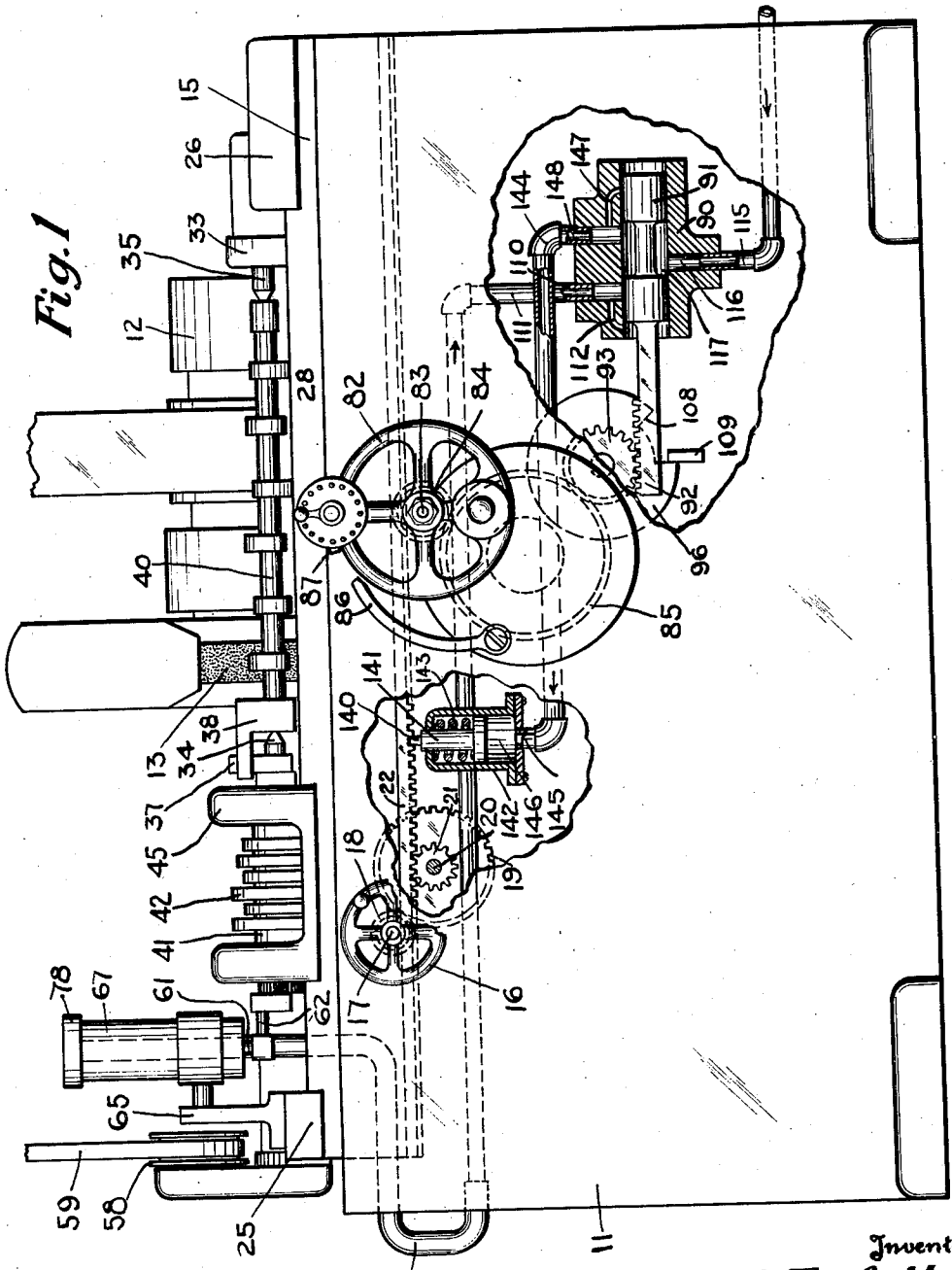
Dec. 2, 1930. C. G. TREFETHEN ET AL 1,783,755

