

March 19, 1957

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2,785,608

CONTOUR-MILLING METHOD AND MEANS

Filed Feb. 14, 1952

6 Sheets-Sheet 1

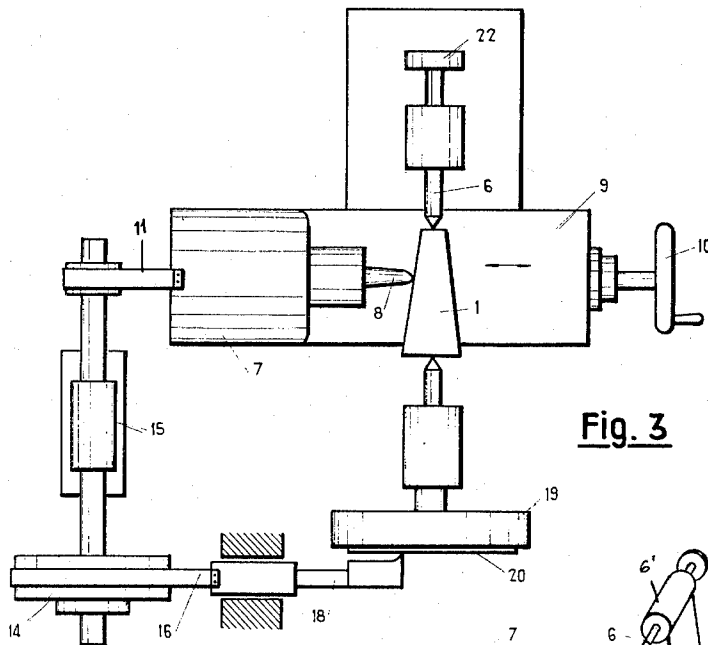


Fig. 3

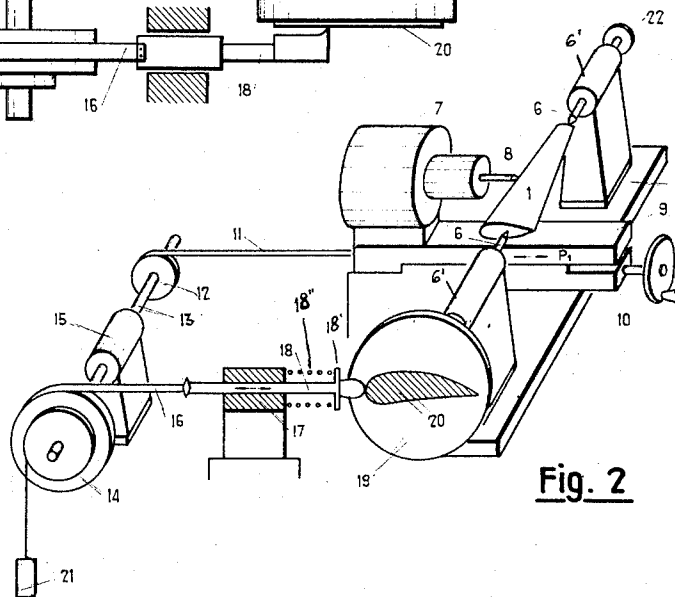
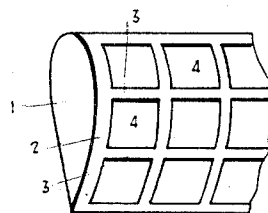


Fig. 2

Fig. 1



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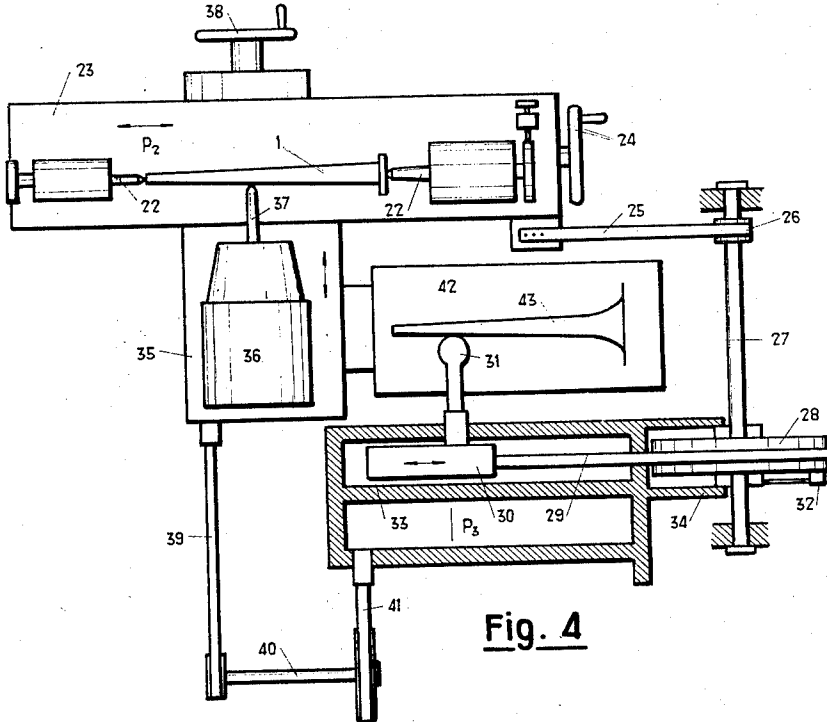


