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(54) Laser operated cutting and engraving device for materials of various kind for electronic control automatic embroidery machines, and working program to embroider materials of various kind for electronic computers to control such laser operated cutting and engraving device for materials

(57) Laser operated cutting and engraving device for materials for electronic control embroidery automatic machines, and/or plotters or rollers, adapted to perform cuts and engravings on pre-established positions and with pre-established forms and sizes on to the materials to embroider. Device comprising the combination of at least a first optical lens (26), operated by a galvanometric motor and provided for the accurate and instantaneous adjustment of the laser beam focal lenght, and at least a second optical lens (27), operated by a step-by-step motor (31) and provided for the rough adjustment of the laser beam focal lenght, between two pre-established positions (A and B). Device comprising an inclined guide member (41) for sliding alternately in the inclined and vertical direction of a system (43) comprising a laser beam source (24), the two optical lenses (26, 27) and two laser beam deflection mirrors (28, 29), so as to deviate the same on to surfaces as wide as possible of the cutting plane (13) onto which the materials (32) to be worked are arranged. Moreover, it is also described the method to embroider materials utilized in this device.

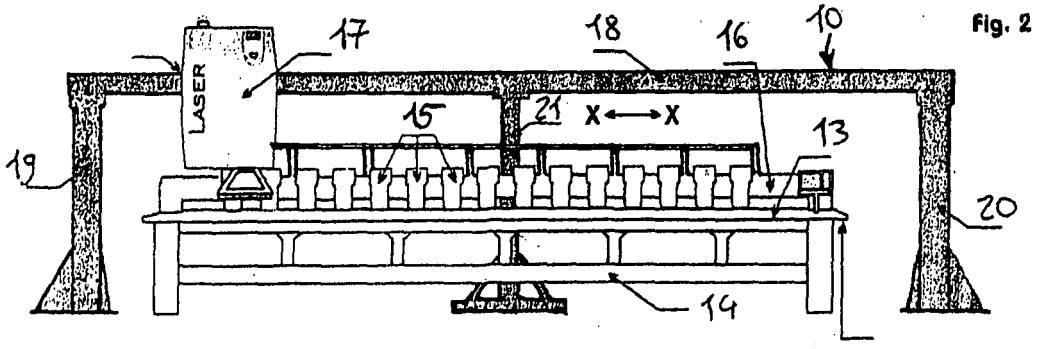

Fig. 2

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Description

[0001] The invention relates to a laser operated cutting and engraving device for cloths, fabrics, leathers and similar materials which can be embroided or worked by means of laser (hereinafter called briefly "materials"), for electronic control automatic embroidery machines and/or for plotters or rollers, adapted to perform cuttings and engravings on pre-established positions and shapes and sizes of materials which are embroided by suitable embroidery heads included into such machines. The invention also relates to a embroidery working program of materials of various kind for electronic computers to control such cutting and engraving device for materials.

[0002] Electronic control automatic embroidery machines are known, which cut and engrave by means of laser the materials to be embroided and comprise substantially a cutting plane onto which the various materials to be embroided are arranged, and which is formed by a rectilinear lenghtened and horizontal loom supported on the floor by a suitable support structure, said loom being movable with alternate movements in a longitudinal direction (X axis) and a transversal direction (Y axis) below some embroidery needles, which are mounted on a set of stationary embroidery heads, arranged to embroider the materials with threads of different kind and colour and supported by a horizontal rectilinear bar, situated above the cutting plane and secured to the support structure, and comprise also at least a laser operated cutting and engraving head, which is slidable alternately along a horizontal rectilinear bar which is supported, on a position situated above and spaced away with respect to the embroidery groups, by means of vertical stanchions fixed to the floor on lateral and external positions with respect to the assembly movable loom-embroidery heads.

[0003] Moreover, these machines are controlled automatically by electronic control systems and the different cutting, engraving and embroidery programs for all the materials to be embroided are set in advance with at least a computer arranged with particular software, and before starting a working program for the different materials to be embroided all the materials to be embroided are arranged onto the cutting plane, below the corresponding embroidery heads provided for the required embroidery operations, along one or more horizontal rows and for the entire width of the same cutting plane. These materials to be embroided, which could be in case also fully or partially overlapped to each other, are laid either onto a relative support cloth (so-called "Flieselina") or on to one loom for each embroidery head, or on to a sole common support cloth for all the embroidery heads, which cloth is arranged into direct contact with the surface of the cutting plane.

[0004] Thereafter, the different embroidery heads and the movable loom are driven contemporaneously in the longitudinal and transversal directions, with synchronized movements such that to provide for all the materials to be embroided to be sewn onto the relative support cloths with threads of the required kinds and colours, which materials are consequently joined together, while in turn the laser operated cutting and engraving head, which on this condition is inactive, is displaced along the rectilinear bar on the rest position thereof. At the sewing end of all the materials to be embroided, the movable loom and all the embroidery heads are stopped, and the cutting and engraving head is driven slowly with an unidirectional movement by displacing it progressively near each sewn material to be embroided, where such head provides for cutting and engraving with laser beam the materials on the established position, then the materials in excess are removed therefore leaving the embroideries and the writings with the desired drawings and sizes directly sewn on to the materials. At the end of these operations, all the so worked materials are removed from the cutting plane and replaced by further materials to be embroided, while the laser operated cutting and engraving head is brought back with a reverse displacement on to the rest position thereof, and under this condition the machine is set to perform additional operative programs in the same manner. In particular, each laser operated cutting and engraving head of these automatic embroidery machines is constituted substantially by a CO2 laser beam source, adapted to generate a laser beam along a rectilinear path, which is intended for cutting and engraving the materials to be embroided arranged on to the cutting plane, upon deflection of the same beam along a vertical path, generally oblique, and is also constituted by an optical lens arranged on the laser beam path and supported by a suitable support structure included in the cutting and engraving head and operated by a galvanometric motor, in order to be displaced into different adjustment positions within an established working range, depending on the different works to be performed, and finally is constituted by a system of deflection mirrors, which are arranged on the same laser beam path and formed by a deflection mirror along the X axis and a deflection mirror along the Y axis, which can be oriented on different positions thereof so as to deflect the laser beam path, and direct it as already explained on to the materials to be embroided on the cutting and engraving points established from time to time in each working program. By changing the distance of the lens with respect to the mirrors, it is possible to change in a different way the focal lenght between the same mirrors and the cutting plane, so as to focalize the laser beam on to the materials to be cut and engraved, and to attain different diameters for each focal point (called "spot"). The thinner the spot on the cutting point the better the cutting quality, in that less material is burnt and it is possible to work with a greater laser speed, with consequent less consumptions of materials and better aesthetical result attainable. Such focal lenght is changed in a different way depending on the needed working area, of square form and fixed measure, on the materials to be embroided, and in particular the nearer the focal lenght the smaller the obtained working area, and the smaller and thinner the obtained cutting

spot, while the more far the focal lenght the greater the obtained working area, however the obtained cutting spot becomes greater. Then, in the first case in which the working areas aren't much wide, and normally of the size 200 x 200 mm. up to 300 x 300 mm., thanks to the adjustment of the distance of the lens with respect to the deflecting mirrors, it is possible to focalize the laser beam on to the materials to achieve very small spot, with consequent satisfactory cut results, while in the second case in which the working areas are larger than the previous ones and may reach also 500 x 500 mm., the adjustement of the distance of the lens with respect to the mirrors provides therefore still the change of the focal lenght, however in this case there are obtained larger spot and therefore less satisfactory cut results than those of the first case. Under these circumstances, for these kinds of workings there are available on the market machines adapted to work on to not much wide working areas with spot having reduced diameters, or machines adapted to work on to wider working areas, however with spot having greater diameters than the optimum ones. The object of present invention is to make available on the market a machine of the type referred to, adapted to work on to working areas which are less wide and also more wide namely of variable wideness, thereby optimizing the spot of the laser beam, by employing on these machines a laser operated cutting and engraving device permitting to work with the same cutting and engraving head even on to working areas of variable wideness, by obtaining anyway cutting spots which are thinner as possible depending on the working range selected from time to time.

