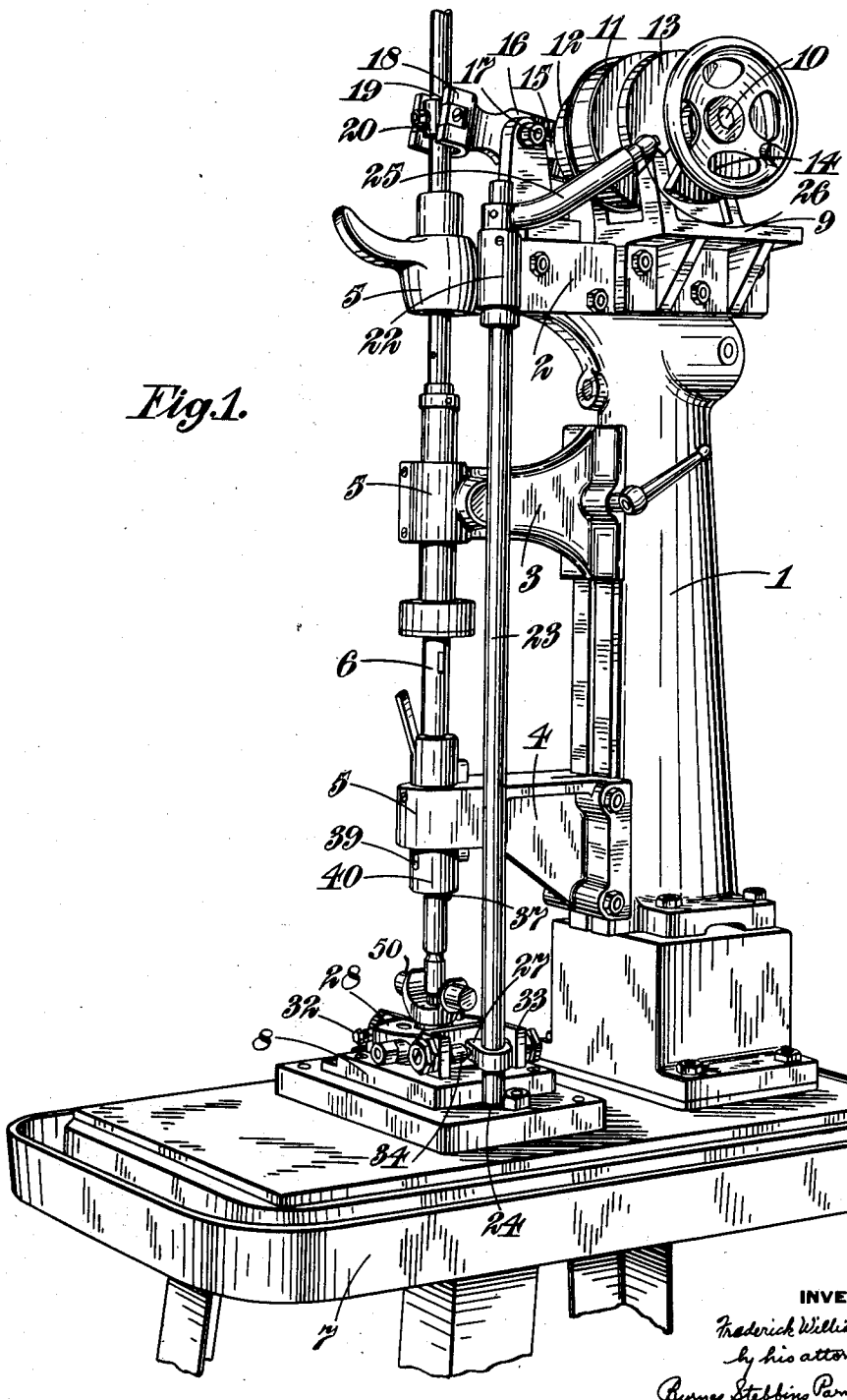
Jan. 15, 1935. F. W. TRENDELL 1,988,025

APPARATUS FOR SURFACE FINISHING THE SIDE WALLS OF SLOTS

Filed May 12, 1933 3 Sheets-Sheet 1

Fig.1.



