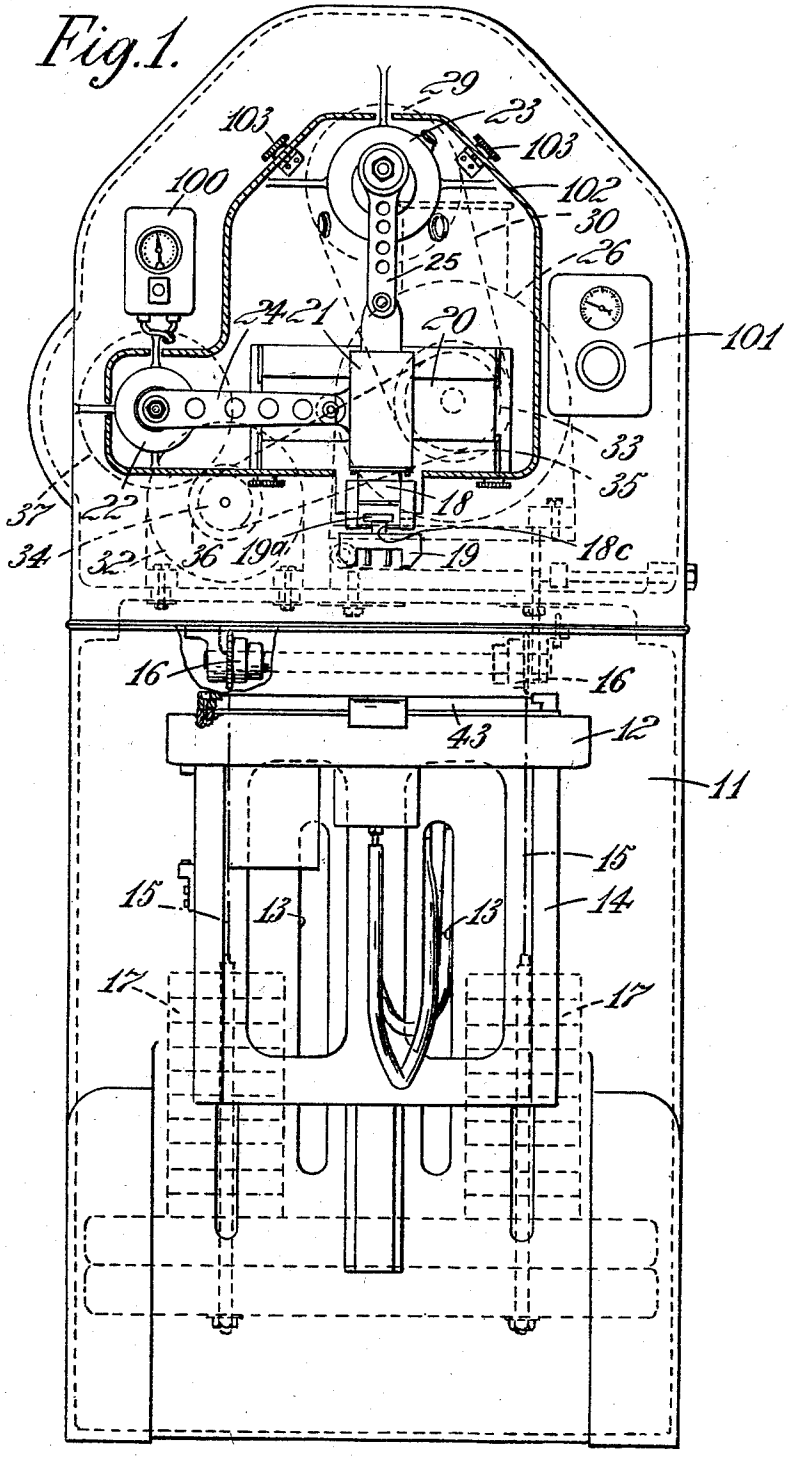
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POLISHING MACHINES

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Fig. 1.

