G. P. THOMAS.

METAL PUNCHING OPERATION.

APPLICATION FILED JUNE 7, 1915.

1,175,197.

Patented Mar. 14, 1916.

4 SHEETS—SHEET 1.

FIG. 2.

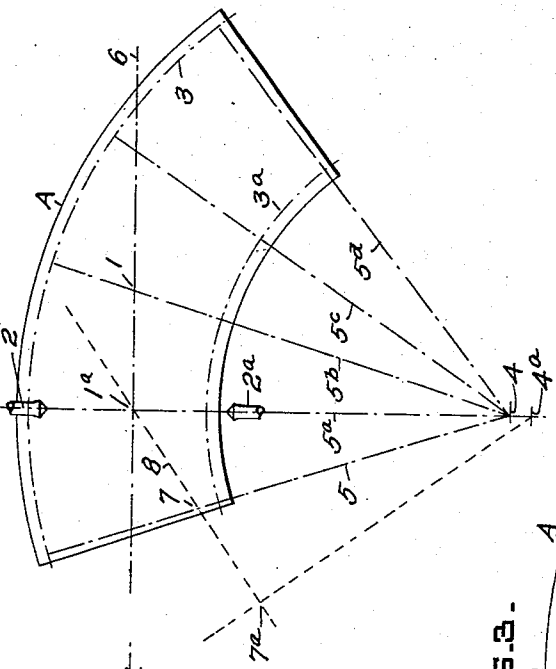


FIG. 3.

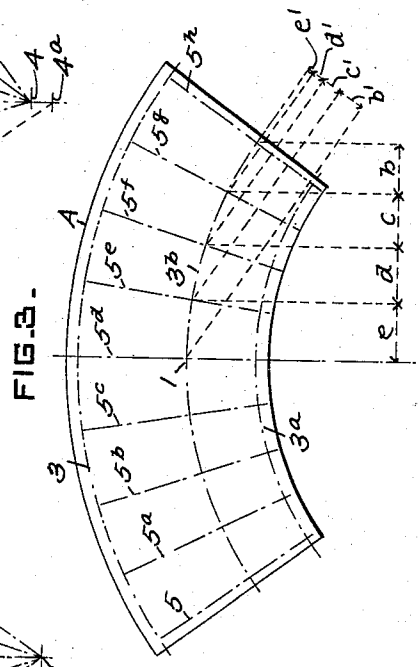
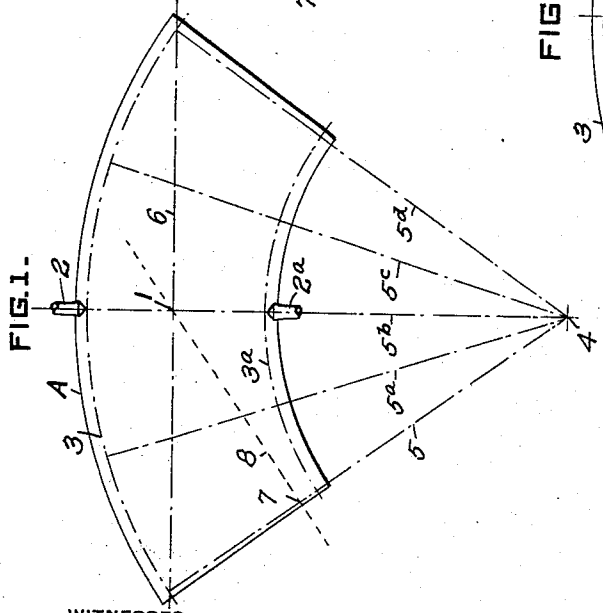


FIG. 1.



