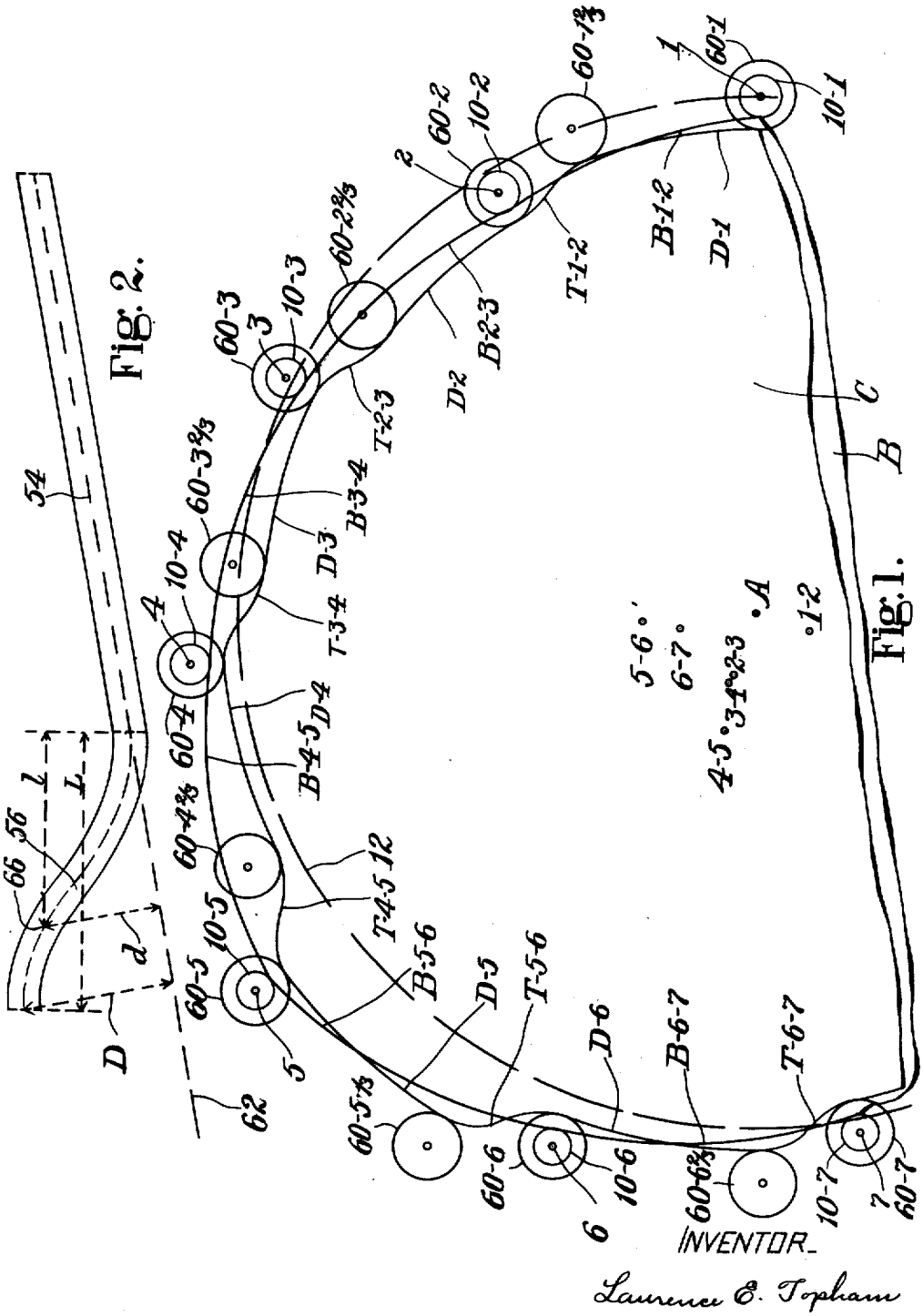
Aug. 31, 1926. 1,597,741

L. E. TOPHAM

CAM GENERATING MACHINE

Filed Nov. 12, 1921 4 Sheets-Sheet 1



Aug. 31, 1926. 1,597,741

L. E. TOPHAM

CAM GENERATING MACHINE

Filed Nov. 12, 1921 4 Sheets-Sheet 2

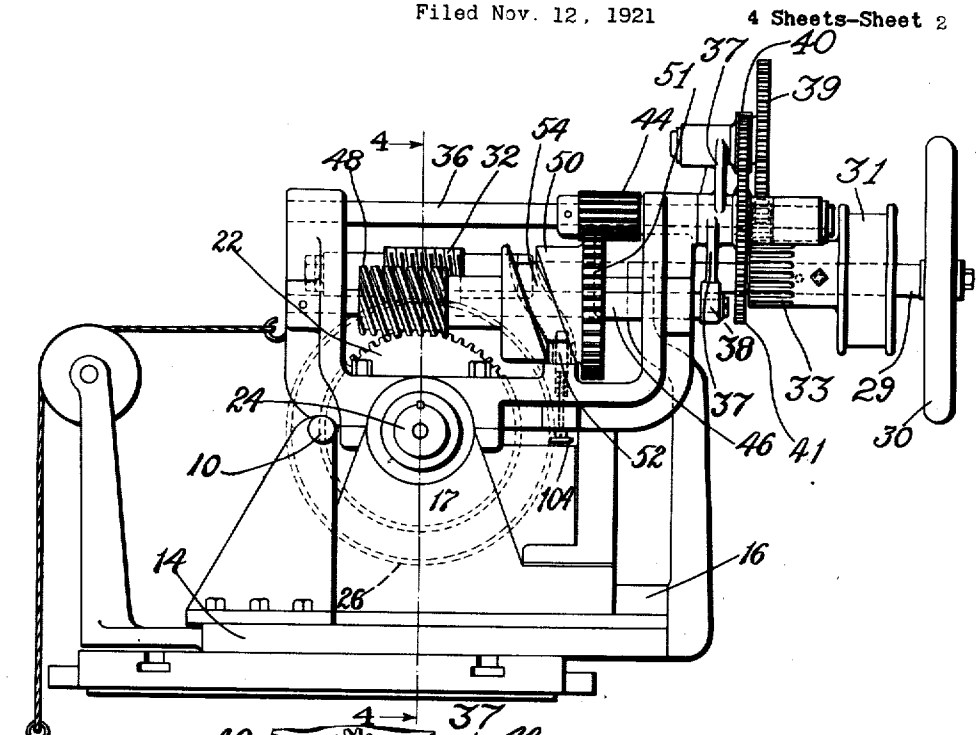


Fig. 3.