GRINDING MACHINE

Filed June 29, 1927 4 Sheets-Sheet 1

Fig. 1



Witnesses

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GRINDING MACHINE

Filed June 29, 1927 4 Sheets-Sheet 2

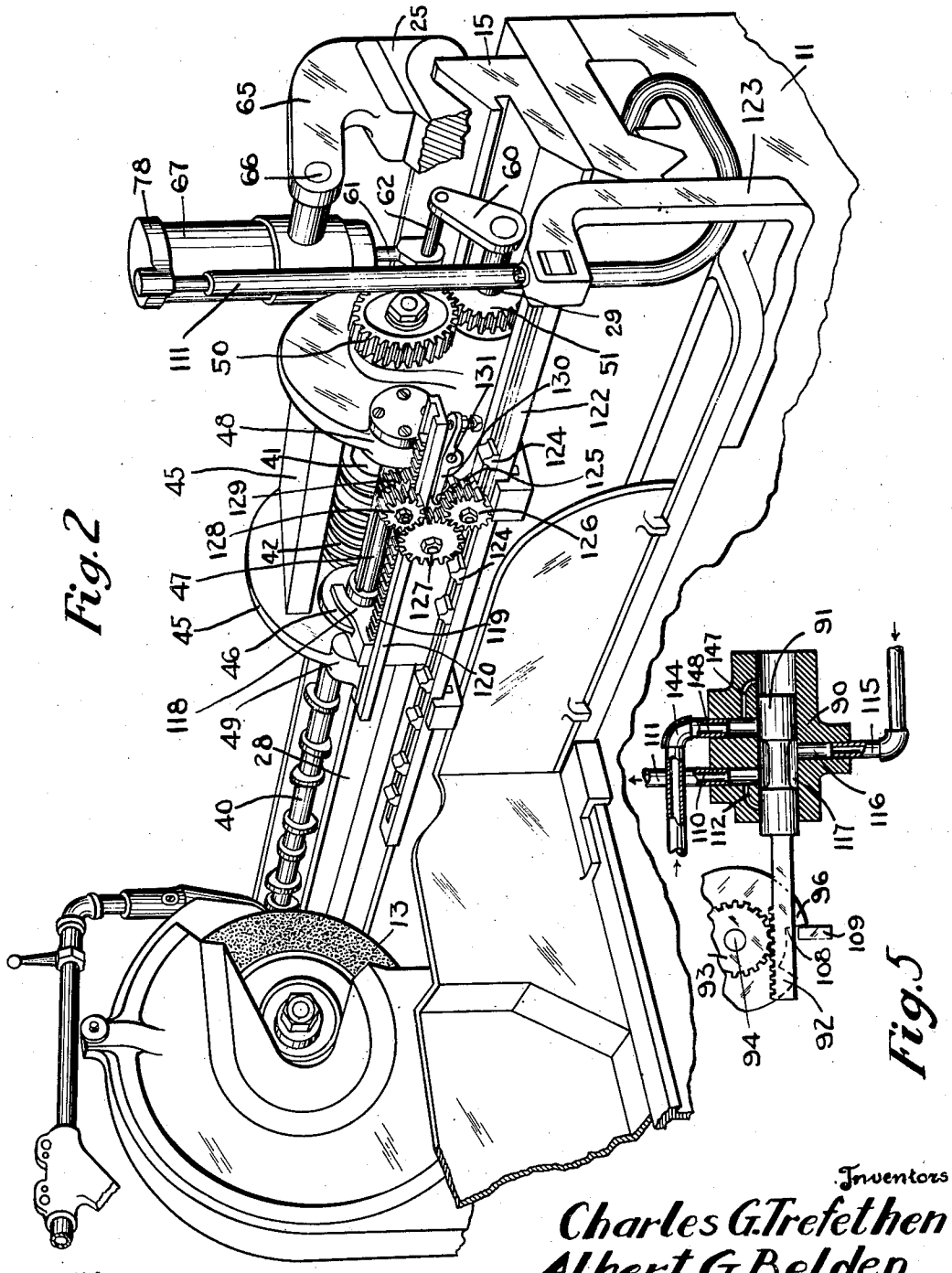


Fig. 2

Fig. 5

Witnesses
W R Greenwood
Harold W. Eaton

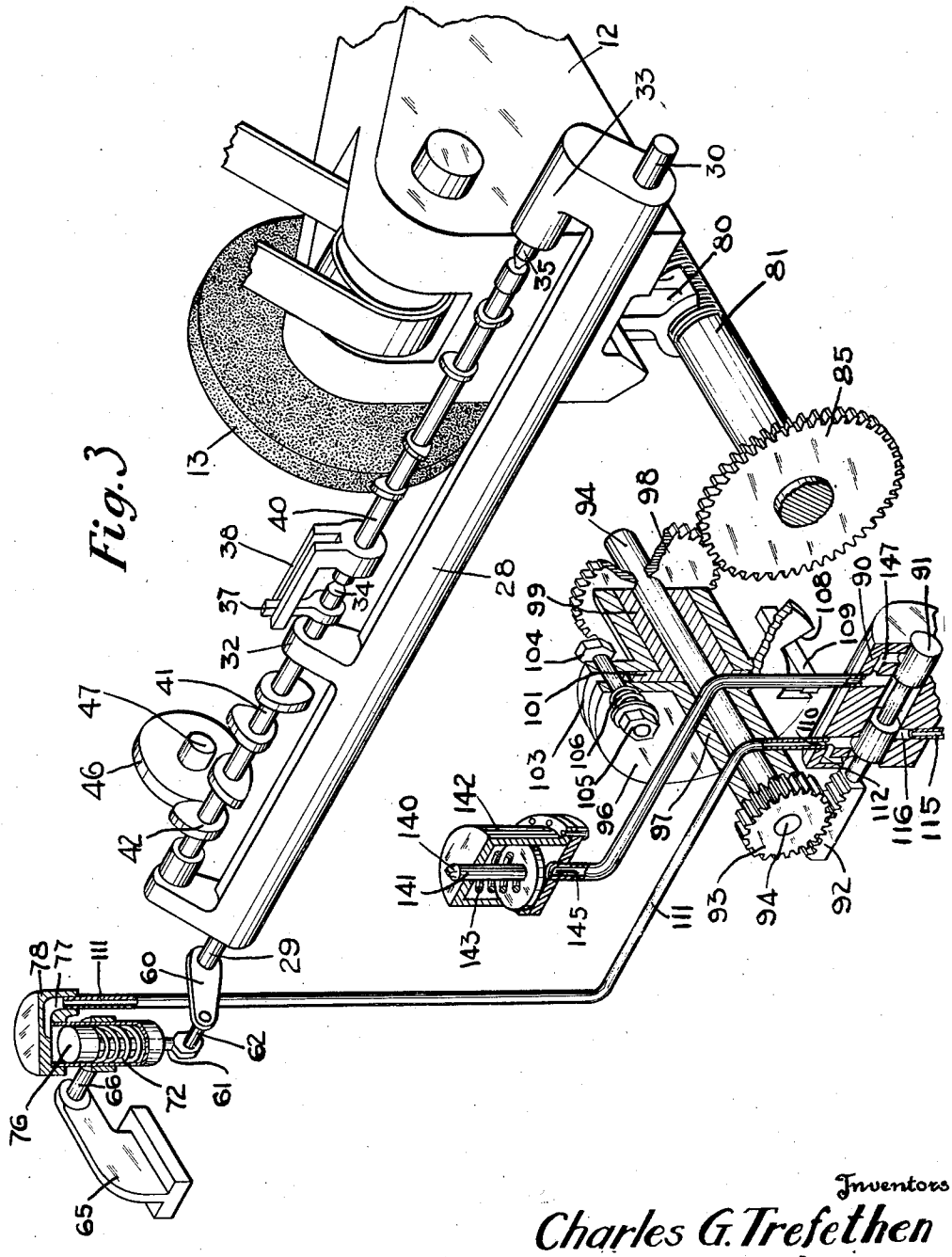
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GRINDING MACHINE

Filed June 29, 1927 4 Sheets-Sheet 3

Fig. 3



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Dec. 2, 1930. C. G. TREFETHEN ET AL 1,783,755