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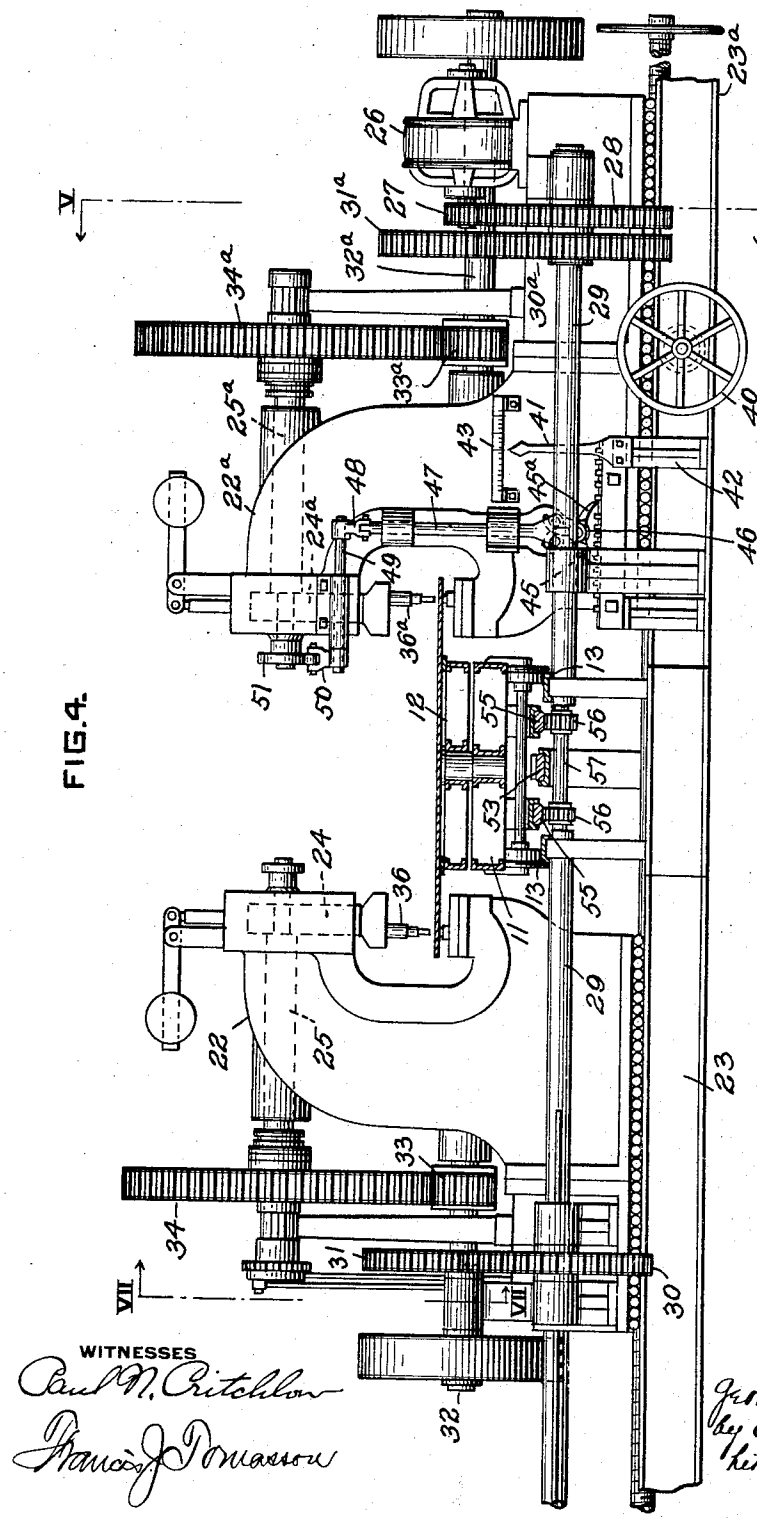


FIG. 4.

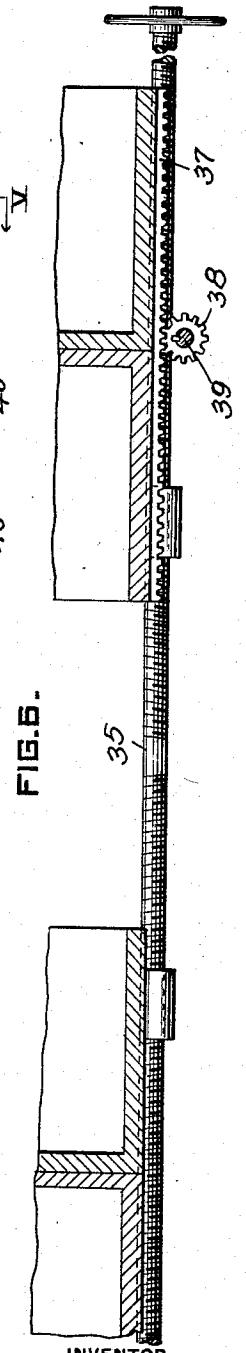


FIG. 5.

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4 SHEETS—SHEET 3.

