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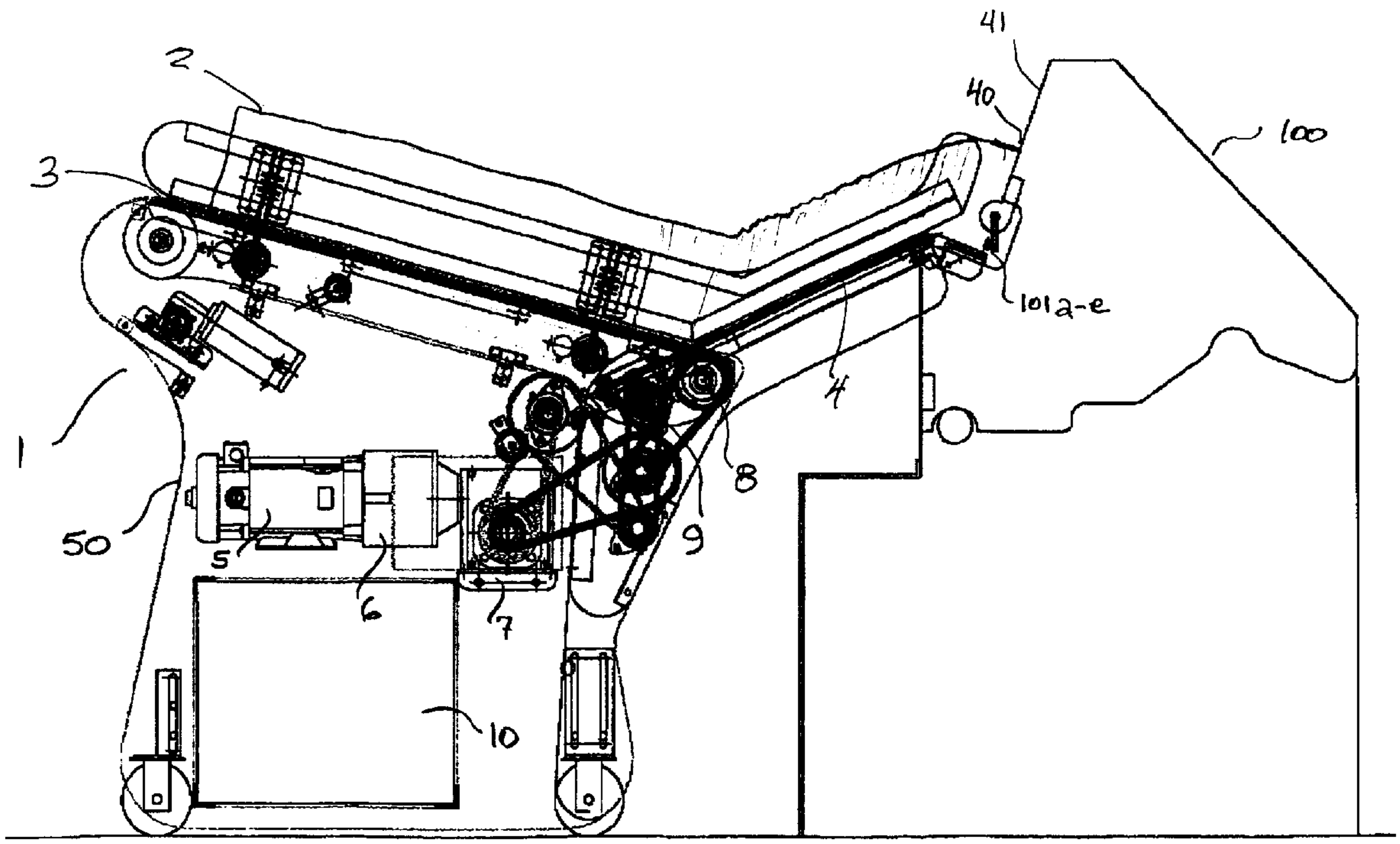
(54) **METHODE ET DISPOSITIF DE FOURNITURE DE PRODUITS PLATS**

(54) **METHOD AND APPARATUS FOR DELIVERING FLAT PRODUCTS**



METHOD AND APPARUATUS FOR DELIVERING FLAT PRODUCTS

BACKGROUND OF THE INVENTION

The present invention relates to methods and apparatus for delivering flat products such as a printed sheet signatures ("signatures"), where the flat products are received stacked adjacently on-edge and must be stacked vertically or horizontally into the hopper of a downstream feeder or processor. Although the present invention will be described by reference to the handling of signatures in a bindery process, it shall be deemed applicable in a variety of applications dealing with flat products in sheet form.

More specifically, the invention aims at providing a high speed and reliable method and apparatus for loading a hopper such as used in systems feeding a signature gathering saddle conveyor of a bindery line for the manufacture of books, magazine or the like. The principal object of the invention is to provide a method and an apparatus featuring a very high level of separation of the signatures coming from the folding operation, in order to assure that the feed system will be able to reliably feed one signature at a time to the bindery line.