GRINDING MACHINE

Filed June 29, 1927 4 Sheets-Sheet 4

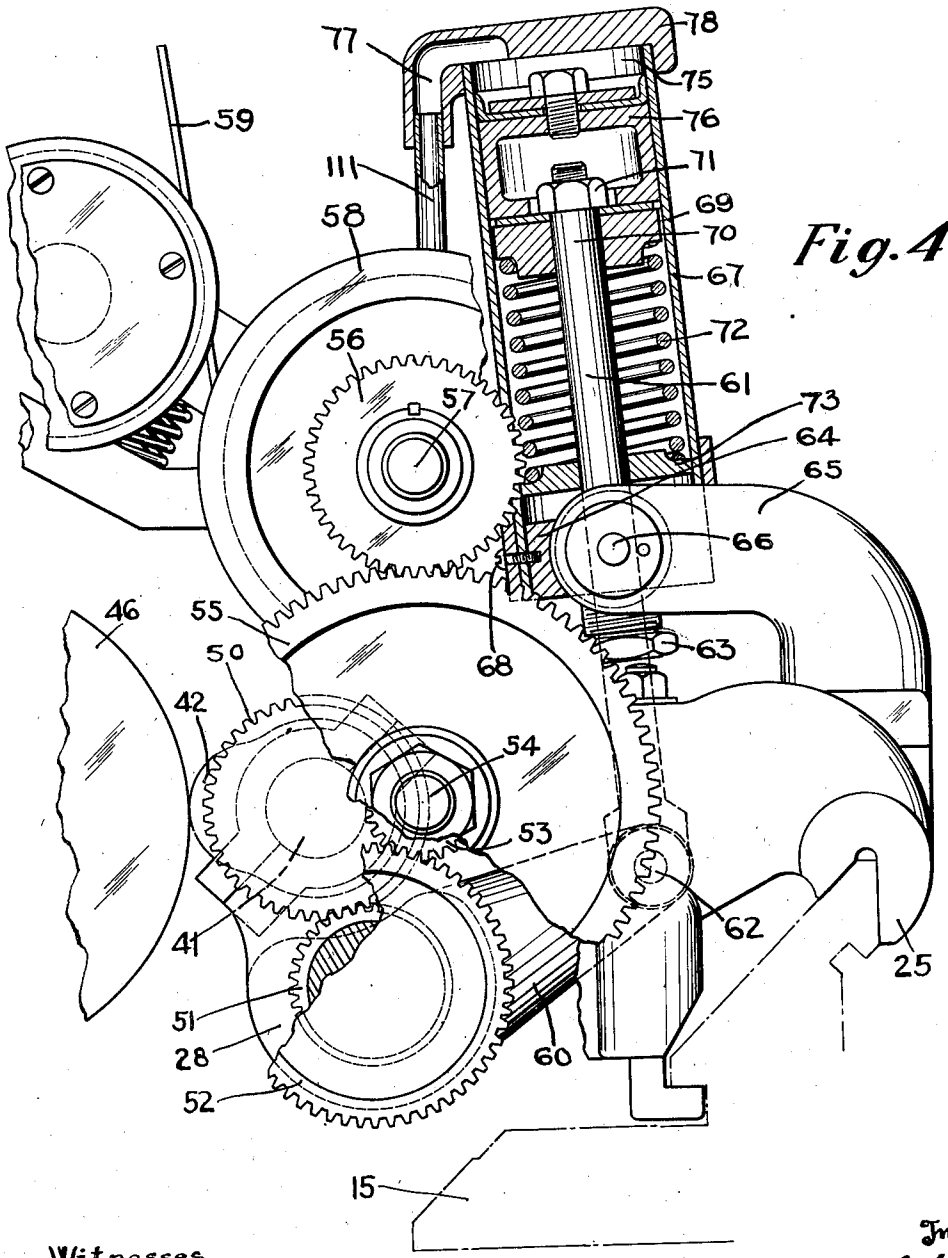


Fig. 4

Witnesses

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1,783,755

UNITED STATES PATENT OFFICE

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GRINDING MACHINE

Application filed June 29, 1927. Serial No. 202,183.

This invention relates to grinding machines and more particularly to a machine for grinding work having several surfaces to be ground separately, such as a cam shaft, a crank shaft and the like.

In grinding such irregular objects as a set of cams, crank shafts and the like, which have a number of round surfaces to be ground, it is necessary, after one surface has been finished and before another may be moved into position, to separate the work and the wheel by a considerable distance, since otherwise the wheel might come in contact with the object to be ground and so injure one or the other. This is due to the fact that the cams on a cam shaft project different distances in a given radial plane and the pins on a crank shaft are not all in axial alignment. Various other grinding operations require producing a number of spaced round surfaces on a single object in which the surfaces must be ground one after another. In ordinary grinding practice, after a surface has been finished, the wheel is removed from the work only a short distance, which is slightly more than the depth to which it will cut the work. If it is necessary to separate the wheel and the work by a greater distance, it is not economical to do this by means of the slow motion crossfeed mechanism. Hence, it is desirable for certain types of grinding that the work and the wheel be separated rapidly through a considerable distance by a mechanism other than the wheel crossfeed.

It is accordingly one object of this invention to provide a grinding machine in which the work and the wheel may be separated rapidly by a separate mechanism from that used to feed the wheel into the work and in particular to accomplish this automatically.

It is a further object to provide a crossfeed mechanism capable of feeding the wheel into the work with a fine degree of precision which is so associated with a further mechanism arranged to move the work so that a slight movement of the wheel crossfeed by the operator will automatically cause a further and greater separation of the work and the wheel.

Various types of cam grinding apparatus have been devised of which the one shown in the patent to Dunbar No. 1,339,746 of May 11, 1920, may be cited as an example. In this machine the cam shaft to be ground is mounted on centers on a rocking support and the rocking movement of this support is controlled by means of a set of master cams and a follower. When a given cam has been ground, the master cam follower is shifted to another master cam intended to control the shape of the next cam to be ground. Before this can take place the cam shaft must be rocked out of operative relation with the grinding wheel by means of a manually operable lever. An arrangement is shown in this patent whereby the table traversing movement automatically shifts the follower to the proper master cam corresponding with the cam to be ground, but this is of limited practical utility inasmuch as it is adapted for use only where the master cams are equally spaced on their shaft and the cam blanks are similarly equally spaced; or if the cam blanks are unequally spaced, then the master cams must be given the same relative separation. Moreover, there is a danger that the operator may attempt to traverse the work carrying table to position another cam in front of the wheel, before the wheel has been removed from its grinding position, and possibly injure the work. It is accordingly desirable that the work be safely away from the wheel before such traversing takes place. The modern autombile, however, requires the use of a cam shaft in which the cam blanks are unequally spaced and these cams are usually grouped in pairs so as to provide an intake and exhaust cam for each cylinder of the engine, these pairs being unequally spaced on their shaft.