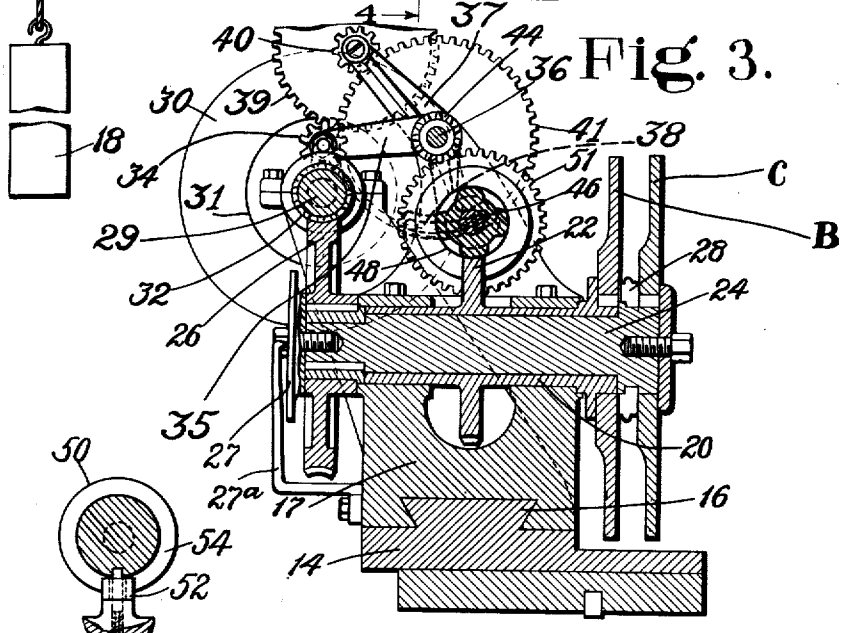


Fig. 4.

Fig. 10.

INVENTOR

Laurence E. Topham

Aug. 31, 1926. 1,597,741

L. E. TOPHAM

CAM GENERATING MACHINE

Filed Nov. 12, 1921 4 Sheets-Sheet 3

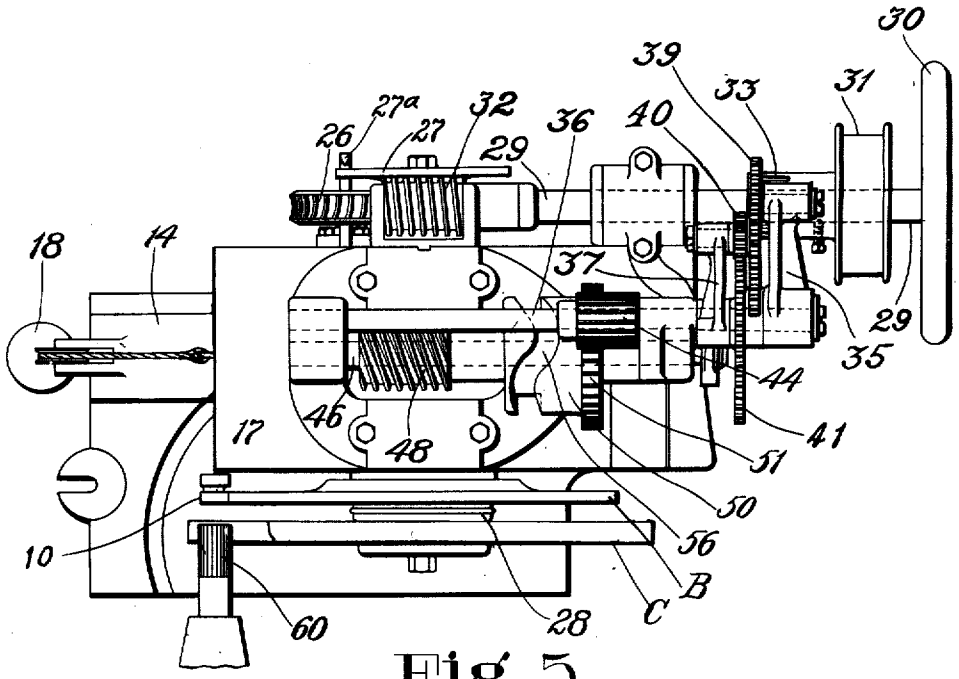


Fig. 5.

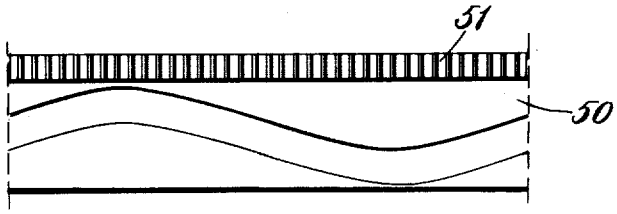


Fig. 6.

INVENTOR

Laurence E. Topham

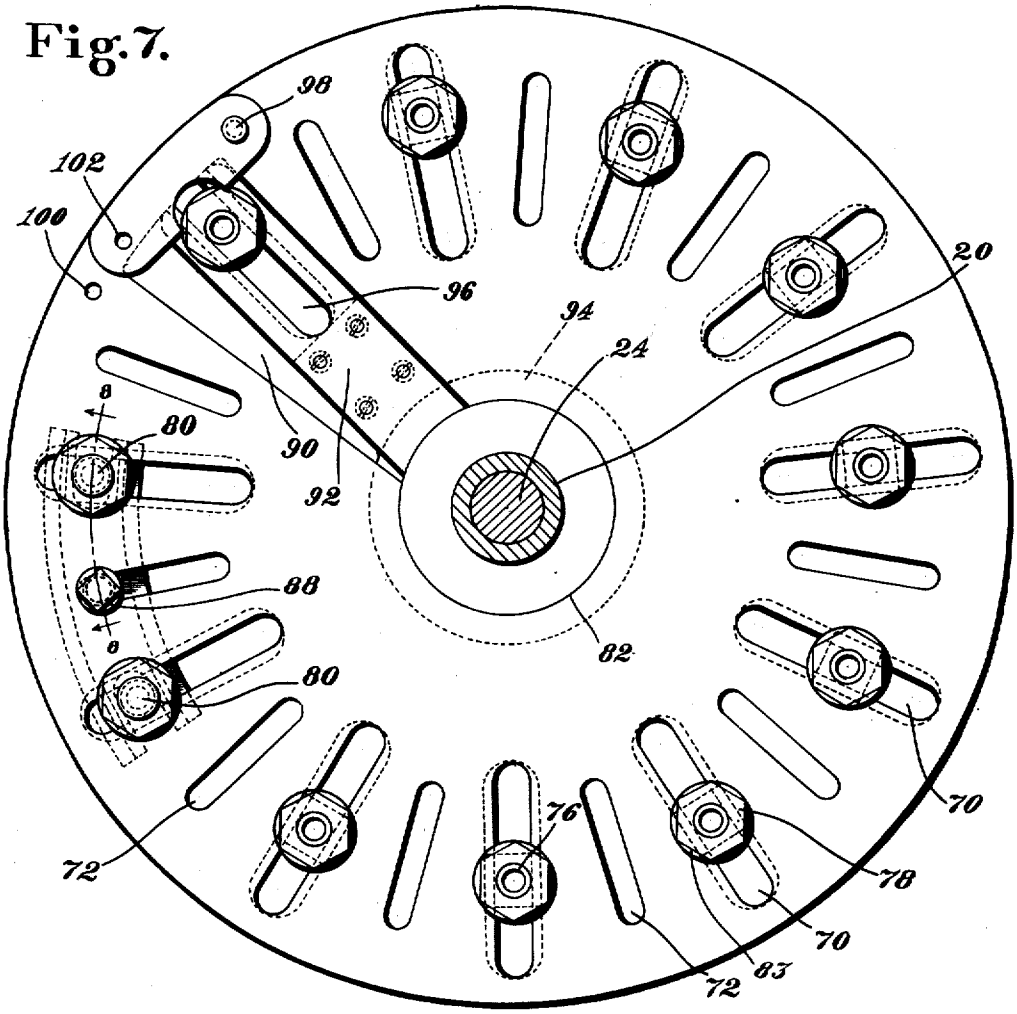
Aug. 31, 1926. 1,597,741

L. E. TOPHAM

CAM GENERATING MACHINE

Filed Nov. 12, 1921 4 Sheets-Sheet 4

Fig.7.