Traditionally, the loading of bindery line systems, generally comprising a hopper and a rotary feeding drum, was manually accomplished by an attendant. When the signatures are coming from the folding operation, they are tightly compressed to form a bundle and some of them frequently adhere to each other depending on various printing and storage conditions. It is well known in the field that the reliability and through-output of the bindery line is mainly lying on the ability to properly operate signature separation, as traditionally executed by the attendant, so that the feeding system will continuously succeed at transferring one signature at a time to the gathering conveyer, thus avoiding costly interruptions of the bindery line. The manual operation of separation is usually carried-out by the attendant by taking a pile of signatures and bending the pile back and forth a few times. Additionally, some tapping of the edges of the pile on a generally horizontal flat surface may be performed. In more recent days, automatic hopper loaders have been provided by the industry to accomplish the task of loading feeding systems, but the main challenge still resides in performing proper separation of the signatures prior to feeding.

While in some situations currently available loaders provide an appropriate level of separation of the incoming tightly stacked on-edge signatures from bundles, there are still many instances where the conditions of the incoming signatures exceed the capacity of the automatic loader to operate proper separation. These conditions relate to the properties of the paper web used to produce the signatures, the thickness of the signatures, the type of ink and the density and intensity of the printed indicia. Indeed, when heavy gauge paper with a good absorption rate is bearing light printed text and is folded to form thick signatures, sticking of folded and stacked signatures together is not likely to happen, and automatic loading can be reliably and effectively accomplished with currently available equipment. However, most of the high volume and high speed bindery productions of the present days involve large and thin signatures obtained from light weight glossy paper web printed with colourful heavy indicia. Such conditions are found in the production of magazines, catalogues, and the like and are generally faced on the stitch bindery lines.

In spite of number attempts to produce signature bundle loaders providing an appropriate level of separation of the tightly stacked incoming signatures, no currently available equipment can load a stitch bindery line feeding system with a sufficient level of reliability, given the adverse conditions generally encountered in that operation.

Actually, most bundle loaders pay little attention to separation and merely rely on passing the signatures from a first conveyor to a second conveyor upwardly inclined with respect to the first one and driven at a higher speed, thereby making the incoming on-edge signatures to space apart at their upper end and gradually adopt the form of an imbricated or shingled stream. Air jets or physical members are sometimes disposed over the upper edge of the signatures to penetrate between the signatures approaching the second conveyer and force them to separate and urge their forward surface toward the surface of the second conveyor. United-States patents 5,374,050 (1994) delivered to Prime-Hall Enterprises, 5,282,613 (1994) granted to R.R. Donnelly & Sons Company and 4,973,038 (1990) owned by AM International Inc. present examples of that technique which converts stacked on-edge signatures to a forward shingle stream, that is with the side edges of the signatures being inclined forwardly and upwardly.

This technique is not much different than the one used in the feeding mechanisms themselves and therefor does not provide a sufficient increase in reliability to maintain down times to a reasonable level when used under the adverse conditions generally encountered on stitching lines. For that reason, certain manufacturers such as Harris-Intertype Corp. (US patent 3,881,718) introduce a transfer of the shingled stream to a third conveyor running at a higher speed than the second one to create an additional relative displacement of the signatures under the shear stress, thus producing a thinner shingle and improving separation. The Harris apparatus also has its third conveyer surface disposed slightly lower than the one of the second conveyor which adds a vertical separating action to the horizontal action provided by the speed change. However, it can be demonstrated that the speed change method as well as vertical stepping become less effective when the signature major faces become substantially horizontal. This is simply due to the fact that the weight of the upstream signatures creates more friction between the layers at such angles, which tends to oppose to the shear stress and keep the signatures attached, while in a more vertical fashion, the weight of the top signatures tends to make them slip downwardly when the lower ones are upwardly accelerated. In a similar manner, a step will make more effective use of the weight of the signatures for separation when the side edges of the signatures adopt a substantially vertical orientation.

Taking into account the fact that on most stitching lines, signatures must be delivered standing on their backbone to form a stack in the hopper of the feeding system, the prior art devices also feature mechanisms to reverse the shingled signature stream or create a shingled stream such that the lagging portion of a downstream signature rests on the surface of the following (upstream) one. This is required when shingled signatures are to be placed substantially vertically in the hopper, since the downstream signatures must not be retained by following signatures in order to fall freely into the hopper. A certain number of mechanism have been proposed to that effect in the past, and only contribute to add more complexity and risks of malfunction.

Very few examples of apparatus performing signature separation in a substantially vertical fashion are found in the prior art. A typical approach is to try to replicate the pile bending operation manually carried-out by the attendant. As shown in United-States patents 5,244,199 (1993) assigned to St-Denis Manufacturing, 4,750,728 (1988) granted to Ferag AG and 4,183,517 (1980) delivered to Harris corporation ,the generally upwardly oriented edge standing signatures are passed trough one or more conveyor sections having convergent wall members spaced by an average distance shorter than the width of the signatures. This technique generally requires side conveyors for proper traction of the signatures. This implies more complex mechanisms, additional costs and a wider apparatus while machine spacing is a critical factor to provide enough room for attending and maintenance. Moreover, the number of bending cycles is limited to one or two, with low amplitude and in only one direction, which is a poor substitution for the manually performed operation.