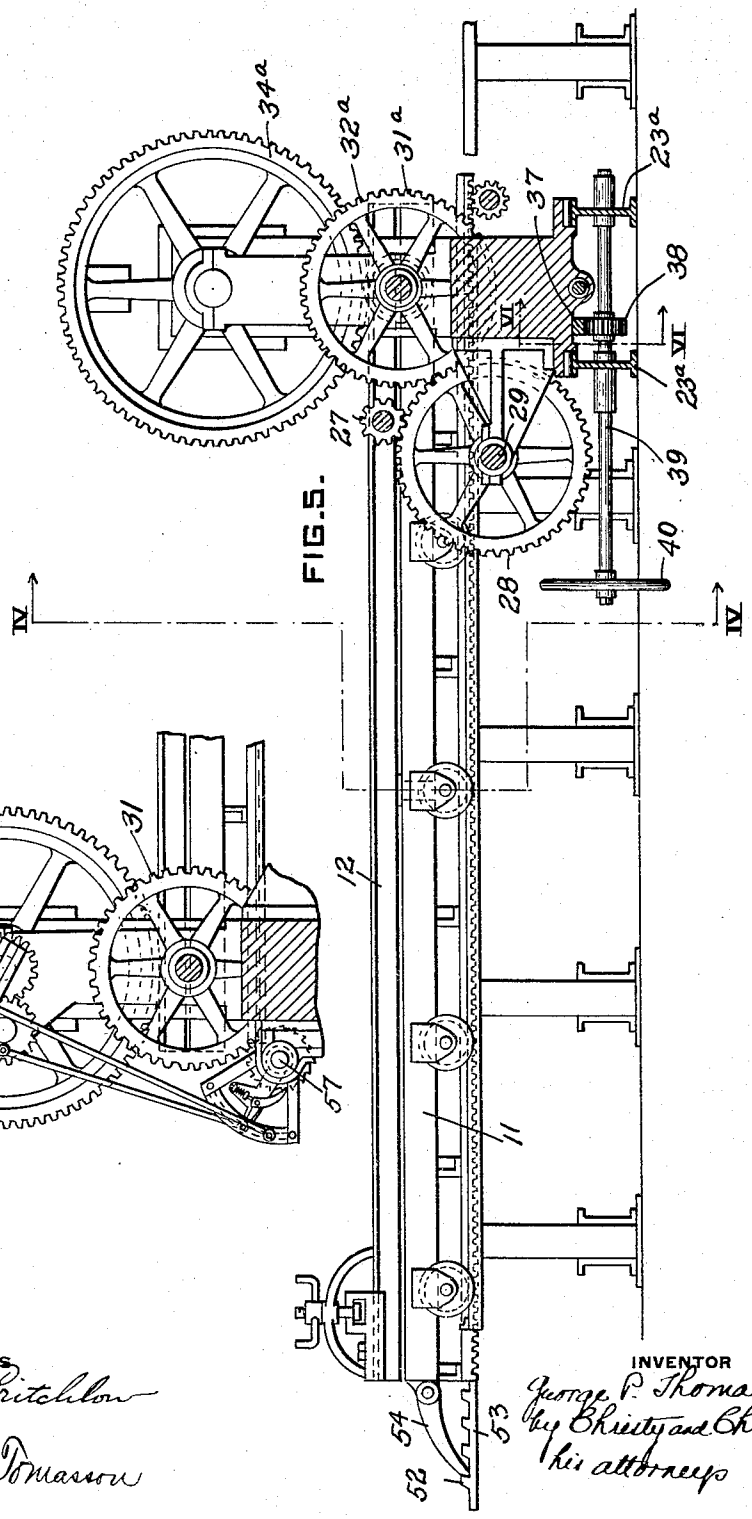


FIG. 5.

FIG. 7.

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4 SHEETS—SHEET 4.