It is accordingly a further object of this invention to provide an automatic machine capable of grinding cams and the like which will automatically position the master cam corresponding to the cam to be ground, without requiring skillful attention on the part of the operator when he shifts the cam shaft to

bring successive cam blanks into operative relation with the grinding wheel.

It is another object of the invention to provide a cam grinding machine in which the master cam follower is moved axially through an equal distance into alignment with successive master cams while the work supporting table is traversed through an unequal distance to position successive cam blanks on the cam shaft in operative position relative to the grinding wheel.

It is another object to provide a mechanism so constructed and arranged that movement of the grinding wheel feed mechanism controls the rocking of the cam shaft support into and out of operative engagement with the grinding wheel.

It is still another object of the invention to provide a mechanism so constructed and arranged that movement of the grinding wheel feed mechanism operates a locking mechanism which automatically locks the work supporting table against longitudinal movement during the period of grinding, thereby eliminating the danger of the table being shifted longitudinally while the work is in contact with the grinding wheel.

The operation of a complex grinding machine, such as one for grinding cams and crank shafts, requires considerable skill on the part of the operator, and any inattention on his part is likely to cause serious damage. One thing that should be avoided is an attempt to traverse the work table during a direct infeed grinding operation. Hence, a further object of the invention is to prevent this and to provide a locking mechanism which will hold the table stationary until the operator has separated the wheel and the work.

Other objects will be apparent from the following disclosure. One embodiment of the invention has been disclosed in the drawings in which:

Figure 1 is a front elevation of the improved cam grinding machine having parts broken away to more clearly show the construction;

Fig. 2 is a fragmentary perspective view taken from the rear of the machine, showing the mechanism for rocking the work supporting member and shifting of the master cam follower;

Fig. 3 is a diagrammatic perspective view showing the operative relation of the various mechanisms:

Fig. 4 is an enlarged fragmentary end view of our attachments showing parts broken away to more clearly illustrate the construction; and

Fig. 5 is a detailed sectional view showing the valve construction.

One form of cam grinding machine made in accordance with the invention, is so arranged that the grinding wheel and cam blanks may be moved relatively toward and from each other to grind the desired contour on the blank by means of a master cam and follower suitably connected for this purpose. This invention contemplates an apparatus in which the relative shifting of the grinding wheel and work automatically causes the follower to be located in front of the proper master cam. The preferred construction is one in which the relative traversing movement between the grinding wheel and a set of unevenly spaced cam blanks causes the cam follower to be moved axially into operative relation with successive evenly spaced master cams in timed relation with the work shifting movement, so that the follower is in operative relation with the proper master cam corresponding to the cam blank to be ground. The work is preferably mounted on a table slidable longitudinally past the grinding wheel. A suitable mechanism is provided for feeding the grinding wheel into the work to size the work, but the grinding action to secure the desired contour on the cam is accomplished by mounting the cam blanks on a pivotally mounted support which preferably rocks toward and from the grinding wheel. To secure this rocking movement, the master cams are mounted on the rocking support and are preferably in axial alignment with the cam blanks to which they are suitably connected so that the parts may rotate together. The cam follower is mounted on a stationary part of the machine, such as the table, so that as the cam blanks and master cams rotate, such rotation through the action of the follower causes the grinding wheel to grind the blank to a contour corresponding with that of the master cam.

In accordance with the form illustrated, this apparatus may comprise an attachment adapted to be applied to any well known cylindrical grinding machine in which a grinding wheel is mounted on a wheel slide and is adapted for transverse movement on the base. The work supporting table is arranged to slide longitudinally relative to the operative face of the grinding wheel. The cam attachment is mounted upon the work table and carries the master cam shaft in axial alignment with the cam shaft to be ground. In the improved construction, a feeding mechanism is provided to move the grinding wheel toward and from the work and is connected to control a fluid pressure mechanism which operates to rock the master cam from contact with the master cam follower into an inoperative position. The fluid pressure mechanism is operated simultaneously to unlock the work table which has been held stationary during the grinding operation and thereby permit longitudinal movement of the work table to bring the next cam into operative relation with the grinding wheel and at the same time shift the master

cam follower into alignment with the corresponding master cam.

As illustrated in the drawings, the grinding machine has a base 11 carrying a wheel slide 12 on which the grinding wheel 13 is rotatably supported. A table 15 is mounted on the front portion of the base and is adapted for a traversing movement longitudinally of the machine base by means of a hand wheel 16, fixed on the outer end of the shaft 17. The inner end of the shaft 17 carries a pinion 18 meshing with a gear 19 on the outer end of the shaft 20. The inner end of the shaft 20 carries a pinion 21 meshing with a rack 22 so that rotation of the hand wheel 16 is transmitted through the gearing to the rack 22 on the under side of the work supporting table 15. These parts are old and well known features of a grinding machine and are not shown in detail. The grinding wheel 13 may be fed toward and from the work supporting table 15 by any suitable feeding mechanism, such, for example, as that shown in the patent to Norton No. 762,838 of June 14, 1904.

In order that work of irregular cross section may be ground, any suitable mechanism may be utilized whereby the work axis or the grinding wheel axis may be moved relative to the other during the grinding operation to generate the desired contour upon the work blank. In the preferred construction, however, the work supporting mechanism is mounted so that it may rock toward and from the operative face of the grinding wheel to produce the desired contour upon the cam shaft to be ground. As shown in the drawings, the supporting brackets 25 and 26 are mounted on the opposite ends of the table 15. The rock bar 28 has a pair of trunnions 29 and 30 projecting from its opposite end. The trunnions 29 and 30 are supported for rotation in the brackets 25 and 26 respectively. The headstock member 32 and the footstock 33 are mounted upon the upper surface of the rock bar 28. These members are provided with work supporting centers 34 and 35 to support the work piece or cam blanks during the grinding operation. The headstock 32 carries a driving member 37 adapted to engage a driving dog 38 which is clamped to one end of the cam shaft 40.