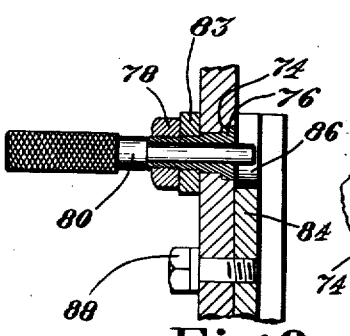


Fig.8.

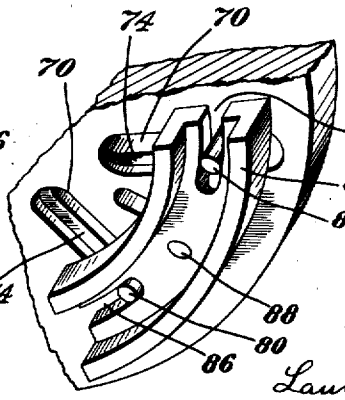


Fig.9.

INVENTOR.

Laurence E. Topham

Patented Aug. 31, 1926. 1,597,741

UNITED STATES PATENT OFFICE.

LAURENCE R. TOPHAM, OF LYNN, MASSACHUSETTS, ASSIGNOR TO UNITED SHOE MACHINERY CORPORATION, OF PATERSON, NEW JERSEY, A CORPORATION OF NEW JERSEY.

CAM-GENERATING MACHINE.

Application filed November 12, 1921. Serial No. 514,597.

This invention relates to methods of cutting cams and to cam cutting machines. Cams are generally cut on a copying lathe, in which the model cam or pattern and the work piece are mounted to rotate against a model wheel or guide and tool respectively, the relative position of tool and work being governed by the continuous contact of the model and model wheel. The model, according to this practice, is made by hand and is exceedingly expensive.

A peculiar cam generating problem has arisen in connection with an automatic side lasting machine invented by R. H. Lawson and described and claimed in his application Ser. No. 539,280, filed Feb. 25, 1922, and a later development of which, involving the cam in question, is described and claimed in his application Ser. No. 637,749, filed May 9, 1923, the present invention is disclosed in connection with a machine for generating the cams for this machine. It should be understood, however, that the present disclosure is illustrative only, and that it is not to be understood as limiting certain broad features of the invention.

In the side lasting machine mentioned, the shoe is mounted on a jack, which is automatically moved to carry the shoe past sewing mechanism. It is necessary that the shoe remain motionless while a needle is in it, so that the feeding has all to be done at the time when the needle is not in engagement with the shoe. The critical or locating points on the continuously moving jack cam are accordingly all dwells, of course of finite and substantial extent, and the problem, therefore, as applied to this particular type of machine, is to locate these dwells accurately and to get from one to the next without jar, it being otherwise immaterial just what shape the cam is between the dwells. Inasmuch as a different system of cam dwells is required for every different style of last, the model making under heretofore existing practice involves great expense.

In view of these and similar conditions it is an important object of the present invention to provide for generating, for example, a cam having such peculiar characteristics, with greater simplicity or ease, and at much smaller expense than is possible under the practice existing prior to the present invention. To this end I contemplate using a pattern having only single points corresponding to the several cam dwells accurately positioned, and using only these points in the generation of the several corresponding dwells. These points on the pattern are joined by curves of substantially optional form which are preferably of substantially even rise or fall as the case may be (for example, Archimedean spirals or circles which closely approximate them) and which are used to generate the transition parts of the cam between dwells. This method of cam generation, in its several aspects, which will be made clear as the description proceeds, constitutes an important part of the invention. It is clear that since only the isolated dwell points of the model need to be accurately plotted, and since, as will be shown, the compounding spoken of can be done mechanically, the making of the model is an extremely economical matter.

As herein exemplified, in another important aspect the invention resides in compounding with the above-mentioned curves (on the model or pattern) of even rise and fall curves of easy starting and stopping characteristics incident to the generation of the transition portions of the cam. I contemplate the mechanical compounding with a curve of a simple nature (for the sake of easy mechanical generation) as, for example, a straight line, circle, or curve of substantially uniform rise or fall, on the model, a curve having arbitrary characteristics as those of easy starting and stopping. Considering the invention in its machine aspect, in the illustrated embodiment of the invention I have advantageously effected both of the objects just discussed by providing a control between the model and work driver (assuming, for example, that we are dealing with that form of pattern reproducing machine in which the model wheel and tool are fixed and the model and work move over them), which holds the model motionless on its dwell points, and

then effects a rotation over the following curve which modifies that curve in the way desired. This is secured by an irregular angular velocity ratio between the model and work which relatively displaces the model points around the work so that the slope of the curve joining them is changed. Or, still more broadly stated, points equally spaced around the cam do not correspond to points equally spaced around the model, the term "equally" being broad enough to mean here that the model points are not spaced equally to the corresponding cam points, nor necessarily even spaced equally among themselves, and vice versa. The method of cam generation implied in what has just preceded and the mechanical means for practicing it constitute very important aspects of the invention. In the illustrated machine for practicing the methods just discussed, which itself also is an important part of the invention, I have provided means for driving the work and a worm wheel and worm for driving the pattern. The worm is a sliding worm which moves tangentially along its motionless worm wheel during the cutting of the dwell, and then moves back, driving the wheel with it, during the generation of the transition portion. This is conveniently accomplished by a path cam running around the worm body, having the same lead as the worm over the dwell cutting part of the circuit, and a portion connecting the ends of the equal-lead part, properly designed to produce the easy starting and stopping feature on the cam on the transition part of the cut.

In another aspect, the invention contemplates broadly the reproduction of a pattern by moving the pattern and work at different speeds past their respectively cooperating model wheel and tool. In one way of looking at the matter, this is effected by the sliding worm feature discussed above. From another point of view, however, it involves something quite different. It is of course desirable, for reasons of economy, to use the same sliding worm in the machine. So far, then, there would always be a correspondence between definite sectors on the model and definite sectors on the work. There would be relative peripheral irregularities between the model and work within these sectors, but the sectors themselves would always correspond, that is, the model wheel and cutter would always be at their end points at the same time, respectively. Under some conditions, there is an advantage in varying this condition, so that a model sector corresponding to a work sector can be made longer or shorter in order to secure greater sensitiveness and accuracy in the cutting on the model. In this aspect of the novel method of cam cutting herein disclosed, the desired result is practically accomplished by a system of change gearing between the model and work so that, for example, a sector on the work can be made to correspond to a sector of different magnitude on the model, or vice versa. For example, if a cam 180° in operative periphery were to be cut, the whole 360° of the model could be used to cut it, by means of a 2:1 gearing, whereby great sensitiveness in the work could be secured.