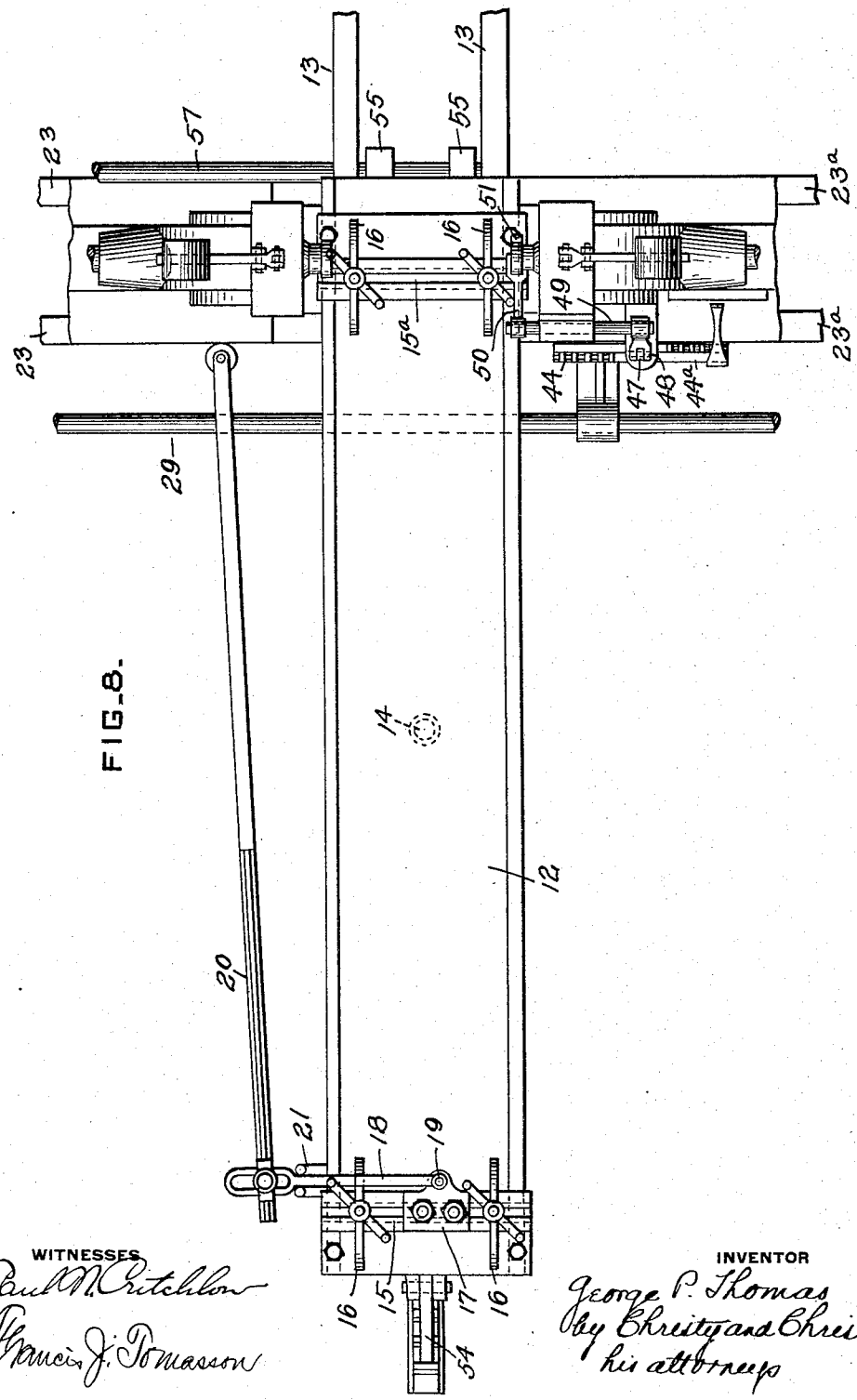


FIG. 8.

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UNITED STATES PATENT OFFICE.

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METAL-PUNCHING OPERATION.

1,175,197. Specification of Letters Patent. Patented Mar. 14, 1916.

Application filed June 7, 1915. Serial No. 32,594.

To all whom it may concern:

Be it known that I, GEORGE PAUL THOMAS, residing at Glenshaw, in the county of Allegheny and State of Pennsylvania, a citizen of the United States, have invented or discovered certain new and useful Improvements in Metal-Punching Operations, of which improvements the following is a specification.

The invention described herein relates to methods of operating punching machines to the end that plates or like structural articles may be provided with holes lying in the arc of a circle or in arcs of concentric circles.

It is well known that, in plates intended to be used in the manufacture of boilers, tanks, stacks, conduits and like cylindrical or curved structures, it is necessary or desirable to have the finished form of the plate that of a portion of the curved surface of a cone. For example, in cylindrical stacks constructed of steel plates, it is desirable that the lower curved edge of each plate lie outside of the upper curved edge of the adjacent lower plate to which it is connected, the result being that each plate must be conical in form. Now to provide such plates with holes so that they may be accurately riveted together, the holes in the opposite curved edges of the plate must, before the plate is bent, lie in arcs of concentric circles; and furthermore, pairs of holes in opposite edges must lie in the lines passing through the center of such circles. The problem that has continually confronted and vexed those concerned with the fabrication of such structures has been to provide a practical and feasible method of operating the essential punching machinery to the end that plates may be accurately punched in the manner described, and particularly when a considerable number of like plates are required. In thus speaking of essential punching machinery, I refer to such machinery as is now, and for a long time has been, considered indispensable in economic punching of structural material, namely a punching machine comprising a punch and a work carriage movable to and from the punch and by which carriage the work is brought into proper positions for punching.