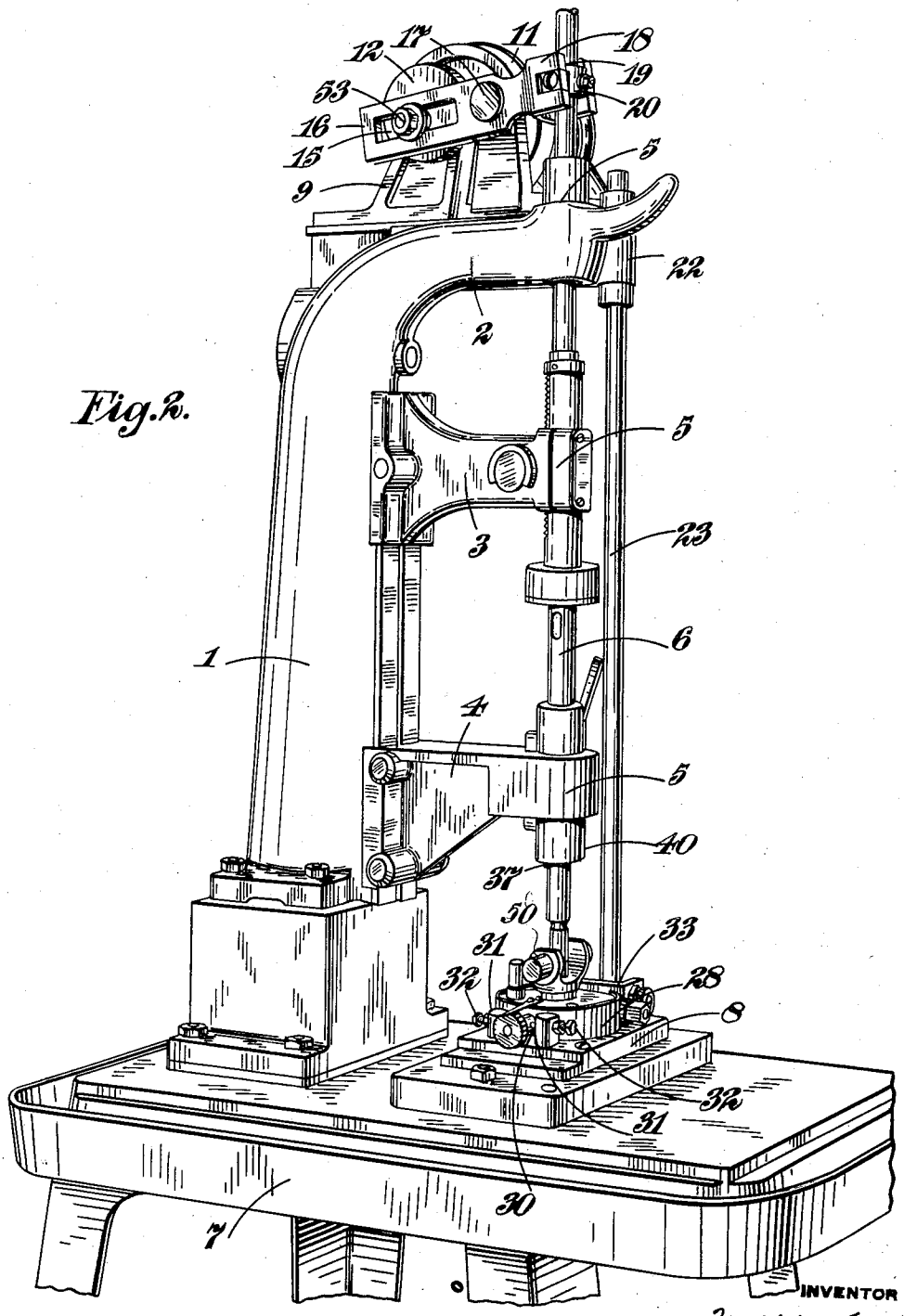
INVENTOR
Frederick William Trendell
by his attorneys
Byrnes, Stebbins, Parmelee & Blenko

Jan. 15, 1935. F. W. TRENDELL 1,988,025

APPARATUS FOR SURFACE FINISHING THE SIDE WALLS OF SLOTS

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Fig. 2.