Another important object of the invention is to provide a cheap, convenient and practical form of model of the type described. The model, as has been stated, consists merely of a number of curves of largely optional form joining a set of accurately located dwell or otherwise critical points in order. Advantageously I have provided a face plate having angularly spaced radial guides in it in which pins or bushings or the like can be accurately positioned to correspond to the carefully located dwell or critical points, in connection with which pins can be secured interchangeable curved guides to connect the points. These guides are furnished in a variety of shapes so that the shape best adapted to that particular locality of the cam may be selected.

It will be understood that while I have disclosed the invention in connection with a machine for cutting revolving cams, the invention is not to be understood as so limited except so far as pointed out in the claims. The invention in many aspects is applicable to the production of cams which have a translatory as distinguished from a rotary movement.

The invention in these and other aspects will be better understood from the following description taken in connection with the drawings, which show an embodiment selected for illustrative purposes.

Fig. 1 is a diagram illustrating the pattern, the cam and the method of generation of the latter;

Fig. 2 is a development of the cam which effects the sliding of the worm;

Fig. 3 is a side elevation of the machine, the pattern B and the work piece C, which are on the side toward the observer, being removed to facilitate the disclosure of the parts behind them;

Fig. 4 is a section on line 4—4 of Fig. 3;

Fig. 5 is a plan;

Fig. 6 is a development similar to Fig. 2 but in another position;

Fig. 7 is an elevation of a universal model;

Fig. 8 is a section on the line 8—8 of Fig. 7;

Fig. 9 is a detail of the other side of the mechanism shown in Fig. 7;

Fig. 10 is a detail of the sliding worm construction.

The side lasting machine of application

Ser. No. 637,749, above mentioned, in connection with which the illustrated embodiment of the present invention was developed was constructed to insert eleven stitches in the shoe. The cam used (numbered 138, Fig. 40 of application Ser. No. 637,749) to control the jack was a flat disk having the cam surface on its periphery. Each stitch cycle was assigned 32° of the cam. The duty of the cam was to get the jack into position and hold it there over two-thirds of the stitch cycle, during which the needle was in the shoe, and then to move the jack to the next position. The eleven stitch cycles used 352° of the cam and the last 8° were used to return the jack to initial position. The improtant parts of the cam are therefore the 21⅓° or ⅔ cycle dwells which hold the jack during the stitching. The only thing required of the other ⅓ cycles was that they move the jack to the next position without jar, the motion being otherwise immaterial.

The master cam or pattern for the cam cutting machine may be developed as follows. The dwell points are accurately located every 32° around the pattern by any convenient method. A practical way is to put a last into the machine and turn the machine and move the jack by hand, marking the critical positions of the cam-roll on a blank. About half of the pattern is shown in Fig. 1. The center of the pattern is at A. The dwell points are plotted on the pattern plate. The points 1, 2, 3, etc. are plotted on the drawing as in the corresponding positions taken by the center of the cam roll. The model wheel also frequently designated as "follower," "model guide," or "leader", used in the reproducing machine is shown at 10 (see any of the positions 10—1, etc., in Fig. 1). It is an important object of the present invention to use these plotted points corresponding to 1, 2, 3, etc. to generate the dwells of the cam, preferably with no movement between the model wheel and pattern during the dwell generation, using the movement of the model wheel between the points 1, 2, 3 etc., solely to generate the transitional ⅓ cycles of the cam. Since these ⅓ cycles do not have to satisfy any rigid conditions, the pattern outline between the points 1, 2, 3, etc., can be filled in in any desired convenient way. The ideal path between two consecutive points is a piece of an Archimedean spiral, but this is more expensive to produce than the simpler circular arc which was adopted and which furnishes a close approximation to a path of uniform rise or fall per degree around the cam. The pattern is then laid on a rotary circular table with two consecutive plotted points on the circumference of the table, and a circular arc milled from one to the other. These arcs are shown in Fig. 1, in connection with the successive model wheel positions. They are all lettered B with suffixes indicating the critical points to which they belong, as B—2—3, the arc corresponding to the points 2 and 3. These arcs are, of course, drawn through the periphery of the model wheel so that its center can fall on the points 1, 2, etc., as shown in Fig. 1. The centers of the arcs are simply marked 1—2, 3—4, etc. The circle 12 drawn about the point A or center shows how the cam rises and falls. The pattern is thus generated at very small expense.

The pattern thus generated is placed in the machine shown in Figs. 3, 4 and 5. The base 14 is equipped with a rib or guide 16, upon which the body 17 of the machine can slide back and forth, being pulled in one direction by the weight 18. This body has a bearing in which is mounted a hollow shaft 20, on one end of which is mounted the pattern B, in any convenient way. This shaft is driven by a worm wheel 22.

Mounted inside the hollow shaft is a second shaft 24, having a worm wheel 26 and an angularly graduated plate 27 keyed on one end, the latter cooperating with a pointer or index 27ª mounted on the frame 17. On the other end of the shaft (toward the observer in Fig. 3 though not shown there in order to disclose the other mechanism more clearly), is mounted the work piece C to rotate with it. The pattern and work piece are spaced by a collar 28, which is so arranged that they are not tightly clamped together, so that the shafts 20 and 24 can rotate independently.

Mounted in the body 17 is the main drive shaft 29, having a hand wheel 30, a pulley 31, a worm 32 to drive the worm wheel 26 and a splined pinion 33 meshing with an idler pinion 34, on an arm 35 pivotally mounted on a shaft 36 mounted in the frame 17. The spline permits ready disengagement of the pinions 33 and 34. A two-armed bell crank 37 is also pivotally mounted on the shaft 36, and one of its arms is clamped by a slot and bolt at 38. The other arm of the bell crank 37 carries pinions 39, 40 keyed together, engaging respectively the idler pinion 34 and a gear 41, fast on the shaft 36. The change gearing described will secure any desired direction and speed relation between the shafts 29 and 36. The shaft 36 also carries a long pinion 44. The shaft 29 will thus drive the shaft 36 and the work shaft 24 continuously.

A shaft 46 is mounted in the body 17 and has rotatably and slidably mounted on it a sleeve having a worm 48 on one end, a cylindrical cam member 50 and a gear 51 meshing with the pinion 44 on the other. The worm drives the worm-wheel 22 on the pattern shaft 20, and the cam engages

a roll 52 (Fig. 3) mounted in the body 17. The cam track in the member 50 consists of two cams arranged end to end; one, 54, having the same lead as the worm 48, and the other 56 joining its ends. (See the development in Figs. 2 and 6.) The cam 56, is shaped in any desired manner to give a gradual "start and stop" to a cam roll which is being carried around the cam track 54, 56. For the purposes of the particular problem being described, the cam 54 extends two-thirds around the member 50, and the cam 56 fills out the other third.

The model wheel 10 (Figs. 3 and 5) is mounted on a stud mounted on the base 16, and the cutter 60 is mounted opposite it, both in positions opposite the pattern B and work piece C, respectively. The weight 18 will hold the pattern up against the model wheel, and the cutter will cut correspondingly into the work piece.