[0005] The invention also relates to a working program to embroider materials of various kind for electronic computers to control such laser operated cutting and engraving device for materials.

[0006] This cutting and engraving device and the working program are made in the manner substantially described, with particular reference to the enclosed claims of the present patent.

[0007] The invention will be better understood from the following description, given solely by way of not limitative example and with reference to the accompanying drawings wherein :

- Fig. 1 shows a schematic view of an automatic embroidery machine provided with a laser operated cutting and engraving device according to the invention, on a first embodiment thereof ;
- Fig. 2 shows a schematic view of an automatic embroidery machine provided with a cutting and engraving device according to the invention, on a second embodiment thereof ;
- Fig. 3 shows a schematic view of the different component parts of a first item of the cutting and engraving device according to the invention ;
- Fig. 4 shows a side view of the different component parts of a second item of the cutting and engraving device according to the invention, on to a first embodiment thereof ;
- Fig. 5 shows a side view of the different component parts of the second item of the cutting and engraving device according to the invention, on a second embodiment thereof ;
- Fig. 6 shows a schematic plan view of another item of the embroidery machine of Figs. 1 and 2, displaced on a first operative position thereof;
- Fig. 7 shows a schematic and enlarged plan view of the item of Fig. 6 ;
- Fig. 8 shows a schematic plan view of the same item of Fig. 6, displaced on to a second operative position thereof ;
- Fig. 9 shows the block diagram of the electric circuit of the cutting and engraving device according to the invention.

[0008] Figs. 1 and 2 schematically show an electronic control automatic embroidery machine 10 on to two different embodiments thereof, provided with a laser operated cutting and engraving device 11 according to the invention, adapted to perform cuts and engravings on pre-established positions and shapes and sizes on to cloths, fabrics, leathers and similar materials which can be embroided or worked by means of laser, hereinafter called briefly "materials", which are embroided by special embroidery heads included on to these machines. Each one of these embroidery machines comprises substantially a rectilinear lengthened and horizontal loom 12 defining a horizontal cutting plane 13 onto which the various materials to be embroider are arranged, said loom being supported on the floor by means of a suitable support structure 14 and being driven by motors and transmissions of conventional type, in accordance to established programs set in at least a computer (not shown), set with particular software, which is connected in a suitable electronic control system, with alternate movements in a longitudinal direction (X axis) and a transversal direction (Y axis), below some embroidery sewing needles (not represented) mounted on a set of stationary embroidery heads 15 identical to each other, in the present example constituted by 14 embroidery heads, which are set to embroider the materials with threads of different kind and colour and supported by a horizontal rectilinear bar 16, situated above the cutting plane 13 and secured to the support structure 14. This machine also comprises at least a laser operated cutting and engraving head 17, slidable alternately along a rectilinear horizontal bar 18 which is supported, at a position situated above and spaced away with respect to the embroidery heads 15, by vertical stanchions 19 and 20 fixed to the floor on lateral and external positions with respect to the assembly movable loom-embroidery heads.

[0009] Figs. 1 and 2 show two different embodiments of embroidery machines, and in particular Fig. 2 shows a single embroidery machine 10 made as just described and provided with a further vertical stanchion 21 disposed at an interposed and central position with respect to the

remaining vertical stanchions 19 and 20, while Fig. 1 shows a double embroidery machine 22 formed by the assembly of two embroidery machines which may be either identical or different to each other and made as described previously, which are arranged spaced away and aligned horizontally from each other and in this case the horizontal rectilinear bar 18 extends beyond the length of the second embroidery machine (at the right side), and the vertical stanchions are still constituted by the two lateral stanchions 19 and 20, which are spaced away of a greater distance with respect to the precedent case, so as to embrace both the embroidery machines, and by additional vertical stanchions 21. Then, in this case the laser operated cutting and engraving head 17 is slidable for the entire length of the rectilinear bar 18, so as to be able to work alternately in either one of the embroidery machines, as it will be described later. Before starting each working program of the different materials to embroider, which is set in advance on the computer, all the materials to embroider are arranged onto the cutting plane 13 of the relative embroidery machine, below the corresponding embroidery heads 15 provided for the needed embroidery operations, along one or more horizontal rows and for the entire width of the same cutting plane. These materials to embroider, which in case may be also fully or partially overlapped to each other, are laid either onto a relative support cloth of suitable material (so-called "flieselina", not represented), or the loom for each embroidery head or a sole common support cloth for all the embroidery heads, which cloth is arranged into direct contact with the surface of the cutting plane 13. Thereafter, the different embroidery heads 15 and the movable loom 12 are driven contemporaneously in the X longitudinal direction and Y transversal direction, with synchronized movements such that to provide for all the materials to embroider to be sewn onto the relative support cloths with threads of the required kinds and colours, which materials are consequently joined together, while in turn the laser operated cutting and engraving head 17, which on this condition is inactive, is displaced along the rectilinear bar 18 on the rest position thereof.

[0010] At the end of sewing operation of all the materials to embroider, the movable loom 12 and all the embroidery heads 15 are stopped, and the laser operated cutting and engraving head 17 is driven with an unidirectional movement along the bar 18, by displacing it progressively near each sewn material to embroider, where such head provides for cutting and engraving with laser beam the materials on the established position, then the materials in excess are removed, by leaving therefore directly sewn onto the materials the embroideries and the writings with the desired drawings and sizes. At the end of these operations, all the so worked materials are removed from the cutting plane 13 and replaced by further materials to embroider, while the laser operated cutting and engraving head 17 is brought back with a reverse displacement along the bar 18 on the rest position thereof, and under this condition the machine is set for performing additional operative programs in the same way. In turn, the laser operated cutting and engraving head 17 is substantially constituted by a laser operated cutting and engraving system formed by a set of component parts for generating, focalizing and deflecting a laser beam, which are enclosed into a closed box-like envelope 23 slidable in an alternate manner along the rectilinear bar 18, such component parts comprising (see Figs. 3, 4 and 5) a CO_2 laser beam source 24 adapted to generate a laser beam 25 along a rectilinear path, which laser beam is intended for cutting and engraving the materials to embroider disposed on the cutting plane 13, as well as an optical lens system arranged along the laser beam path, having variable focal length as it will be described later, and a deflection mirror system 26 and 27 arranged in the same laser beam path, downstream said optical lens system, so as to deflect the laser beam path and therefore direct it onto the underlying sewn materials arranged on the machine cutting plane 13. In particular, the optical lens system (see Fig. 3) is formed by a first and a second pair of optical lenses 28, 29 and 30, 31, secured at a position spaced away from each other at the end portions of a common rectilinear bar 32, supported internally the box-like envelope 23, and is also formed by an additional optical lens 33 supported as it will be described later and slidable with a determinate stroke at a position intermediate between the first and second pair of optical lenses. Such pairs may be also constituted respectively by a single lens. The first pair of optical lenses 28 and 29 is constituted by the two lenses 28 and 29 arranged approached to each other in the laser beam path and enclosed by a frame 34, secured to the rectilinear bar 32 and situated near the laser source 24, and this for the purpose to widen of an established range the wideness of the concentrated laser beam which is generated by the source 24 and directed against such pair of lenses 28, 29. In turn, the central optical lens 33 is also arranged in the laser beam path and supported by a movable support 35 slidable alternately with a determinate stroke along the rectilinear bar 32, between two established adjustment positions A and B, such optical lens 33 being movable in the support 35 with a very limited stroke in the longitudinal direction and being joined to a galvanometric motor 36, supported by the movable support and controlled automatically by the machine electronic control, and adapted to provide for some very quickly instantaneous displacements of the same lens, in order to adjust the focal length of this lens with an accurate and instantaneous adjustment, thereby changing the focal length and therefore also the focalization of the laser beam on to the materials to embroider, with consequent changing of the diameter of each focal point (called "spot") being affecting the material to be cut and/or engraved. The thinner the spot on the cutting and engraving point and the better the cut quality, in that less material is burnt and it is possible to work with a greater laser speed, with consequent less consumption of materials and better aesthetical result attainable. Such focal

