G. HORN.

MILLING MACHINE.

APPLICATION FILED MAY 16, 1919.

1,406,866.

Patented Feb. 14, 1922.

7 SHEETS—SHEET 1.

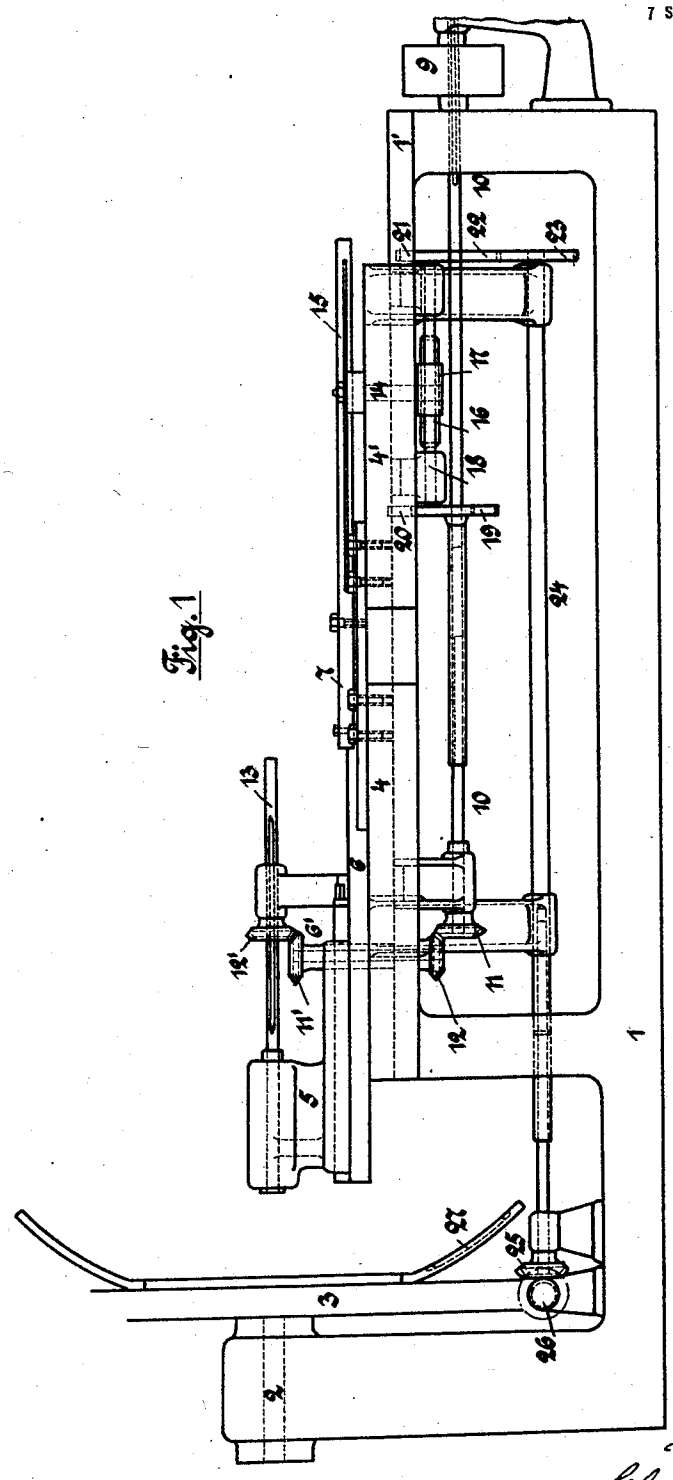

Fig. 1

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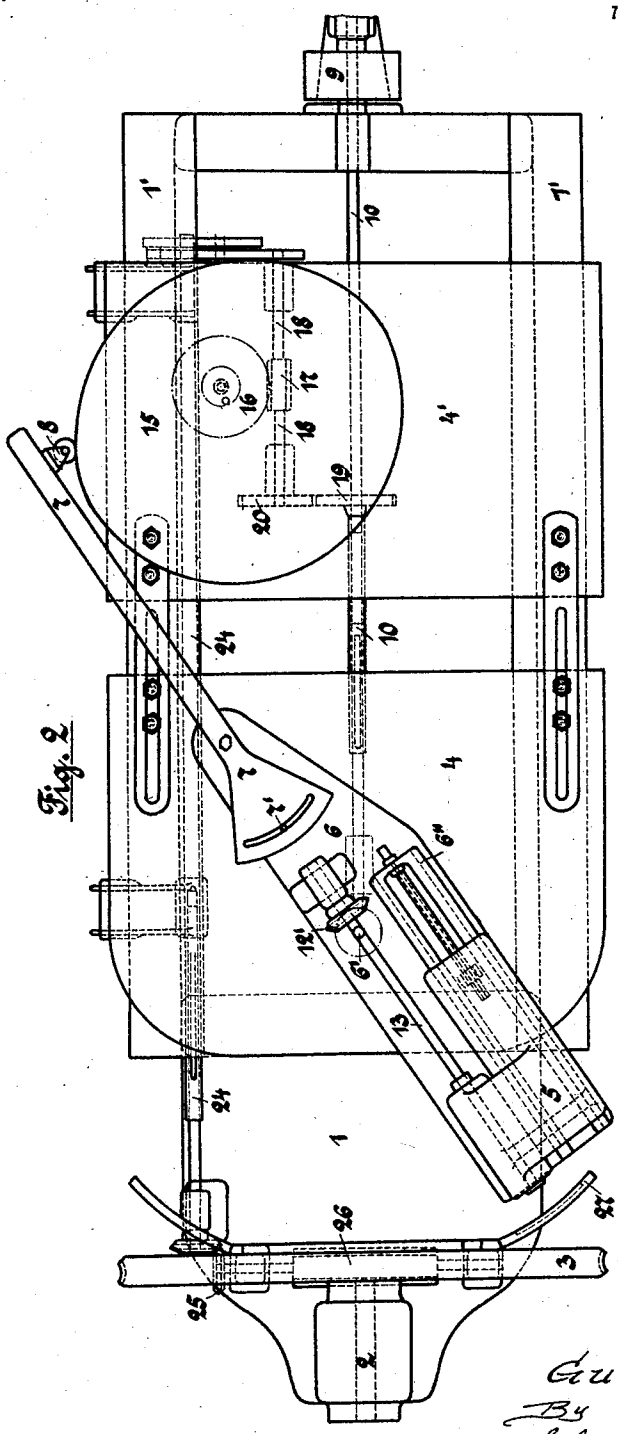