When the pulley 31 is driven, the wheel 26, shaft 24 and work piece C are driven continuously, and the gearing in the present arrangement is such that while the work rotates through 32°, the worm 48 will make one complete revolution. The lead of the worm 48 is such that the wheel 22 also rotates 32° in one revolution of the worm. This rotation is, however, intermittent. During the first two-thirds of the cycle, the "straight" cam 54 of the cam 50, having the same lead as the worm 48, causes the worm simply to screw to the right in Fig. 3, causing no rotation of the wheel 22. During the last third of the cycle, the roll 52 and cam 56 return the worm to the left in Fig. 3, carrying the wheel 22 with it, the movement of the wheel being the sum of two movements due to the translatory and rotary movements of the worm during the one-third cycle. The wheel 22 thus moves with non-uniform velocity, in general, during this part of the cycle. If the worm merely drove it without sliding, it would move uniformly, and the curves B—1—2 etc. would be duplicated in the work. The non-uniform drive, however, causes a modification of the curves B—1—2 etc. which can be regarded from several points of view; it amounts to superposing upon the curves B of substantially uniform rise or fall a curve having easy starting and stopping characteristics; and it is also equivalent to the relative displacement of the points of the curves B around the center of the cam to form curves of easy starting and stopping characteristics.

Returning now to Figs. 1 and 2, the cutter starts with the model wheel at 10—1, and the cutter at 60—1. The cutter is shown in Fig. 1 as larger than the model wheel in order to keep the work and pattern from confusion in that diagram. Also, the figure shows the model wheel and cutter as rolling around the pattern and work piece, instead of stationary with the model and work piece rotating independently. During the first two-thirds cycle, the work rotates continuously while the pattern remains motionless, with the model wheel 10 on the plotted point 1. During the time the cam roll 52 is moving over the cam 54, a circular dwell D—1 is cut on the work piece C. This brings the cutter to the point 60—1 2/3 on the work piece. During the final one-third cycle, the pattern turns 32°, and the model wheel moves from 10—1 to 10—2 while the cam roll 52 traverses over the cam 56 and the cutter drops from 60—1 2/3 to 60—2. The shape of the transition path T—1—2 joining these points depends upon the shape of the cam 56, which is so chosen as to give the movement desired. If we assume that the arcs B—1—2 etc., are parts of Archimedean spirals, the relation between the cam 56 and the curve T—1—2 etc., can be found as follows: If we extend the axis of the cam 54 (Fig. 2), as shown at 62, the perpendicular distance d between any point 66 of the cam 56 and the axis 62 represents the rotation of the wheel 22 during the portion l of the final one-third cycle up to the instant when the cam roll 52 is at the point 66. The total throw of the cam 56 is shown at D, and the total time of the one-third cycle is represented by L. If the radial drop from the position 60—1 2/3 to 60—2 is represented by K, the cam T—1—2 will have dropped

$$\frac{d}{D}K \text{ at a point } \frac{l}{L}\times\frac{32°}{3}$$

angularly distant from 60—1 2/3. Since there need be nothing exact about the cam portions T, this relation is close enough to design the cam 56 by, even under our approximate assumption about the arcs B—1—2, etc.

The described cycle is repeated around the cam as described. The last eight degrees of the came are cut by other means as the machine shown will deal only with complete cycles.

It is obvious that the 2/3 and 1/3 division of the cycle may be altered at will by proper design of the cams 54—56, and that the 32° length of cycle can be altered by proper gear relation between the worm wheel 22 and worm wheel 26, which can be secured by the change gears. A detailed description will make this clearer. The particular machine shown was built in order to deal with the specific problem presented by the Lawson machine, and contains some features which might have been designed otherwise if the purpose had been to construct a machine for general use in practising the invention in its broadest

aspects. In the illustrated machine the gears are as follows:

#33 has 33 teeth.
#39 has 32 teeth.
#40 has 32 teeth.
#41 has 127 teeth.
#44 has 15 teeth.
#51 has 44 teeth.
#22 has 45 teeth
#26 has 127 teeth.
#48 has 4 threads.
#32 has 1 thread.

The ratio $\frac{45}{4}$ between the gears 22 and 48 was adopted because it simplified the treatment of the Lawson problem. Thus one turn of the worm 48 causes directly a 32° turn of the model. The gear ratio between the shaft 29 and the worm wheel 22 is

$$\frac{33\times32\times15\times4}{32\times127\times44\times45}=\frac{1}{127}$$

which is the ratio between the shaft 29 (worm 32) and the worm wheel 26. (The gear 40 is shown much too small in the drawing, for the sake of clearness). It is planned to do all the changing with the gear 39. It is apparent that the ratio of the average angular velocity of the wheel 22 during a cycle or turn of the shaft 46 to that of the wheel 26 will vary inversely with the number of teeth in the gear 39, if everything else remains unchanged. The illustrated 32-toothed gear 39 causes the work to revolve 32° for every 32° turn of the model. If a 77-toothed gear 39 were inserted, the work would revolve 77° for every 32° of the model

The dwell part of the cycle can be varied in extent, and can be reduced even to zero if desired, (see Fig. 6) by shortening the part 54 and lengthening the part 56 of the cam member 50. Any cam comprising a number of regularly spaced cycles can be cut by forming a model with the end points of the cycles laid out and joined by Archimedean spirals or an approximation thereto and designing the corresponding parts of the cam 56 to produce the difference between a uniform rise or fall and the shape desired. In general, the curve on the model is distorted by having its points moved irregularly over arcs of circles about the center of the cam, the irregularity being controlled by the cams 54—56. The part 54, when present, reproduces a model point into a whole set of displaced points, lying on a circular arc.

Figs. 7, 8, 9 show a set of model apparatus embodying a part of the present invention, and which has proved simple and convenient in use. A face plate, having radial slots 70 as shown in Fig. 7, is mounted on the pattern shaft 20. The slots 70 are 32° apart for the purposes of the particular Lawson problem described, and slots 72 are arranged half way between adjacent slots 70. The slots 70 are countersunk as shown at 74 to receive bushings 76 shaped to fit the countersunk portions and projecting out through the back of the plate as shown in Fig. 7. These bushings are threaded for nuts 78. A gage pin 80 when placed in a bushing serves to adjust its distance from the central hub 82 by a micrometer. After adjustment it is clamped by the nut 78 and washer 83. The pin 80 extends clear through the bushing and projects on the inside, as shown in Figs. 8, 9. A circular segment 84, in the shape of a trough and having slots 86 at the ends of its bottom, just fitting the pins 80, is mounted on two adjacent adjusted pins and fastened by a screw 88 through the slot 72. The width of the trough in the segment is the diameter of the model wheel 10. The radius of the segment is so chosen as to coincide best with the Archimedean spiral joining the pins 80. It can be made to pass through any one desired point of the spiral as well as the two end points. The intermediate point can be selected as desired by the choice of the segment of the proper radius, and thus the cam point corresponding to the center of the throw can be displaced from the center of the corresponding sector, as is sometimes the practice in constructing cams having a pivoted arm follower.

In view of the 32° cycle adopted in the specific problem discussed, the beginning and end slots 70 would come 8° apart, and would intersect. To meet this difficulty a larger slot 90, bounded by two radii instead of two parallel sides, is cut from the plate, and a tongue 92 having a circular boss 94 engaging the hub of the plate, is mounted in it. A single slot 96 is formed in this tongue, which can be swung to either side of the slot 90 and held in position by a pin 98 in holes 100, 102, in the plate and tongue respectively to co-operate with either adjoining slot 70.