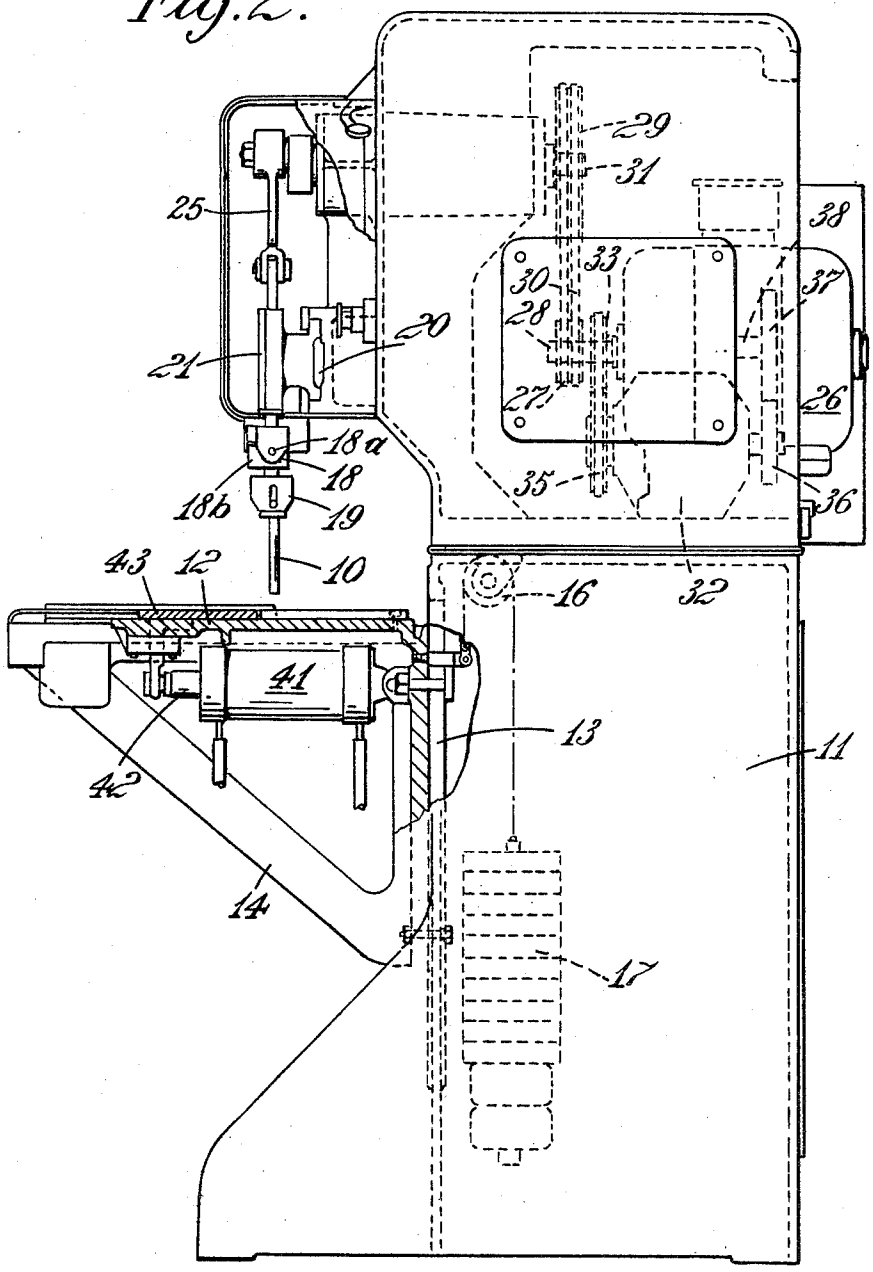


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Fig. 2.