Fig. 2

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7 SHEETS—SHEET 3.

Fig. 5

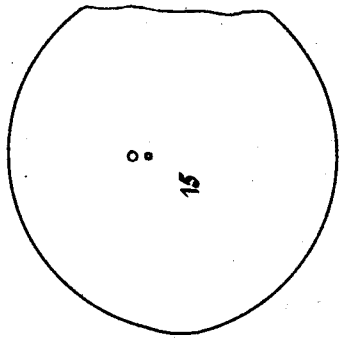


Fig. 4

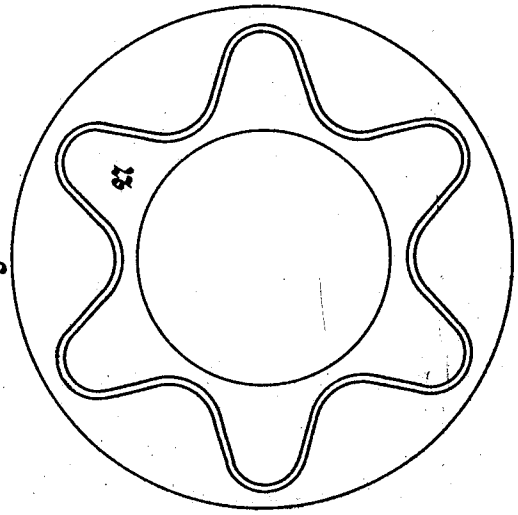
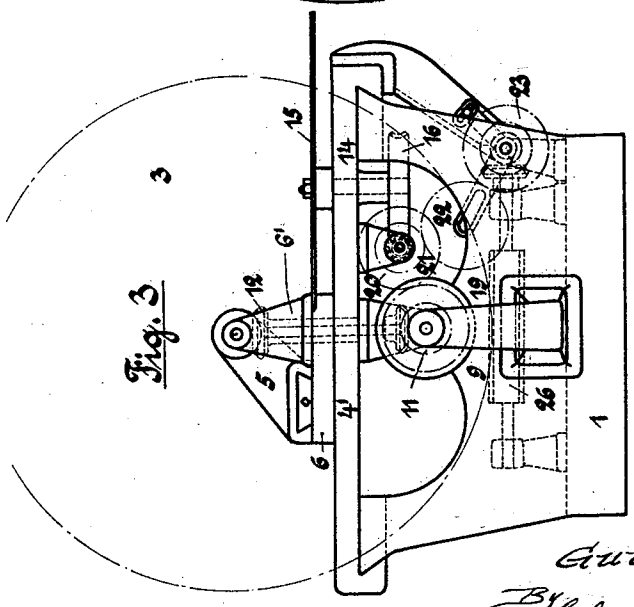


Fig. 3



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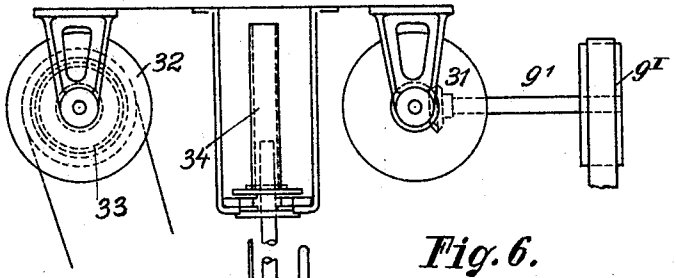
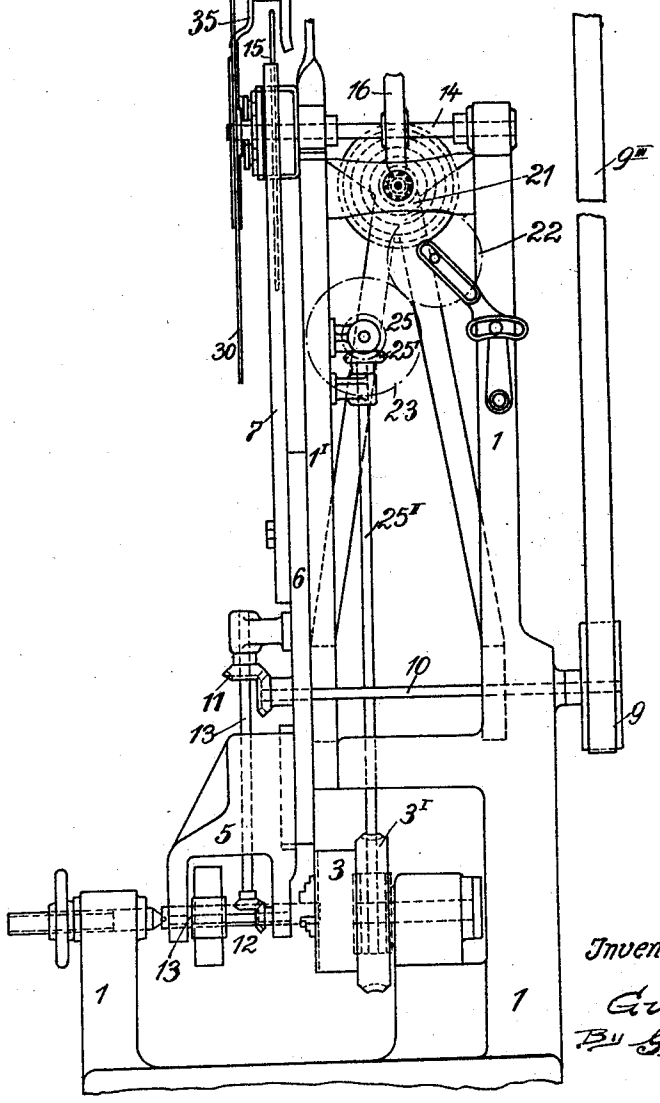