length is changed from time to time instantaneously in a different manner, depending on the needed working area, of square form, of the materials to be cut and engraved, and in particular the nearer the focal length and the smaller the obtained working area and the smaller and thinner the obtained cutting spot, while the more far the focal length the greater the obtained working area, however the obtained cutting spot becomes greater. Then, in the first case it is possible to work on less wide working areas, the size of which is normally comprised between 200 x 200 mm. and 300 x 300 mm., with consequent satisfactory cut results. On the contrary, in the second case in which the working areas are larger than the previous ones and may reach also 500 x 500 mm., the instantaneous change of the focal length of the central optical lens 33 if on the one hand would permit to work on very wide working areas (even 500 x 500 mm.), on the other hand wouldn't allow to obtain very small spot, and consequently wouldn't produce satisfactory cut results. In order to obviate this drawback, the invention provides the possibility to change the focal length of the central lens 33 in a larger extent than that attainable with such lens only, and this is obtained by displacing the movable support 35 along the bar 32 between the above mentioned two adjustment positions A and B, by means of a step-by-step motor 37 also supported by the same movable support, in a separate and independent position from the galvanometric motor 36, and acting onto such movable support through a suitable transmission (not shown). In particular, the adjustment of the displacement position of the movable support 35 is performed in a very slow manner before starting the cutting and engraving step, depending on the wideness of the area of the material which must be worked from time to time. In this way, the accurate and instantaneous adjustment of the focal length of the central lens 33, obtained though the galvanometric motor 36 in combination with the adjustment of a larger wideness (also of different cm.) of the focal length of the same lens, obtained by displacing the movable support 35 with the step-by-step motor 37, and therefore by either raising or lowering the cutting head with respect to the material, permits to direct the laser beam against working areas of the materials which are of both limited wideness and greater wideness (up to 500 x 500 cm.). By considering now the second pair of optical lenses 30 and 31, it is noted that they are also constituted by the two lenses 30 and 31 arranged approached to each other in the laser beam path, in a position downstream the central optical lens 33 and enclosed by a frame 38, fixed on to the rectilinear bar 32, and this for the purpose to receive the laser beam focalized by the central lens 33 and direct it, through the deflection mirror system 26 and 27, on to the material to be worked. Finally, the deflection mirror system is constituted by a first and a second deflection mirror 26 and 27 of orientable type, which are separated and independent to each other and controlled with a very high speed by a respective galvanometric motor (not indicated) connected thereto, and operated by the machine electronic control, in synchronism with the control of the central optical lens 33, with consequent instantaneous change of the orientation of each deflection mirror, said first deflection mirror 26 being adapted to receive the laser beam passing through the lenses 30 and 31 and to deflect the path thereof toward the second mirror 27, providing for deflecting the laser beam along the X longitudinal axis of the underlying machine cutting plane, while said second deflecting mirror 27 is adapted to deflect the laser beam path along the Y transversal axis, towards the underlying machine cutting plane. The laser beam deflected by the mirrors 26 and 27 along such axes X and Y, and directed towards the underlying material arranged on to the flat surface of the machine cutting plane, would tend to focalize itself onto a virtual hemispheric surface (not indicated) situated above the same material, so that in this case the beam falling on to the material would be out-of-focus and would form on to the same some spots with a size larger than the optimum one. In order to eliminate these drawbacks, the machine operative program is so set as to control the relative galvanometric motors of the optical lens 33 and the mirrors 26 and 27, in a manner to displace all these component parts instantaneously and in synchronism to each other, in such positions as to focalize the laser beam always and exclusively on to the flat surface onto which the material is arranged, and not on to the virtual hemispheric surface. By considering now the Figs. 6, 7 and 8, shown therein are the action manners of the laser beam falling on to the materials, in the different displacement positions of the movable loom 12. In particular, Figs. 6 and 7 show the movable loom 12 displaced in a first operative position thereof, in the transversal direction (along the Y axis) in a position fully displaced outwards the machine, where the rear rectilinear edge 39 of the loom 12 is disposed in a position almost coincident with those of the sewing needles (not shown) of the stationary embroidery heads 15. Then, under this condition the needles are able to sew the materials always near such loom rear edge 39, while on the contrary the cutting and engraving head 17 being not able to be arranged in the same position of the needles is arranged in front of the embroidery heads 15, so that during the material cutting and engraving step the laser beam which is deflected on to the material falls in different positions onto it, which are moved away therefrom with respect to those of the sewings effected on to the same material. As a consequence thereof, it isn't possible to effect cuts and engravings of the material at the positions near such loom rear edge, which cannot be reached by the laser beam and therefore can only be embroided. Fig. 8 shows the movable loom 12 displaced in the second operative position thereof, in the Y transversal direction in which it is fully displaced inwardly the machine, where the embroidery heads 15 are arranged near the front edge 40 of the same movable loom, so that the needles may sew the material near such loom front edge anf the cutting and engraving head 17 may perform without difficulty the cut and en-