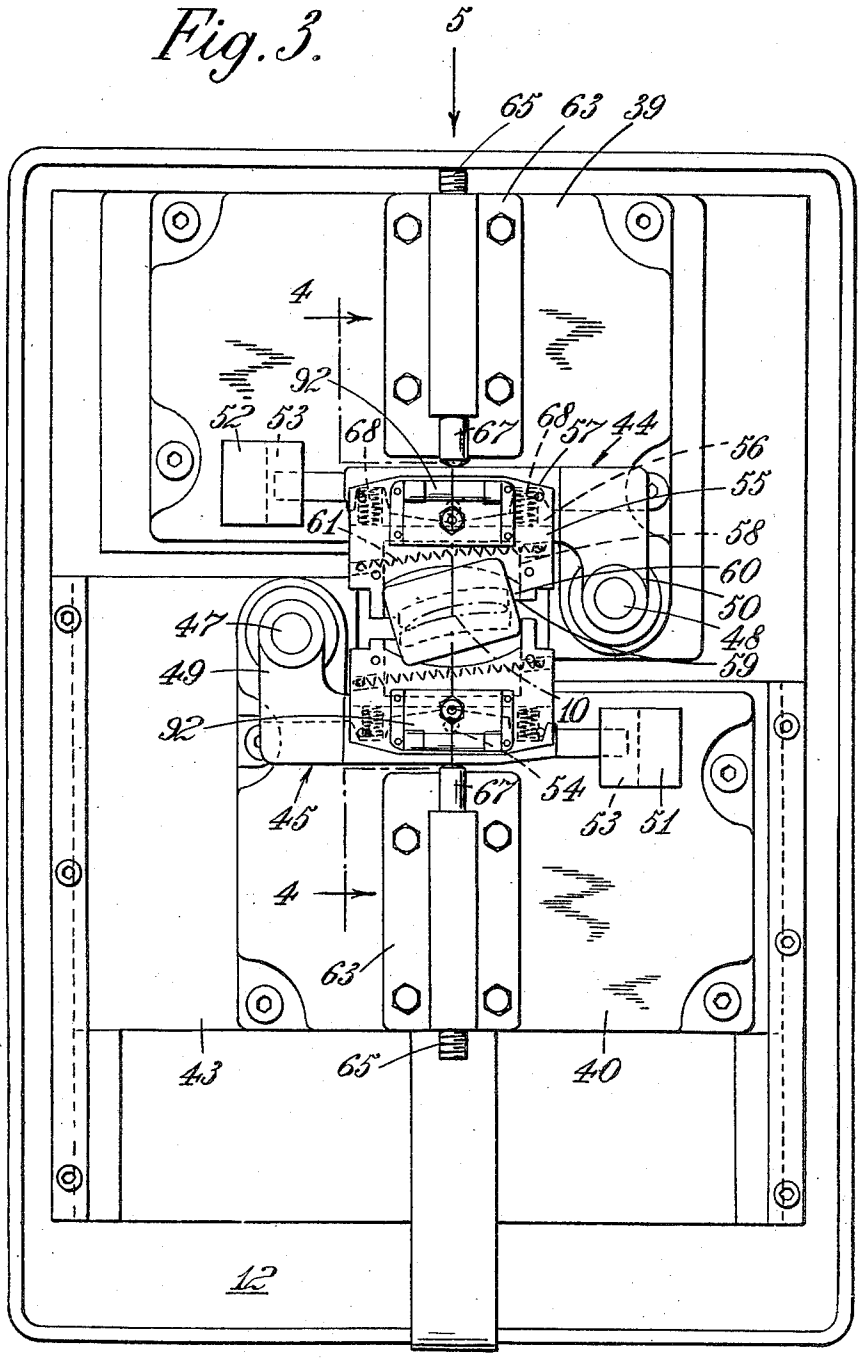


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Fig. 3.

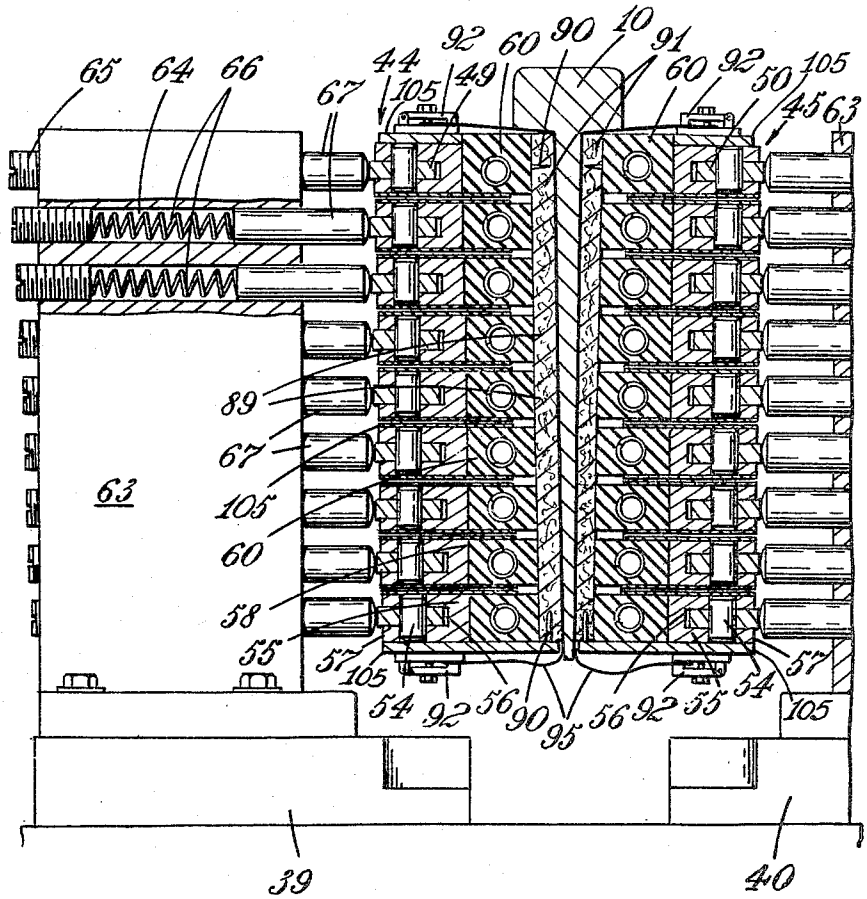


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Fig. 4.