Fig. 6.



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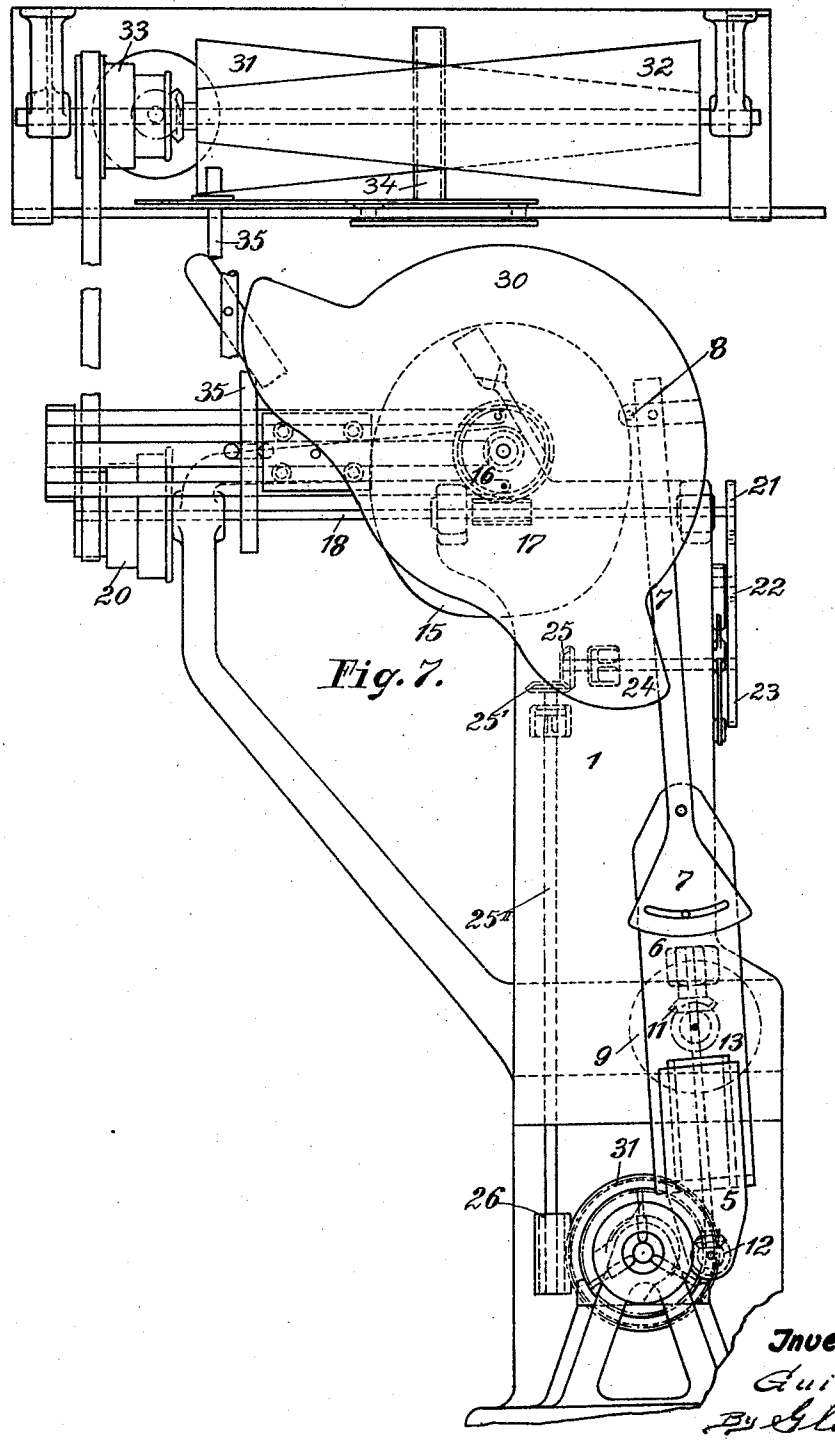

Fig. 7.

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7 SHEETS—SHEET 6.

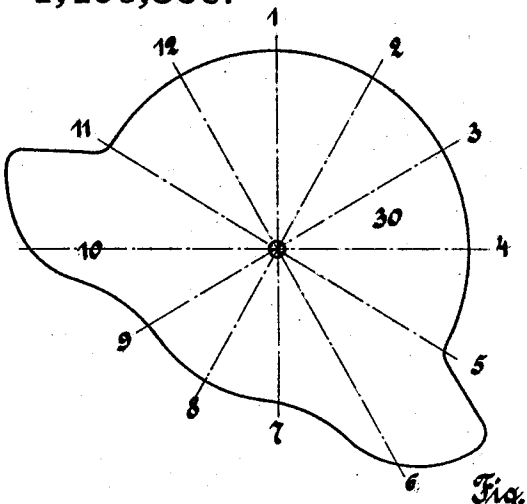


Fig. 11.