As will be shown in the foregoing description of the present invention, complex mechanisms as described above can be avoided with increased reliability and cost reduction while also avoiding the formation of the signatures into a thin shingle. Furthermore, significant space savings can be achieved by maintaining signatures in a substantially vertical fashion and avoiding transportation over long belt runs in thin shingle form.

The above review of the prior art clearly shows that no reasonably reliable and practical solution to the problem of automatically handling a bundle of signatures to load the feeding system of a stitch binding machine or a comparable piece of equipment has been provided until now.

SUMMARY OF THE INVENTION

The present invention overcomes the limitations and drawbacks of the above mentioned inventions of the prior art, and more specifically:

it is a first object of the instant invention to provide a method and an apparatus carrying-out the method for delivering flat objects such as signatures to a hopper receiving the objects for one at a time feeding, in which separation of the products potentially adhering to each other is accomplished with a high level of reliability;

it is another object of the present invention to provide a simple and very reliable method and an apparatus carrying-out the method for delivering flat objects such as signatures to a hopper handling the objects in the form of a on-edge stack;

it is a further object of the present invention to provide a method and an apparatus carrying-out the method for delivering flat objects such as signatures to a hopper, said method and apparatus satisfying high speed operation requirements;

it is a still further object of the present invention to provide a simple method and an apparatus carrying-out the method for delivering flat objects such as signatures to a hopper, said apparatus being of simple and economical construction, while featuring a high overall reliability;

it is a further object of the present invention to provide a method and an apparatus carrying-out the method for loading flat products into a hopper, said method and apparatus having the flexibility to comply with the operating conditions of a very wide range of signature types, while requiring minimal and easy set-up. Accommodated conditions shall include paper gauge and finish, type of ink, signature size, thickness and stiffness, and density and intensity of the printed indicia.

it is another object of the present invention to provide a method and an apparatus carrying-out the method for delivering flat objects such as signatures to a hopper, performing separation operations on the products while their side edges form an angle of less than 45 degrees with respect to a vertical plane, so that the most part of their weight is supported by their backbone and contributes to the separating action;

It is a further object of the present invention to provide a method and an apparatus carrying-out the method witch avoids transportation of signatures in flat shingle form, thus providing significant space savings.

It is a still further object of the present invention to provide a method and an apparatus carrying-out the method where the signature feed rate is automatically adjusted to the speed of the downstream processing equipment.

These objects and other objects and features of the present invention will become apparent through the following description that will be carried out by reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view of the preferred embodiment of the apparatus of the present invention, cooperating with a gatherer feeder.

FIG.2 is a plane view of the apparatus of the present invention cooperating with a gatherer feeder.

FIG. 3 is a close-up plane view of a portion of the apparatus showing the relative position of the needles and proximity sensors.

Fig. 4a-d are different side elevation views of one of the screws of the screw conveyor.

FIG. 5 is a side elevation view of the preferred embodiment of the apparatus of the present invention, provided with its optional one-at-a-time signature transporting/feeding attachment.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the method and flat product delivering apparatus of the present invention will now be described in detail referring to the appended drawings.

Referring to FIG.1, there is provided an apparatus generally identified by numeral **1**, which is designed to deliver incoming bundled signatures **2** standing upright on their backbone to a vertical hopper **40** co-operating with the feeding system of a bindery line, preferably a stitch bindery line, according to a high reliability separation delivering method.

The preferred delivering method for performing high reliability separation basically resides in:

a) placing and transporting the signatures on a downwardly and forwardly inclined feed conveyor, standing on their backbone with their sides substantially normal to the plane of the conveyor;

b) transferring the signatures to a upwardly and forwardly inclined screw conveyor running at a higher speed with respect to the feed conveyor, so that the signatures are accelerated at their lower edge and tend to mesh with the threads of the screws to slightly space apart and form a generally vertically oriented pile;

c) vertically jogging the signatures through a slipping action, through successive passages from crests to grooves of the screws of the screw conveyor;

d) dragging the lower edge (backbone) of the signatures on a row of substantially vertical needles to provide a gating action which retains the upstream signatures when the leading one is being pulled by the feeding system of the downstream apparatus.

Preferably, in using this method, an upwardly oriented air flow is directed toward the backbones of the signatures transported on the screw conveyor to help performing separation;

The preferred method also contemplates variation of the speed of the signatures while they are riding on the screw conveyor as an ultimate means for further increasing the reliability of signature separation for optimal yield of the feeding action. This is accomplished by varying the pitch over the screws length, either in a continuous manner or in successive cycles of acceleration and deceleration. Those repeated cycles of acceleration/ deceleration can be provided by the screw conveyor by proper design and machining of the threads while maintaining a constant angular speed (rpm) drive. The result can be equivalent to successive passages of the signatures on several belt conveyors running at different speeds. Therefor a very performing separation means is thereby provided, adjacent signatures being forced to adopt variable relative horizontal and vertical positions along the path, causing sustained shear and tensile stress in the bundle, thus separation.

Furthermore, in the preferred embodiment the global feed rate is automatically adjusted according to the speed of the downstream apparatus being fed by the present apparatus, and the conveying screws are provided with dual threads as shown in Fig. 4d, for adaptability to a wide range of signature thickness.