Fig. 4

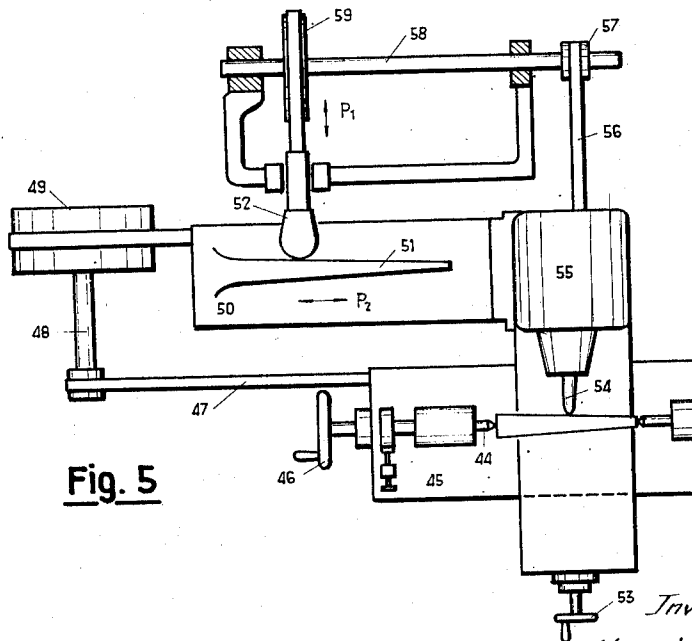


Fig. 5

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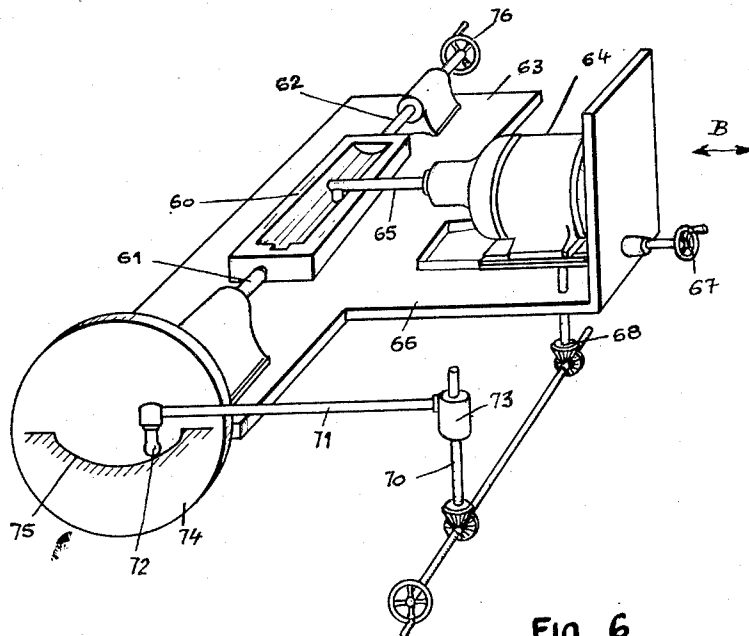