Fig. 9

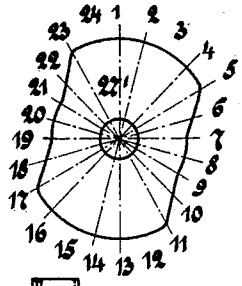


Fig. 10

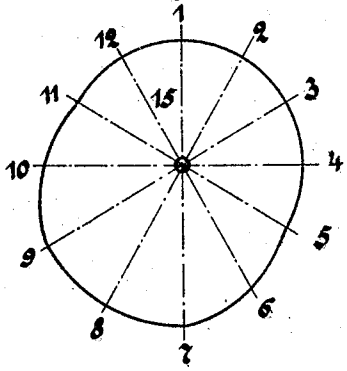
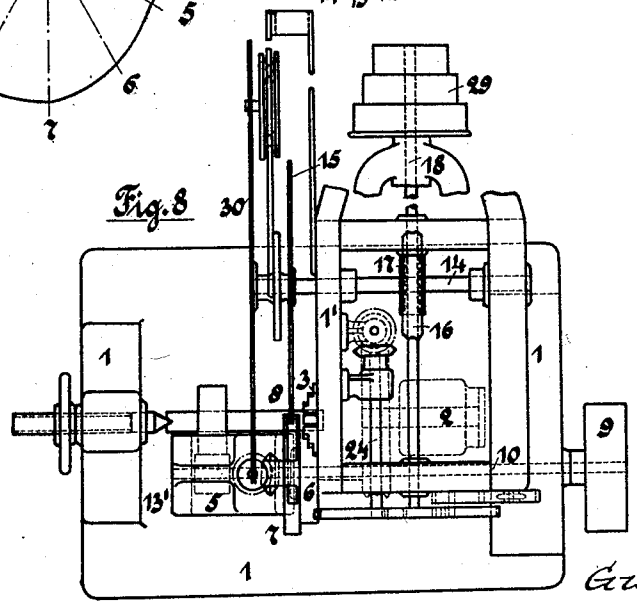


Fig. 8



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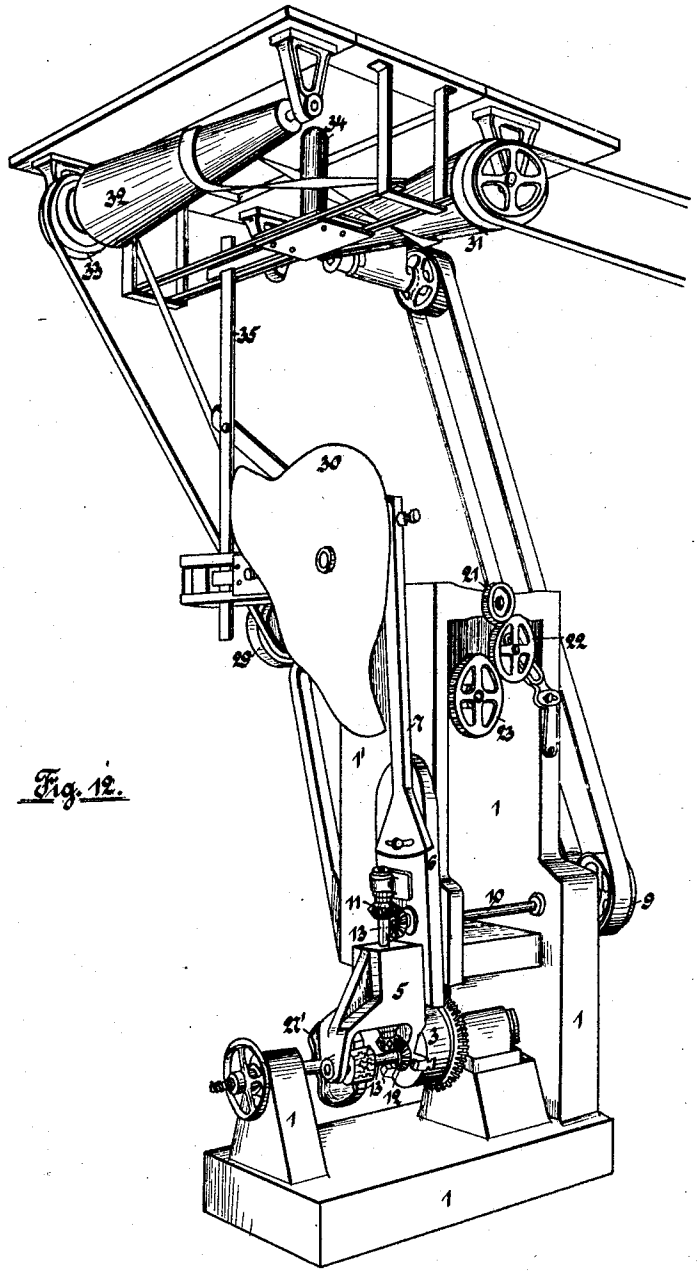

Fig. 12.

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UNITED STATES PATENT OFFICE.

GUIDO HORN, OF BERLIN-WEISSENSEE, GERMANY.

MILLING MACHINE.

1,406,866. Specification of Letters Patent. **Patented Feb. 14, 1922.**

Application filed May 16, 1919. Serial No. 297,713.