graving of the materials at the same positions of the sewings. By way of example, there are represented two different working areas 41 and 42 situated near such loom front edge, which can be reached by the laser beam. Figs. 4 and 5 now shows the presente cutting and engraving device mounted in the machine in two different embodiments thereof. In the first embodiment of the Fig. 4, the cutting and engraving system 43 of the cutting and engraving head 17, comprising the laser beam source 24, the two pairs of optical lenses 28, 29 and 30, 31, the central optical lens 33 and the two deflection mirrors 26 and 27, is slidable in an alternate manner, from one to the other one of the adjustment positions A and B, along a vertical rectilinear guide member 44 which is orthogonal to the cutting plane 13, by means of suitable driving mechanisms which in the example here represented are constituted by a lenghtened screw 45, driven by an electric motor 46 operated by the machine electronic control circuit and co-operating with corresponding nut screws 47 secured to said system 43, in a way that the same system may be from time to time either raised or lowered on the more suitable adjustment position thereof. Figs. 6 and 7 illustrate by way of example the two working areas 48 and 49, of the size respectively 250 x 250 mm. and 500 x 500 mm., which can be reached by the laser beam when the movable loom 12 is fully displaced outwardly. In the second embodiment of Fig. 5, the cutting and engraving system 43 is slidable in an alternate manner, from one to the other one of the adjustment positions A and B, along an inclined rectilinear guide member 50 with vertical extent, secured to the system 43, and under these circumstances the system is slidable in an inclined direction, with consequent possibility to work on materials arranged nearer the movable loom rear edge and therefore to make available a larger working surface onto which it is possible to work with laser (see Fig. 7). Figs. 6 and 7 illustrate by way of example the two working areas 51 and 52 of the size respectively 250 x 250 mm. and 500 x 500 mm., which can be reached by the laser beam when the movable loom 12 is fully displaced outwardly. Moreover, from Figs.4 and 5 it is noted that the cutting and engraving system 43 of both solutions is adequately secured to a set of grooved wheels 53 driven by an electric motor 54 connected thereto, so as to allow the whole assembly to slide alternately along the rectilinear bar 18. The so realized cutting and engraving device allows to cut and engrave always in an optimum manner the materials to embroider with working areas of different widenesses. Finally, Fig. 9 shows the block diagram of the electric circuit of the present laser operated cutting and engraving device, which is connected operatively with the personal computer 55 for setting the different pre-established machine operative programs, and is substantially constituted by a control group 56 for the laser operated cutting and engraving head 17, communicating with the personal computer 55 through an optical fiber 57, and by a control group 58 for the displacement of the laser operated cutting and engraving head 17, communicating with the personal computer 55 through a supply cable 59. In particular, the control group 56 of the laser operated cutting and engraving head 17 is formed by a microprocessor central unit 60, in which the different cutting and engraving operative programs for the same head are stored in a coded form, which programs are provided to control and manage, for each operative program sets in the personal computer 55, the movements to be effected by the central lens 33 and the deflection mirrors 26 and 27, said microprocessor central unit being connected to the personal computer 55 through the optical fiber 57, and with the following electronic blocks :

- a driver 61 connected operatively with the galvanometric motor of the deflection mirror 27, to control the instantaneous displacements of such deflection mirror 27 along the X longitudinal axis, so as to control the laser beam position ;
- a driver 62 connected operatively with the galvanometric motor of the deflection mirror 26, to control the instantaneous displacements of such deflection mirror 26 along the Y transversal axis; to control the laser beam position ;
- a driver 63 connected operatively with the galvanometric motor of the optical lens 33, to control the accurate and instantaneous adjusment of the focal lenght of such optical lens 33, in order to focalize the laser beam on to the cutting plane instead of on to the virtual hemispheric surface ;
- a driver 64 connected operatively with the step-by-step motor 37 of the movable support 35 including the optical lens 33, to control the adjustment with the larger wideness of the focal lenght of such optical lens 33, in order to focalize the laser beam on the different working ranges.

[0011] In turn, the control group 58 for the displacement of the laser operated cutting and engraving head 17 is formed by a microprocessor central unit 65, in which the different operative programs of displacement of the laser operated cutting and engraving head along either the orthogonal guide member 44 or the inclined guide member 50 and along the rectilinear bar 18 are stored in a coded form, in order to control and manage, for each operative program sets in the personal computer 55, the displacements to be effected by such laser operated cutting and engraving head, in synchonism with the movements of the optical lens 33 and the deflection mirrors 26 and 27, said microprocessor central unit being connected operatively with the personal computer 55 through the supply cable 59, and with the following electronic blocks :

- a driver 66 connected operatively with the motors 46 and 54 to control the displacements of the laser operated cutting and engraving head 17 along respectively either the orthogonal guide member 44 or the inclined guide member 50 and the rectilinear bar 18, to displace the same head near the different embroi-

dery heads 15 ;

- a safety system 67 to control and manage the machine operation safety ;
- a control unit 68 of the operation start and stop of each machine operative program, and of any other possible inlets to be connected with such central unit 65, to perform additional functions to be defined for the machine.

Claims

1. Laser operated cutting and engraving device for materials to embroider of various kind for electronic control automatic embroidery machines, and/or for plotters or rollers, adapted to perform cuts and engravings on pre-established positions and forms and sizes on to the materials, each embroidery machine comprising substantially a rectilinear lenghtened and horizontal movable loom defining a horizontale cutting plane, on to which the various materials to be worked are arranged, and supported by a suitable support structure, and which can be driven by means of per se known control and transmission means with alternate movements in the longitudinal direction (X axis) and the transversal direction (Y axis), each machine comprising also a set of stationary embroidery heads, identical to each other, provided with embroidery needles and set to embroider the materials with threads of different kind and colour, and supported by a horizontal rectilinear bar situated above said cutting plane and secured to said support structure, and at least a laser operated cutting and engraving head slidable alternately along a horizontal rectilinear bar supported by vertical stanchions, on a position situated above and spaced away with respect to said embroidery heads, said laser operated cutting and engraving head being provided with means to generate a laser beam, at least two pairs, each one with one or two lens, supported by support means in a position spaced away to each other and provided to widen the wideness of the laser beam generated by said generator means, optical means with variable focal lenght interposed between said first and second pair and operated by motor means, and at least a first and a second deflection mirror, operated by galvanometric motor means, arranged in the laser beam path and adapted respectively to focalize with variable focal lenghts and to deflect the laser beam on to the material to be worked in the longitudinal direction (X axis) and transversal direction (Y axis), in a way that such laser beam be directed on to the material by forming points (or spots) having reduced diameter, the machine being adapted to perform preestablished working programs, which can be set on and controlled by at least a personal computer or similar computer means, in which the various materials to embroider arranged on to said cutting plane are firstly sewn with the needles of said embroidery heads, by driving said movable loom with alternate movements in the longitudinal and transversal directions, and then they are cut and engraved in the required positions and with the required forms and sizes by means of said laser operated cutting and engraving head, the device being **characterized in that** said optical means with variable focal lenght comprise at least an optical lens (33) operated by galvanometric motor means and supported by a movable support structure (35), operated by additional motor means (step-by-step motor 37), so as to be able to slide with a limited stroke of established wideness on to said support means (rectilinear bar 32), from one to another one of two adjustment positions (A, B) spaced away from each other, said optical lens (33) being adapted to be displaced slowly by said movable support structure (35), before the cutting and engraving step, in the required adjustment position to be able to focalize the laser beam on to the materials of variable size, by changing from time to time the focal lenght of said lens (33) with respect to the same materials, and being adapted to be displaced during the cutting and engraving step with extremely quickly movements, controlled by said galvanometric motor means, in synchronism with the movements of said first and second deflection mirror (26, 27), to adjust accurately and instantaneously the laser beam focal lenght, and **characterized by** vertical orthogonal (44) or inclinated guide means (50), co-operating with control and transmission means (45, 46, 47), to provide for the alternate sliding in either a vertical orthogonal direction or an inclinated direction and in different adjustment positions of a system (43) comprising said laser beam generator means (24), said first and second pair (28, 29 ; 30, 31), said central optical lens (33), said movable support structure (35) with said additional motor means (37) and said first and second deflection mirror (26, 27) with the relative galvanometric motor means, and **characterized** also by first and second electronic control means (56, 58) connected to said personal computer (55) or similar computer means, and adapted to control and manage in synchronism to each other the movements respectively of said optical lens (33), said additional motor means (37) and said first and second deflection mirror (26, 27), as well as said system (43) along either said vertical orthogonal guide means (44) or said inclined guide means (55) and along said rectilinear horizontal bar (18), depending on each working program respectively set with said personal computer (55) or similar computer means.

