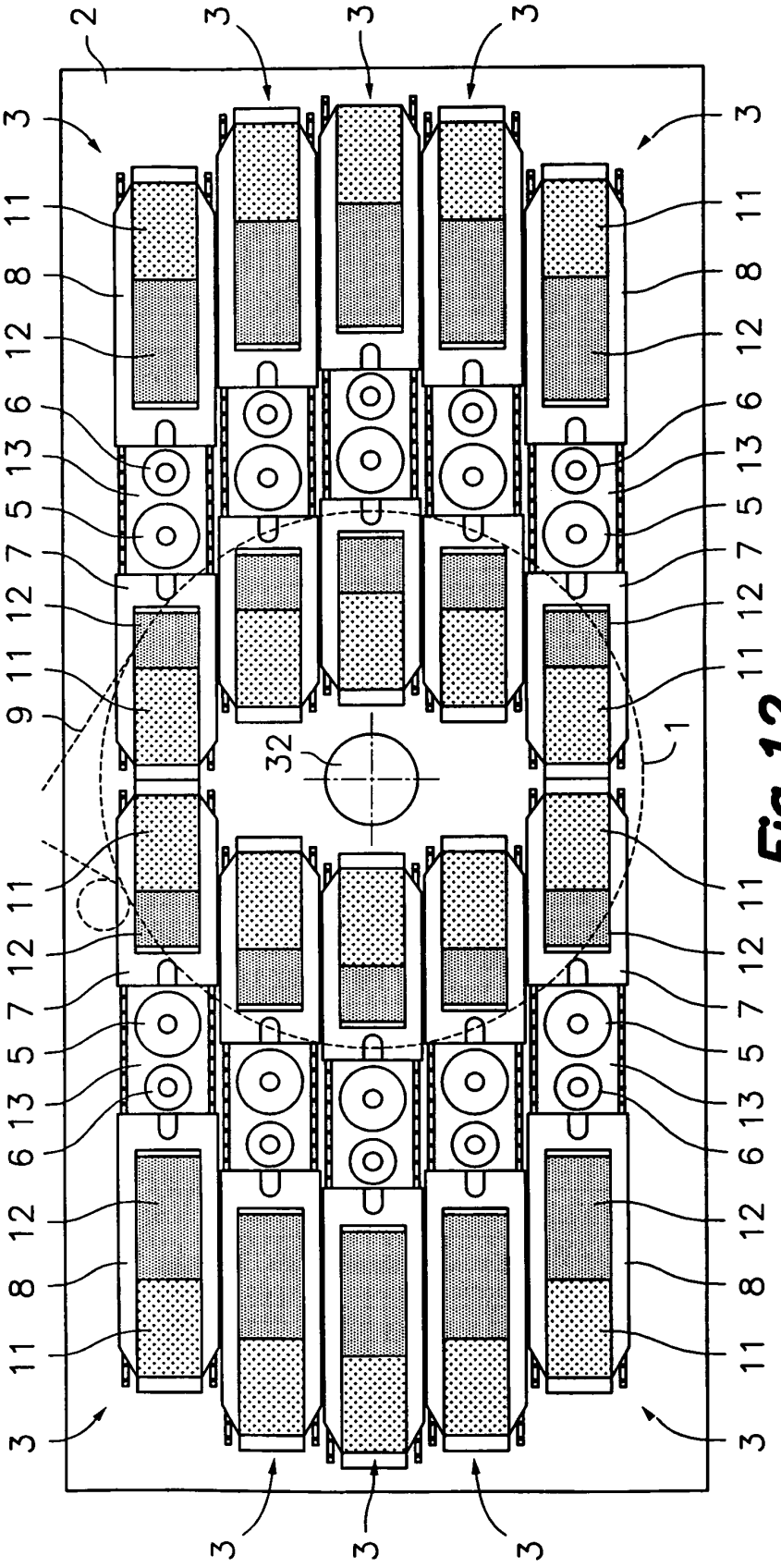
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Fig. 12