INVENTOR

Frederick William Trendell

by his attys

Byrnes, Stebbins, Parmelee & Blenko

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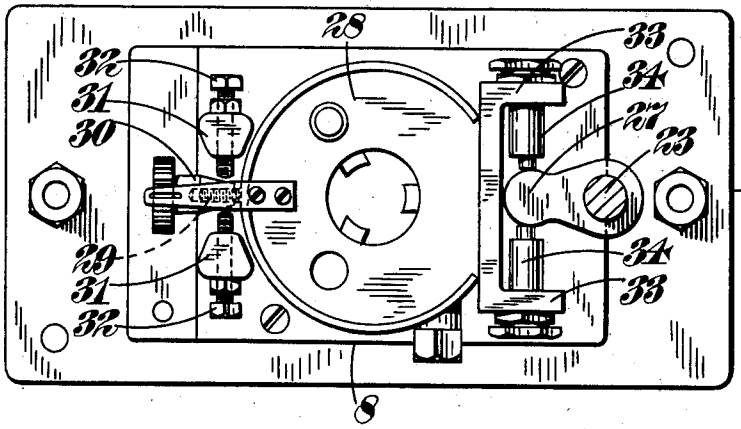


Fig.3.

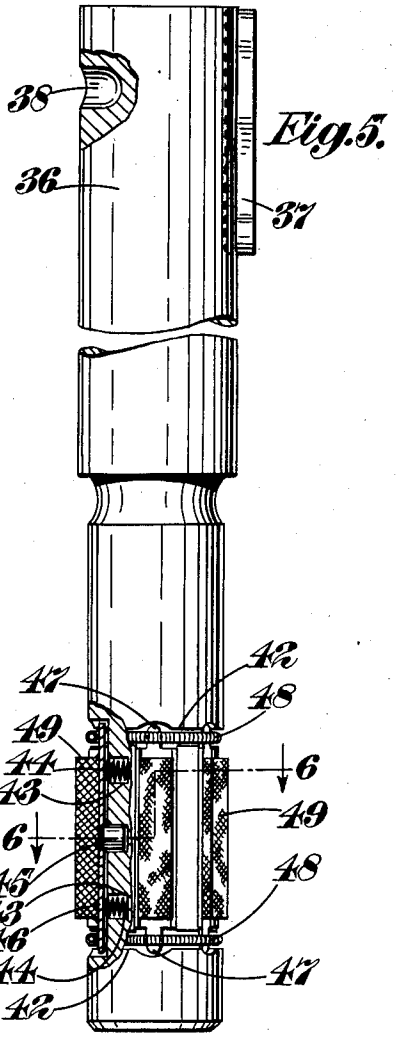


Fig.5.

Fig.4.

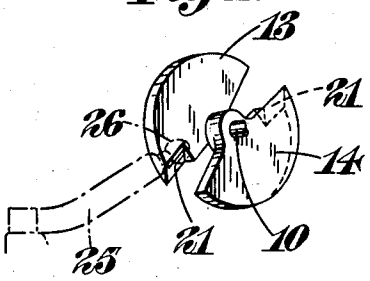
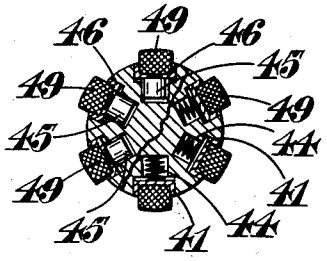


Fig.6.