To transmit a rocking motion to the cam shaft 40 to cause a movement toward and from the grinding wheel and produce the desired contour, a master cam mounted to move with the work and a cam follower mounted on the table are employed. As illustrated, a master cam shaft 41 is mounted on the headstock member 32 in axial alignment with the cam shaft 40 to be ground. The cam shaft 41 comprises a plurality of master cams 42 which are shaped and timed to correspond with the cams to be produced on the finished cam shaft. In order that rotation of the master cam may rock the bar 28, a bracket member 45 is clamped to the table 15 to support a master cam roller or follower 46. The follower 46 is slidably keyed to the shaft 47 which is rotatably supported in the bearings 48 and 49, depending from the bracket 45. From this construction, it will be readily apparent that rotation of a master cam 42 which is in alignment with the cam shaft 40, against the master cam roller 46, will cause a rocking motion of the bar 28 determined by the shape of the master cam, thereby moving the cam shaft being ground toward and from the grinding wheel axis to produce the desired contour.

Any suitable driving mechanism may be utilized to rotate the master cam shaft to be ground. In the preferred construction, a simplified drive is illustrated which comprises a gear 50 mounted on a projecting end of the master cam shaft 41. The gear 50 in turn meshes with a gear 51 rotatably mounted on the trunnion 29 of the rock bar 28. Formed integrally with the gear 51 is a second gear 52 which meshes with a pinion 53 on one end of a shaft 54. The other end of the shaft 54 carries a gear 55 meshing with a gear 56 on the drive shaft 57. The pulley 58 is mounted on the shaft 57 and is driven by a belt 59 from any suitable source of power. It will be readily seen from the foregoing description that the drive to the master cam by belt 59 through gears 56, 55, 53, 52, 51 and 40 on the master cam shaft permits rotation of the master cam and the shaft to be ground during the rocking motion of the bar 28.

A mechanism is provided to yieldably maintain the master cam 42 in contact with the periphery of the master cam roller 46. As shown in the drawings, the rock bar 28 is provided with a projecting arm 60. The lower end of a rod 61 is pivoted by means of a pin 62 to the outer end of the arm 60 and is slidably supported in a threaded bushing 63. The bushing 63 is screw-threaded into the supporting member 64 which is in turn pivoted to the bracket 65 projecting from the supporting member 25 by means of a stud 66. The cylinder 67 surrounds the rod 61 and is secured to the pivotally mounted supporting member 64 by means of screws 68 passing through the cylinder 67 and threaded into the supporting member 64. The upper end of the rod 61 is provided with a collar 69 which is rigidly fixed to the rod by means of a pin 70 and a nut 71 threaded on the end of the rod and is adapted to support the upper end of a spring 72. The lower end of the spring 72 is supported by a collar 73 which is slidably mounted on the rod 61. This collar is supported against the upper face of the threaded bushing 63. The tension of the spring 72 may be varied by adjusting the threaded bushing 63 relative to the supporting member 64 to increase or decrease the tension as desired. The tension of

the spring 72 is exerted on the arm 60 to rock the bar 28 and thereby maintain the master cam 42 against the periphery of the master cam roller 46 with sufficient pressure to maintain operative contact therebetween during the grinding operation.

In order that the master cam 42 may be withdrawn from engagement with the follower 46 to permit the follower to be shifted into alignment with the next master cam, a mechanism is utilized to rock the bar 28 against the tension of the spring 72. In the preferred construction, a device operated by air pressure is provided, which has a cylinder chamber 75 in the upper portion of the cylinder 67 carrying a piston 76 slidably mounted therein. This piston may be directly connected to the rod 61 so that it will slide within the cylinder as the rod moves relative thereto. In the preferred construction, however, as shown in Fig. 4, the piston 76 is constructed as a separate member which is adapted to contact with the upper face of the collar 69. As fluid under pressure is admitted through the port 77 in the cylinder head 78, the piston 76 will be forced downwardly against the tension of the spring 72 to rock the bar 28 and withdraw the master cam 42 and the cam shaft 40 from contact with the master cam roller 46 and the grinding wheel 13 respectively. After the table 15 has been traversed to bring the next cam on the cam shaft 40 into alignment with the grinding wheel 13, the fluid pressure within the chamber 75 is reduced and the released tension of spring 72 moves the rod 61 upwardly to rock the bar 28 and the master cam 42 and cam shaft 40 into operative contact with the master cam roller 46 and grinding wheel 13.

As illustrated in the drawings, the wheel slide 12 is provided with a half-nut 80 depending from the under side of the slide and adapted to engage a feed screw 81 mounted in suitable bearings (not shown) in the base of the machine. A hand wheel 82 is mounted on the shaft 83 to turn the feed screw to produce a feeding action of the grinding wheel. The inner end of the shaft 83 is provided with a small gear 84 meshing with a gear 85 on the outer end of the feed screw 81. By turning the hand wheel 82, the feed screw 81 may be turned in either direction to feed the grinding wheel toward or from the work. The movement toward the work is limited by means of a stop lever 86 adapted to contact with an abutment 87 on the hand wheel 82.

To operate the cylinder mechanism so as to automatically withdraw the cam at the proper time, a valve mechanism operated in timed relation with the moving parts of the grinding machine is provided, and in the preferred construction, this valve mechanism is operated in timed relation with the wheel feeding mechanism to rock the bar 28 when the operator starts to feed the wheel away from the work. As shown, the valve mechanism comprises a casing 90 fixed to the base 11. A balanced piston type valve 91 is slidably mounted therein. The extended portion of the piston 91 is provided with a rack 92 meshing with a gear 93 on the shaft 94. In the operation of the mechanism, it is desirable that the valve mechanism operate when the wheel 82 is turned in either direction but that this mechanism be so constructed and arranged that continued movement of the feeding mechanism to position the grinding wheel is permissible after the valve has been shifted. To accomplish this, a friction device is preferably provided as illustrated in Fig. 3. As shown, the gear 93 is rotatably mounted on the shaft 94 and is formed integral with the friction disc 96 having the sleeve 97 interposed between the two members. A gear 98 is keyed to the other end of the shaft 97 and meshes with a gear 85 on the screw 81. A sleeve 99 is also mounted on and keyed to the shaft and is provided with an outwardly extending flange 101 which contacts with the inner faces of the flange 96 and the flange 103. It will be thus readily apparent that by turning the feeding mechanism the gear 85 turns the gear 98 which in turn rotates the friction flange 101. The friction between the surfaces of flange 101 and the flanges 96 and 103 turns the gear 93 to operate the valve piston 91.