In practice the bushings are all carefully adjusted, and the pins and proper segment 84 placed in the first cycle, which is then cut, the model wheel running around the trough and no weight 18 being necessary. The machine is then stopped, the segment removed and the proper segment is placed in position for the next cycle, and so on. Thus no cutting, even of the simple type described, is necessary for the model.

It is obvious that the machine will cut closed cams as illustrated in Fig. 5, as well as open ones.

To practice the invention in its broadest aspects, the machine would preferably be constructed as follows:—

The face plate would be divided into equal

parts, such as 30° sectors, for example, and the ratio between the gears 48 and 22 would correspond, as 4 threads to 48 teeth, for the same example. Thus the model cycle is 30° long, and the model turns 30° for every turn of the shaft 46. A spring impelled stop pin 104 (Figs. 8 and 10) can be incorporated in the machine to stop the shaft at the exact end of each revolution. The change gearing would also be made as before, so that a wheel 39 had a number of teeth equal to the number of degrees turned by the wheel 26 during a model cycle. Suppose now that we wish to cut a cam having in succession along its edge a drop over 27°, a dwell over 34°, a drop over 26°, a dwell over 13° etc. We will set up these drops in succession in successive 30° intervals around the face plate as above described, ignoring the dwells. (These can be set up also, in the face plate, but it is not necessary). We put in a 27 toothed wheel 39, and turn off the first drop in the drop in the first 27° of the work, until the stop pin falls, the approximate Archimedean spiral on the model being modified by the cams, 54—56 adopted to compound anything we desire with the spiral. The pinion 33 is then pulled out of the train, and the rotation of the work continued over 34° from the 27° to the 61° point as measured on the plate 27. The pinion 33 is then replaced in the train. (A slight turn of the shaft 29 may perhaps be necessary to accomplish this.) This will affect the length of the dwell by less than half of

$$\frac{360°}{33 \times 127} = 0°.086.$$

(If this error is prohibitive the spline drive of the gear 33 may be changed to a clamp). A 26° toothed gear 39 is inserted and the second drop, set up in the second 30° of the model, is turned off on the 61°–87° interval of the work. The gear 33 is then pulled out and the next dwell turned off, etc. Thus, any cam whatever can be cut by the machine.

The machine will ordinarily be driven by the hand wheel 30, especially when the stop pin 104 is used.

Having described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:—

1. That improvement in the art of cam generation which consists in providing a pattern having accurately plotted points corresponding to the dwells of the cam to be formed, said points being connected by curves, generating the dwells on the work piece from the points, and generating the transition curves of the cam between the dwells from the curves on the pattern.

2. That improvement in the art of cam generation which consists in generating a curve of finite length on the work piece from a single point of the pattern, and a following curve on the work piece from a curve of finite length on the pattern.

3. That improvement in the art of cam generation which consists in mounting a pattern and a work piece in a pattern copying machine, and moving them relatively to the model wheel and tool at different speeds so that the corresponding parts of the pattern and work vary in angular extent.

4. That improvement in the art of cam generation which consists in placing a pattern and work piece in a pattern copying machine, and rotating them relatively to the model wheel and tool respectively, the rotation of one of said objects being intermittent.

5. That improvement in the art of cam generation which consists in providing a model having portions corresponding to the critical points accurately plotted, and joined by curves of substantially constant rise or fall, and generating the transition curves between the critical points of the cam by superposing a curve of easy starting and stopping characteristics upon the said curves of rise or fall.

6. That improvement in the art of cam generation which consists in providing a model having portions corresponding to the critical points accurately plotted, and joined by curves of substantially constant rise or fall, and generating the transition curves between the critical points of the cam by longitudinally relatively displacing the points of the said curves of rise or fall to produce curves of easy starting and stopping characteristics.

7. That improvement in the art of cam generation which consists in providing a model having curves of approximately uniform curvature and superposing upon said curves in the reproduction a curve having certain predetermined characteristics not embodied in the model whereby the said characteristics will appear in the work.

8. In a machine of the class described, a model wheel and a model holder; a tool, and a holder, and mechanism for effecting relative traverses between the members of each of said pair of instrumentalities, and a variable motion mechanism between the two pairs whereby one relative traverse may be interrupted while the other proceeds.

9. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool around the work, said movements having a variable ratio of angular velocities.

10. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool

around the work, one of said movements being intermittent, but of the same average angular velocity as the other.

11. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool around the work, one of said movements being intermittent.

12. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool around the work, one of said movements being discontinuous.

13. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool around the work, said movements having different (but the same average) angular velocities.

14. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool around the work, said movements occurring in cycles, and the angular velocity of the first said movement differing from that of the second in every cycle.

15. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool around the work, comprising a prime mover, and drives connected thereto for effecting the two said movements, one of said drives having an intermittent motion mechanism to alter its relation to the movement of the prime mover.

16. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting relative movement of the model wheel around the model holder and of the tool around the work, comprising a prime mover, and drives connected thereto for effecting the two said movements, one of said drives having an automatic variable motion mechanism to alter its relation to the movement of the prime mover.

17. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm wheel and sliding worm to vary the uniformity of the drive.

18. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, and a device for augmenting and retarding the action of one of said drives in timed relation to the other.

19. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm and worm wheel, and means for moving said worm in the direction of its axis to vary the speed of the drive.

20. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm and worm wheel, and means for moving said worm in the direction of its axis in timed relation to the other drive to vary the speed of the drive.

21. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm wheel and sliding worm to vary the uniformity of the drive, and a cam for sliding said worm in the direction of its axis.

22. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm constructed and arranged to slide in the direction of its axis, and a cam constructed and arranged to slide the worm during a certain revolution by an amount equal to its lead during such revolution, whereby the corresponding drive may be stopped during the activity of the cam.

23. In a machine of the class described, four primary instrumentalities, viz, a model

wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm constructed and arranged to slide in the direction of its axis, a cam mounted on the worm, and an element engaging the cam to slide the worm.

24. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm constructed and arranged to slide in the direction of its axis, a spiral cam mounted on the worm body and having a lead equal to that of the worm, and a cam roll mounted on the frame of the machine to cooperate with the cam.

25. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, one of said drives comprising a worm constructed and arranged to slide in the direction of its axis, a spiral cam mounted on the worm body and having a portion with a lead equal to that of the worm and a return portion connecting the ends of the said equal-lead portion whereby the worm may drive its worm wheel intermittently at normal average velocity.

26. In a machine of the class described, four primary instrumentalities, viz, a model wheel and tool, a model holder and work holder and mechanism for effecting relative traverses between said instrumentalities in pairs, comprising a prime mover, a drive between the prime mover and an instrumentality of each pair, said drives being arranged to transmit the same average velocity to their driven instrumentalities, one drive comprising a worm arranged to move in the direction of its axis to vary the uniformity of its drive.

27. A cam generating machine comprising a model wheel and a model having isolated points plotted on it corresponding to the dwells of the cam, and curves of substantially constant rise or fall connecting the said points in order, a tool and a work holder, means for driving the work holder, means for driving the model in timed relation to the work holder and a device for holding the model wheel on a said point of the model while a corresponding dwell is cut on a work piece held by the work holder.