Fig. 6

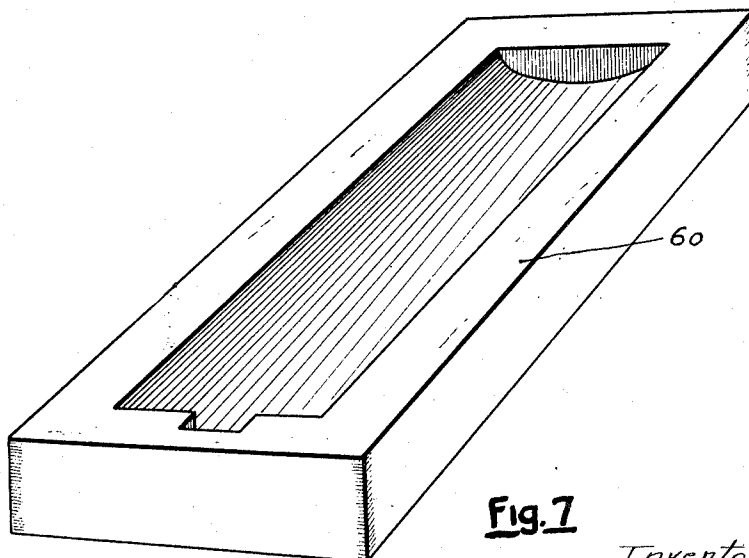


Fig. 7

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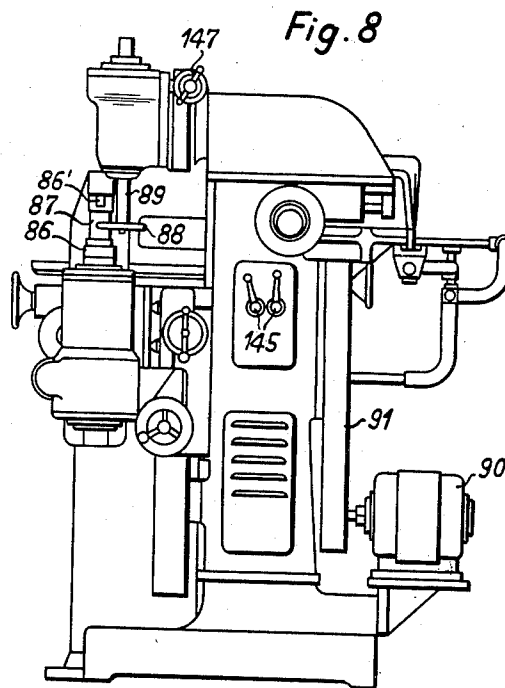
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2,785,608

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Filed Feb. 14, 1952

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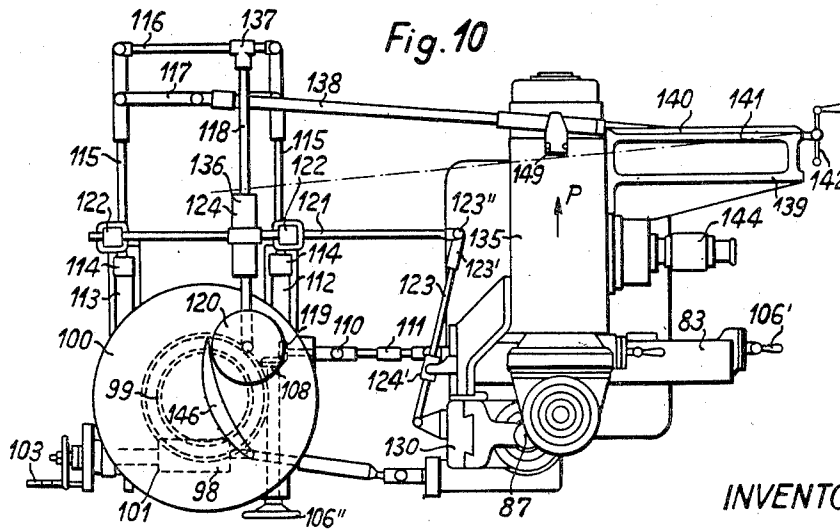
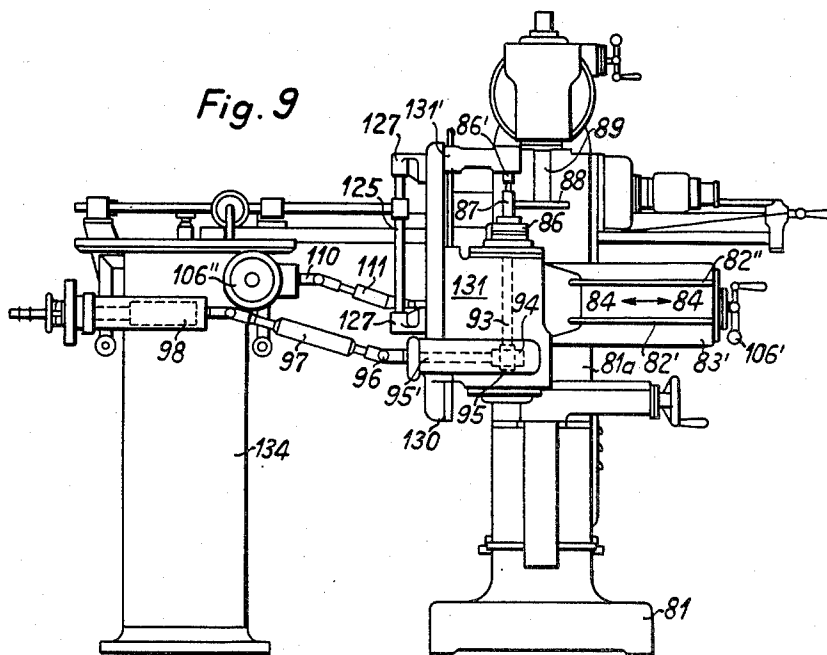
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Filed Feb. 14, 1952