In order that the friction between the discs may be varied, a yieldable connection is provided between the discs 96 and 103. A plurality of bolts 104 pass through holes in the two plates and are provided at their outer ends with nuts 105. Interposed between the nut 105 and the flange 96 is a spring 106. By tightening the nuts 105, the operator may adjust the friction between the parts of the mechanism as desired. To limit the rotation of the mechanism so as to control the position of the piston 91 relative to its casing 90, the flange 96 is provided with an opening 108 which is adapted to engage a projection 109 of the base 11.

It will thus be seen from this construction that the turning of the hand feed wheel 82 is transmitted through the friction discs 101, 103 and 96 to turn the gear 93 and thereby slide the valve piston 91 within the valve casing 90 to control the rocking of the bar 28. The motion of the valve piston 91 continues until one end of the opening 108 contacts with the projection 109 on the base thereby limiting the motion of the valve piston 91. The hand wheel 82 may be rotated thereafter against the friction of the discs 96, 101 and 103 to feed the grinding wheel toward the work to size the same.

During the grinding operation, the valve piston 91 is in the position shown in Fig. 1, that is, in the extreme position toward the

right. The port 110 in valve case 90 is connected by means of a pipe 111 with the port 77 in the cylinder head 78. In the position shown in Fig. 1, the air or fluid pressure may exhaust from the cylinder chamber through the pipe 111, the port 110 and through the exhaust port 112 and out the end of the cylinder. The valve remains in this position during the infeed of the grinding wheel thereby permitting the tension of the spring 72 to hold the master cam 42 in contact with the roller 46 to grind the cam blank to the desired shape and size. Air under pressure is admitted to the valve 90 from the supply pipe 115 and is passed through the port 116 which opens into the cylinder chamber 117 between the enlarged portions of the balanced valve pistons 91.

The feeding movement of the grinding wheel is continued until the abutment 87 on the hand wheel contacts with the stop lever 86 to grind the cam blank to the required shape and size. As the operator turns the feed wheel 82 in the opposite direction, that is, a clockwise direction, the motion is transmitted through the gearing and friction device to move the valve piston 91 toward the left as viewed in Fig. 1 and into a position as shown in Fig. 5. The rotation of the hand feed wheel 82 is continued until the opposite end of opening 108 of the flange 96 contacts with the stop 109 thereby limiting the motion of the valve toward the left. The operator by continued rotation of the hand feed wheel 82 against the friction of the discs may move the grinding wheel rearwards a greater distance from the work. This movement of the valve opens the port 110 and closes the exhaust port 112 so that air pressure is admitted to the cylinder chamber 75 and the piston 76 is moved downwardly to rock the bar 28 which supports the work and the master cams and to remove the master cam 42 and the cam shaft 40 from contact with the follower roller 46 and grinding wheel 13 respectively. The work support bar 28 is now in its inoperative position and the operation may turn the hand traverse wheel 16 to move the table 15 longitudinally or parallel with the wheel axis to bring the next cam into operative relation with the grinding wheel.

In the preferred construction, the traversing movement of the table 15 is utilized to move the follower roller 46 axially into alignment with successive master cams as the table is moved to bring the corresponding cam blank into operative relation with the grinding wheel. As illustrated in the drawings, the master cam roller 46 is slidably keyed to the shaft 47 which is mounted in the bearings 48 and 49. A shifting yoke 118, adapted to engage opposite sides of the roller 46, is fixed to the end of a rack 119 which slides in the slideway 120. A bar 122 is supported on the base of the machine by a bracket 123 and is provided with a plurality of adjustably mounted dogs 124 which are positioned along the bar to correspond with the spacing of the cam blanks on the cam shaft to be ground. A star wheel 125 is rotatably supported on a portion of the bracket 45 and is so positioned and arranged that as the bracket 45 is traversed longitudinally with the table, the star wheel 125 is moved in the path of the dogs 124. As the star wheel 125 strikes one of the dogs 124, it is rotated thereby and turns the gear 126 which meshes with the gear 127. The gear 127 in turn meshes with a gear 128 having a pinion 129 meshing with a rack 119. It will be readily seen that longitudinal movement of the table 15 moves the star wheel 125 into contact with one of the dogs 124 and the rotating movement of the star wheel 125 is transmitted through the gears 126, 127, 128 and 129 to slide the rack 119 and the roller 46 axially into alignment with the next master cam.

To limit the rotation of the star wheel per indexing movement, any suitable indexing mechanism may be utilized. In the drawing, however, a simplified construction is illustrated in which a pawl 130 is pivotted on a stud 131 supported on the under side of the slide 120. The pawl is adapted to engage the notches in the star wheel 125 and is preferably held yieldably in contact with the star wheel 125 by a spring (not shown). As the dogs 124 contact with and turn the star wheel 37, the pawl 130 rides over the projection of the star wheel 125 and is forced into the next space or notch in the wheel by the spring. The ratio of the gearing is such that for each indexing movement by a dog 124, the master cam follower 46 is moved axially a sufficient distance to bring it into alignment with the next master cam. This mechanism as illustrated is so constructed and arranged that it will function as the work table 15 is moved in either direction.