Fig.1 and Fig.2 show a global view the preferred apparatus to carry-out the aforementioned method. The apparatus generally identified by numeral **1** is supported on a mobile frame **50**. A bundle of signatures **2** is placed on the upstream portion of the feed conveyor **3** and the straps and end plates of the downstream bundle are removed to release the signatures, retained between the new bundle and the downstream signatures. The free signatures are conveyed on a downwardly inclined feed conveyor **3** preferably made of flat steel chains, up to a screw conveyor consisting of four parallel screws **4a-d** upwardly inclined. Conveyors **3** and **4** are driven by variable speed motor **5** through electrical clutch **6**, speed reducer **7** and a conventional chain and sprocket transmission system finally coupled to drive shafts **8** and **9**. Shaft **8** drives a sprocket driving in turn chain conveyor **3**, and shaft **9** drives four 90 degree gear boxes **11 a-d** connected to the lower end of the screws **4a-d**. The system provides a fixed ratio of about 1.15:1 to 1.2:1 between the linear speed of the screw conveyor **4** and that of the chain conveyor **3**. Said motor **5** and clutch **6** are controlled by controller **10**, according to the information provided by proximity sensors **21**, **22**, a speed encoder installed on a rotary member of the downstream feeder **100** and a control panel.

As shown in Fig. 3, proximity sensor **22** is located downstream proximity sensor **21**, but at the same vertical level between flat plates **17a-d**. Therefor, automatic adjustment of the signature feed rate is accomplished as follows: The speed encoder provides the controller **10** with the number of signatures being processed per minute. The controller calculates a linear feed rate for a reference average signature thickness and sets the motor speed accordingly while monitoring the signals from proximity sensors **21** and **22**. Fine speed adjustments are then made so that the leading signature is always comprised between the two sensors, i.e. sensor **22** sees no signature while **21** sees one all the time. After a few iterations, the appropriate speed is found and maintained, limiting start and stop cycles through clutch **6**, since the clutch stops the conveyors when the signatures reach sensor **22** and starts them when sensor **21** senses no presence. In the application represented in Fig. 1, the accurate and soft operation thereby provided ensures that no excessive pressure is applied on the signatures against the wall **41** of hopper **40**, which could prevent the suckers **101a-e** and feeding mechanism **100** from successfully pulling the leading signature. The suction cups **101a-e** repeatedly pick-up the lower portion of the leading signature at a position comprised between the two proximity sensors, representing a variation of a few millimetres.

It shall be noted that the aforementioned assembly provides continuous transfer without any gap between conveyors **3** and **4**, so that signatures **2** are smoothly transferred from one conveyor to the other. However, as indicated above, screw conveyor **4** is driven to a considerably higher linear speed with respect to chain conveyor **3** for a given angular speed of motor **5**, and creates a change in the signature path of about 45 degrees in the vertical direction. The signatures **2** are therefor transferred from feed conveyor **3** to screw conveyor **4** by being suddenly accelerated at their lower edge and forced to form an upward slope. These actions provide a first means of separation by way of axial pulling and vertical shearing of adjacent signatures, mainly at the interface of the two conveyors.

Also, the signatures are not positively transported by the screw conveyor **4** due to the rising of the slope and to the high difference in linear speed with respect to conveyor **3**, such that some slipping occurs making the signatures to travel along the path of the screw threads. The resulting zig-zag like reciprocating vertical travel across crests and grooves creates numerous cycles of shearing action between adjacent signatures all along the screw path. Experience showed that such a jogging carried-out at 10 to 20 strokes per second with a vertical amplitude of about 3 millimetres was much more effective at separating signatures than vibration performed at higher frequency and lower amplitude. That shearing action combined with the axial separation due to the tendency of the signatures to align with the grooves and match the thread pitch provide a second means of separation. It shall be pointed out that the screws preferably comprise a dual thread as illustrated in Fig. 4d, for optimal performance with thin as well as thick signatures.

Furthermore, it is contemplated to vary the pitch of the screw threads to create a definite number of axial dilatation and compression cycles to further improve separation reliability. Consequently, it can be observed in operation that the top of the signature bundle gradually matches the screw slope without irregularities when approaching the forward end of the screw conveyor **4**.

As shown in Figures 2 and 3, a pair of spring biased needles **19,20** are located next to the pick-up line between proximity sensors **21, 22** and projects beyond the top surface of flat bottom plates **17a-d** by a few millimetres to act as a soft stop on the lower edge of the leading signature and provide a gating action. When the suction cups **101a-e** pull the leading signature forwardly, the needles bend forwardly and return to their original position under spring action, stopping the next signatures as soon as they are cleared by the lower edge of the leading signature. That action provides an ultimate means of separating the signatures to ensure one-at-a-time feeding. It is indeed of primary importance for proper operation of the bindery line that the pulled signature separates easily from the stack in hopper **40** to be placed on the saddle conveyor one at a time and avoid costly interruptions of the line upon miss feed. The apparatus according to that embodiment can perform that task at high signature feed rates up to about 20 000 signatures per hour.

Optionally, air jets fed through series of holes **18a-d** provided in the flat plates **17a-d** can be directed toward the lower edge of the signatures approaching the pick-up line signatures. Air penetrates between adjacent signatures and builds a pressure that in turn creates an axial separation force, and increase their susceptibility to vertical slipping.