Various forms of punching machinery and method of operating the same have been suggested for the purpose contemplated by my invention, but none have proven satisfactory or practical. Of such machinery, and the principles of operation on which they have been constructed, two need special mention herein, first because they represent the types of a large proportion of machinery suggested heretofore, and secondly because a knowledge of them is of material assistance to a full understanding of my invention. In the first of said forms or types of punching machinery, the punch is placed in position and the plate to be punched is, while being supported on a carriage, swung bodily about the center of the arc or arcs in which it is desired that the holes should lie. As examples of machines of this sort, reference may be had to the disclosures of United States Patents No. 759,308 to Reeves and No. 793,051 to Chapman. In the former the tracks are curved in arcs of circles concentric with those in which it is desirable to punch the plate, and the carriage with its supported plate manifestly moves about the common center of curvature. In the latter the plate is dragged by means of a carriage moving in a straight line at right angles to the line of punches, and the plate, slidable upon its supporting guides, is caused to move around the general center of curvature by means of a curved guide. The principle of operation of machines of this general character is correct—that is to say, the opposite edges of the plate may be punched in true arcs of concentric circles, and the pairs of holes in such arcs will lie in lines passing through the center of curvature of such arcs. However, it is apparent that the accurate bending of tracks or guides to suit the different required curvatures is both difficult and time consuming, and it is believed that it is for this reason that machines operating on this principle have not been adopted in actual practice. In the second of said forms or types of punching machinery, the punch is in fixed position, and the carriage moves in a straight line adjacent to it. The plate to be punched is carried upon a platform or table which is so pivoted to the carriage that it may swing in a horizontal plane, and a straight line guide, adapted to be adjusted at various angles to the line of advance of the table, is provided to cause the table to turn on its pivotal axis as the carriage advances. Punching machinery of this type is shown in United States Patent No.

501,152 to Mohr. It has long been recognized that, while such punching machinery when operated in its intended manner will cause holes to be punched in curves, such curves are not the arcs of circles. The result is that when plates are punched with such machinery the holes will not match accurately, and the greater the required curvature (that is to say the smaller the radius of curvature) the greater the error.

With the foregoing explanations in mind, the object of my invention is to provide a method of operating punching machinery of the second described type (that is, machinery wherein the carriage moves in straight tracks and the plate is pivotally supported thereon and turned by a straight guide disposed at an angle to the carriage track or line of advance) so that plates may be punched with the same precise degree of accuracy as when punched by machinery of the first described type.

My invention proceeds upon my discovery, which having been made is capable of precise demonstration, that by observing certain relations, which will be fully explained hereinafter, a plate may be punched with holes lying on concentric arcs of circles by pivotally mounting it on a carriage which is movable along straight line tracks adjacent to the punch, by causing the plate to rotate upon its pivotal axis while the carriage is advanced, and between successive punching operations causing the punch and carriage to move one with respect to the other in a direction transverse to that of the carriage advance.

In describing my invention reference is had to the accompanying sheets of drawings, wherein—

Figures 1 and 2 are diagrams of a plate and punches; Fig. 3 a plate showing convenient ways of determining distances for advance and lateral movements; Fig. 4 a combined sectional view of a work-carriage and end elevation of a punch on which my invention may be practised, the plane of view being indicated by the line IV—IV, Fig. 5; Fig. 5 a sectional view and side elevation taken on the line V—V, Fig. 4; Fig. 6 a sectional view taken on the line VI—VI, Fig. 5; Fig. 7 a sectional view taken on the line VII—VII, Fig. 4; and Fig. 8 a plan view of the work carriage and the portions of the punches adjacent thereto as illustrated in Figs. 4 and 5.

In the several figures like numerals are used to designate like parts.

In describing my improved method in detail, I will first explain it with reference to the diagrammatic figures, and then with reference to the machinery.

In Fig. 1 I have indicated, in the most convenient relative positions for explanation, a plate to be punched, the punches and the lines for determining the punching points and the travel of the plate. The plate A is pivoted substantially at its center 1, and this point is shown as lying in the line (hereinafter referred to as the punching line) drawn between the two punches 2 and 2^a, situated at opposite sides of the plate in positions to punch holes in the concentric arcs 3 and 3^a, respectively. The center of curvature of the arcs is indicated at 4, and the points to be punched are the intersections of the radial lines 5, 5^a, 5^b, 5^c and 5^d and the arcs 3 and 3^a. Of course in actual practice many more holes are punched in each plate than for illustrative purposes are indicated in this figure. The line of advance of the pivot point 1 is, as is indicated by the broken line 6, perpendicular to the punching line, which is the usual practice in punching machinery for this purpose, although, as will presently appear, it is not essential to the practice of my invention that such perpendicularity be observed. As will be seen, the plate A is indicated as being in the proper position to punch holes at the intersections of the radial line 5^b with the arcs 3 and 3^a, such radial line coinciding with the punching line.