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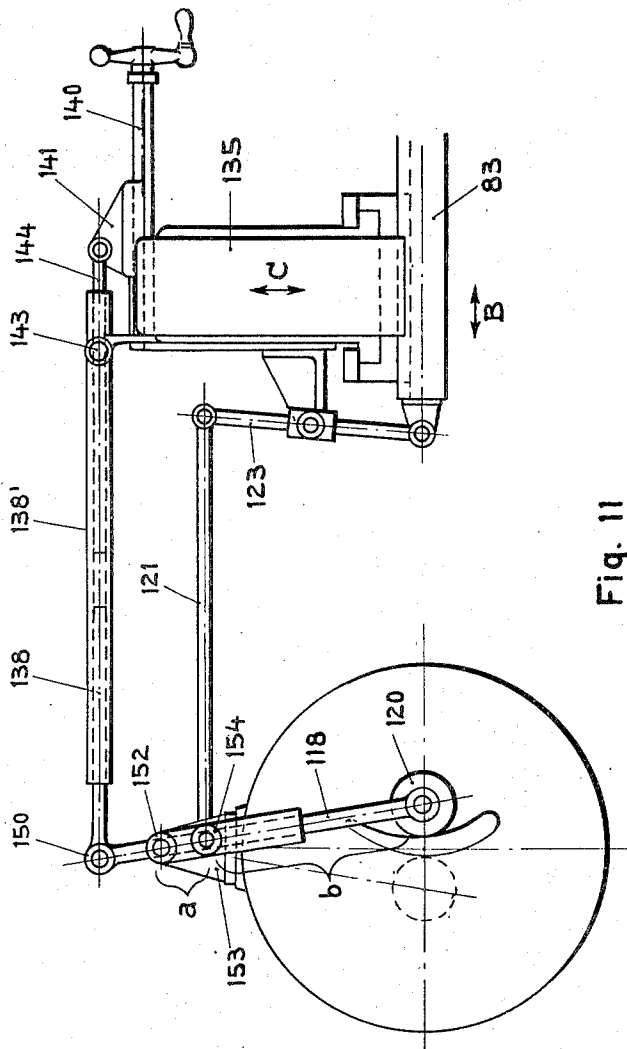


Fig. 11

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CONTOUR-MILLING METHOD AND MEANS

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Application February 14, 1952, Serial No. 271,514

9 Claims. (Cl. 90—13.4)

Master forms having irregular surfaces, such as are used in profiling thus far have been filed by hand down to the desired final dimensions according to workshop drawings. Such operation is very time-consuming and costly. The present invention discloses a new way for machining such master forms.

The method disclosed in my present invention is characterized in that first a net of any desired fineness is produced on the rough or semi-finished work, such net comprising for example milled longitudinal and transverse grooves of which the bottom corresponds to the desired final dimension, whereupon the remanent material is removed at least until the desired final dimension has been reached, i. e. until the said grooves have disappeared. In a modification of such method, the material is removed down to a level which is below the said dimension, so that the said net projects in raised form from the remanent surface, whereupon the latter is brought up to the said dimension by depositing a filling material.

The means for carrying out such method disclosed herein, comprises elements for gripping the work, and a cutting tool within the range of the latter, the said elements and work and tool being variable both axially and at right angles thereto. The essence of the invention is defined by operatively connecting the setting or adjusting elements to a tracer which is adapted to be moved along patterns which are reproduceable in two dimensions, the relative movement between work and tool being defined by the relative position of feeler and pattern.

Various forms of the means disclosed by my present invention are shown in the accompanying drawings, in which—

Fig. 1 shows a perspective view of a semi-finished work,

Fig. 2 illustrates one form in a perspective view of the means for machining a work at right angles to its longitudinal axis,

Fig. 3 shows the same means in plan view,

Fig. 4 shows the means for machining the work along its longitudinal axis,

Fig. 5 depicts a modification of Fig. 4,

Fig. 6 shows a modification of the means for die-sinking,

Fig. 7 is a perspective view, in a larger scale, of a die,

Figs. 8-10 show another form of the invention, and

Fig. 11 is a modification of such last form.

For explaining the method and subsequently the means for carrying the same into effect, the preparation of a compressor-blade master form will be described by way of example. The particular compressor blades may be made by profiling for which purpose a profiler is used which is controlled by tracing a three-dimensional master form. Up to the present, the latter has been made by manual filing on the basis of the workshop drawing, which is very time-consuming and costly.