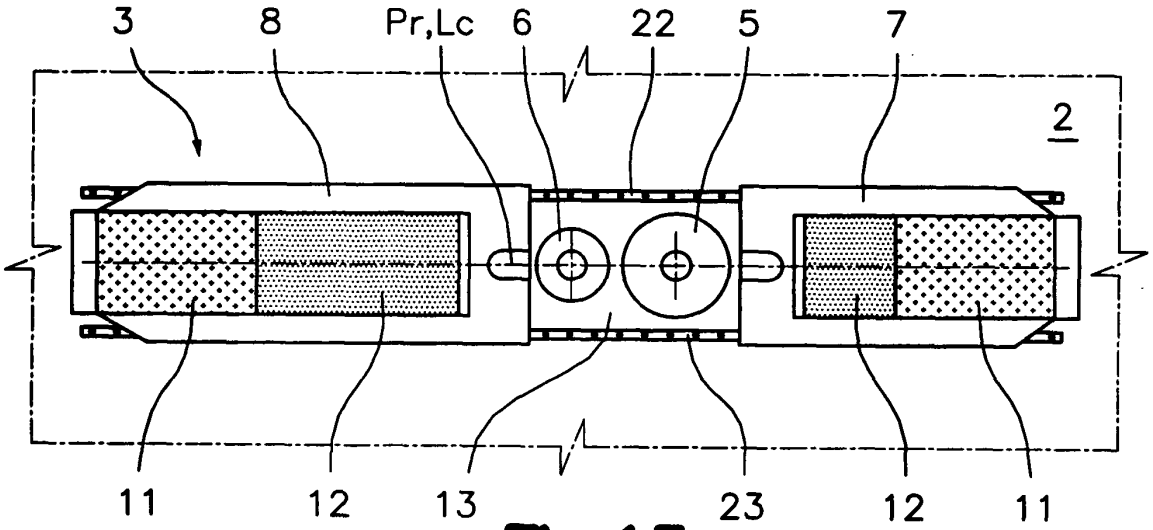

Fig. 13

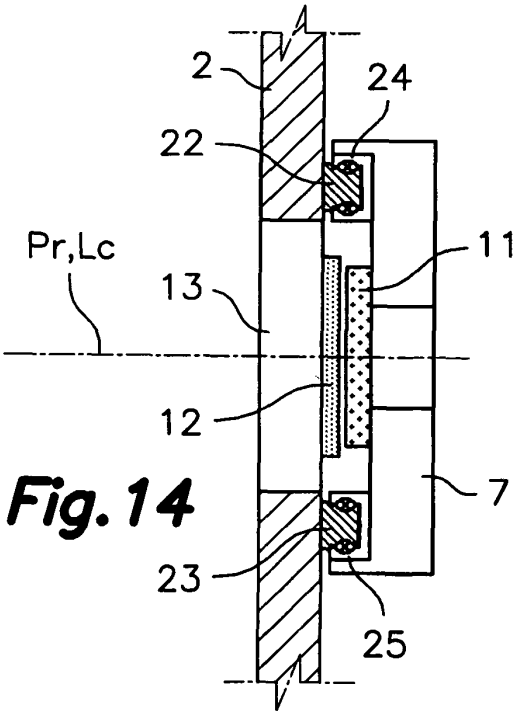

Fig. 14

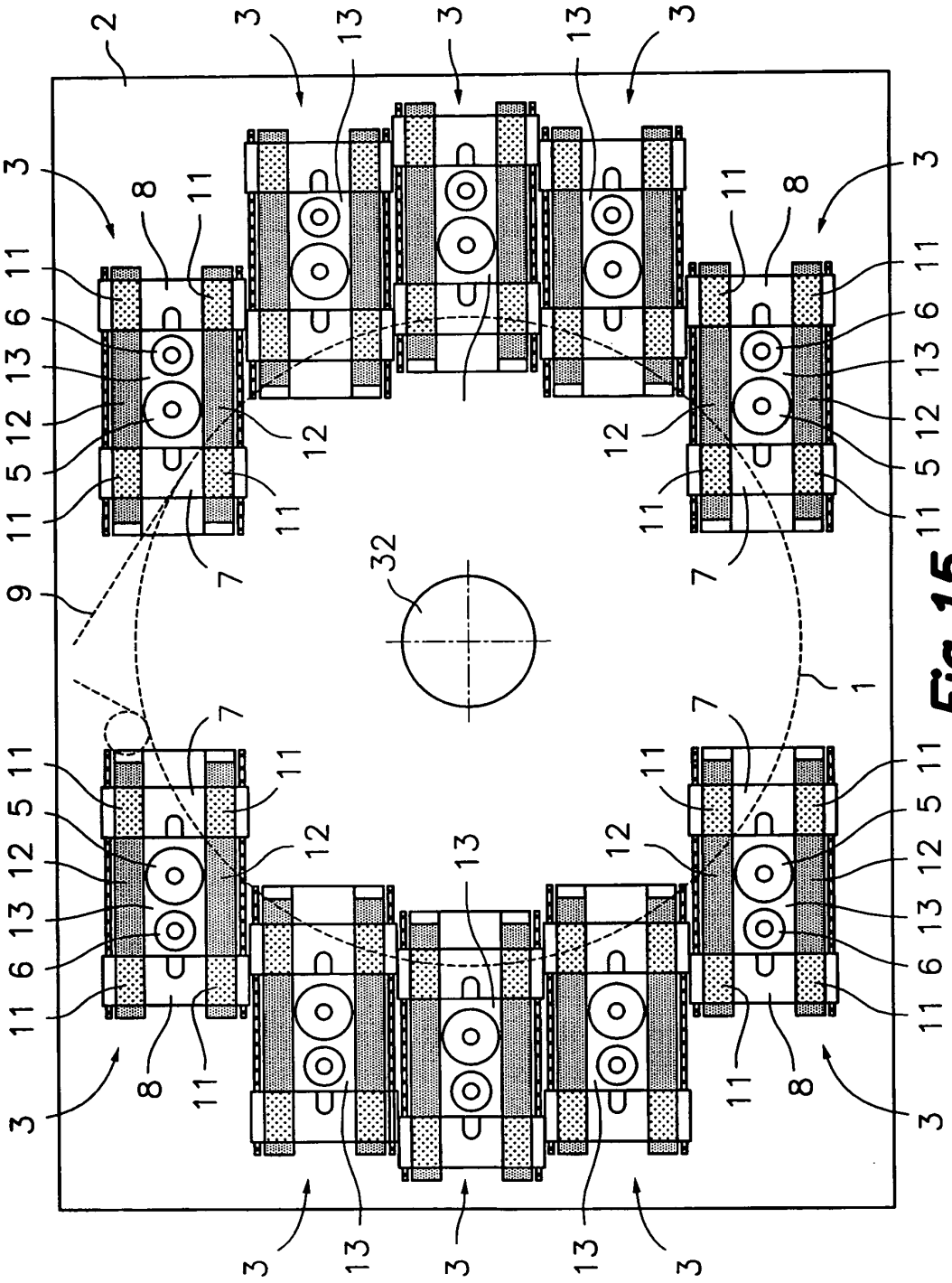

Fig. 15

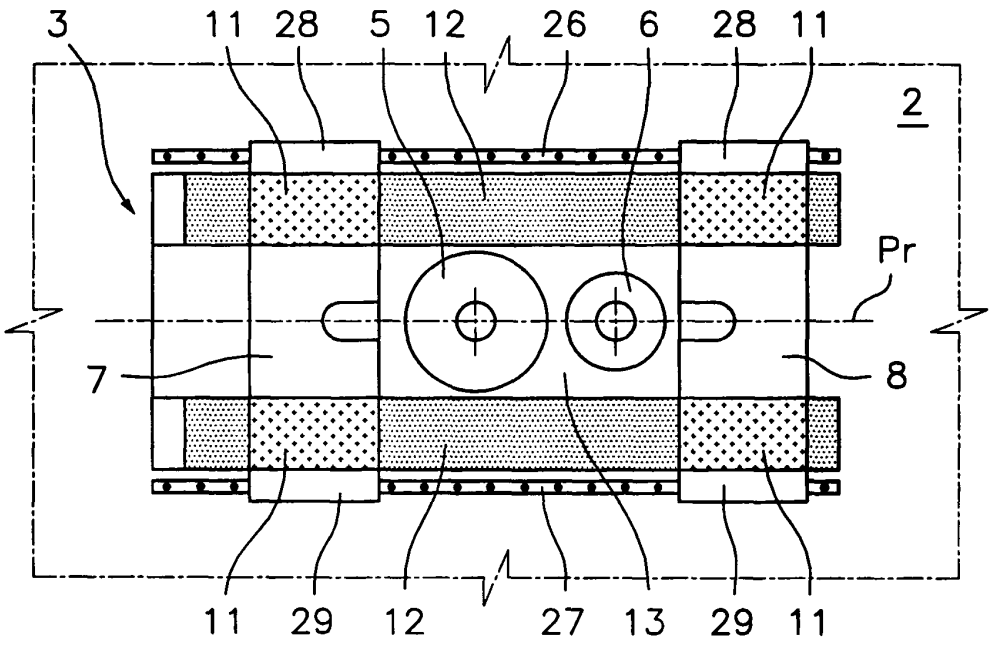
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Fig. 16

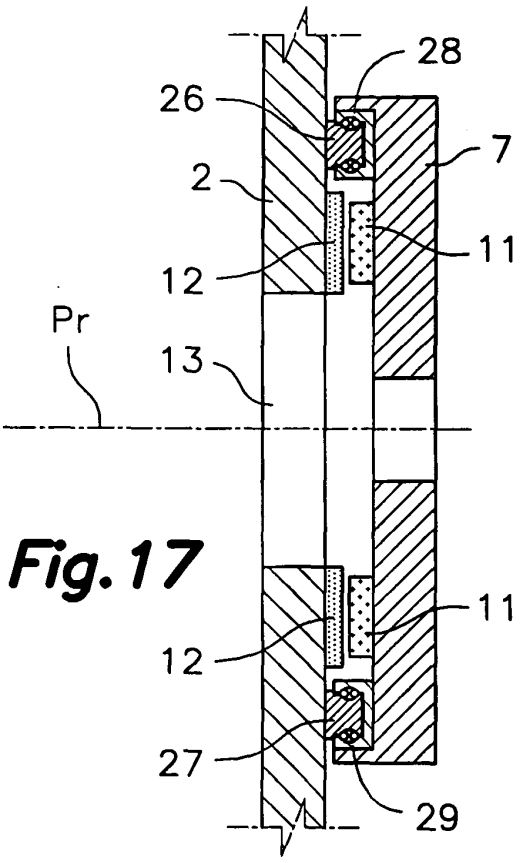
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Fig. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ ES 2007/000743

A. CLASSIFICATION OF SUBJECT MATTER

see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CIBEPAT,EPODOC,WPI,NPL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 2006/015889 A1 (KOENIG & BAUER AG) 16.02.2006, 125 the whole document.	1-25
A	KR 20030089114 A (KOREA MACHINERY & METAL INST) 21.11.2003, 1-25 the whole document.	1-25
A	US 2002/0078844 A1 (DILLING) 27.06.2002, the whole document.	1-25
A	US 6360664 B1 (GÖTTLING et alii) 26.03.2002, the whole document.	1-25
A	US 5953991 A (GEISSENBERGER et alii) 21.09.1999, the whole document.	1-25

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20.May.2008 (20.05.2008)	**(23/05/2008)**
Name and mailing address of the ISA/ O.E.P.M. Paseo de la Castellana, 75 28071 Madrid, España. Facsimile No. 34 91 3495304	Authorized officer M. Fluvià Rodríguez Telephone No. +34 91 349 53 86

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/ ES 2007/000743

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/ ES 2007/000743

CLASSIFICATION OF SUBJECT MATTER

B41F 13/38 (2006.01)
B41F 5/24 (2006.01)

Form PCT/ISA/210 (extra sheeet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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