INVENTOR

Frederick William Trendell

by his attys

Byrne Stebbins Parmelee & Banks

Patented Jan. 15, 1935 1,988,025

UNITED STATES PATENT OFFICE

1,988,025

APPARATUS FOR SURFACE FINISHING THE SIDE WALLS OF SLOTS

Frederick William Trendell, London, England, assignor to Clement Talbot Limited, London, England, a British company

Application May 12, 1933, Serial No. 670,711
In Great Britain September 29, 1932

12 Claims. (Cl. 51—59)

This invention is for improvements in or relating to the abrading or finishing of slots, keyways, splines or the like in metal parts, and particularly slots or the like which are to be formed within a bore.

According to this invention, slots or the like in an unfinished state in the work, are subjected to a finishing operation which comprises the insertion of an abrading tool (e. g. an abrasive stone) into the slot, effecting constant pressure, preferably resilient pressure, of the tool against a side of the slot and effecting by mechanical means relative reciprocatory movement between the work and said tool in a direction along the length of the slot. It will be appreciated that the above finishing operation is particularly suitable to finishing slots which have been formed in full size in a steel work-piece which is subsequently subjected to a hardening process. Hardening processes usually distort the work and a feature of the invention consists in that the mechanical abrading operation is carried out on the hardened metal.

A further feature of the invention consists in that one side of a slot is operated upon by the abrading tool during one stroke of the reciprocatory movement, while the other side of the slot is operated upon during the return stroke of said movement.

A machine for carrying out the process described above comprises a work-holder, a tool-holder having means for securing thereto one or more abrading tools positioned so as to enter the slot or slots in the work, and means for effecting relative reciprocatory movement between the tool-holder and the work along the length of the slot. Preferably, the work-holder is secured to a fixed part of the machine and the tool-holder is reciprocated, but it will be appreciated that the reverse arrangement might also be employed.

A further feature of the invention consists in that the abrading tool is resiliently mounted in the tool-holder so as to be capable of movement in a direction towards or away from the bottom of the slot which is to be machined.

A still further feature of the invention consists in that means are provided for effecting relative oscillatory movement between the work-holder and tool-holder about an axis parallel with the axis of reciprocation, the degree of movement of which oscillatory motion is such that the abrading tool is brought alternately into contact with the two sides of the slot in the work-piece.

A still further feature of the invention consists in that one half of said oscillatory movement is arranged to take place towards one end of the reciprocatory movement, while the other half of the oscillatory movement is arranged to take place towards the end of the other stroke of the reciprocatory movement.

A still further feature of the invention consists in that means are provided for adjusting the extent of the oscillatory movement and/or the extent of the reciprocatory movement..

A still further feature of the invention consists in that the sides of the abrading tool which are arranged to engage the sides of the slot are so shaped as to converge as they extend away from the tool holder in order that they may be disposed in the same plane as the sides of the slot at the limits of the oscillatory movement.

The following is a description of one embodiment of the invention as applied to a machine for finishing internal splines in a cylindrical bore of a work piece—reference being made to the accompanying drawings, in which—

Figure 1 is a perspective side elevation of the machine;

Figure 2 is a perspective elevation of the opposite side of the machine to that of Figure 1;

Figure 3 is a plan view of the work holder;

Figure 4 is a detail view of the cam mechanism for operating the shafts which control the movement of the work holder;

Figure 5 is a part elevation and part section of the tool holder; and

Figure 6 is a section on the cranked line 6—6 of Figure 5.

As shown in Figures 1 and 2, the machine comprises an upright pillar 1 having upper, intermediate and lower overhanging arms 2, 3 and 4 respectively, which carry bearings 5 for accommodating a vertical reciprocable shaft 6. The pillar is mounted on a base-plate 7 to which is also secured a work holder 8 immediately beneath said reciprocable shaft. Mounted upon the top of the pillar and upon the upper overhanging arm is a bearing cradle 9 which carries a rotatable horizontal shaft 10. Secured to the centre of the shaft is a driving pulley 11, while at one end of the shaft there is secured a disc 12 and crank pin 53 (best seen in Figure 2) and at the other end two cam plates 13, 14 (best seen in Figures 1 and 4). The aforesaid crank pin is arranged to engage a slot 15 in a lever arm 16 which is pivotally mounted at 17 to oscillate in a vertical plane, one end of which lever arm is forked at 18 and is connected by a universal joint 19 to

a part 20 of the aforesaid reciprocable shaft which extends above the upper overhanging arm.