According to the method disclosed herein, a net is produced on the work, e. g. by milling a plurality of grooves or by drilling a plurality of bores of which the bottom corresponds to the final dimension of the master

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form. Such net in the example shown comprises grooves 2 and 3 which subdivide the entire surface of the work 1 into zones 4. Having produced these grooves, the material is removed until the final dimensions are reached, the groove bottom serving as profiling face whereby it is no longer necessary to continuously check the dimensions of the work. The material thus is removed down to the level of the groove bottoms, so that the grooves disappear.

A further possibility consists in removing so much material from the zones that the net projects from the remanent surface in the manner of a relief, i. e. the initial grooves are converted to ribs. The surface subsequently is completed to the final blade dimension by applying a filling material up to the level of said ribs.

The net suitably is so arranged that the grooves are substantially parallel or at right angles to the longitudinal gravity axis of the blade. To produce the net, sectional drawings first are made of the master form, the sections being taken along the grooves to be produced. These drawings serve as pattern for producing the net, in a manner to be described later on.

A means for such purpose is shown in a perspective view in Fig. 2. The operating table 5 comprises two conventional centers 6 which are axially movable and mounted in bearings 6', and serve to receive the work 1 which is to be machined. The latter suitably is so secured and centered that its longitudinal axis is coaxial to the longitudinal axis of the centers 6. The arrangement is such that the work 1 is rotatably engaged through rotation of the work spindle by means of a driver and center 6. The machining tool, e. g. a milling cutter, is designated by 8 and is driven by an electric motor 7 for which purpose the cutter is connected to the motor shaft in known manner. The electric motor 7 is mounted on a cross-slide 9 which is movable at right angles to the axial direction of the work. Such movement is carried out by means of a handwheel 10 in the directions indicated by the arrows P₁, the structural details of such moving mechanism not being shown in detail. Such mechanism may comprise, in conventional combination, a spindle connected to the handwheel and a spindle nut connected to the slide 9. The latter is connected to one end of a flexible tape 11 of which the other end is wound on a roller 12. The latter is fixed to a shaft 13 which extends in parallel relation to the longitudinal axis of the clamped work and which at its other end supports a second roller 14, an intermediate shaft bearing being disposed at 15. On the roller 15 also a tape 16 is wound which at its other end is connected to a tracer 18.

The tracer 18 comprises a shank which is axially movable in a bearing 17, and at its other end extends into the range of a support or wheel 19. The tracer shank has a collar 18' integral therewith, against which abuts a compression spring 18''. The wheel 19 is mounted on the shaft of one of the holding elements 6, being secured thereto for rotation therewith, and serves to receive a cross-sectional drawing 20. The latter is exchangeably mounted on the wheel 20 and represents a cross-section through the master form in accordance with which a groove of the said net is to be machined. The tool 8 also is longitudinally adjustable with respect to the work and is set at that position which corresponds to the mounted cross-section. In order to keep the tapes 11 and 16 always taut, a weight 21 is suspended from the roller 14.

When moving the tracer 18 along the contour of the cross-section 20, which is done by simultaneously actuating the handwheel 10 and a handwheel 22 for rotating the work 1 together with the wheel 19 around the longitudinal axis, whereby the milling cutter or tool is rotated, a groove is milled in the work corresponding to the contour of the cross-sectional drawing. In place of the

manual operation, a push-button control could be provided. Similarly, other cross-sectional drawings are successively mounted on the wheel 19, with the aid of which other grooves are milled until all the grooves of the net have been produced, which grooves run parallel to a transverse work plane.

In order to dispense with full-size drawings and attain reduced errors through reducing the scales, the diameters of the discs 12 and 14 are so chosen that the movements of tracer 18 are transmitted to the tool movements in accordance with the scale of the drawing.

The longitudinal grooves 3 (Fig. 1) are milled with the aid of longitudinal-section drawings. The work 1 is again clamped between centers 22 which are disposed on the workbench 23 (Fig. 4). The latter is movable by actuating a handwheel 24 in the directions of arrows P₂. Such movement is transferred on to a spline shaft 27 by means of a tape 25 and pulley 26. The spline shaft 27 carries a roller 28 on which is wound a tape 29 which is connected to a support 30 of a tracer 31. A weight 32 tends to turn the shaft 27 so as to keep the tapes 25 and 29 always taut. By means of the arrangement described, the reciprocatory movements of workbench 23 are transferred onto the tracer 31, any desired gear ratio being attainable between the movement of the workbench and the tracer through a suitable choice of the relation of diameters of the two discs 26 and 28. The support 30 and tracer 31 are mounted on a slide 33 which is movable at right angles to the direction of movement of the workbench in direction of the arrows P₃, the slide 33 being provided with a driver 34 which transmits the slide movements in direction of the arrows P₃ to the disc 28 which is movable but non-rotatable on the spline shaft 27.