To all whom it may concern:

Be it known that I, GUIDO HORN, a citizen of Germany and a resident of Berlin-Weissensee, in Germany, have invented certain new and useful Improvements in Milling Machines, (for which I have filed application in Germany on the 21st of August, 1916,) of which the following is a specification.

My invention relates to milling machines and particularly to milling machines designed for producing cams and the like objects of irregular contour. The object of my present invention is to produce an improved milling machine whereby spherical and other copy milling work may be produced by means of readily producable copy cams.

The known copy milling machines are designed to transfer the contour of a copy cam upon the work, the milling spindle moving either parallel within the same plane or axially, unless the contour of the work is eventually produced through corresponding movements of the latter. The former method requires very accurate copy cams and is not applicable for any repetition of the same contour upon the same work, nor for milling spherical contours. While those milling machines which are especially designed for producing spherical contours do not employ copy cams.

According to my present invention spherical as well as other cam contours are produced after simple copy cams by means of an oscillating milling tool which produces the desired contours after an evolution method. The essential feature of this evolution method consists in the fact that the oscillating milling tool is controlled by means of a simple revolving cam and produces upon the work the desired contour as the result of the movement of the milling tool and the feed of the work, the latter revolving in a definite relation to the movement of the milling tool control cam.

The milling device according to my invention is mainly designed for such revolving work on which a certain contour occurs more than once within the effective path of the cam. For spherical milling work the axis of the work to be wrought upon is arranged at right angle to the axis of oscillation of the milling spindle; for milling other contours the axis of the work, the axis of the milling tool, and the axis of oscillation of the latter are disposed parallel.

With a uniform revolving feed or cross feed milling work of this character causes the milling tool to cut varying lengths within a given unit of time. For the economical utilization of such a machine it is therefore desirable that provisions be made for a feed regulator that adjusts itself automatically so that the working capacity of the milling tool remains constant throughout.

It is a further object of my invention to provide an automatically acting feed regulator that adjusts the feed in relation to the actual length of the cutting path of the milling tool.

On account of the difference in operation from the ordinary milling machines, this invention may be designated as an evolution milling machine, thereby indicating that the mill form does not have a form which is similar to that of the finished piece, the form of the latter being developed during the operation of the machine.

To render my invention more clear I have illustrated embodiments of the same in the accompanying drawings by way of example.

In Figures 1 to 3 I have shown a machine according to my present invention for producing spherical cam contours, Figure 1 being an elevation, Figure 2 a plan view, and Figure 3 a side view of the machine. Figure 4 represents a milling work such as may be produced by the machine illustrated in Figures 1 to 3, while Figure 5 shows a copy cam suitable for a work shown in Figure 4. With the kind of work shown for instance in Figure 4, the milling tool is required to perform an approximately unvarying cutting length for a unit time throughout, hence, no feeding speed regulator is required which I have therefore omitted in the construction shown in Figures 1 to 3. However, such a device is shown in another embodiment of my invention illustrated in Figures 6 to 8 inclusive, Figure 6 being an elevation, Figure 7 a side view seen from the left of Figure 6, and Figure 8 a plan view of the main parts of the machine. Figure 9 shows a typical example of a work, and Figures 10 and 11 the milling and feeding cams for the production of such work. The modified embodiment of my invention as shown in Figures 6 to 8 is

illustrated in Figure 12 in a perspective view.

The machine frame 1 is provided with a bed like structure carrying the tracks 1′. At one end of the frame 1 there is mounted the spindle 2 of the circular table 3 which is provided at its circumference with teeth engaging a worm shaft 26 by means of which the feed is communicated to the said table. Upon the tracks 1′ is lengthwise movable a divided slide 4, 4′. The slide part 4 carries upon a hollow pivot 6′ the oscillation plate 6 with the extension 7 and the adjustably mounted guide roller 8 mounted at the end of the latter. The angular position of the extension 7 is rendered adjustable relative to the oscillator 6 by means of a screw and slot connection 7′. The spindle stock 5 is adjustably mounted upon a track 6″ of the oscillation plate 6. The axis of the milling spindle 13 crosses the axis of oscillation at a right angle; and the axis of revolution of the work 27 to be wrought upon is likewise disposed at a right angle to the axis of oscillation.

The machine is operated by means of the shaft 10 receiving its driving power over the belt pulley 9. Two pairs of bevel gears 11, 12 and 11′, 12′ communicate the driving power to the milling spindle 13. I have omitted from the drawings the milling tool since such tools are well known to those skilled in the art to which this invention refers. The slide part 4′ carries the upright shaft 14; on the upper end of the latter is mounted the contour control cam or copy cam 15. The lower end of the shaft 14 carries the gear wheel 16 that engages the worm 17 upon the shaft 18. The latter is actuated from the main shaft 10 over the gear wheels 19 and 20. From the end opposite to the driving wheel 20, the shaft 18 actuates the feed shaft 24 over a set of change wheels 21, 22, and 23. The feed shaft 24 revolves the worm shaft 26 by means of a pair of bevel wheels 25.

The work to be wrought upon is designated 27, and it is presumed that the same is to be provided with the spherical, viz. concave cam groove illustrated in Figure 4. The copy cam required for this species of work is reproduced in Figure 5 and is of a very simple structure.

When the machine is set into operation the copy cam 15 is caused to revolve owing to the gear connection above described. The circular table 3 revolves also and its ratio of speed with regard to the revolution of the copy cam 15 is determined by the size of the change wheels 21 and 23. In the present instance the copy cam is required to perform six full revolutions while the work is once turned, in order to reproduce the groove contour six times. The contour that can be produced by means of the copy cam 15 can be milled into the work as many times during one revolution of the latter as may be desired; all that is necessary is to change the ratio of speed between the copy cam and the work table correspondingly.