I will now explain the essential movements of the punching machinery and plate to bring the parts to the proper relative positions to punch holes at the intersections of the line 5^a with said arcs, it being understood that the line 5^a represents any line passing through the center of curvature 4 and intersecting the arcs 3 and 3^a. In the first place it is necessary to determine the effective point of engagement of the plate for turning it and at what angle to the line of advance 6 the straight line guide for such point must be set in order to properly turn the plate upon its pivotal point as the plate is advanced. When, as is usual, the line 6 is perpendicular to the punching line, the effective point of engagement of the plate may be any point determined by the intersection of any radial line passing through the center of curvature 4 and a line perpendicular to such radial line and passing through the pivot 1, and when such pivot lies in the punching line, the guide line angle with the line 6 is the angle made between the line 6 and the line passing through the effective point of engagement and the pivot point. For example, the point 7, being the point of intersection of the radial line 5 and a line 8 drawn perpendicular to the line 5 and passing through the pivot point 1, may be taken as the effective point of engagement of the plate. When such point is thus chosen, and caused to move along the line 8 as the pivot point 1 is simultaneously moved along the line 6, any radial line, as for example the line 5^a, will be brought to the position of the line 5^b, that is to say it will

be brought to a position wherein it coincides with the punching line.

Fig. 2 shows the relative positions of the parts and lines when the plate is advanced and turned as thus described. It will be observed first that the center of curvature 4 has moved from its former position 4^a toward the punches 2 and 2^a, and along the punching line, and secondly that the point 7 has moved along the line 8 from its original position 7^a, the pivot point 1 remaining on the line of advance 6. That this relation actually exists may be readily demonstrated by a geometric consideration of the triangles 1^a, 4^a, 7^a and 1, 4, 7. It remains now to state that this advance movement and rotation of the plate A will not of itself bring the plate to a position to be punched on the arcs 3 and 3^a. There must be a relative lateral movement between the plate and the punches, such movement being measured by the distance between the points 4 and 4^a. This may be accomplished between successive punching operations either by moving the punches themselves or by simultaneously moving the work carriage, its straight line tracks represented by the line 6, and the guide represented by the line 8.

From the foregoing description certain relations will be readily understood without entering into further detailed explanations. In the first place it will be observed that as far as the movements of the parts are concerned, holes may be punched in any desired number of concentric circular arcs, and that the plate to be punched may be any fraction or multiple of that shown. Such being the case, it will be seen that the effective point of the plate may be at any convenient point within or without the area of the plate, and that the effective point of engagement of the plate may be chosen as desired providing it fulfils the conditions already explained. Furthermore, by a geometric consideration of the triangle 1^a, 4^a, 7^a and 1, 4, 7, it will be seen that the line 6 is not necessarily perpendicular to the punching line.

Before explaining the construction and method of operation of a concrete example of punching machines in which my invention may be practised, I will briefly describe a convenient way of determining the distances, which, between successive punching operations, it is necessary to advance the work carriage, and also the corresponding increments of relative lateral movements between the carriage and punches.

Fig. 3 shows a plate A in which holes are to be punched on the concentric arcs 3 and 3^a at their intersections with the several equally spaced radial lines 5, 5^a, 5^b, etc. The pivot point 1 of the plate is on the radial line 5^d which is the middle of the several said lines, and the arc 3^b passes through the point 1 and is concentric with the arcs 3 and 3^a. Now, if the radial line 5^h were in the punching-line, the distance necessary to advance the carriage to bring the line 5^g to such punching-line is the distance b, that is the distance between lines drawn parallel to the radial line 5^d and passing through the intersections of the radial lines 5^g and 5^h with the arc 3^b. In the same way the distances c, d and e represent the necessary advances to successively bring the radial lines 5^f, 5^e and 5^d to the punching-line; and, since the plate shown herein is symmetrical about the radial line 5^d, the successive distances which the carriage must be moved to bring the radial lines 5^c, 5^b, 5^a and 5 to the punching-line are, respectively, the distances e, d, c and b.