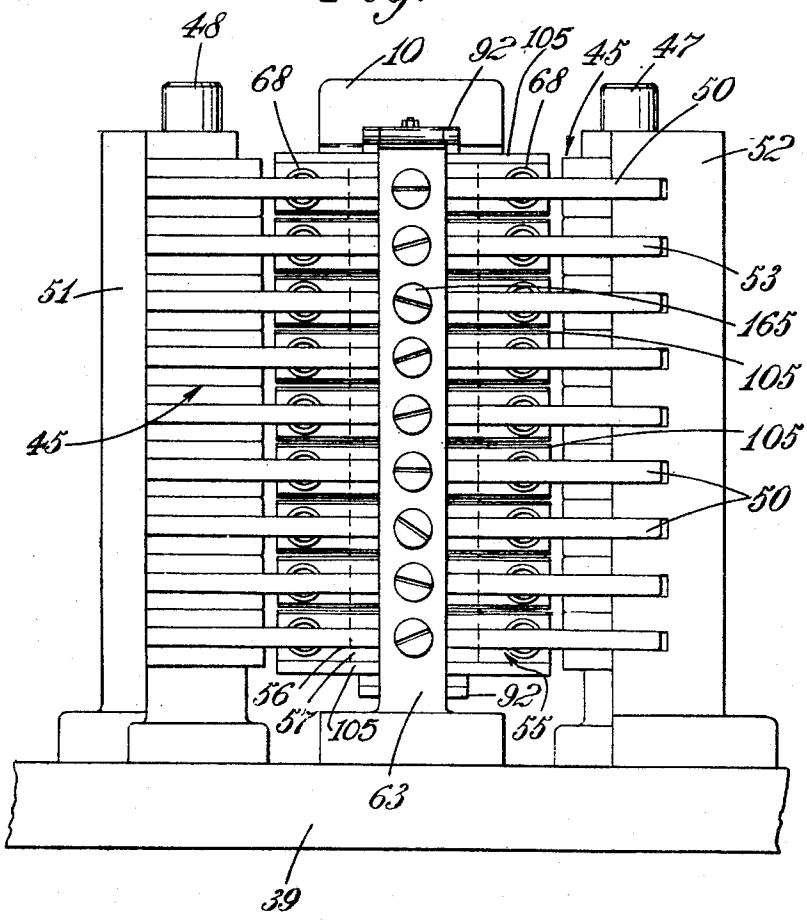


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Fig. 5.



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2,759,303

POLISHING MACHINES

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17 Claims. (Cl. 51—151)

This invention relates to machines for use in polishing by a process in which the article to be polished is oscillated while in contact with a pad treated with abrasive material in dry powder, paste or liquid suspension form, or with a sheet treated with such abrasive material and supported by a pad. The invention concerns more particularly machines for use in polishing blade-like articles such as axial flow turbine blades.

According to the present invention, a machine for use in polishing the two side surfaces of a blade-like article comprises two opposed stacks of pad holders which are spaced apart at least far enough to enable a pad mounted in each holder and a blade-like article to be accommodated between the stacks, a work holder for supporting a blade-like article between the two stacks of pad holders with sufficient space between the blade-like article and each stack to enable at least a pad mounted in each holder to be accommodated between the holder and the blade-like article, means for supporting said pad holders so that each pad holder is individually movable towards and away from a blade-like article when it is supported by said work holder, means for resiliently pressing each pad holder towards the other stack of pad holders, and means for linearly oscillating said work holder so that it oscillates a blade-like article in its lengthwise direction when the blade-like article is mounted in the work holder.

According to a feature of the present invention the machine may further comprise pads mounted one in each pad holder each of which pads has an exposed face directed away from its holder, which exposed face is shaped so that it together with the exposed faces of the other pads in the same stack lie in and provide substantially the whole of a surface conforming in shape and extent to the whole of one side surface of a blade-like article to be polished, the pads in one stack providing a surface conforming to one side surface on such a blade-like article and the pads in the other stack providing a surface conforming to the other side surface of such a blade-like article.

During operation the exposed faces of the pads may come into contact with the side surfaces of a blade-like article which is mounted in the work holder, and in this case it is preferred that the pads be composed of felted fibrous material such as wool felt.

Alternatively, however, the exposed faces of the pads may, during operation, be spaced from the side surfaces of a blade-like article, which is mounted in said work holder, and in this case the machine further comprises a pair of strips of polishing material, one located over the exposed faces of the pads in each stack, so that when a blade-like article is mounted in a work holder there is a strip of polishing material sandwiched between the blade-like article and each stack of pads.

According to another feature of the present invention each of the pads when mounted in its holder may have its exposed face resiliently movable with respect to the holder. This may be achieved by making the pads of resilient material and/or by providing for the mounting

of each pad in its holder in a resilient manner. Thus according to another feature of the present invention each pad holder may have means for supporting the ends of a resilient beam or the like on which its pad is mounted, said beam end support means being arranged to support the beam at right angles to the lengthwise direction of a blade-like article which is mounted in the work holder. The pads when mounted on resilient beams are enabled to wrap around the curved profile of an axial flow turbine blade and this helps to maintain an equal bearing pressure over the whole exposed face of the pad. Preferably the resilient beam comprises a stiff coiled spring which passes through a bore in the pad, and which has its end projecting from the pad and retained in seatings in the pad holder.

It is preferred that at least one of the stacks of pad holders is bodily movable in relation to the work holder to an inoperative position to facilitate the mounting of a blade-like article in the machine and also its removal therefrom. In practice, each stack of pad holders is mounted on a separate support and one of the supports is carried in a slide so as to be movable away from the other of the supports when it is required to mount a blade-like article in the machine or remove a blade-like article from the machine.

Preferably means is provided for imparting to the work holder a simultaneous oscillation to move a blade-like article, when it is supported from the work holder, in the direction of its width as well as in the direction of its length, so that the complete motion imparted to the article is of a rotary or wavy nature.