The two aforesaid cam plates comprise segmental discs including an angle slightly less than 180°, which segmental discs are spaced apart and are so disposed that their adjacent flat faces are nowhere opposite one another. The leading radial edge of each disc is bevelled at 21 for the purpose hereinafter described. Also carried on the upper overhanging arm is a bearing 22 in which is rotatably mounted a vertical shaft 23 which extends downwardly to the work-holder where it is mounted in a second bearing 24. A crank arm 25 is fixed to the upper extremity of said vertical shaft and extends to a location between the flat faces of said cam plates. A roller 26 is mounted at the end of said arm. The planes of the opposed faces of the cam plates are arranged at a distance apart less than the diameter of the roller, so that when the roller is engaged by a bevel-leading edge of one plate it is moved toward the plane of the face of the other plate, whereby the roller is first moved into contact with one flat face and then into contact with the other flat face, whereby said vertical shaft is operated. The lower end of the vertical shaft is provided with another crank-arm 27 which is arranged to engage the work-holder in the manner hereinafter set forth. The work-holder comprises a chuck 23 (see Figure 3) which is mounted so as to be capable of a limited rotational movement about a vertical axis. For this purpose, the chuck is provided with a downwardly-extending shank which is mounted in a bearing in the work holder 8 and is also provided with a radially extending screw-threaded stud 29 which is engaged by an externally tapered sleeve 30 having an internally threaded bore. The tapered sleeve is arranged to extend between two uprights 31 secured to a fixed part of the work-holder. An adjusting screw 32 is arranged to extend through each upright towards said tapered sleeve. It will be seen with this arrangement that the oscillatory movement of the chuck may be adjusted to within rough limits by said adjusting screws, and to within fine limits by rotating said tapered sleeve so as to move different parts of the taper into the path of travel of the adjusting screws. On the opposite side of the chuck to that of the tapered sleeve, there is mounted a forked member 33 from the inside faces of each arm of which extends a spring buffer. The two spring buffers 34 are arranged to grip the ends of the lever arm 27 which is mounted at the lower extremity of the aforesaid vertical oscillatable shaft 23. The chuck is arranged to grip the work-piece which, for the purpose of illustration, may comprise a part of a universal joint 50 (see Figures 1 and 2) having a shank with internal splines.

The tool-holder (see Figures 5 and 6) comprises a shank 36, the upper end of which is provided with a key 37 and a recess 38 which are arranged to engage a keyway and a plug 39 respectively arranged within a collar 40 secured to the end of the aforesaid reciprocable vertical shaft. The other end of the tool-holder is formed with a number of longitudinal slots 41, and with circumferential slots 42 one at each end of the longitudinal slots. Three holes 43 are formed in the bottom wall of each longitudinal slot and the two outer holes are arranged to accommodate helical compression springs 44 while the centre hole 45 in each slot is arranged to engage a shank formed on a holder 46 for an abrading element 49. The abrading element may comprise a substance sold under the trade name of "India oil stone". The oil stone is cut into required lengths and of a width slightly less than the width between the splines which it is required to finish. The holder comprises a channel-sectioned strip (best seen in Figure 6) having a length about equal to the length of the longitudinal slot in the tool-holder, and having at each end lugs 47 (best seen in Figure 5) which are arranged to project into the circumferential slots in said tool-holder. The pieces of oil stone are secured in the channel-section by means of shellac. The holder is a snug fit in said longitudinal slot and is held in position by spring rings 48 which engage the aforesaid lugs, which spring rings are accommodated in the circumferential groove 42. The helical compression springs are arranged to force the oil stone outwardly against the tension of the spring rings. As intimated earlier in the specification, the side faces of the pieces of oil stone are so shaped as to lie flat against the sides of the splines to be finished. The tool-holder may be provided with the same number of pieces of oil stone as there are splines to be finished, or a sub-multiple thereof, in which case after one set of splines has been finished, the work is rotated in the work-holder until a new set of splines are positioned in the path of travel of the oil stones.