Bearing in mind that the radial lines 5, 5^a, etc., are spaced evenly, the relative lateral movement between punch and carriage which must be effected between the punching of holes on the radial lines 5^h and 5^g is the distance b'. As will be seen, this is the distance between a line drawn from the pivot point 1 perpendicular to the radial line 5^h and a second line drawn from the intersection of the radial line 5^e with the arc 3^b and parallel with the line drawn from the point 1. This is true, of course, only when the space between the lines 5^g and 5^h is equal to that between 5^d and 5^e. However, the principle underlying this manner of obtaining the lateral movement distances may be applied when the spacing intervals are not equal by laying-off on the arc 3^b the spacing intervals in the reverse order. In a similar way the successive lateral movement distances for punching on the lines 5^f, 5^e and 5^d are, respectively, c', d' and e'. When the pivot point of the plate passes the radial line 5^d, the successive lateral movement distances for punching on the lines 5^c, 5^b, 5^a, and 5 are respectively e', d', c' and b', but in the opposite direction to the movements effected while the pivot point 1 approaches the punching line.

It will be understood that the two sets of distances described above may be obtained in other ways. The procedures which I have indicated are simple and lend themselves readily to computation or laying out in templet shop. Since the accuracy of their underlying principles may be mathematically demonstrated, further explanations are unnecessary.

The punching machine illustrated herein is particularly adapted to carry out the method of operation described above. The machine is not claimed in my present application, but except for the carriage driving mechanism, is fully described and claimed in another application, Serial No. 32,595, filed of even date herewith. The

carriage driving mechanism is described and claimed in my earlier pending application, Serial No. 879,275. And because a full description of the several features of construction of the machinery shown herein is found in said applications, the present explanation of the machine will be as brief as possible consistent with an adequate understanding of my present invention.

As already stated, the relative lateral movements between punches and carriage may be effected by moving either punches or carriage or both. In the present machine the punches, including frames and driving connections, are thus moved. The work carriage comprises a truck frame 11 adapted to travel on suitable tracks 13, and a turntable 12 pivoted as at 14 to such table. The opposite ends of the table are provided with transversely-extending longitudinally-adjustable bars 15 and 15ª, which in turn carry clamps 16 for holding a plate in its adjusted position on the table; and, to cause the table to turn as the carriage advances, the bar 15 is further provided with a laterally adjustable block 17 to which an arm 18 is pivoted as at 19. This arm engages, at its outer end, a guide 20, which may be adjusted at any desired angle to the line of advance of the carriage; also the arm is, by means of a forked member 21 secured to the frame 11, held at substantially a constant angle to the line of advance of the carriage during such advance. In attaching to the carriage a plate, such as shown in Figs. 1, 2 and 3, the determined pivot point 1 of the plate is placed in vertical alinement with the pivot point 14 of the table, the plate is adjusted so that the radial line 5ª will coincide with the punching line when the carriage has been advanced, and the block 17 is so adjusted laterally that the pivot point 19 of the arm 18 is in vertical alinement with the effective point of engagement 7 of the plate. Also, the guide 20 is adjusted so that it makes, with the line of advance of the carriage, the same angle as the line 7 makes with the line 6 (Figs. 1 and 2). Thus it will be seen that the effective point of engagement of the plate will be caused to follow the required line during the advance of the carriage.

Before describing the means for advancing and stopping the carriage, I will briefly explain the construction and operation of the punching machines. They comprise frames 22 and 22ª, mounted for lateral movements upon beams 23 and 23ª, and provided with punching heads 24 and 24ª adapted to be reciprocated in the usual manner by the rotation of shafts 25 and 25ª. As will be seen the heads 24 and 24ª are provided with punching tools 36 and 36ª, which correspond with the punches 2 and 2ª diagrammatically shown in Figs. 1 and 2, and it will be understood that a line between these punches is the punching line heretofore mentioned. For reciprocating the punching heads a single motor 26, through pinions 27 and 28 drives a shaft 29. The driving connections from this shaft to the shaft 25ª comprise pinions 30ª, 31ª, shaft 32ª, and pinions 33ª and 34ª; while the shaft 25 is driven through connections bearing similar reference characters, the pinions 30 being feathered to the shaft so that the punch frames may be adjusted with respect to each other. For effecting such adjustment the punch frames are connected to each other by an oppositely threaded shaft 35, as seen in Fig. 6. The lateral movement of the punches is, in this embodiment of my invention effected manually. For this purpose the lower side of the frame is provided with a rack 37 which meshes with a pinion 38 secured to a shaft 39 adapted to be turned by a hand wheel 40. The extent of each lateral movement of the punches may be determined visually, as by a pointer 41 secured to a support 42, and a scale 43 borne by the frame 22ª; or stopping mechanism may be provided for arresting the punches when they have been moved the required distances. As shown herein, such mechanism consists of bars 44 and 44ª provided with adjustable stops and secured to the support 42, and coöperating pawls 45 and 45ª pivotally mounted on an arm 46 projecting laterally from the frame 22ª. These pawls are, through a rod 47, arm 48, shaft 49, arm 50 and cam 51 secured to the shaft 25ª, adapted to be lifted from engagement from the stops of the bars 44 and 44ª after the completion of each punching stroke so that the punches are free to be moved by turning the hand wheel 40 until the next stop of a bar is engaged. The bars and their stops are arranged to arrest both the right and left lateral movements of the punches, which, as already explained, is necessary when the plate to be punched is pivoted at its center or other intermediate point. As to the spacing of the stops of the bars 44 and 44ª, it will be understood that they should be arranged at the intervals b', c', d', and e' (Fig. 3), whether such intervals are obtained in the manner already explained or in some other way.