It is also preferred that said pressing means act on each pad holder through a pivot which allows the pad holder to tilt, said pivot being arranged with its axis parallel to the lengthwise direction of a blade-like article when it is mounted in the work holder. This pivot allows the pad holder to tilt to maintain its pad or an interposed strip of polishing material in contact with the whole width of the blade-like article.

In the preferred machine according to the invention each pad holder is pivoted to an arm which in turn is pivoted about an axis lying in a plane in which the mean plane between the side surfaces of the blade-like article lies when the article is supported from the work holder, the pivot axes of the pad holder and of the arm extending parallel to the lengthwise direction of the article when it is supported in the work holder. This is done so that the surfaces of the pads approach the blade-like article as nearly as possible normally to its surfaces.

A machine in accordance with the invention for use in polishing the front and back surfaces of axial flow turbine blades will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a front elevation of the machine with certain parts removed for the sake of clarity,

Figure 2 is a side elevation of the machine shown in Figure 1, and showing a tubine blade supported from the work holder,

Figure 3 shows in plan the stacks of pad holders holding pads, these being in an operative position in relation to a turbine blade,

Figure 4 is a partial elevational cross-section on line 4—4 of Figure 3, and

Figure 5 is a view of Figure 3 in the direction of arrow 5.

Referring to Figures 1 and 2 of the drawings, the machine comprises a casing 11 upon which a table 12 is mounted, the height of which is adjustable by means of a pair of vertical slides 13 in which the table supporting structure 14 is bolted. The weight of the table is balanced by a pair of chains 15, which pass over a pair of pulleys 16 mounted within the casing 11, and a number

of weights 17 suspended on the end of the chain opposite to that connected to the table.

The machine has a workholder 18 disposed above the table 12, in which a chuck 19, to grip the root of a blade 10, may be mounted. The work holder 18 is forked and carries a horizontal pivot 18*a* (see Figure 2), upon which a chuck carrier 18*b* is pivotally mounted. The carrier 18*b* is provided with a slot 18*c* (Figure 1) to receive a "collar-stud" projection 19*a* on the chuck such that the chuck may also pivot about the longitudinal axis of the blade 10, the blade projecting vertically downwards as can be clearly seen from Figure 2. The chuck 19 is supported for movement vertically and transversely approximately in the mean plane of the blade 10, in transverse and vertical slides 20 and 21 respectively.

These movements are controlled by the setting of two eccentrics, one 22 associated with the transverse slide 20 and the other 23 associated with the vertical slide 21. Connecting rods 24 and 25 connect the eccentrics 22 and 23 with their respective slide blocks. The eccentrics are of adjustable throw and are driven by a single electric motor 26 (see Figure 2). A pulley 27 is mounted on the motor shaft 28 and through belt 30 drives a pulley 29 mounted on a shaft 31, upon the opposite end of which the eccentric 23 associated with the vertical slide 21 is mounted. For each reciprocation of the transverse slide 20 there are preferably a number of reciprocations of the vertical slide 21 so that the total motion imparted to the chuck 19 is of a rotary or wavy nature; for example, for polishing aluminum blades the preferred ratio is approximately 5:1, while for polishing steel blades the preferred ratio is approximately 8:1. It is therefore necessary to provide a reduction gear box 32 to obtain the desired ratio. A pulley 33 mounted on the shaft 28 drives an input pulley 34, associated with the reduction gear box 32, by means of a belt 35. A gear wheel 36 on the output shaft of the reduction gear box drives a second gear wheel 37 drivingly mounted on one end of a shaft 38, the other end of which carries the eccentric 22 associated with the transverse slide 20.

The blade 10 is mounted in the chuck 19 so that the mean plane of the blade lies approximately transversely of the machine, as seen by an operator standing in front of it.

Referring more especially now to Figure 3, the machine table 12 supports a rear part 39 which is fixed thereto by set screws, and a front part 40 which is slidable to move forwardly or rearwardly (i. e. towards or away from the operator). This movement is controlled by a pneumatic jack 41 (Figure 2), the plunger 42 of which is connected to a slide 43 upon which the front part 40 is mounted. Parts 39 and 40 each support a stack of pad holders generally indicated at 44 and 45 respectively, the two stacks being brought together on operation of the pneumatic jack 41 (i. e. the front part 40 is moved towards the rear part 39) and stacks 44 and 45 (complete with pads) co-operate to polish the front and rear faces of the blade 10 when it is reciprocated between them.

When it is required to remove the blade 10 from the machine, the front part 40 is moved back towards the operator by operation of the pneumatic jack 41 to an inoperative position.