2. Laser operated cutting and engraving device according to claim 1, **characterized in that** said vertical orthogonal guide means (44) or inclined guide means (50) are formed by at least a relative rectilin-

ear ortogonal or inclined guide member, supported by said system (43).

3. Laser operated cutting and engraving device according to claim 2, **characterized in that** said control and transmission means comprise a lenghtened screw (45) co-operating with corresponding nut screws (47) secured to said system (43) and driven by a motor (46) operated by said second electronic control means (58).

4. Laser operated cutting and engraving device according to claim 3, **characterized in that** said first electronic control means (56) comprise a microprocessor central unit (60), in which the different cutting and engraving operative programs for said laser operated cutting and engraving head (17) are stored in a coded form, said microprocessor central unit (60) being connected operatively with said personal computer (55) or similar computer means through an optical fiber (57), and being also connected operatively with a first, a second, a third and a fourth driver (61, 62, 63, 64) respectively connected to the galvanometric motors of said second and said first deflection mirror (26, 27), to the galvanometric motor of said optical lens (33) and to said additional motor means (37) of said movable support structure (35), in order to control and manage, for each operative program sets with said personal computer (55) or similar computer means, the movements to be effected respectively by said second and said first deflection mirror (26, 27), by said optical lens (33); and by said movable support structure (35).

5. Laser operated cutting and engraving device according to claim 4, **characterized in that** said second electronic control means (58) comprise a microprocessor central unit (65), in which the different programs for displacement of said system (43) along either said vertical orthogonal guide member (44) or inclined guide member (50) and along said rectilinear bar (18) are stored in a codified form, said microprocessor central unit (65) being connected operatively to said personal computer (55) or similar computer means, through a supply cable (59), and being also connected operatively to an additional driver (66) connected to said motor (46) and a further motor (54) operating the displacement of said system (43) along said longitudinal bar (18), in order to control and manage, for each operative program sets with said personal computer (55) or similar means, the movements to be effected by said system (43) respectively along said vertical orthogonal guide member (44) or inclined guide member (50) and said rectilinear bar (18), said microprocessor central unit (65) being finally connected operatively to a safety system (67), to control and manage the machine operation safety, and to a control unit (68) of the start and stop of each machine operative program and to any other possible inlet to be connected to said central unit (65), for performing additional functions to be defined of the machine.

6. Embroidery working program for materials of various kind for an electronic computer such as a personal computer, to control an embroidery automatic machine provided with laser operated cutting and engraving device according to claims 1-5, **characterized in that** in each working program, which can be set through said personal computer (55) depending on the positions, forms and sizes of the materials to be worked, arranged in correspondence of the relative embroidery heads (15), there are provided the following working steps :

- contemporaneous driving of the different said embroidery heads (15) and said movable loom (12), in the longitudinal direction (X) and transversal direction (Y). with such synchronized movements that to provide for in each embroidery head (15) the sewing with the threads of the required kinds and colours of all the materials to be worked on to the relative support clothes,
- contemporaneous arrangement in the machine of said laser operated cutting and engraving head (17) in the inactive and the rest position thereof, obtained by operating said further motor (54) through said microprocessor central unit (65) and said additional driver (66) ;
- adjustment of the laser beam focal lenght, before the cutting and engraving step, obtained by displacing said movable support structure (35), and therefore also said central lens (33), of the required wideness along said support means (32), by operating said additional motor means (37) through said microprocessor central unit (60), and said fourth driver (64), in order to be able to focalize the laser beam on to the materials with variable size, by changing from time to time the focal lenght of said lens (33) with respect to the same materials ;
- when all the materials are sewn, stopping of the operation of the various embroidery heads (15) and of the movements of said movable loom (12), with contemporaneous displacement of said laser operated cutting and engraving head (17) near one of the embroidery heads (15), coincident with the materials to be worked, obtained by operating said further motor (54) through said microprocessor central unit (65) and said additional driver (66), and by operating said laser operated cutting and engraving head (17) ;
- accurate and instantaneous adjustment of the laser beam focal lenght, during the laser oper-

ated cutting and engraving step, with extremely quickly movements of said central lens (33), by operating said galvanometric motor means (36), through said microprocessor central unit (60) and said third driver (63), in synchronism with the movements of said first and second deflection mirror (26, 27), by operating the relative galvanometric motors through said microprocessor central unit (60) and said first and second driver (61, 62) ;

- at the end of cut and engraving of all materials, stopping the operation of said laser operated cutting and engraving head (17) and bringing back it in the rest position thereof, obtained by operating said further motor (54) through said microprocessor central unit (65) and said additional driver (66) ;
- arrangement of further materials to be worked on to the embroidery machine and progressive sewing thereof through said embroidery heads (15) and with the movements of said movable loom (12), with the same operative sequences as described above, and repetition of the operative cycle in the same manner.