The slide 33 is so coupled to a tool carriage 35 which carries an electric motor 36 and cutter 37, that the movements of carriage 35 are transmitted to the slide 33 at right angles to the longitudinal axis of the work. The carriage 35 is moved in said direction by means of a handwheel 38. The slide 33 and the carriage 35 may be interconnected, for example, by means of a tape transmission 39 to 41, or the two members 33 and 35 may be integral. Within the range of the tracer is arranged a work table 42 which serves to receive longitudinal-section drawings 43.

The mode of operation of the automatic profiling-machine portion described is as follows.

On the worktable 42 is tacked down a longitudinal-section drawing 43 of the master form according to which a groove 3 is to be milled. The work 1 is so set with respect to the cutter 37 that the horizontal plane passing through the work coincides with the cutting plane of the drawing. Through simultaneous actuation of the handwheels 24 and 38, or through an automatic push-button control, the tracers are caused to accurately follow the longitudinal edge of the drawing. The cutter 37 undergoes a corresponding movement so that the work 1 is machined in accordance with the drawing. By using various sectional drawings representing longitudinal sections laid through different axial planes, the longitudinal work grooves 3 are produced.

After having milled the net shown in Fig. 1 in the work, so much material is removed from the zones 4 (Fig. 1) between the grooves until the final dimensions have been reached or just passed or understepped. In the latter case, the said zones are filled with a plastic material up to the final dimensions.

A modification of the means shown in Fig. 4 illustrated in Fig. 5. Here the work 1 again is clamped between two centers 44 which are disposed on a slide 45. The latter through actuation of a handwheel 46 is movable in direction of the arrow P₄, and such movement is transferred through a transmission 47 to 49 to a worktable 50 which serves to receive the longitudinal-section drawings 51. To trace the latter, again a tracer 52 is provided to which is coupled the cutter 54 which is operated by an

electric motor 55. The movement is transmitted by means of steel tapes 57 and 59 via pulleys 57 and 59, the pulley diameters being in the same relationship as the master form and the drawing.

By simultaneously actuating the two handwheels 46 and 53, the tracer 52 and table 50 are so moved relatively to each other that the movement takes place in accordance with the longitudinal contour of the sectional drawing 51 and is transmitted onto the tool 54 and work 1.

In Figs. 6 and 7 is shown a die-sinking form of invention. The article 60 to be machined is clamped between the centers 61 and 62 of a workbench 63. In this case also, a milling cutter 65 is driven by an electric motor 64 which together with the cutter is mounted on a cross-slide 66 which by means of a handwheel 67 is movable in direction of the arrows B at right angles to the axial direction of the work. The reciprocatory movement of cross-slide 66 is transferred on to a tracer 72 through a rigid gearing 68—70 and a flexible tape 71, the latter being windable and unwindable on to and from a drum 73. The arrangement is such that the drum 73 is operatively connected to the last link 70 of said gearing. The tracer 72 is disposed in the range of a wheel 74 which is secured to the shaft of center 61 and which serves to receive a cross-sectional drawing 75. The latter is exchangeable on wheel 74 and shows a cross-section through the master form according to which a groove of the net is to be milled. The tool 65 with respect to the work also is adjustable in the longitudinal direction and is so adjusted that the selected position corresponds to the cross-section shown in the drawing 75. When the tracer 62 is moved along the contour of the drawing 75, which may be done through actuating the handwheel 67 and a further handwheel 76, and when the cutter 65 is rotated, a groove is milled in the work 60. The longitudinal grooves are produced through the use of corresponding longitudinal-section drawings. In order to make the electric motor movable along the work 60, the cross-slide 66 may be mounted in similar manner as shown in Fig. 2.

A last form of invention is shown in Figs. 8—10. Also in this case, a work 87 shall be machined which is to serve as a master form. The machining means comprises a frame 81, Fig. 9, which is provided with a vertical guide 130 in which a rise-and-fall rest 83 is mounted. The adjustment is known per se and may for example be accomplished by means of a spindle gearing. A slide 131 is mounted movable in direction of the arrows 84, 84' on the rest 83. For such purpose, a guide track 82', 82'' is provided on the rest 83, which track consists of two grooves extending in horizontal direction. The slide 131 is moved longitudinally in its guide track 82', 82'' by means of a spindle (not shown) which is actuable by means of a handwheel 106' which is connected to an articulated shaft. The latter, as best shown in Fig. 10, comprises a telescoping portion 111 and an articulated portion 110 which is operatively connected to an angle gearing. The latter comprises two bevel gear wheels of which the axes stand at right angles to each other, the wheel 108 being actuable by means of a handwheel 106''. In this manner it is possible to move the slide 131 through the handwheel 106' as well as through the handwheel 106''. The telescoping portion 111 is not further detailed in the drawing and may conventionally comprise two telescopic sleeves or sliding bushes.