Referring now to Figures 3, 4 and 5, spaced from the leading and trailing edges of the blade 10 and lying approximately in its mean plane are two vertical shafts 47 and 48 carried respectively by the front and rear parts 40, 39, and on each shaft is journalled a stack of arms 49 and 50 respectively each arm being L-shaped. The arms are journalled at the extremities of their shorter limbs and the longer limbs of the arms of the two stacks extend transversely of the machine in opposite directions respectively behind and in front of the blade 10. The extremities of the longer limbs are supported by guide posts 51 and 52 carried by the respective front and rear parts 40, 39 and provided with spaced grooves 53 in which the extremities slide horizontally. In the machine being described, nine such arms in each stack are provided spaced over the full height of the working part of the blade 10.

Opposite the middle of the width of the blade 10 each arm 49, 50 is connected by a pivot pin 54 to a pad-holder 55 comprising a block provided with a groove 56 in one face 57 to receive the arm, and with a substantially box-like recess 58 in the opposite face 59 to receive a rubber pad 60 which is greater in width than the blade at the chordwise section at which the pad is positioned. The pivot pins 54 have their axes parallel to the lengthwise direction of the blade 10 when it is mounted in the chuck 19. Each pad 60 and its associated pivot pin 54 are retained in place by top and bottom plates 105 secured to the block by countersunk screws, the total thickness of the blocks and cover-plates being slightly less than the spacing of the arms 49, 50 to provide a suitable working clearance between adjacent pad holders 55. As will be seen from Figure 4, the intermediate cover-plates 105 are made very thin so that the exposed faces 89 of the pads later referred to compose substantially the whole of a surface corresponding to one side surface of the blade 10.

Each rubber pad 60 is also retained in the recess 58 by a stiff coil spring 61 which extends transversely through the pad approximately parallel to the mean plane of the blade 10 and at right angles to its lengthwise direction, and fits in seatings on either side of the recess 58. The spring thus acts as a resilient beam supported at it ends by the block. In this way a certain wrapping effect of the pads 60 around the curved profile of the blade 46 is obtained, this helping to maintain an equal bearing pressure over the whole exposed face of the pad. To increase the resilience of the pad a piece of sorbo rubber, i. e., rubber having a cellular sponge-like quality, may be inserted in the recess 58 behind the pad.

The exposed face 89 of each pad is shaped to conform to the profile of the blade 10 at the particular section at which it is located. The rubber pads 60 of the front part 40 are mounted with their exposed faces 89 directed away from their holders and facing the exposed faces of the pads 60 of the rear part 39, which are also directed away from their holders, and the exposed faces of each stack of pads lie in a surface conforming in shape to the whole of the front and back surfaces of the blade 10 respectively.

The uppermost rubber pads 60 and lowermost pad holders 55 of each stack 44, 45 are provided with metal pins or spikes 90 for supporting strips of felt constituting polishing pads 91, one over the exposed faces 89 of each stack of pads 60. It will also be seen that the top and bottom cover plates 105 respectively of the top and bottom pad holders 55 of each stack are each provided with a hinge clamp 92 for securing a strip of emery cloth 95 over the felt pads 91. The emery cloth is used for preliminary polishing and is removed to permit finish polishing by the felt pads 91 employing a suitable abrasive material. Both the emery cloth and felt pads 91 are somewhat wider than the blade 10 so that they together wrap completely round it.

To allow the pad holders 55 to tilt about their pivot pins 54 and thereby reduce the deformation of the rubber and felt pads necessary to maintain the faces of the felt pads (or the emery cloth strips) in contact with the whole width of the blade, the arms 49, 50 do not extend to the bottom of the grooves 56 in the pad holders 55, the clearance preferably being increased with distance from the pivot pins 54 by suitably tapering the arms 49, 50 as shown in Figure 3. Towards each end of each groove 56 a coil spring 68 is suitably seated in the groove, at right angles thereto, and bears at its opposite end on the arm so that the pair of coiled springs, one on each side of the pivot pin 54, serves to align the pad holder with respect to the arm.

Mounted upon each part 39, 40 between the vertical shaft 47, 48 and the guide post 51, 52 is a block 63, the stacks of arms 49, 50 lying between the two blocks. Each block has one horizontal bore 64 (see Figure 4) in the plane of, and directed towards, each of the L-shaped arms 49 or 50 of the adjacent stack 44 or 45. Each bore 64 is provided at its end remote from the arm with a screw threaded abutment 65 for a coil spring 66, the other end of which bears upon a plunger 67 having an end projecting from the block 63 into contact with the respective arm and constituting pressing means to press the arm towards the other stack of arms. Adjustment of the abutments 65 thus permits the pressures with which the pads are applied to the blade 46, either directly or indirectly, to be set individually.

When operating the machine a strip of emery cloth 95 is attached to both stacks of pad holders 44, 45 over the felt pads 91. A blade is inserted in the chuck 19 and the movable part 40 is moved into its working position by the pneumatic jack 41 so that the blade is gripped between the opposed strips of emery cloth. The driving motor 26 is started to oscillate the blade vertically and transversely. During this movement the pad-holders 55 tilt slightly about their pivot pins 54 so that uniform polishing pressure is maintained over the whole surface of the blade. This is continued for a desired time to complete preliminary polishing whereupon the machine is stopped, the part 40 moved away from part 39 and the blade is removed. The emery cloth will serve to polish a large number of blades before requiring renewal. For the final polishing process the emery cloth is removed, the blade is immersed in a viscous mixture of oil and powdered abrasive such as emery so as to apply a thin coating of the mixture to it, and is re-inserted in the chuck. The movable part 40 is again moved into its working position so that the blade is gripped between the two opposed felt pads 91 and the machine is started as before to perform the final polishing operation.