In order that the table 15 may be held against endwise movement during the grinding operation so as to prevent the table being shifted from one cam to the next and thereby damaging either the master cams or the shaft being ground, any suitable locking device may be utilized which is operated in timed relation with the mechanisms of the machine. In the preferred construction, a fluid pressure mechanism is provided which has tooth 140 adapted to engage the rack 22 on the underside of the table 15. The tooth 140 is formed on the end of a piston rod 141 which is slidably mounted within the cylinder 142. The piston is normally held in an inoperative position, that is, so that the tooth 140 is out of engagement with the rack 22 by a spring 143. As the grinding wheel is fed forward as illustrated in Fig. 1 the feeding mechanism turns the flange 96 to move the piston 91 until the side of the opening 108 con-

tacts with the projection 109 of the base. This acts as a stop to position the piston 91 as shown in Fig. 1. The valve 90 is provided with a second outlet port 148 connected by a pipe 144 to the port 145 in the cylinder 142. In the position as shown in Fig. 1, the air or fluid pressure enters the cylinder chamber 146 and forces the piston 141 upwardly to engage the tooth 140.

The operation of the mechanism will be readily apparent from the foregoing description. The cam shaft 40 is rotatably mounted on the centers 34 and 35 between the headstock 32 and the footstock 33 and is driven by a driving member 37. The operator then turns the feed wheel 82 in a counterclockwise direction to feed the grinding wheel 13 toward the work. This movement slides the valve piston 91 toward the right (as viewed in Fig. 1) and admits air under pressure through the port 145 into the cylinder 146 thereby moving the tooth 140 upwardly into engagement with the rack 22 to lock the table 15 against endwise movement. This movement of the valve piston 91 opens the exhaust port 112 and permits air to exhaust from the cylinder chamber 75 thereby releasing the tension of spring 72. The spring 72 then rocks the bar 28 to move the master cam 42 and the cam shaft 40 into operative relation with the roller 46 and the grinding wheel 13 respectively. The rotation of the master cam 42 in contact with the roller 46 rocks the bar 28 to produce the desired contour on the cam blank. The operator continues to turn feed wheel 82 in a counterclockwise direction until the cam blank has been ground to the predetermined shape and size as determined by an adjustable stop on the wheel cross feed mechanism.

When the cam blank has been sized, the operator turns the feed wheel 82 in the reverse or a clockwise direction as viewed in Fig. 1 to remove the grinding wheel 13 from contact with the cam blank. This movement slides the piston valve 91 toward the left into the position shown in Fig. 5. In this position of the valve, air in cylinder chamber 146 is exhausted through pipe 144 and port 147. The spring 143 then withdraws the tooth 140 from engagement with the rack 22 thereby unlocking the table 15. At the same time, the port 110 is opened to admit air under pressure through the pipe 111 into the cylinder chamber 75 to force the piston 76 downwardly. The downward movement of the piston 76 rocks the bar 28 to move the master cam 42 and the cam shaft 40 into an inoperative position out of contact with the roller 46 and the grinding wheel 13 respectively.

The operator then turns the hand traverse wheel 16 to move the table 15 longitudinally to position the next cam blank on the cam shaft 40 into operative relation with the face of the grinding wheel 13. As the table 15 moves longitudinally the star wheel 125 contacts with a dog 124 and slides the roller 46 axially into alignment with the next master cam. The machine is now in position to grind the next cam on the cam shaft 40. This cycle of operation is continued until all of the cam blanks on the shaft have been ground.

It will be apparent from the above disclosure that the broad features of the invention are applicable for grinding other objects besides cams and that suitable modifications may be made for this purpose within the scope of our invention.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A grinding machine comprising a rotatable grinding wheel, a support for holding a piece of work in grinding position which is movable towards and from the wheel, mechanism to feed the wheel into the work and means operated in timed relation with said mechanism to move the work to an inoperative position when the wheel is also moved away from the work.

2. A grinding machine comprising a rotatable grinding wheel, a support for holding a piece of work in grinding position which is movable toward and from the wheel, mechanism to feed the wheel into the work and means operated in timed relation with said mechanism to move the work to an inoperative position when the wheel is moved away from the work and to return the work when the wheel is moved towards the same.

3. A cam grinding machine comprising a rotatable grinding wheel, a support for work having a plurality of surfaces to be ground, said support being movable both transversely and towards and from the wheel, means to move the support transversely to position one of the work surfaces opposite the wheel, fine precision mechanism to move the grinding wheel towards and from the work and means controlled by said mechanism to move the work to an inoperative position when the wheel is moved out of contact therewith.

4. A cam grinding apparatus for a cylindrical grinding machine comprising a rotatable grinding wheel, a work support, fine precision mechanism for feeding the grinding wheel towards and from the work, means including a master cam and roller to move the work support towards and from the grinding wheel to grind the work to a desired contour and automatic means operating in timed relation with the rearward movement of the grinding wheel to separate the master cam from its roller.

5. A cam grinding apparatus comprising a rotatable grinding wheel, a support for a set of cam blanks, means including a set of master cams and a follower which are relatively movable to cause the cam blank to be ground to a desired contour, means to sepa-

rate the grinding wheel and cam blanks, means for relatively traversing the grinding wheel and the cam blanks to position the wheel in front of a desired blank, and means operating in timed relation with the separation of the wheel and cam blanks to move the master cam automatically away from the cam followers so that it may be shifted longitudinally into operative relation with another cam corresponding with the new cam blank selected.

6. A cam grinding apparatus comprising a rotatable grinding wheel, a work supporting table, means to traverse said table and grinding wheel relatively in a longitudinal direction, a pivotally mounted work support on the table arranged to rotatably support a set of cam blanks, means including a set of master cams and a cam follower, one of which is mounted on the rocking support and the other on the table, arranged to move the cam blanks toward and from the grinding wheel to cause the latter to grind a desired contour thereon, fine precision mechanism for feeding the grinding wheel toward and from the cam blanks and means operated by movement of said mechanism to separate the master cam from its follower and to remove the cam blank from the normal position of grinding.

7. A cam grinding apparatus for cylindrical grinding machines comprising a base, a table, means to traverse said table, a rocking support pivotally mounted on said table, a set of rotatable master cams and a follower, one of which is mounted on the table and the other on the rocking support, means for supporting a set of cam blanks on the rocking support, means to rotate the master cams and cam blanks, a rotatable grinding wheel, fine precision mechanism for feeding the grinding wheel toward and from the cam blanks through a desired distance, and means operated automatically in timed relation with the wheel feeding mechanism to rock said support to separate the master cams from the follower.