28. A cam generating machine comprising a model wheel and a model having isolated points plotted on it corresponding to the dwells of the cam, and curves of substantially constant rise or fall connecting the said points in order, a tool and a work holder, means for driving the work holder, means for driving the model in timed relation to the work holder, a device for holding the model wheel on a said point of the model while a dwell is cut on a work piece held by the work holder, and means for compounding with the movement due to the said curves a modifying movement to shape transition curves between dwells on the work piece.

29. A cam generating machine comprising a model wheel and a model having isolated points plotted on it corresponding to the dwells of the cam, and curves of substantially constant rise or fall connecting the said points in order, a tool and a work holder, means for driving the work holder, means for driving the model in timed relation to the work holder, a device for holding the model wheel on a said point of the model while a dwell is cut on a work piece held in the work holder, and means for feeding the said curves of substantially constant rise or fall over the model wheel at a non-uniform speed to shape transition curves of predetermined characteristics between dwells on the work piece.

30. A cam generating machine comprising a model wheel and a model having isolated points plotted on it corresponding to the dwells of the cam, and curves of substantially constant rise or fall connecting the said points in order, a tool and a work holder, means for driving the work holder, means for driving the model in timed relation to the work holder, a device for holding the model wheel on a said point of the model while a dwell is cut on a work piece held in the work holder, said means comprising a worm arranged to move parallel to its axis while rotating, and a cam arranged on the worm body and having a lead equal to the worm-lead to effect said movement.

31. A cam generating machine comprising a model wheel and a model having isolated points plotted on it corresponding to the dwells of the cam, and curves of substantially constant rise or fall connecting the said points in order, a tool and a work holder, means for driving the work holder, means for driving the model in timed relation to the work holder, a device for holding the model wheel on a said point of the model while a dwell is cut on a work piece held in the work holder, said means comprising a worm arranged to move parallel to its axis while rotating, a cam arranged on the worm body and having a lead equal to the worm-lead, to effect said movement, and a second cam connected and arranged to compound

a non-uniform axial movement in the opposite direction with the rotary movement of the worm.

32. A cam generating machine having a model wheel, tool, model holder and work holder, means for effecting relative traverses between the said four instrumentalities in pairs whereby a model contour may guide the tool and mechanism for compounding with the model contour a contour having predetermined characteristics not embodied in the model itself.

33. A machine for generating cams comprising a tool, a work holder, and a model holder, arranged to guide a relative traverse of the tool over the work by means of the model and means for unequally spacing, in a direction transverse to the direction of cam pressure, points on the work reproduced from points equally so spaced in the model.

34. A machine for making peripheral cams comprising a tool, a work holder and a model arranged to guide the tool around the work by means of the model periphery, and mechanism for equally angularly spacing points in the work reproduced from points unequally angularly spaced in the model.

35. A cam generating machine having a model wheel, tool, model holder and work holder, means for effecting relative traverses between the said four instrumentalities in pairs whereby a model contour may guide the tool, and mechanism for relatively displacing perpendicularly to the direction of cam action the points on the work piece as compared with the model points from which they were reproduced to form a curve of gradual starting and stopping characteristics on the work piece.

36. A cam generating machine having a model wheel, tool, model holder and work holder, means for effecting relative traverses between the said four instrumentalities in pairs whereby a model contour may guide the tool, and mechanism for compounding with the model contour a contour having predetermined characteristics not embodied in the model itself, said mechanism comprising a cam for adding to the normal movement of one of the four first-named instrumentalities a component having the characteristics it is desired to compound with the model contour.

37. A cam generating machine having a model wheel, tool, model holder and work holder, means for effecting relative traverses between the said four instrumentalities in pairs whereby a model contour may guide the tool, and mechanism for compounding with the model contour a contour having predetermined characteristics not embodied in the model itself, said mechanism comprising a worm wheel and a worm arranged to slide along the direction of its axis, and a cam having the said characteristics constructed and arranged to slide the worm, and impart the said characteristics to the movement of the worm wheel.

38. A cam model in which the dwells of the cam are represented only by isolated points.

39. A cam model in which the dwells of the cam are represented only by isolated points and in which the transition curves between the dwells are represented by curves of substantially uniform rise or fall joining the points.

40. A cam model having the points corresponding to the cam-dwells accurately plotted on it, said points being joined by curves of substantially uniform rise and fall.

41. A cam model in which the transition curves between the dwells of the cam are represented by curves of substantially uniform rise or fall joining the portions corresponding to the dwells.

42. A cam model consisting of isolated points at generally different distances along the direction in which the cam drives its cooperating member, said points being joined by arcs of circles.

43. A peripheral cam model consisting of isolated points at generally different radial distances from the center, joined by arcs of circles having their centers near the center of the model.

44. A model for a cam generating machine comprising a face plate having means for adjustably attaching separable guides, and separable guides arranged to cooperate with said face plate to form a model periphery and to engage the model wheel of a cam generating machine.

45. A model for a cam generating machine comprising a face plate having slots, studs adjustable in said slots, and separable guides connecting said studs to form the model periphery.

46. A model for a cam generating machine comprising a face plate having radial slots, studs adjustable in said slots, and guides adjustable with the studs and connecting them two by two to form the model periphery.

47. A model for a cam generating machine comprising a face plate having slots, studs adjustable in said slots, said studs and face plate being constructed and arranged to cooperate with members of a set of interchangeable guides to form the model periphery.

48. A model for a cam generating machine comprising a face plate having radial slots, studs adjustable in said slots, and a separable guide constructed and arranged to cooperate with the model wheel and connecting two of said studs to form the model periphery.

49. A model for a cam generating ma-

chine comprising a face plate having radial slots, studs adjustable in said slots, and a sector mounted adjustably in the face plate and having a radial slot, whereby said slot may be used in connection with either of the adjoining slots to locate a model arc.

50. A model for a cam generating machine consisting of a face plate having sectors relatively angularly adjustable, each of said sectors having a radial slot, studs adjustable in said slots and separable guides connecting said studs to form the model periphery.

51. A model for a cam generating machine consisting of a face plate having sectors relatively argularly adjustable, each of said sectors having means for radially adjustably attaching a guide constructed and arranged to act as the model periphery.

52. In a machine of the class described, a model holder, a work holder, a model guide and a tool, and means for relatively rotating the model relatively to the guide and the work relatively to the tool, corresponding points of contact on the model and work being differently angularly spaced.

53. In a machine of the class described, a model holder, a work holder, a model guide and a tool, and means for relatively rotating the model relatively to the guide and the work relatively to the tool, corresponding points of contact on the model and work being differently angularly spaced, comprising a gearing between the pairs of said relatively rotating instrumentalities.

54. In a machine of the class described, a model holder, a work holder, a model guide and a tool, and means for relatively rotating the model relatively to the guide and the work relatively to the tool, corresponding points of contact on the model and work being differently angularly spaced, comprising a gearing for driving the model in definite cycles and a gearing having a member the number of whose teeth is a direct measure of the angular movement of the work corresponding to a cycle of movement of the model.

55. A machine for generating cams comprising a tool, a work holder, and a model holder, arranged to guide a relative traverse of the tool over the work by means of the model and means for circumferentially proportionally spacing, at any desired ratio, points on the work as regards the corresponding points of the model.