The unit 100 with the dial on the upper left-hand side of Figure 1 is a cycle timer which may be set by adjustment of its pointer to a desired cycle time so that the machine is automatically stopped on completion of the cycle. The unit 100 is self resetting. The dial 101 on the right of Figure 1 records the air pressure for operating the pneumatic jack 41.

The eccentrics 22, 23, the connecting rods 24, 25 and the slides 20, 21 are covered by a protective casing or guard 102 removably attached to the casing 11 as at 103.

The pads 60, instead of being made of rubber, may be composed of wool felt, in which case the pads may bear directly on the blade during a final polishing operation. It is preferred to have an interposed polishing pad such as 91 however, or an interposed strip of felt clamped across the exposed faces of the pads in each stack like the emery cloth strips which have been described, because the gap between the adjacent pads 60 is then bridged, giving a more even polishing with a small vertical oscillation of the blade.

The use of rubber pads 60 is also preferred, although a felt pad such as 91 can be used over felt pads 60, because rubber pads have a greater degree of resilience then felt pads. If felt pads 60 are used, these are mounted on transverse springs 61 which give them a certain amount of resilience in relation to their holders which is essential. The need for mounting the rubber pads 60 on springs 61 is not, however, necessary, and instead the rubber pads 60 may be dove-tailed into their holders, the resilience of the pads themselves being relied on to give the necessary resilience between the exposed faces 89 of the pads and the pad holders.

I claim:

1. A polishing machine for polishing the two side surfaces of a blade-like article, said machine comprising a base structure, a work holder carried from said base structure for supporting a blade-like article, the side surfaces

of which are to be polished, in a workpiece position with the length dimension of the article in a fixed direction relatively to said support structure and with said side surfaces exposed for polishing by the machine, means for linearly oscillating said workholder in said fixed direction, two opposed stacks of pad holders carried by said base structure, one on each side of said workpiece position, each of said stacks of pad holders comprising a support means, a plurality of pad holders carried by said support means so as to be distributed in side by side relation in said fixed direction and so as to be individually movable towards and away from the workpiece position, and for each pad holder a resilient means engaged between the pad holder and an abutment carried from said support structure for urging the pad holder individually towards the workpiece position, a polishing pad mounted in each pad holder, each pad having an exposed face directed away from its holder, the exposed faces of the pads in one stack forming substantially the whole of a surface conforming in shape and extent to the whole of one side surface of a blade-like article to be polished, and the exposed faces of the pads in the other stack forming substantially the whole of a surface conforming in shape and extent to the whole of the other side surface of such a blade-like article, said stacks of pad holders being spaced apart, at least far enough to enable a blade-like article mounted in said work holder to be accommodated between the stacks with the blade-like article gripped between two stacks of pads with one of its side surfaces facing towards the pads in one of the stacks and the other of its side surfaces facing towards the pads in the other of the stacks.

2. A machine as claimed in claim 1, wherein, during operation, the exposed faces of the pads are spaced from the side surfaces of a blade-like article when it is supported from said work holder, the machine further comprising a pair of strips of polishing material one located over all the exposed faces of the pads in one of the stacks and the other located over all the exposed faces of the pads in the other of the stacks so that when a blade-like article is mounted in the work holder there is a strip of polishing material sandwiched between the blade-like article and each stack of pads.

3. A machine as claimed in claim 1, wherein each pad holder has means for supporting the ends of a resilient beam on which its pad is mounted, said beam end support means being arranged to support the beam at right angles to the lengthwise direction of a blade-like article which is supported from the work holder.

4. A machine as claimed in claim 3, wherein said resilient beam comprises a stiff coiled spring which passes through a bore in the pad, and which has its ends projecting from the pad and retained in seatings in the pad holder.

5. A polishing machine for polishing the two side surfaces of a blade-like article, said machine comprising a base structure, a work holder carried from said base structure for supporting a blade-like article, the side surfaces of which are to be polished, in a workpiece position with the length dimension of the article in a fixed direction relatively to said support structure and with said side surfaces exposed for polishing by the machine, means for linearly oscillating said work holder in said fixed direction, two opposed stacks of pad holders carried by said base structure, one on each side of said workpiece position, each of said stacks of pad holders comprising a support means, a plurality of pad holders carried by said support means so as to be distributed in side by side relation in said fixed direction and so as to be individually movable towards and away from the workpiece position and for each pad holder a resilient means engaged between the pad holder and an abutment carried from said support structure for urging the pad holder individually towards the workpiece position, said stacks of pad holders being spaced apart at least far enough to enable a pad mounted

in each holder and a blade-like article mounted in said work holder to be accommodated between the stacks of pad holders with the blade-like article gripped between the two stacks of pads with one of its side surfaces facing towards the pads in one of the stacks and the other of its side surfaces facing towards the pads in the other of said stacks.