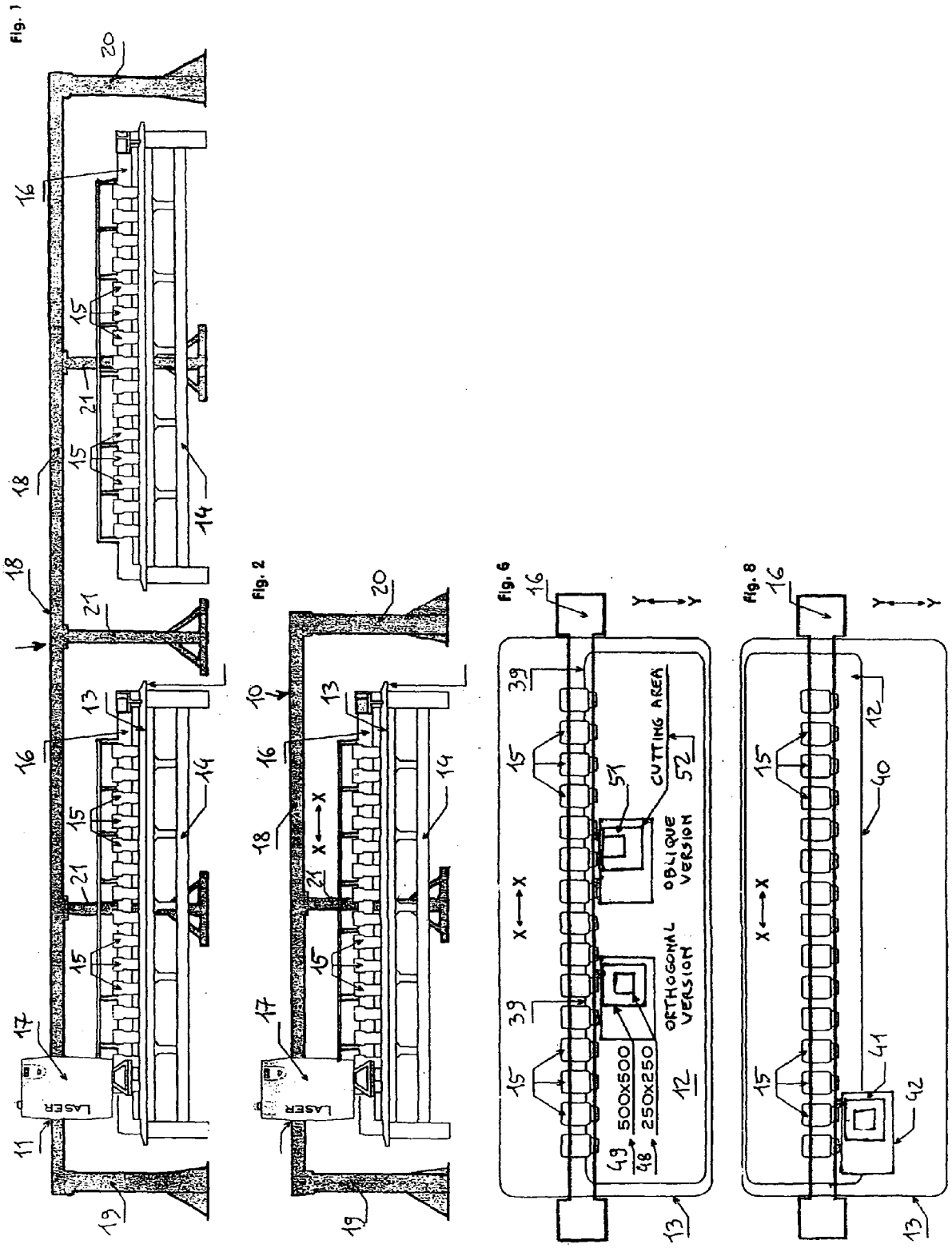
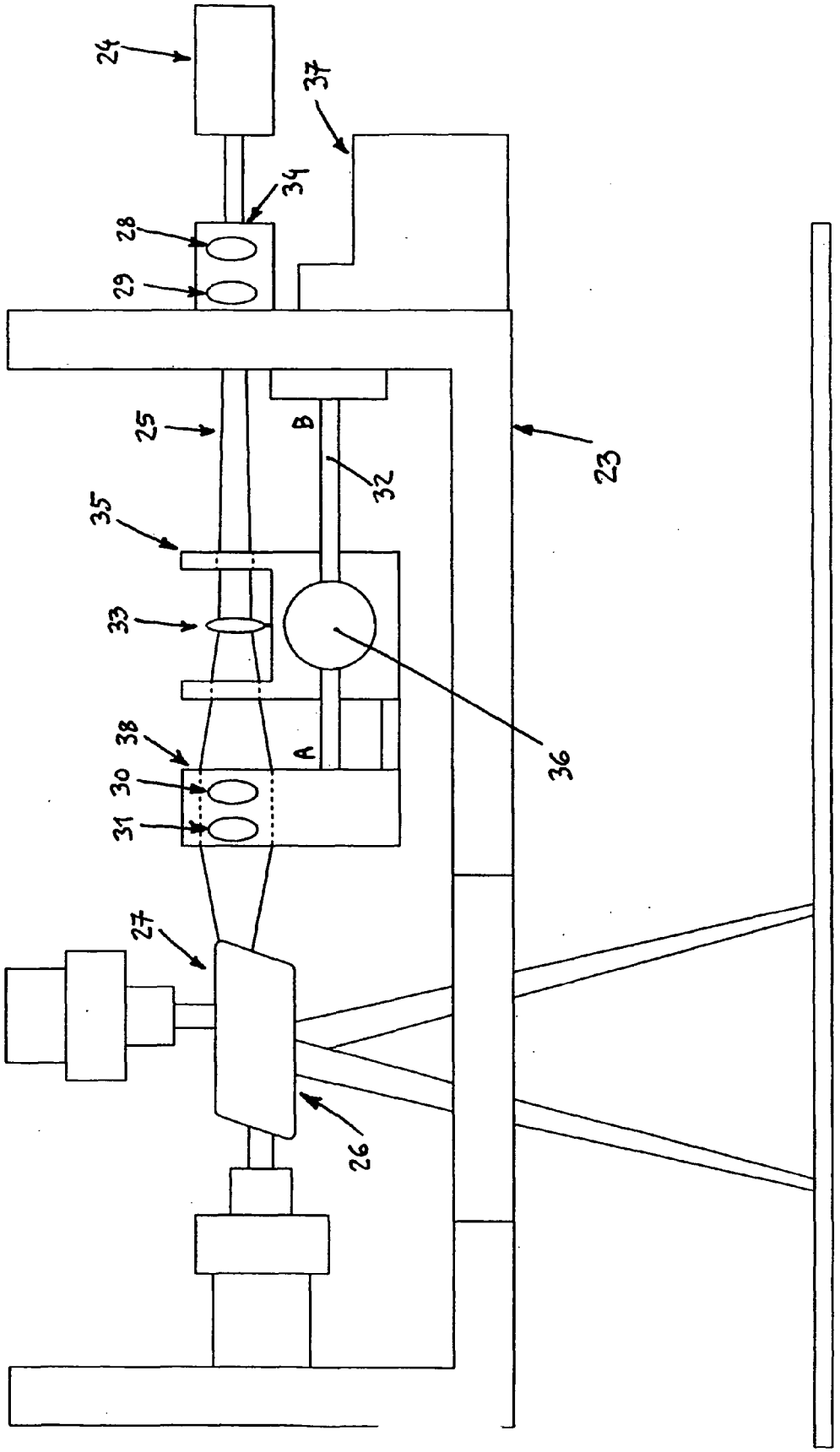