The means shown herein for effecting an intermittent advance of the carriage is in all essential respects the same as fully shown and described in my above mentioned application, Serial No. 879,275. They comprise instrumentalities for causing the carriage, between each punching stroke to move forwardly a distance greater than the largest spacing interval, and, after each of such advances, to move rearwardly into engagement with a stopping element. As shown in Figs. 4 and 5, the stopping element 52 may

be formed on the upper face of a bar 53, supported beneath the center of the carriage, and adapted to be engaged by a pawl 54 secured to the truck frame 11. This frame is also provided with racks 55 adapted to mesh with pinions 56 secured to the shaft 57, which shaft extends to the left side of the punch frame 22. The rotation of the shaft 57 in opposite directions is accomplished in the same manner as shown in my above mentioned application, Serial No. 879,275, that is to say, by means of pawl-and-ratchet connections extending from the punch reciprocating shaft 25, as is shown in Fig. 7 of my present application. As to the arrangement of the detents or stopping elements 52, it will be understood that they are to be spaced at the intervals *b*, *c*, *d*, etc., (Fig. 3).

The operation of the machine shown herein is readily apparent from the foregoing description. After a plate to be punched has been properly adjusted on, and secured to, the table 12, the guide 20 adjusted to the proper angle with relation to the advance of the carriage, and detent bars 52 and 44, 44ª properly adjusted, the machine may be set in operation by starting the motor 26. The punching heads will then be reciprocated, and the carriage intermittently advanced, by the coördinated driving connections already explained. The lateral movements of the punches will be effected by turning the hand wheel 40 in the required direction and between each punching stroke.

It will be understood that, while I have shown and described but one machine with which my invention may be practised, various other machines may be used, and a number of such other machines are shown and described in my application Serial No. 32,595 filed of even date herewith.

I claim as my invention:

1. In the operation of a metal-punching machine which includes in its structure a punch and a work-carriage, the method herein described which consists in causing the carriage to advance relatively to the punch, causing the work to rotate upon the carriage, and causing punch and carriage to move one with respect to the other in a direction transverse to that of the carriage advance first specified, said respective transverse movement including the point of rotation of the work upon the carriage, the said three movements being in progress as the work advances through the machine.

2. The herein described method of operating a punch and a work-carriage for punching through a plate a line of holes lying in the arc of a circle, which method consists of pivotally supporting a plate upon a carriage, advancing such carriage in a straight line adjacent to the punch, turning the plate on its pivot point during such advance of the carriage by guiding a point lying in the plane of the plate in a straight line intersecting the line of advance of the carriage, and between the punching of successive holes effecting a relative movement between said punch and carriage in a direction transverse to the line of advance of the carriage, said lateral movement including the point of pivotal support of the plate upon the carriage.

3. The herein described method of operating a metal punching machine comprising a multiple punch and work carriage whereby a plate may be provided with holes lying in arcs of concentric circles, which method consists of pivotally supporting a plate upon a carriage, causing the carriage to advance in a straight line at right angles to the punching line of the multiple punch, causing the plate to rotate on its pivot point during such advance of the carriage and by guiding a point lying in the plane of the plate in a straight line intersecting the line of advance of the carriage, said point being that of the intersection of two lines at right angles to each other one passing through the pivot point of the plate and the other through the common center of curvature of the concentric arcs, and the angle between said straight line guide and the line of advance of the carriage being determinable with respect to the position of said point, and between the punching of successive holes effecting a relative movement between said punch and carriage in a direction at right angles to the line of advance of the carriage, said lateral movement including the point of pivotal support of the plate upon the carriage.

4. In the operation of a metal punching machine which includes in its structure a punch movable transversely with respect to a piece of work advancing beneath it and a work-carriage provided with a turn table and movable in the direction of advance of work beneath the punch, the method of operation herein described which consists in causing the carriage to advance, the turn-table to rotate and the punch to move transversely of the advancing work, all in the course of advance of a piece of work through the machine.

In testimony whereof I have hereunto set my hand.

GEORGE PAUL THOMAS.

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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."