6. A machine as claimed in claim 5, wherein at least one of said stacks of pad holders and the abutments of the resilient means of said one of said stacks of pad holders are movable together in relation to the work holder to an inoperative position to facilitate the mounting of a blade-like article in the machine and also its removal therefrom.

7. A machine as claimed in claim 6, wherein said one of said stacks of pad holders and the abutments of the resilient means thereof are mounted on said base structure in a slide so as to be movable away from the workpiece position when it is required to mount a blade-like article in the machine and to remove a blade-like article from the machine.

8. A machine as claimed in claim 5, wherein means is provided for imparting to said work holder a simultaneous oscillation to move a blade-like article, which is supported from the work holder, in the direction of its width as well as in the direction of its length.

9. A machine as claimed in claim 8, wherein each of said oscillation imparting means includes an adjustable throw eccentric, said eccentrics being drivable from a common motor.

10. A polishing machine as claimed in claim 5, wherein said pressing means act on each pad holder through a pivot disposed so as to lie substantially centrally of the width of a pad mounted in the holder, said pivot being arranged with its axis parallel to the lengthwise direction of a blade-like article which is supported from the work holder and allowing the pad holder to tilt about said axis.

11. A polishing machine as claimed in claim 5, wherein each pad holder is pivoted to an arm by means of a pivot disposed so as to lie substantially centrally of the width of a pad mounted in the holder and the arm is in turn pivoted about an axis lying in a plane in which the mean plane between the side surfaces of a blade-like article lies when the article is supported from the work holder, the pivot axes of the pad holder and of the arm extending parallel to the lengthwise direction of the article when it is supported from the work holder.

12. A polishing machine as claimed in claim 11, wherein a pair of springs is provided between each pad holder and the arm to which it is pivoted, said springs being positioned one on each side of the pivot connection between the pad holder and the arm and acting on the pad holder to align the pad holder with the arm.

13. A polishing machine as claimed in claim 11, wherein the arms of the pad holders in each stack are pivoted about a common axis lying at one end of the arms, the arm axes pertaining to the respective stacks lying on opposite sides of the work holder, and wherein each arm is supported at its free end by guide means on which it is able to slide.

14. A polishing machine as claimed in claim 13, wherein each arm is L-shaped and is pivoted towards the free end of one of its limbs, the free end of the other of its limbs being supported in said guide means.

15. A polishing machine as claimed in claim 11, wherein said pressing means each comprises an adjustable spring-loaded plunger bearing upon one of said arms.

16. A polishing machine for polishing the two side surfaces of a twisted aerofoil sectioned blade, said machine comprising a base structure, a work holder carried from said base structure for supporting a blade, the side surfaces of which are to be polished, in a workpiece position with the length dimension of the blade in a fixed direction relatively to said support structure and with said side surfaces exposed for polishing by the machine, means for linearly oscillating said work holder in said fixed direction, two opposed stacks of pad holders carried by said base structure, one on each side of said workpiece position, each of said stacks of pad holders comprising a support means, a plurality of pad holders carried by said support means so as to be individually movable towards and away from the workpiece position, and for each pad holder a resilient means for urging the pad holder towards the workpiece position, said stacks of pad holders being spaced apart at least far enough to enable a pad mounted in each holder and a blade mounted in said work holder to be accommodated between the stacks of pad holders with the blade gripped between the two stacks of pads with one of its side surfaces facing towards the pads in one of the stacks and the other of its side surfaces facing towards the pads in the other of said stacks.

17. A polishing machine for polishing the two side surfaces of a twisted aerofoil sectioned blade, said machine comprising a base structure, a work holder carried from said base structure for supporting a blade, the side surfaces of which are to be polished, in a workpiece position with the length dimension of the blade in a fixed direction relatively to said support structure and with said side surfaces exposed for polishing by the machine, means for linearly oscillating said workholder in said fixed direction, two opposed stacks of pad holders carried by said base structure, one on each side of said workpiece position, each of said stacks of pad holders comprising a support means, a plurality of pad holders carried by said support means so as to be individually movable towards and away from the workpiece position, and for each pad holder a resilient means for urging the pad holder towards the workpiece position, a polishing pad mounted in each pad holder, each pad having an exposed face directed away from its holder, the exposed faces of the pads in one stack forming substantially the whole of a surface conforming in shape and extent to the whole of one side surface of a blade to be polished, and the exposed faces of the pads in the other stack forming substantially the whole of a surface conforming in shape and extent to the whole of the other side surface of such a blade, said stacks of pad holders being spaced apart, at least far enough to enable a blade mounted in said work holder to be accommodated between the stacks with the blade gripped between the two stacks of pads with one of its side surfaces facing towards the pads in one of the stacks and the other of its side surfaces facing towards the pads in the other of the stacks.

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