Fig. 1
Fig. 2
Fig. 6
Fig. 8
LASER
ORTHOGONAL VERSION
OBLIQUE VERSION
CUTTING AREA
500x500
250x250
X ⟷ X
Y ⟷ Y

FIG. 3



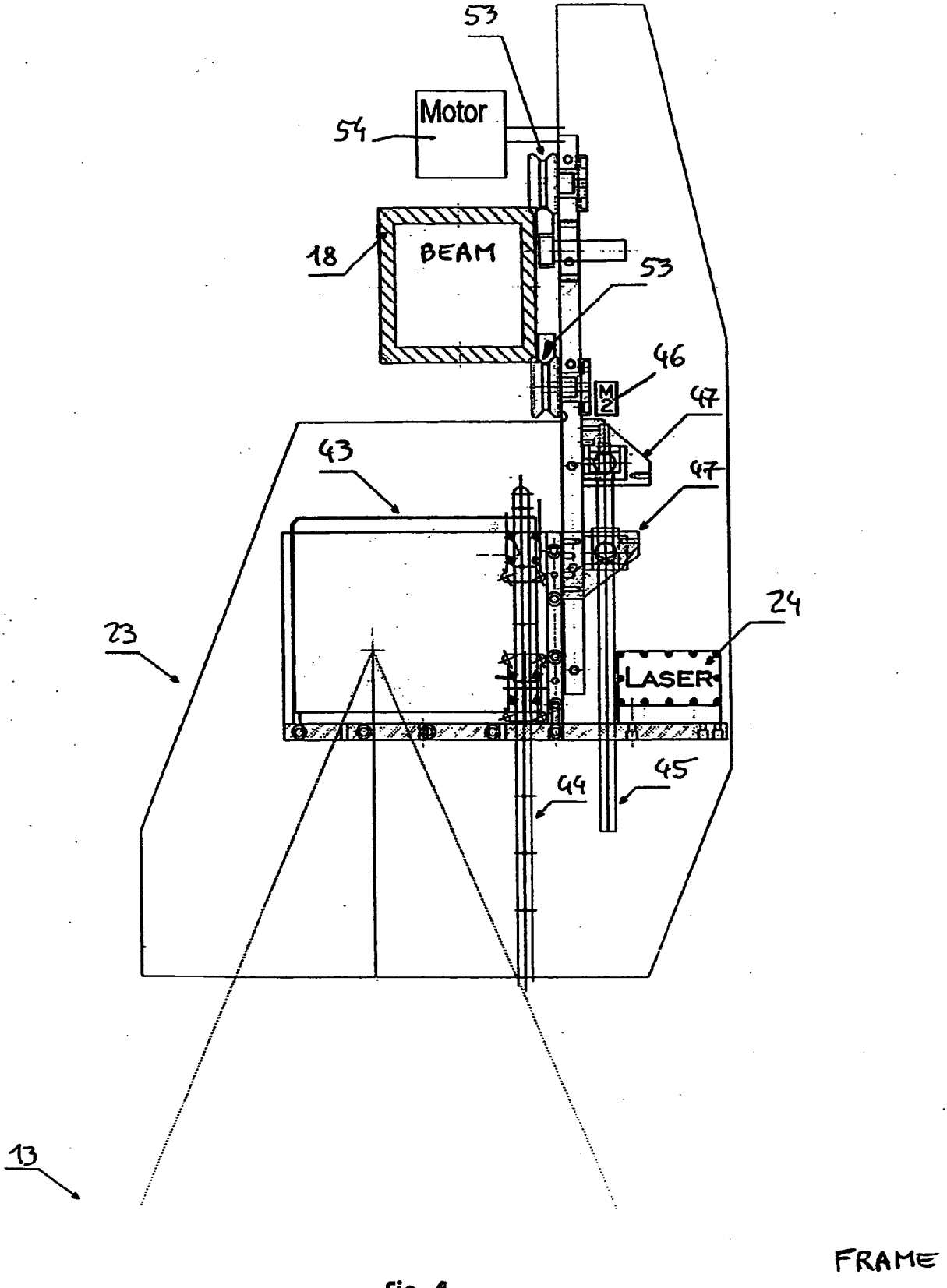


Fig. 4

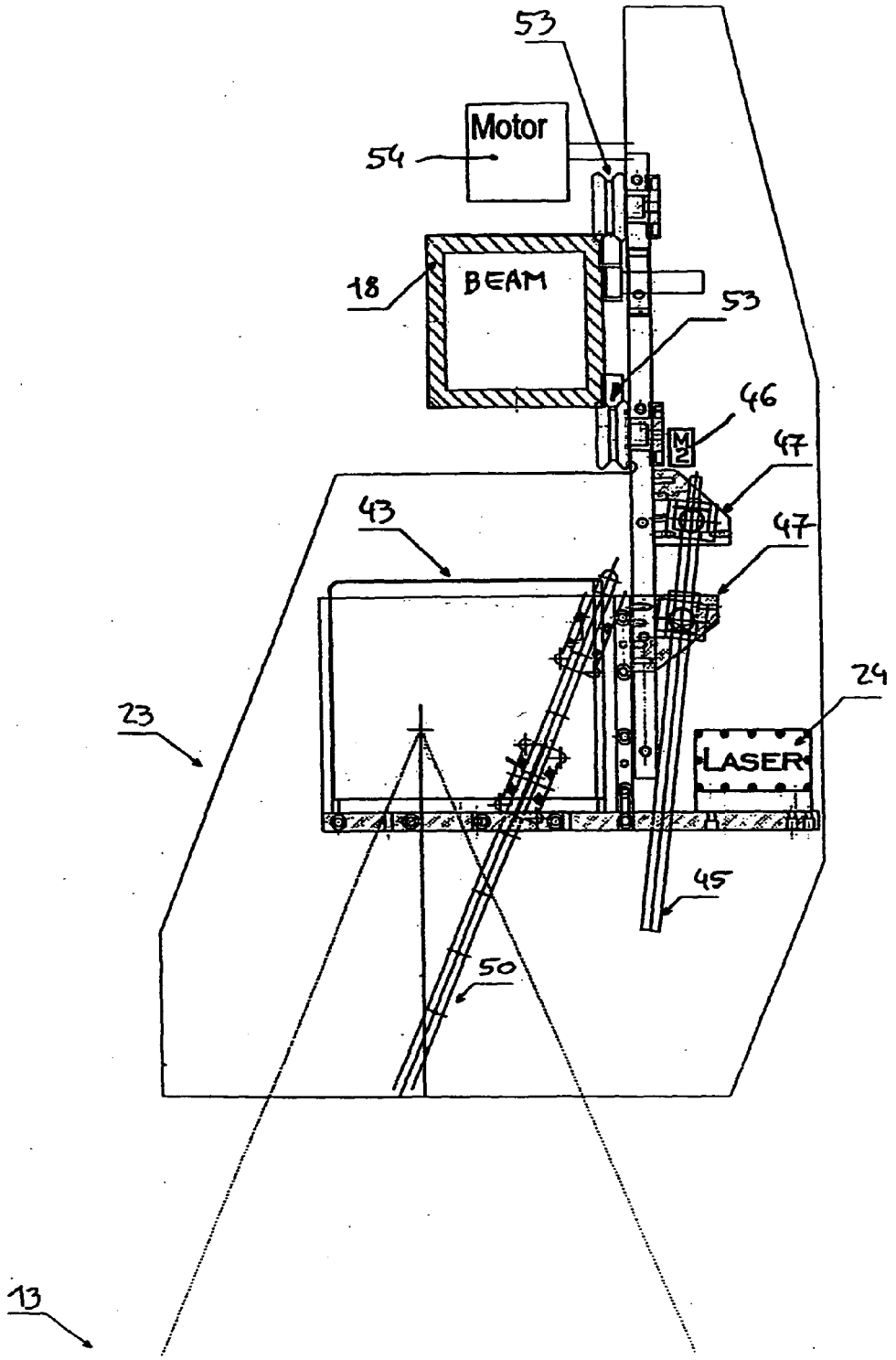


Fig. 5

FIG.7

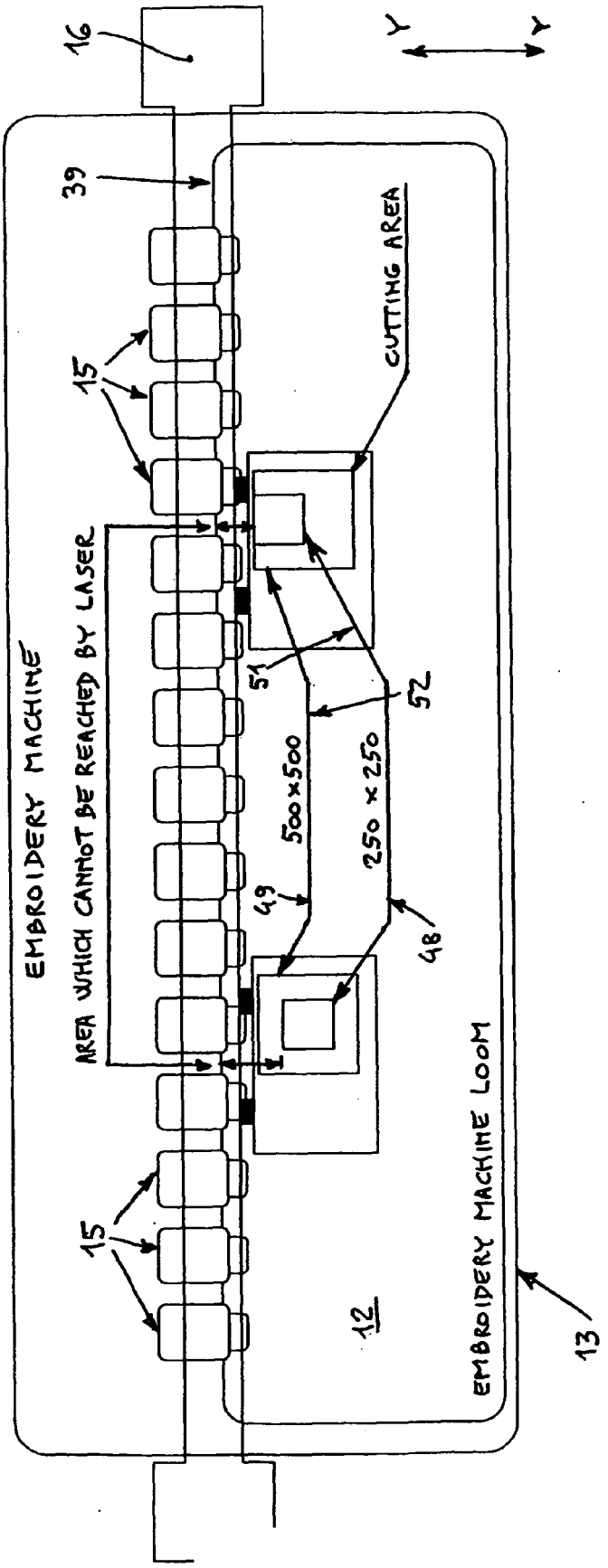
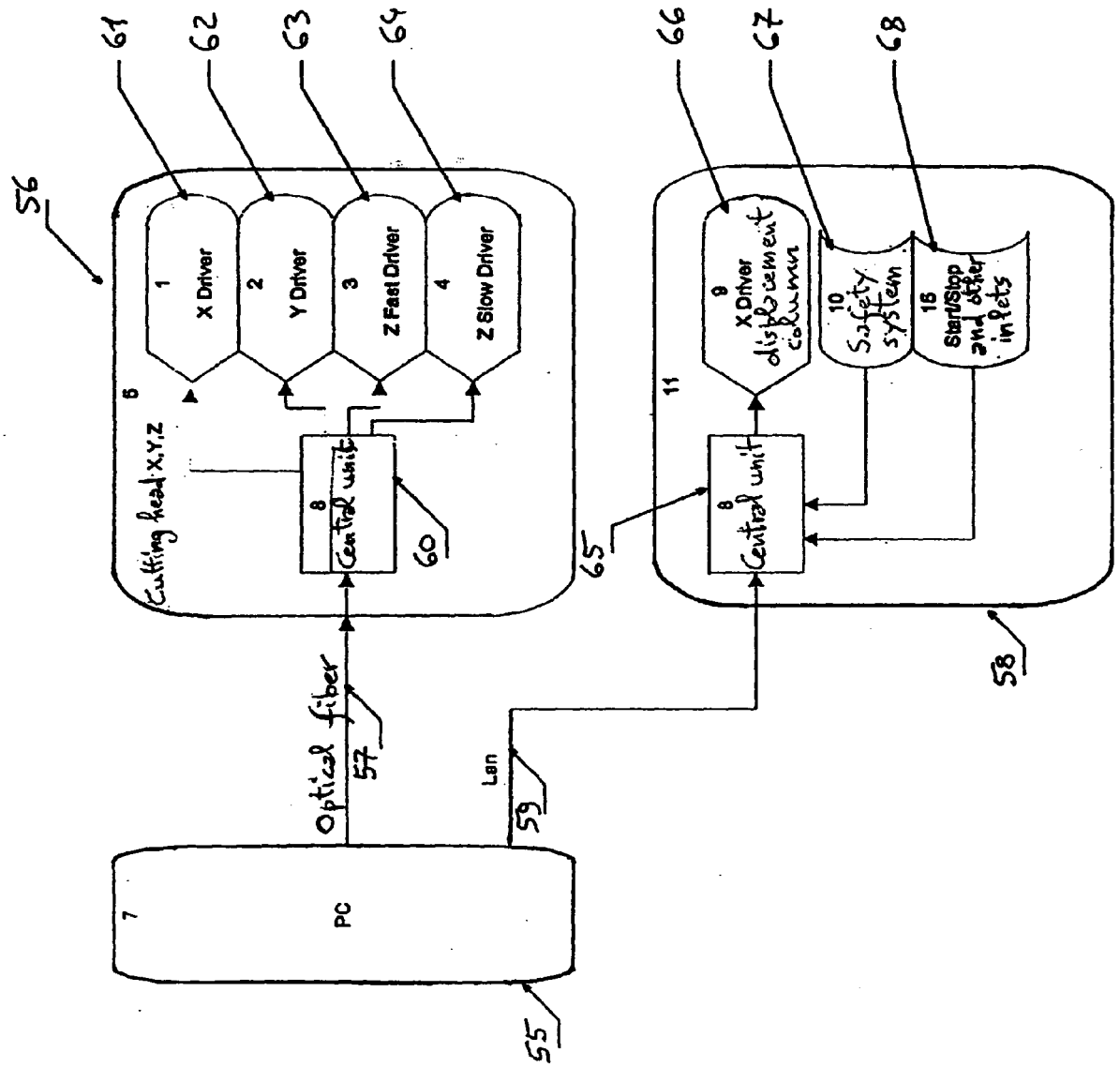

16
Y
Y
39
15
CUTTING AREA
EMBROIDERY MACHINE
AREA WHICH CANNOT BE REACHED BY LASER
51
52
500×500
250×250
49
48
15
12
EMBROIDERY MACHINE LOOM
13

Fig. 9


56
61
62
63
64
66
67
68
1 X Driver
2 Y Driver
3 Z Fast Driver
4 Z Slow Driver
5 Cutting head X,Y,Z
8 Central unit
60
65
9 X Driver displacement column
10 Safety system
15 Start/Stop and other inputs
11
58
Optical fiber
57
Lan
59
7 PC
55

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 02 3121

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A	EP 0 753 372 A (TOKAI KOGYO MISHIN KABUSHIKI KAISHA) 15 January 1997 (1997-01-15) * page 11, last line - page 12, line 3 * * page 12, line 39 - line 47 * * page 22, line 16 - line 26 * * page 30, line 55 - last line * * page 32, line 15 - line 31; figures 13,14,23,56,74-78 *	1,6	D05C7/10
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D05C
D06C
B23K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 February 2006	Aran, D

CATEGORY OF CITED DOCUMENTS

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