It is also contemplated within the present invention to provide the bundle loader with a one-at-a-time signature transporting/feeding attachment **200** as illustrated in Fig. 5. Said attachment comprises a set of suction cups like a gatherer feeder which pulls the lower portion of the leading signature from the hopper **40** to bring it in contact with a first static roller. A second powered roller then engages the signature and feeds it to a belt conveyor provided with rows of cleats contacting the backbone to positively transport the signature. The signatures are thereby loaded on behind the other and transported over successive downward and upward vertical paths to perform operations such as ink jet printing on either face thereof. Signatures are terminating their travel on the top of the apparatus and dropped one by one in a vertical or horizontal hopper to feed an apparatus such as a drum gatherer feeder for a stitching or a binding line.

Although the present invention has been described by means of preferred embodiments thereof, it is contemplated that various modifications may be made thereto without departing from the spirit and scope of the present invention. Accordingly, it is intended that the embodiments described be considered only as illustrative of the present invention and that the scope thereof should not be limited thereto but be determined by reference to the claims hereinafter provided and their equivalents.

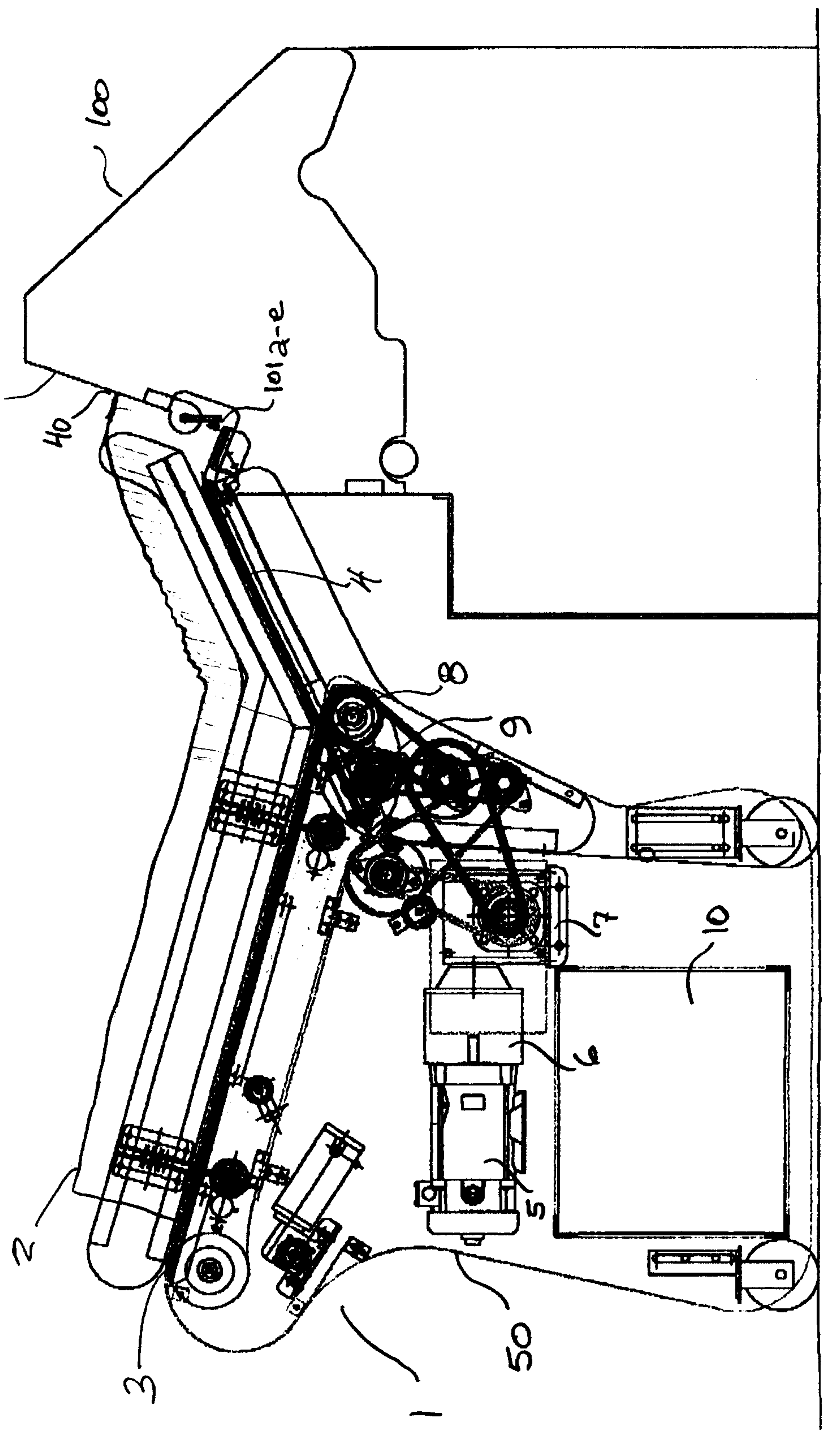


Fig.1

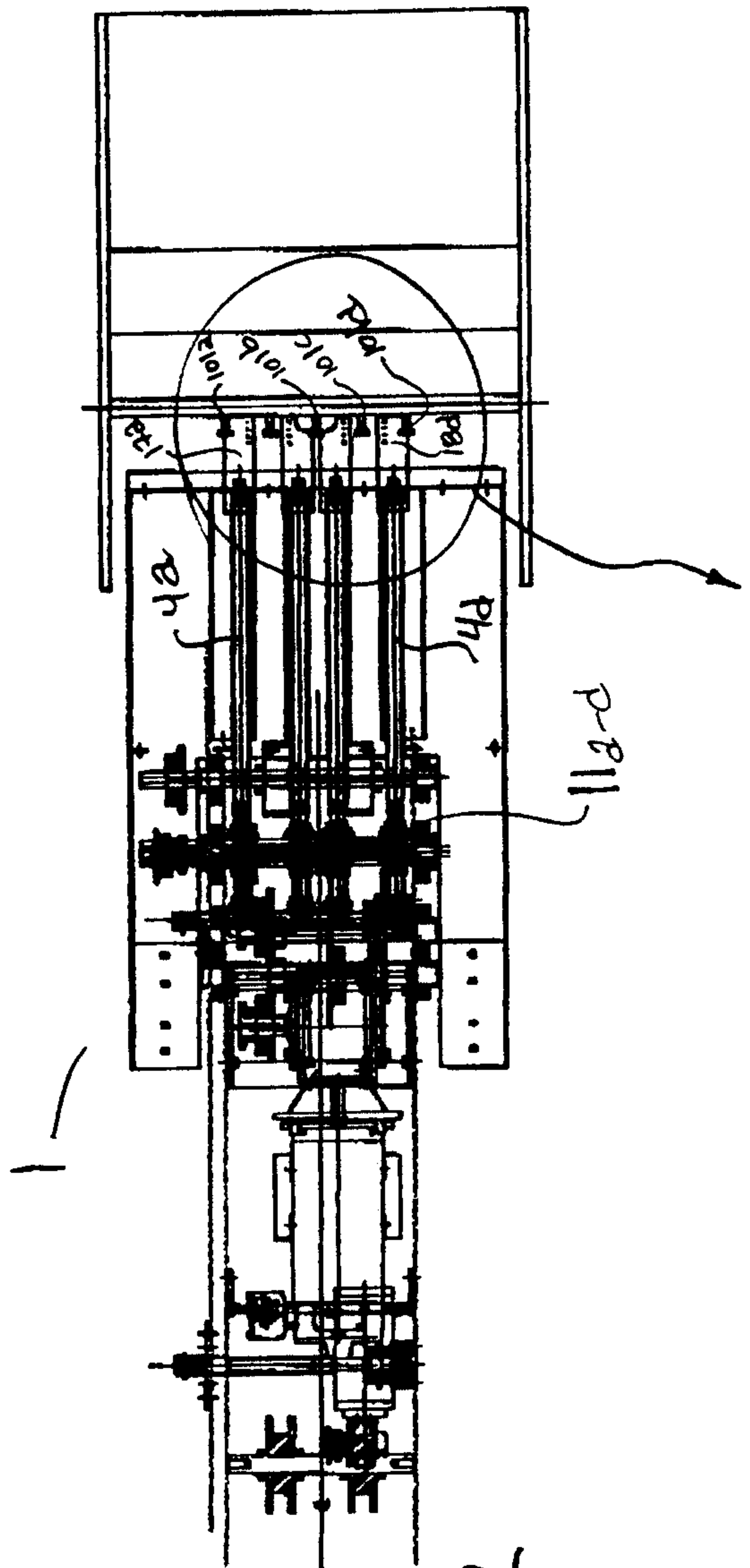

1
4a
4d
11a-d
17a
101a
101b
101c
101d
18d

Fig. 2

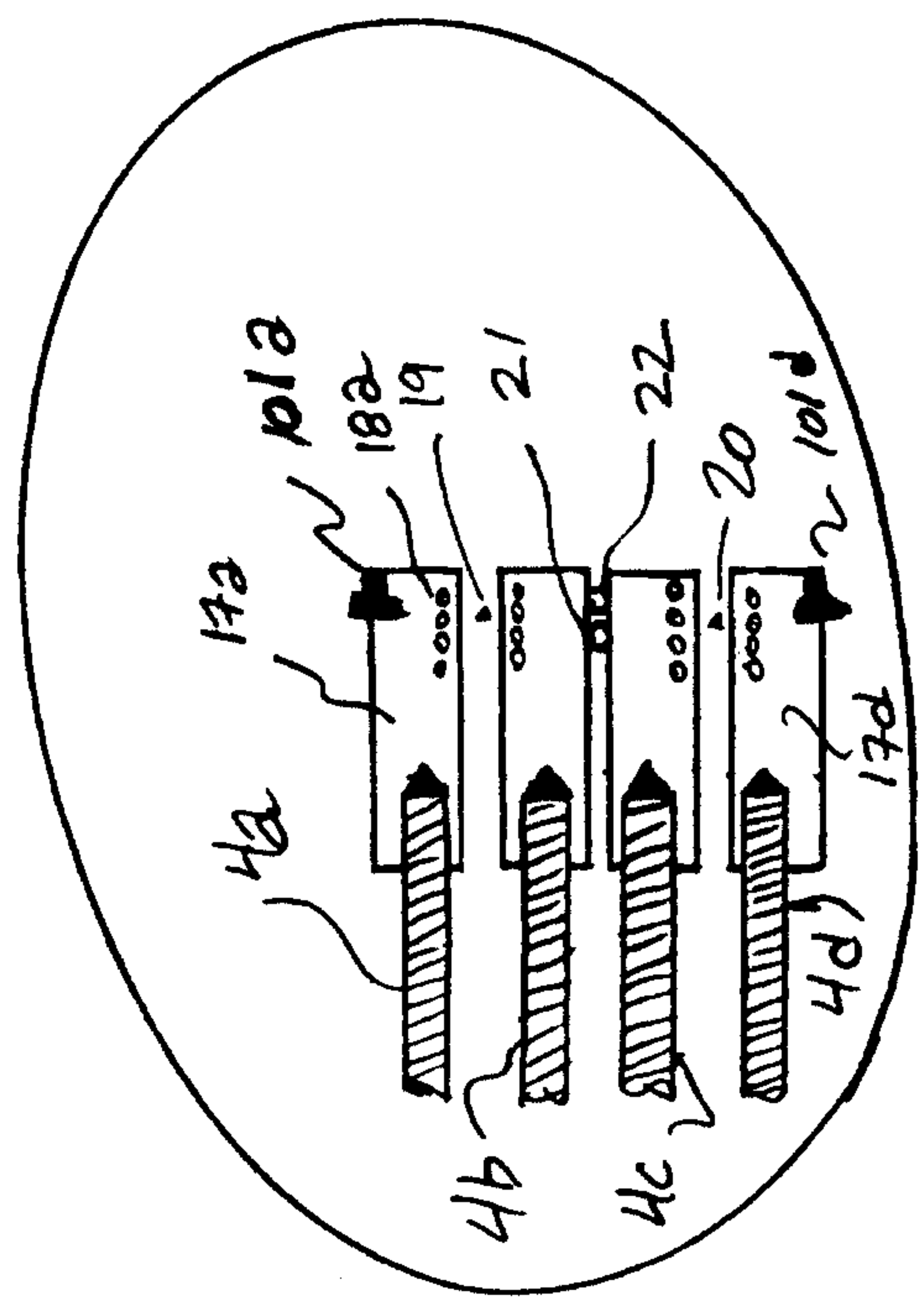

4a
17a
101a
18a
19
21
22
20
101d
17d
4d
4b
4c

Fig. 3

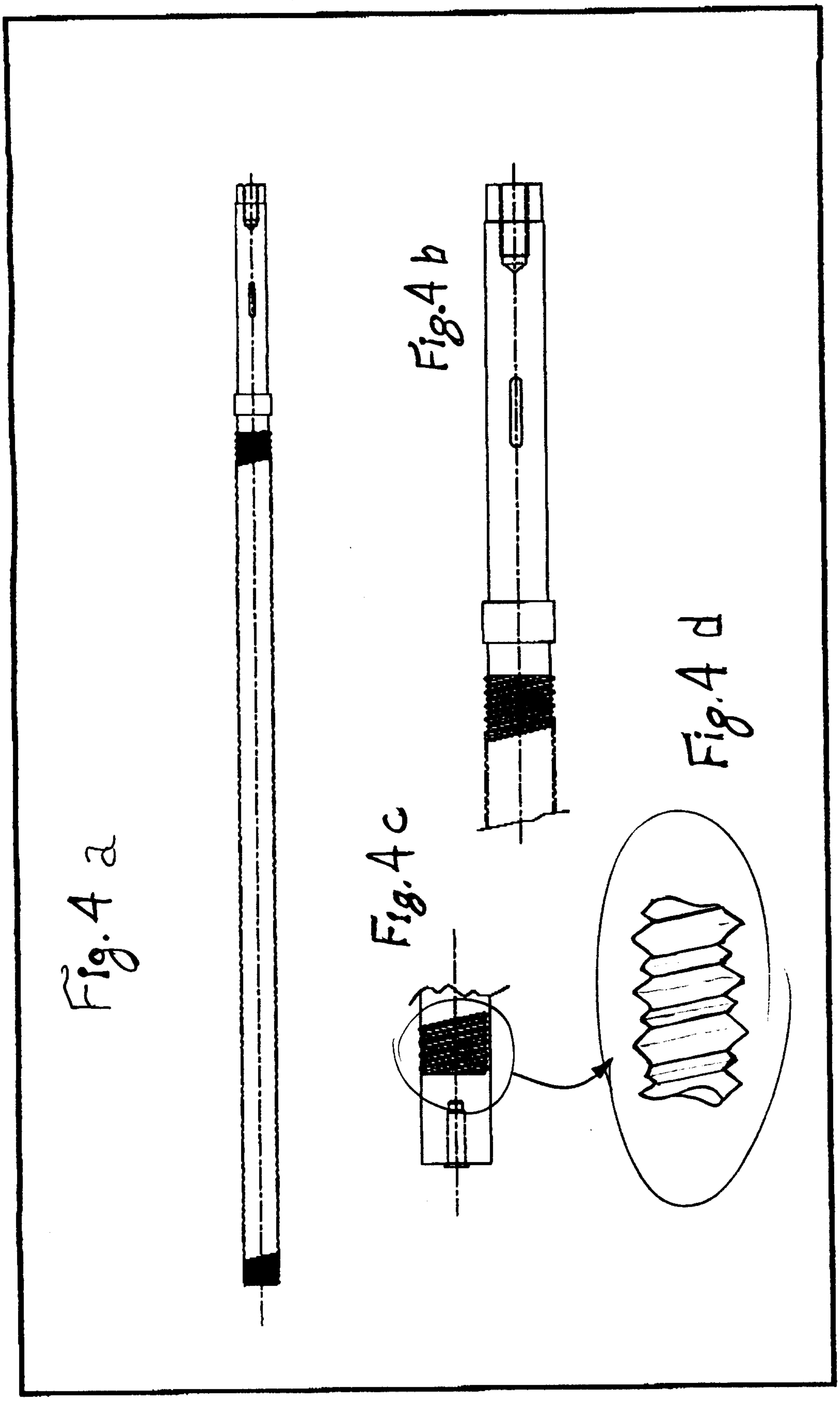


Fig. 4 a
Fig. 4 b
Fig. 4 c
Fig. 4 d

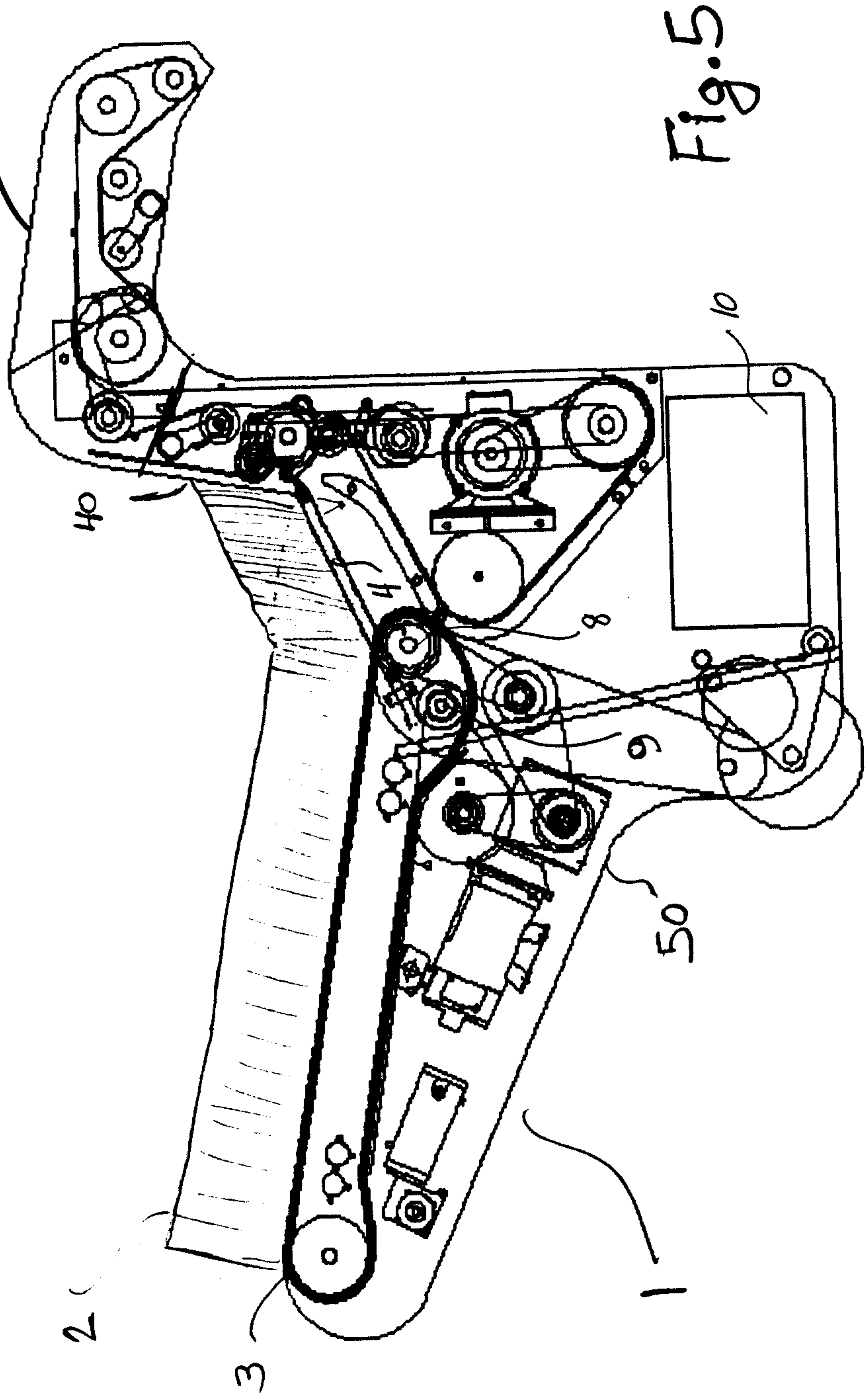


Fig.5