The slide 131 comprises a clamping device 86 in which the work 87 is received. At the other end a conventional center 86' is provided, which is secured in an arm 131' of slide 131. Within the range of work 87 a cutter 88 is secured to a rotatable shaft 89. The cutter 88 is driven by means of an electric motor 90, Fig. 8, through a belt 91 in a manner known per se.

The clamping means 86 is rigidly connected to a shaft 93 which also is mounted in the slide 131 and carries a worm 94 at its end remote from the tool. The worm 94

coacts with a worm wheel 95 which is secured to a shaft 95' standing at right angles to shaft 93. The other end of shaft 95' is connected to an articulated shaft 96 which is coupled to a telescoping element 97. The latter is formed similar to the element 111 and transmits the rotation of worm wheel 95 on to a worm 98, Figs. 9 and 10, which is mounted in a frame 134 and engaged to a worm wheel 99 which serves to drive a turntable 100. The cross-sectional drawing of the work to be machined, which drawing may have any desired scale, is tacked down on the table 100 and is traced by means of a tracer 120. The shaft 101 of worm 98 is actuated through a handwheel 103. By actuating the latter, the turntable 100 and the work 87 are synchronously rotated. Another possibility would consist in driving the table 100 and the work 87 coupled thereto through an electric motor via an infinitely variable gearing.

An articulated mechanism is provided for transmitting the movement of slide 131, which movement is brought about through the actuation of the handwheel 106' or 106'', on to the tracer 120. Such articulated mechanism comprises the following parts. On the horizontally movable slide or milling table 131 are provided two holders 127, Fig. 9, for mounting a vertical shaft 126 on which one end of a connecting rod 123, Fig. 10, is rotatably mounted. The latter is rotatably mounted in a slide way and movably secured to the column 81. The spindle carrier 131 only performs the feed motion at right angles to the direction of movement of the carriage 83. The other end of rod 123 is provided with a slide bush 123' and is connected to a rod 121 at 123''. The rod 121 is guided through the two fixed bearings 122, a cross way 124 being provided between the two bearings. The said cross way is rigidly secured to the rod 121 and forms, so to speak, a portion of the latter, the cross way comprising a bore 136 which extends at right angles to the rod 121 for receiving a rodlike carrier 118. The latter is guided axially movable in said bore 136. At one end of the carrier which extends to the turntable 100, the tracer 120 is secured, whilst the other end of carrier 118 carries a socket 137 which is slidably mounted on a tie rod 116. The latter is disposed between two rods 115 which extend parallel to each other and parallel to the carrier 118, and at their other ends are slidably mounted in bearings 114. The latter suitably are fixed to the standard 134. Another tie rod 117 is disposed parallel to the rod 116 which is connected to the two rods 115. The tie rod 117 carries one end of a rod 138 which at its other end is pivoted to a slide member 141. The latter is formed as spindle nut and coacts with a spindle 140 which is mounted in bracket 139 and carries a handwheel 142. The latter serves to the lever ratio through shifting the slide member 141. An electric motor 144 serves to automatically feed the cutter tool.

The arrangement described again allows of moving the tracer 120 along the contour of a drawing 146, such movement being transformed to a relative movement between the work and the cutter. Tracing the contour on drawing 146 may be done according to polar or Cartesian co-ordinates. In the former case, the turntable 100 is rotated by actuating the handwheel 103, which rotary movement is transmitted in the manner described via the articulated transmission on to the shaft 93 of the chuck 86 so as to cause a corresponding rotation of the work. Furthermore, the tracer 120 is moved axially with respect to the rodlike carrier 118, brought about by actuating the feed mechanism. When the spindle carrier 135 is fed in direction of the arrow P, which may be done either automatically through the electric motor 144 or by actuating a handwheel (not shown), such feed is transmitted through the rod 138 which is swiveled about its point of connection to the handwheel 142. Such swiveling motion of the guide rod gives origin to an axial movement of the rods 115, and the latter movement in turn gives origin to the said axial movement of the tracer 120. In order to allow of varying the ratio of feed to the movement of

the rods 115, the said spindle arrangement 140, 141 is provided, the effective length of rod 138 being variable through actuation of the handwheel 142.

When the master-form drawing is to be traced according to the system of Cartesian co-ordinates, the tracer 120 is given two movements at right angles to each other. One of said two movements released by the feed of the spindle carrier 135, whilst the other movement is brought about by actuation of the handwheel 106' or 106''. By rotating the said handwheel, the carriage 83 is moved in the ways 82' and 82'', which movement is transmitted on to the rod 123 which is connected to the carriage 83. By moving the latter, the rod 123 is swung to the position shown by dash-and-dot lines in Fig. 10, and the rod 121, which is connected to the rod 123, is axially moved. Since the rod 121 is rigidly connected to the cross-guide 119, the latter and the carrier 118 (which is mounted axially movable in said guide) follow such swing, one end of said carrier moving on the tie rod 116. A movement at right angles to the axial direction of carrier 118 thus is imparted to the tracer 120.