It will be appreciated that many modifications may be made to details of the above construction without departing from the scope of the invention; for example, the combined reciprocatory movement and oscillatory movement may be given to the tool-holder only, or to the work-holder only. Also, instead of effecting an oscillatory movement at the end of each reciprocating stroke, a number of reciprocatory strokes might be effected before oscillation is effected.

I claim:—

1. An apparatus for surface finishing the two side walls of a slot comprising a tool having an abrasive element adapted to fit into said slot, means for effecting reciprocatory motion between said abrasive element and slot along the length of the slot, a resiliently yielding transmission member for effecting oscillatory movement between the abrasive element and the slot so that one side of the slot is brought under resilient pressure into engagement with the abrasive element during a forward stroke of the reciprocatory movement and the other side is brought under resilient pressure during the return stroke and means for adjusting the extent of movement of the transmission member whereby a required width of finished slot is obtained.

2. An apparatus for surface finishing the two side walls of a slot formed in a cylindrical bore of a work piece comprising a work holder, a tool having an abrasive element adapted to fit into said slot, means for reciprocating said tool along the length of the slot, means for rotatably oscillating said work holder about the axis of the cylindrical bore in the work piece so that one wall of the slot is abraded on the outward stroke and the other wall is abraded on the return stroke, and means for adjusting the extent of oscillatory movement of the work holder whereby a required width of finished slot is obtained.

3. An apparatus for surface finishing the two side walls of a slot formed in a cylindrical bore of a work piece comprising a work holder, a tool having an abrasive element adapted to fit into said slot, means for reciprocating said tool along the length of the slot, means for rotatably os-

cillating said work holder about the axis of the cylindrical bore in the work piece so that one wall of the slot is abraded on the outward stroke and the other wall is abraded on the return stroke, a projection fixed to the work holder and extending away from the axis of said bore, two abutments arranged on a fixed part of the apparatus one on either side of said projection and adjustable in the direction of travel of said projection whereby its extent of travel is adjusted and a required width of finished slot is obtained.

4. An apparatus for surface finishing the two side walls of a slot formed in a cylindrical bore of a work piece comprising a work holder, a tool having an abrasive element adapted to fit into said slot, means for reciprocating said tool along the length of the slot, means for rotatably oscillating said work holder about the axis of the cylindrical bore in the work piece so that one wall of the slot is abraded on the outward stroke and the other wall is abraded on the return stroke, a projection fixed to the work holder and extending away from the axis of said bore, a taper member mounted on said projection and adjustable along the length thereof, two abutments arranged on a fixed part of the apparatus one on either side of said taper member and adjustable in the direction of travel of said projection where its extent of travel is adjusted and a required width of finished slot is obtained.

5. An apparatus for surface finishing the two side walls of a slot formed in a cylindrical bore of a work piece, comprising a work holder mounted to rotate about the axis of said bore, a tool having an abrasive element adapted to fit into said slot, means for reciprocating said tool along the axis of the bore, an oscillating transmission member, means for resiliently coupling said transmission member to said work holder so that one wall of said slot is brought under resilient pressure into engagement with the abrasive element on the outward stroke of said tool and the other wall is brought under resilient pressure into engagement with the abrasive element on the return stroke, and means for adjusting the extent of oscillatory movement of the work holder whereby a required width of finished slot is obtained.