The extent of the oscillation of the milling tool can be adjusted by approaching or moving apart the slide sections 4 and 4′ and readjusting the active length of the extension arm 7. Hence, figures of similar contour but different size can be produced with one and the same copy cam.

The described construction is designed for spherical milling work of a character similar to that shown in Figure 4. Cams of this spherical curvature are required, for instance, as control cams for the guidance of machine parts the axis of rotation of which meet in the point about which the milling spindle oscillates. For cams of the character shown, for instance, in Figures 9, 10, and 11, I have designed the construction shown in Figures 6 to 8. However, the machine shown in Figures 1 to 3 may be adapted to like requirements by arranging the milling spindle at a right angle to the actuating shaft and by rendering the machine table angularly adjustable.

Referring to the construction shown in Figures 6 to 8, the oscillation plate 6 rests directly upon the track 1′ of the bed 1 which carries the shaft 14 on which the copy cam 15 is secured. The oscillation plate 6 is operated from an independent gear. The milling tool is actuated from the driving pulley 9 receiving its power from an overhead shaft 9′ over a pulley 9″ and a belt 9‴. The stepped cone pulley 29 is provided for the operation of the feed. The cone pulley 29 is secured upon a shaft 18 from which is derived the drive for the copy cam 15 and for the chuck 3 for the work in a similar manner as described with reference to the first embodiment of the invention shown in Figures 1 to 3. The shaft 18 is positively connected to the shaft 14 by means of a worm gear 17, 16, and to the shaft 24 by means of toothed gear wheels 21, 22, 23. The shaft 24 drives the shaft 2 and the chuck 3 secured thereon by means of a pair of bevel wheels 25, 25′, the shaft 25″ and the worm gear 26, 3′.

Besides the copy cam 15, the shaft 14 carries the control cam 30 for the feed adjustment. The latter comprises a countershaft and a pair of pulleys. The cone pulley 31 drives while the cone pulley 32 and the stepped pulley 33 are driven parts of the gear. The belt mover 34 is operated by means of a lever 35 directly controlled by the cam 30. I provide counter weights which are omitted for the sake of clearness and by means of which the cam actuated parts are kept in contact with the respective cams.

In Figure 10 I have illustrated a copy

cam adapted for the production of the work 27′ shown in Figure 9. In this case the feed control cam 30 would require a contour similar to that shown in Figure 11.

The cooperation of the different machine parts I will now describe with reference to the modified construction shown in Figures 6 to 8. In this case both of the worm gears, viz. that for the operation of the copy cam 15 and that for the revolution of the chuck 3 for the work, have equal numbers of threads and teeth respectively. The change wheel 21 upon the shaft 18 is half as large as the wheel 23 upon the feed shaft 24. Hence, the work is revolved one half a turn when the worm 17 has revolved the worm wheel 16 and the copy cam 15 a full turn. When the work is finished, its contour is therefore doubled.

The division of the sectional face of the work 27′ into 24 parts, as shown in Figure 9, corresponds to the division of the copy cam, Figure 10, into 12 parts; the figures indicating the coinciding angular positions, the largest radius of the work 27′ corresponds to the smallest radius of the copy cam 15. If the angular speed of the feed remains constant, the cutting capacity of the milling tool remains equal between the points 1 to 5, increases between the points 5 and 6, decreases between the points 6 and 7, is considerably less between the points 7 and 9, and increases thereafter in the same proportion in which it decreased previously. If it is desired that the machine operates with the maximum milling tool feed allowable, the corresponding speed need only be ascertained between the points 1 to 5 of the milling tool path and the feed regulator adjusted accordingly. At the moment when the feeding speed tends to increase the ascending portion between the points 5 and 6 of the feed control cam operates the lever 35 of the feed regulating gear which is thereby slowed down accordingly. Since the effective curve of the cam 30 descends rapidly between the points 6 and 7 and remains unchanged up to the point 9, the result is that the speed regulator increases the angular speed of both the work and the copy cam to such an amount that the speed of the milling tool remains constant.

For the adjustment and readjustment of the cutting depth I have provided the adjustable roller 8 (see Figure 7). By increasing its distance from the extension 7, the milling tool is caused to cut deeper into the work.

With the construction shown in Figures 1 to 3, the cutting depth of the milling tool is adjusted by a movement of the spindle stock 5 upon the track 6″ of the oscillation plate 6.

If it is desired to give the contours produced a finishing grinding, it is only necessary to put a grinding wheel in place of the milling tool and to provide a separate drive for the same. However, the grinding wheel must have a diameter as equal as possible to that of the willing tool as otherwise the produced contour of the work will be affected.

The limit of the size of the copy cam depends upon the size of the machine. A circle is made upon the copy cam plate. This circle may be considered as the basis circle and is divided into as many parts as the contour to be milled. Into the latter a basis circle is made from which the distance of the contour is measured successively within the division lines and transferred upon the copy cam plate at a proportion equal to the proportion of the lengths of the levers between the oscillation axis and milling tool and oscillation axis and guide roller.

Should the form of the work require it the circular feed of the latter may be substituted by a cross table feed.

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

1. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanism for said table, a milling spindle adapted to receive a milling tool, an oscillatory carrier for said milling spindle and adapted to be cam controlled, the axis of oscillation of said carrier being disposed at a right angle to the axis of said spindle, a revoluble cam for said carrier to control its oscillatory movement, feeding mechanism for said cam, said second named mechanism operating in timed relation to said first named mechanism, actuating means for said milling spindle, and means in connection with said second named mechanism for altering the ratio of speed between the feed of said cam and the feed of said table, whereby the contour of said cam may be reproduced more than once within the course of the complete cam contour to be produced upon the work.