The machine of Figs. 8-10 may be employed for cutting both the longitudinal and the transverse grooves. To cut the longitudinal grooves it is merely necessary to turn the workpiece 87 through an angle of 90° and to secure it in this position by means of the chuck or clamping device 86.

Fig. 11 shows a simplified modification of the form of invention shown in Figs. 8-10. The parallel guiding arrangement 115, 116 is replaced by a lever construction. One end of the rod 138 is pivoted at 150 to the rodlike carrier 118 of tracer 120. The carrier 118 is guided in a sleeve 151 and at one end at 152, is pivoted to the support 153. The rod 121 is pivoted to said sleeve 151, the fulcrum being designated by 154.

A movement in direction of the arrows B is transmitted through the connection 123 and 121 on to the sleeve 151 which thereby is swung about the fulcrum 154. The tracer 120 is deflected in accordance with the transmission ratio defined by the ratio of the lengths a to b . A movement in direction of the arrows C is transmitted through the rod 138 and the carrier 118, as has been described above with the aid of the form of invention shown in Figs. 8-10. In the modification shown in Fig. 11, the rod 138 at one end is pivoted to a slide 141 which is movable by rotating a thread spindle 140. The rod 138 further is guided in a sleeve 138' which in turn is pivoted at 143. By moving the slide 141, the transmission ratio is variable with which the movements are transmitted on to the carrier in direction of the arrows C.

I claim:

1. A profiling machine, comprising a cutter having horizontal feed, a vertical movable carriage having a work-carrier horizontally movable at right angles to the feed movement, a first articulated connection between the work-carrier and the tracer and adapted to transmit the horizontal work-carrier movement on to the tracer, a second articulated connection between the work carrier and the tracer to transmit the work-carrier feed on the tracer, a third connection arranged between the work-carrier and a turntable, which turntable carries a two-dimensional pattern, said third connection transmitting the rotary movement of the work-carrier on to said turntable.

2. A profiling machine according to claim 1, having a first articulated connection comprising a lever transmission which has a pivotable lever and a connecting rod, said lever being pivoted to a horizontal rod and adjustable in elevation and connected to the work-carrier, the other end of said lever coupled to the rod end, which rod is provided with a crossway and guided in fixed guides.

3. A profiling machine according to claim 2, having a tracer-carrying slide, guided by the crossway axially movable at right angles to the rod.

4. A profiling machine according to claim 3, having a

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second articulated connection comprising an articulated lever, pivoted at one end to the frame and at the other end to an adapter and at a point intermediate of the ends to a further guide, two parallel guides extending at right angles to the adapter and rigidly connected to said adapter and to a connecting element, extending parallel to the adapter, said guides being mounted at one end in slides and said connecting element being connected in axially movable manner to the carrier-end, which is remote from the tracer, the swinging movement of said articulated lever, initiated by said further guide causing the axial movement of said parallel guides.

5. A profiling machine according to claim 4, having a guide rod, one end of said guide-rod being connected to a spindle nut, which coacts with a spindle mounted on a head.

6. A profiling machine according to claim 5, having a third connection, said connection comprising a telescopable member and an articulated shaft coupled to the latter, said member being connected to a turntable carrying a drawing pattern by means of a worm wheel and worm, said articulated shaft being also coupled to the cutter carrier shaft by worm and worm wheel means.

7. A profiling machine comprising a work carrier, a cutter disposed in the range of the work, means for setting said cutter and work carrier with respect to each other both horizontally and vertically, means operatively connecting said work carrier to a tracer which is adapted to be guided along two-dimensionally reproducible patterns, the relative movement between work and cutter being defined by the relative position between tracer

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and pattern, said cutter having a horizontal feed, a vertically movable slide on which said work carrier is horizontally movable at right angles to the direction of said feed, said tracer slide being guided in a sleeve which is pivotally mounted on the cutter slide and through a lever transmission is connected to the work carrier, the tracer slide end remote from the tracer being connected to the work carrier by means of a two-arm lever.

8. A profiling machine according to claim 7, having a two-arm lever, which comprises two rods which are guided in a sleeve, one of said rods being mounted in a slide, said sleeve being connected pivotably but axially nonmovably to the work-carrier or the spindle head respectively.

9. A profiling machine according to claim 7, having a lever transmission comprising a swing lever and a connecting rod, the swing lever being connected to the work carrier.

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