56. A machine for generating cams comprising a tool, a work holder, and a model holder, arranged to guide a relative traverse of the tool over the work by means of the model, comprising means for rotating the model and work at a constant angular velocity ratio, other than unity.

57. A cam generating machine comprising a model guide and a model consisting of a succession of curves of substantially uniform rise or fall, a tool and a work holder, and means for effecting relative circumferential traverses between the members of the said respective pairs of instrumentalities constructed and arranged to reproduce a curve on the model into a curve of differing angular extent in the work.

58. A cam generating machine comprising a model guide and a model consisting of a succession of curves of substantially uniform rise or fall, a tool and a work holder, and means for effecting relative circumferential traverses between the members of the said respective pairs of instrumentalities constructed and arranged to reproduce a curve on the model into a curve of differing linear extent in the work.

59. A cam generating machine comprising a model wheel and a model having isolated points plotted on it corresponding to the dwells of the cam, and curves of substantially constant rise or fall connecting the said points in order, a tool and a work holder, and means for driving the work holder and model relatively to the tool and model wheel in timed relation with permissive holding of the model wheel on a said point of the model while a corresponding dwell is cut on a work piece held by the work holder.

60. A cam generating machine comprising a model wheel and a model having isolated points ploted on it corresponding to tne dwells of the cam, and curves of substantially constant rise or fall connecting the said points in order, a tool and a work holder, and means for driving the work holder and model relatively to the tool and model wheel in timed relation with permissive holding of the model wheel on a said point of the model while a corresponding dwell is cut on a work piece held by the work holder, comprising means for feeding the said curves of substantially constant rise or fall over the model wheel at a non-uniform speed to shape transition curves of predetermined characteristics between dwells on the work piece.

61. That improvement in the art of cam generation which consists in accurately plotting points on the model corresponding to the dwells desired in the cam and connecting them by arbitrary curves which are simple considered relatively to the transition curves desired on the work.

62. That improvement in the art of cam generation which consists in accurately plotting points on the model corresponding to the dwells desired in the cam and connecting them by arbitrary curves which are simple considered relatively to the transition curves desired on the work, and generating from said arbitrary curves transition curves having desired characteristics.

63. That improvement in the art of cam generation which consists in using as a model a curve which is of relatively uniform curvature as regards the cam to be formed, and compounding with the said curve a curve having desired characteristics, as for example, those of easy starting and stopping.

64. That improvement in the art of cam generation which consists in measuring off the proper distances from the model center to the dwell points, holding the model motionless in the pattern copying machine during the generation of the dwells in the work, and rotating the model from one dwell point to the next to generate the transition curves in the work.

65. A cam model in which the dwells are represented only by isolated points and in which the transition curves between the dwells are represented by curves of substantially uniform curvature joining the points.

66. A cam model in which the dwells are represented only by isolated points and in which the transition curves between the dwells are represented by curves of simple character considered relatively to the corresponding portions of the work, joining the points.

67. A cam generating machine comprising model wheel, tool, model holder and work holder, arranged to guide the tool around the model periphery by the contact of the model wheel and model, and a control for compounding with the model periphery a curve of predetermined characteristics.

68. A cam generating machine comprising model wheel, tool, model holder and work holder, arranged to guide the tool around the model periphery by the contact of the model wheel and model and a control comprising a variable rotation device for compounding with the model periphery a curve of predetermined characteristics.

69. A cam generating machine comprising model wheel, tool, model holder and work holder, arranged to guide the tool around the model periphery by the contact of the model wheel and model, and a control for deforming the model periphery in the work to produce characteristics not present in the model periphery.

70. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting movement of the model wheel relatively to the model holder and of the tool relatively to the work, one of said movements being intermittent, but of the same average velocity as the other.

71. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting movement of the model wheel relatively to the model holder and of the tool relatively to the work, said movements occurring in cycles, those of successive cycles having different relative angular velocities.

In testimony whereof I have signed my name to this specification.

LAURENCE E. TOPHAM.

63. That improvement in the art of cam generation which consists in using as a model a curve which is of relatively uniform curvature as regards the cam to be formed, and compounding with the said curve a curve having desired characteristics, as for example, those of easy starting and stopping.

64. That improvement in the art of cam generation which consists in measuring off the proper distances from the model center to the dwell points, holding the model motionless in the pattern copying machine during the generation of the dwells in the work, and rotating the model from one dwell point to the next to generate the transition curves in the work.

65. A cam model in which the dwells are represented only by isolated points and in which the transition curves between the dwells are represented by curves of substantially uniform curvature joining the points.

66. A cam model in which the dwells are represented only by isolated points and in which the transition curves between the dwells are represented by curves of simple character considered relatively to the corresponding portions of the work, joining the points.

67. A cam generating machine comprising model wheel, tool, model holder and work holder, arranged to guide the tool around the model periphery by the contact of the model wheel and model, and a control for compounding with the model periphery a curve of predetermined characteristics.

68. A cam generating machine comprising model wheel, tool, model holder and work holder, arranged to guide the tool around the model periphery by the contact of the model wheel and model and a control comprising a variable rotation device for compounding with the model periphery a curve of predetermined characteristics.

69. A cam generating machine comprising model wheel, tool, model holder and work holder, arranged to guide the tool around the model periphery by the contact of the model wheel and model, and a control for deforming the model periphery in the work to produce characteristics not present in the model periphery.

70. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting movement of the model wheel relatively to the model holder and of the tool relatively to the work, one of said movements being intermittent, but of the same average velocity as the other.

71. In a machine of the class described, a model wheel and tool, a model holder and work holder, and mechanism for effecting movement of the model wheel relatively to the model holder and of the tool relatively to the work, said movements occurring in cycles, those of successive cycles having different relative angular velocities.

In testimony whereof I have signed my name to this specification.

LAURENCE E. TOPHAM.

CERTIFICATE OF CORRECTION.

Patent No. 1,597,741. **Granted August 31, 1926, to**

LAURENCE E. TOPHAM.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 16, strike out the word "and" and insert the same after "1923," in line 20; page 3, line 17, for the misspelled word "improtant" read "important"; page 4, line 43, for the word "is" read "in", and line 113, for the word "came" read "cam"; page 5, line 40, after the word "reduced" insert a comma; same page, line 63, after the article "the" insert the word "hollow"; page 6, line 23, strike out the words "drop in the"; page 10, line 16, claim 51, for the misspelled word "argularly" read "angularly", and line 99, claim 60, for the word "ploted" read "plotted"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of June, A. D. 1927.

M. J. MOORE.
Acting Commissioner of Patents.

Seal.

CERTIFICATE OF CORRECTION.

Patent No. 1,597,741. Granted August 31, 1926, to

LAURENCE E. TOPHAM.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 16, strike out the word "and" and insert the same after "1923," in line 20; page 3, line 17, for the misspelled word "improtant" read "important"; page 4, line 43, for the word "is" read "in", and line 113, for the word "came" read "cam"; page 5, line 40, after the word "reduced" insert a comma; same page, line 63, after the article "the" insert the word "hollow"; page 6, line 23, strike out the words "drop in the"; page 10, line 16, claim 51, for the misspelled word "argularly" read "angularly", and line 99, claim 60, for the word "ploted" read "plotted"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of June, A. D. 1927.

M. J. MOORE.

Seal. Acting Commissioner of Patents.