2. Milling machine, comprising, in combination, a revoluble table for the work to be wrought upon, feeding mechanism for said table, a milling spindle adapted to receive a milling tool, an oscillatory carrier for said milling spindle and adapted to be cam controlled, the axis of oscillation of said carrier being disposed at a right angle to the axis of said spindle as well as to the axis of said table, a revoluble cam for said carrier to control its oscillatory movement, feeding mechanism for said cam, said second named mechanism operating in timed relation to said first named mechanism, actuating means for said milling spindle, and means in connection with said second named mechanism for altering the ratio of speed between the feed of

said cam and the feed of said table, whereby the contour of said cam may be reproduced repeatedly within the course of the complete cam contour to be reproduced upon the work.

3. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanism for said table, a milling spindle adapted to receive a milling tool, an oscillatory carrier for said milling spindle and adapted to be cam controlled, the axis of oscillation of said carrier being disposed at a right angle to the axis of said spindle, a revoluble cam for said carrier to control its oscillatory movement, feeding mechanism for said cam, said second named mechanism operating in timed relation to said first named gear, actuating means for said milling spindle, means in connection with said second named mechanism for allowing of altering the ratio of speed between the feed of said cam and the feed of said table, whereby the contour of said cam may be reproduced more than once within the course of the complete cam contour to be produced upon the work, and means for adjusting the position of said spindle upon said carrier and relative to the work.

4. Milling machine, comprising, in combination, a revoluble table for the work to be wrought upon, feeding mechanism for said table, a milling spindle adapted to receive a milling tool, an oscillatory carrier for said milling spindle and adapted to be cam controlled, the axis of oscillation of said carrier being disposed at a right angle to the axis of said spindle as well as to the axis of said table, a revoluble cam for said carrier to control its oscillatory movement, feeding mechanism for said cam, said second named mechanism operating in timed relation to said first named mechanism, actuating means for said milling spindle, means in connection with said second named mechanism for altering the ratio of speed between the feed of said cam and the feed of said table, whereby the contour of said cam may be reproduced more than once within the course of the complete cam contour to be reproduced upon the work, and means for adjusting the position of said spindle upon said carrier and relative to the work.

5. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanism for said table, an oscillatory carrier extending in opposite directions from its axis of oscillation, a milling spindle adapted to receive a milling tool, said milling spindle being mounted upon one extension of said carrier, an adjustable arm at the extension of said carrier that is opposite to said first named extension carrying said milling spindle, said arm being adapted to be cam controlled, a revoluble cam acting upon said arm so as to control the oscillatory movement of said carrier, the axis of oscillation of said carrier being disposed at a right angle to the axis of said milling spindle, actuating means for said milling spindle, and feeding mechanism for said cam.

6. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanism for said table, an oscillatory carrier extending in opposite directions from its axis of oscillation, a milling spindle adapted to receive a milling tool, said milling spindle being mounted upon one extension of said carrier, an adjustable arm at the extension of said carrier that is opposite to said first named extension carrying said milling spindle, an adjustable cam follower at the free end of said arm, a revoluble cam acting upon said arm so as to control the oscillatory movement of said carrier, the axis of oscillation of said carrier being disposed at a right angle to the axis of said milling spindle, acuating means for said milling spindle, a slide consisting of two relatively adjustable sections, one of said sections carrying said oscillatory carrier while the second section carries said revoluble cam, whereby the ratio of leverage between the axis of oscillation and the actuating point of said cam on the one hand and the milling point on the other hand may be altered, and actuating means for said cam.

7. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanism for said table, an oscillatory carrier extending in opposite directions from its axis of oscillation, a milling spindle adapted to receive a milling tool, said milling spindle being mounted upon one extension of said carrier, an adjustable arm at the extension of said carrier that is opposite to said first named extension carrying said milling spindle, said arm being adapted to be cam controlled, a revoluble cam acting upon said arm so as to control the oscillatory movement of said carrier, the axis of oscillation of said carrier being disposed at a right angle to the axis of said milling spindle, actuating means for said milling spindle, and feeding mechanism for said cam, said last named mechanism operating in timed relation to said first named mechanism.

8. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanim for said table, an oscillatory carrier extending in opposite directions from its axis of oscillation, a milling spindle adapted to receive a milling tool, said milling spindle being mounted upon one extension of said carrier, an adjustable arm at the extension of said carrier that is opposite to said first named extension carrying said milling spindle, an adjustable cam follower at the free end of said arm, a revoluble cam acting upon said arm so as to control the oscillatory movement of said car-

rier, the axis of oscillation of said carrier being disposed at a right angle to the axis of said milling spindle, actuating means for said milling spindle, a slide consisting of two relatively adjustable sections, one of said sections carrying said oscillatory carrier while the second section carries said revoluble cam, whereby the ratio of leverage between the axis of oscillation and the actuating point of said cam on the one hand and the milling point on the other hand may be altered, feeding mechanism for said cam, said last named mechanism operating in timed reation to said first named mechanism.

9. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanism for said table, an oscillatory carrier extending in opposite directions from its axis of oscillation, a milling spindle adapted to receive a milling tool, said milling spindle being mounted upon one extension of said carrier, an adjustable arm at the extension of said carrier that is opposite to said first named extension carrying said milling spindle, said arm being adapted to be cam controlled, a revoluble cam acting upon said arm so as to control the oscillatory movement of said carrier, the axis of oscillation of said carrier being disposed at a right angle to the axis of said milling spindle, actuating means for said milling spindle, feeding mechanism for said cam, said last named mechanism operating in timed relation to said first named mechanism, and means in connection with said last named mechanism for altering the ratio of speed between the feed of said cam and the feed of said table, whereby the contour of said cam may be reproduced more than once within the course of the complete cam contour to be produced upon the work.