6. An apparatus for surface finishing the two side walls of a slot formed in a cylindrical bore of a work piece comprising a work holder mounted to rotate about the axis of said bore, a tool having an abrasive element adapted to fit into said slot, means for reciprocating said tool along the axis of the bore, an oscillating transmission member, two spring buffers fixed on said tool holder one on either side of said oscillating transmission member so that one wall of said slot is brought under resilient pressure into engagement with the abrasive element on the outward stroke of said tool and the other wall is brought under resilient pressure into engagement with the abrasive element on the return stroke, and means for adjusting the extent of oscillatory movement of the work holder whereby a required width of finished slot is obtained.

7. An apparatus for surface finishing the two side walls of a slot formed in a cylindrical bore of a work piece, comprising a work holder mounted to rotate about an axis of said bore, a tool holder having an abrasive element adapted to fit into said slot, means for reciprocating said tool along the axis of the bore, a rotatably mounted shaft having two arms fixed thereto one of which is coupled to said tool holder and a rotatable cam member arranged to engage said other cam to oscillate said shaft and work holder one complete oscillation for each complete reciprocation of the tool holder so that one side of said slot is abraded during one stroke of the tool and the other side during the return stroke of the tool.

8. An apparatus for surface finishing the two side walls of a slot formed in a cylindrical bore of a work piece comprising a work holder mounted to rotate about an axis of said bore, a shaft mounted to reciprocate along said axis, a tool holder mounted on said shaft and having an abrasive element adapted to fit said slot, a rotatably mounted shaft arranged parallel with said reciprocable shaft, two arms fixed to said rotatable shaft one of which arms is coupled to the work holder, a driving shaft having mounted therein an eccentric and cam mechanism, which latter mechanism engages said second arm, link mechanism connecting said eccentric to the reciprocable shaft, which eccentric and cam mechanism are arranged so that one side of said slot is abraded during the forward stroke of said abrasive element and the other side of said slot is abraded during the return stroke.

9. An apparatus for surface finishing the walls of a plurality of splines in a bore of a work piece, comprising a tool having formed therein a plurality of longitudinal slots and circumferential slots at the ends of the longitudinal slots, a channel shaped carrier in each longitudinal slot which carriers are formed at each end with a lug projecting into a circumferential slot, a piece of abrasive material fixed in each carrier adapted to fit a channel between said splines, springs disposed between the back of each carrier and the bottom of the longitudinal slot and spring rings within the circumferential slots engaging said lugs, means for effecting relative reciprocating movement between the tool and the work and means for bringing first one side of each spline into engagement with abrasive material and then the other side.

10. An apparatus for surface finishing the two side walls of a slot in a work piece comprising a holder for said work piece, a tool having attached thereto a projecting block of abrasive material of less width than said slot, means for reciprocating said element in said slot, means for so oscillating said work holder that one side of the slot is brought into engagement under substantially constant pressure with the abrasive block during a forward stroke thereof and the other side of the slot is brought into engagement under substantially constant pressure with the abrasive block during the return stroke thereof.

11. An apparatus for surface finishing the two side walls of a slot in a work piece comprising a holder for said work piece, a tool having secured thereto a projecting block of abrasive material of less width than said slot, means for reciprocating said abrasive block in said slot, means for imparting oscillatory movement to said work holder through a resiliently yielding transmission member so that one side of the slot is brought under constant resilient pressure into engagement with the abrasive block during a forward stroke thereof and the other side of the slot is brought under constant resilient pressure into engagement with the abrasive block during the return stroke thereof.

12. An apparatus for surface finishing the side walls of an internally multi-splined work piece, comprising a work holder, a tool having secured thereto a plurality of projecting blocks of abrasive material adapted to engage said splines, means

for effecting relative reciprocatory movement between said abrasive blocks and said splines in the direction of the length of the splines, and means for effecting relative oscillatory movement between the abrasive blocks and the work holder at the commencement of said reciprocatory movement so that one side of each spline is abraded during one stroke of said reciprocation and then the other side of each spline is abraded during the return stroke.

FREDERICK WILLIAM TRENDELL.