8. A grinding machine, comprising a rotatable grinding wheel, a work support movable toward and from the grinding wheel, means for moving the grinding wheel towards and from the work support, means for supporting a set of cam blanks on the support in operative relation with the grinding wheel, means including a set of master cams and a cam follower arranged to move the work support toward and from the grinding wheel to cause the latter to grind a desired contour on a cam blank, means for traversing the work support and the grinding wheel relatively longitudinally, means operated by the rearward movement of the grinding wheel to move the master cam away from the follower and means operated by the relative traversing movement of the wheel and work to move the master cam follower into position opposite to another cam.

9. A grinding machine comprising a rotatable grinding wheel, a support to hold a piece of work in rotative contact with the wheel, fine precision cross feed mechanism to move the wheel towards and from the work, and fluid pressure mechanism to move the work support and wheel relatively and independently of the cross feed mechanism.

10. A grinding machine comprising a rotatable grinding wheel, a work support movable towards and from the wheel, fine precision cross feed mechanism to move the wheel towards and from the work and fluid pressure mechanism to move the work support and the wheel relatively towards and from each other and independently of the wheel feed.

11. A grinding machine comprising a base, a slide thereon, a grinding wheel rotatably mounted on the slide, a work support movable towards and from the wheel, fine precision mechanism for moving the slide towards and from the work, and fluid pressure mechanism to move the work support towards and from the wheel.

12. A grinding machine comprising a base, a slide thereon, a grinding wheel rotatably mounted on the slide, a work support movable towards and from the wheel, fine precision mechanism for moving the slide towards and from the work, and fluid pressure mechanism automatically controlled by said precision mechanism to move the work support towards and from the wheel.

13. A grinding machine comprising a rotatable grinding wheel, a work support, a wheel feed mechanism to feed the grinding wheel towards and from said support, means to traverse said wheel and support relatively, means to rotate the work on said support, and fluid pressure mechanism operated in timed relation with said wheel feed mechanism to move said support away from the wheel to an inoperative position when the wheel is removed from the work.

14. A cam grinding apparatus comprising a rotatable grinding wheel, a work support movable toward and from the grinding wheel, fine precision mechanism for moving the grinding wheel toward and from the work support, means for holding a set of cam blanks on the support in operative relation with the grinding wheel, means including a set of master cams and a follower arranged to move the work support toward and from the grinding wheel as the work rotates to grind a desired contour on the work, and fluid pressure mechanism to move the work support toward and from an inoperative position as the grinding wheel is moved from and toward the work.

15. A grinding machine comprising a rotatable grinding wheel and a work support

which are relatively traversable, means for feeding the grinding wheel toward and from the work, and means permitting forward feeding of the wheel into the work which is arranged to prevent relative traversing movement between the wheel and work during the grinding operation.

16. A grinding machine comprising a rotatable grinding wheel, a work support traversable longitudinally past the grinding wheel, a wheel feed mechanism for moving said wheel toward and from the work, and means to prevent traversing movement of the work during the grinding operation which is released automatically by moving the wheel away from the work.

17. A grinding machine comprising a rotatable grinding wheel, a work support, means for moving the grinding wheel towards and from the work support, means for traversing the work support longitudinally parallel with the grinding wheel axis, locking mechanism to prevent such traversing movement during the grinding operation and means effective upon moving the wheel away from the work to release such locking mechanism and permit the traversing movement of the work support.

18. A grinding machine comprising a rotatable grinding wheel, a work support arranged to traverse the work substantially parallel with the grinding wheel axis, a wheel feeding mechanism to move the grinding wheel toward and from the work, a locking device adapted to prevent longitudinal movement of the table during the grinding operation and fluid pressure mechanism operated by the wheel feeding mechanism to release said locking means and permit traversing of the work support when the wheel has been removed from contact with the work.

19. A grinding machine comprising a rotatable grinding wheel, a work support movable towards and from the wheel, means to rotatably support a set of cam blanks thereon, means including a set of master cams and a cam follower adapted to move said support toward and from the wheel to grind a predetermined contour on one of the cam blanks, fine precision mechanism for feeding the wheel toward and from the work, means for traversing the work support and the grinding wheel relatively to position the grinding wheel in front of another cam blank, and locking mechanism to prevent such relative traversing movement except when the work is out of contact with the grinding wheel.

20. A grinding machine comprising a rotatable grinding wheel, a work support, means for rotatably supporting a set of cam blanks thereon in operative relation to the grinding wheel, means for feeding the grinding wheel toward and from the work support, means including a set of master cams and a follower for moving the work support toward and from the wheel to grind a desired contour on a cam blank, means for relatively traversing said grinding wheel and cam blank to position the wheel in grinding relation with any cam to be ground, locking mechanism to prevent relative traversing movement of the support and wheel, means to release said locking mechanism when the wheel is moved out of contact with the work and means operated in timed relation with the rearward movement of the wheel to remove the master cam from its follower so as to permit placing the wheel in front of another cam blank.

21. A cam grinding machine comprising a rotatable grinding wheel, a table movable substantially parallel with the grinding wheel axis, a wheel slide movable toward and from said table, a work support on said table movable toward and from the grinding wheel, means for rotatably mounting a set of cam blanks on said support, means including a set of master cams and a cam follower arranged to move said work support toward and from the grinding wheel to grind a desired contour on a given cam blank, fine precision feeding mechanism to feed the grinding wheel toward and from the work, a locking mechanism to hold the table against longitudinal movement during the grinding operation, and pneumatic mechanism operated in timed relation with said wheel feed to unlock said table and to move said work support to an inoperative position.

22. A cam grinding machine comprising a grinding wheel, a table, a pivotally mounted support for a set of cam blanks on said table, means to feed the grinding wheel towards and from the cam shaft to grind a cam, traversing mechanism to move said table lengthwise of said cam shaft to position a cam blank in operative relation with the grinding wheel, a set of master cams rotatably mounted on said support, a follower mounted on the table, means to rotate said master cams to rock said support and produce a predetermined contour on the cam being ground and automatic means actuated by turning said feed mechanism in one direction to lock the table against lengthwise movement during the grinding operation and to unlock said table and rock said support to an inoperative position when the feed mechanism is turned in the reverse direction.

Signed at Worcester, Massachusetts, this 27th day of June, 1927.

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