10. Milling machine, comprising, in combination, a table for the work to be wrought upon, feeding mechanism for said table, an oscillatory carrier extending in opposite directions from its axis of oscillation, a milling spindle adapted to receive a milling tool, said milling being mounted upon one extension of said carrier, an adjustable arm at the extension of said carrier that is opposite to said first named extension carrying said milling spindle, an adjustable cam follower at the free end of said arm, a revoluble cam acting upon said arm so as to control the oscillatory movement of said carrier, the axis of oscillation of said carrier being disposed at a right angle to the axis of said milling spindle, actuating means for said milling spindle, a slide consisting of two relatively adjustable sections one of which carrying said oscillatory carrier while the second section carries said revoluble cam, whereby the ratio of leverage between the axis of oscillation and the actuating point of said cam on the one hand and the milling point on the other hand may be altered, feeding mechanim for said cam, said last named mechanism operating in timed relation to said first named mechanism, and means in connection with said second named feeding mechanism for altering the ratio of speed between the feed of said cam and the feed of said table, whereby the contour of said cam may be reproduced at least twice within the course of the complete cam contour to be produced upon the work.

11. Milling machine, comprising, in combination, a device for holding the work to be wrought upon, feeding mechanism for said device, a milling device, an oscillatory carrier for said milling device and adapted to be cam controlled, a revoluble cam for said carrier to control its oscillatory movement, actuating mechanism for said milling device, feeding mechanism for said cam, and a speed regulating device operatively connected with both said first named feeding mechanism and said last named feeding mechanism, whereby the feed of the work and the feed of said cam is automatically regulated in accordance to the milling work to be performed.

12. Milling machine, comprising, in combination, a device for holding the work to be wrought upon, feeding mechanism for said device, a milling device, an oscillatory carrier for said milling device and adapted to be cam controlled, a revoluble cam for said carrier to control its oscillatory movement, actuating mechanism for said milling device, feeding mechanism for said cam, and a speed regulating device operatively connected with both said first named feeding mechanism and said last named feeding mechanism and comprising a controlling cam mounted concentrically with said first named cam and so as to participate of the revolving movement of the latter, whereby the feed of the work and the feed of said cam is automatically regulated in accordance to the milling work to be performed.

13. Milling machine, comprising, in combination, a device for holding the work to be wrought upon, feeding mechanism for said device, a milling device, an oscillatory carrier for said milling device and extending in opposite directions from the axis of oscillation, said milling device being mounted upon one extension of said carrier, an adjustable arm at the carrier extension that is opposite to said first named extension, said arm being adapted to be cam controlled, a revoluble cam acting upon said arm so as to control the oscillatory movements of said carrier, actuating means for said milling device, feeding mechanism for said cam, and a cam controlled speed regulator operatively connected with both said first named feeding mechanism for the

work and said last named feeding mechanism for said revoluble cam, the controlling cam of said regulator being mounted concentrically with said first named cam and so as to participate of the revolving movements of the latter, whereby the feed of the work and the feed of said first named controlling cam is automatically regulated in accordance to the amount of milling work to be performed.

14. Milling machine, comprising, in combination, a device for holding the work to be wrought upon, feeding mechanism for said device, a milling device, an oscillatory carrier for said milling device and adapted to be cam controlled, a revoluble cam for said carrier to control its oscillatory movement, actuating means for said milling device, feeding mechanism for said cam, and in operatve connection with said last named feeding mechanism means for altering the ratio of speed between the feed of said cam and the feed of said work holding device, whereby the contour of said cam may be reproduced at least twice within the course of the complete cam contour to be produced upon the work, and a speed regulating device operatively connected with both said first named feeding mechanism and said last named feeding mechanism, whereby the feed of the work and the feed of said cam is automatically regulated in accordance to the milling work to be performed.

15. Milling machine, comprising, in combination, a device for holding the work to be wrought upon, feeding mechanism for said device, a milling device, an oscillatory carrier for said milling device and extending in opposite directions from the axis of oscillation, said milling device being mounted upon one extension of said carrier, an adjustable arm at the carrier extension that is opposite to said first named extension, said arm being adapted to be cam controlled, a revoluble cam acting upon said arm so as to control the oscillatory movements of said carrier, actuating means for said milling device, feeding mechanism for said cam, a cam controlled speed regulator operatively connected with both said first named feeding mechanism for the work and said last named feeding mechanism for said revoluble cam, the controlling cam of said regulator being mounted concentrically with said first named cam and so as to participate in the revolving movements of the latter, whereby the feed of the work and the feed of said first named controlling cam is automatically regulated in accordance to the amount of milling work to be performed, and in operative connection with said second named feeding mechanism means for altering the ratio of speed between the feed of said cam and the feed of said work holding device, whereby the contour of said cam may be reproduced at least twice within the course of the complete cam contour to be produced upon the work.

16. Milling machine, comprising, in combination, a device for holding the work to be wrought upon, feeding mechanism for said device, a milling device comprising a milling spindle of two positively connected spindle parts disposed at a right angle to each other, an oscillatory carrier for said milling device and adapted to be cam controlled, a revoluble cam for said carrier to control its oscillatory movement, actuating mechanism for said milling device, feeding mechanism for said cam, and a speed regulating device operatively connected with both said first named feeding mechanism and said last named feeding mechanism, whereby the feed of the work and the feed of said cam is automatically regulated in accordance to the milling work to be performed.

GUIDO HORN.