A. E. GREENE.

MACHINE FOR GRINDING BALLS.

APPLICATION FILED FEB. 20, 1911.

1,026,350.

Patented May 14, 1912.

6 SHEETS—SHEET 1.

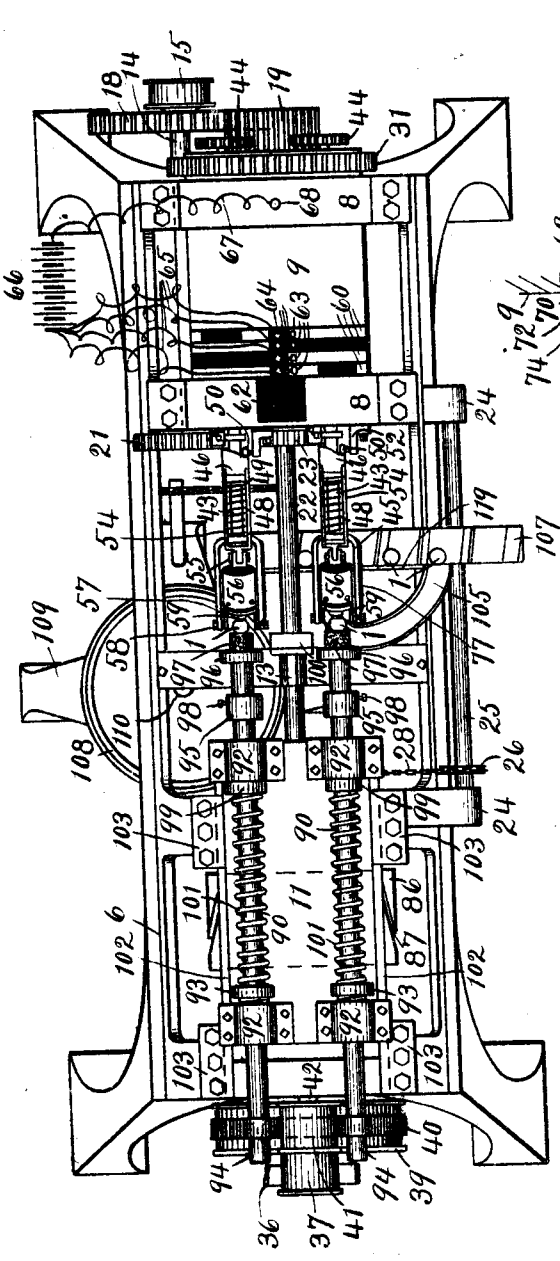

FIG. 1.

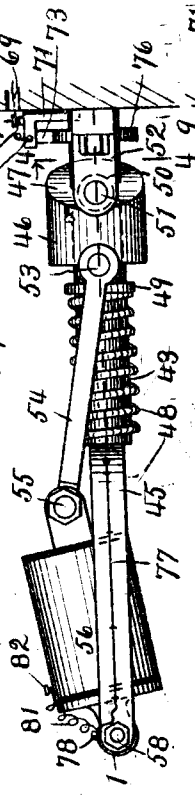

FIG. 2.

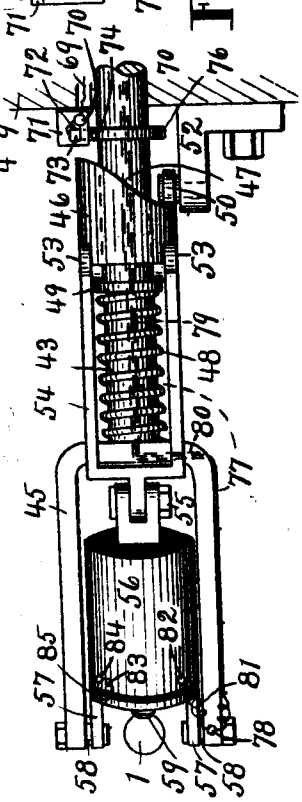

FIG. 3.

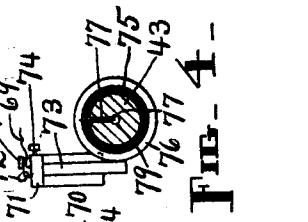

FIG. 4.

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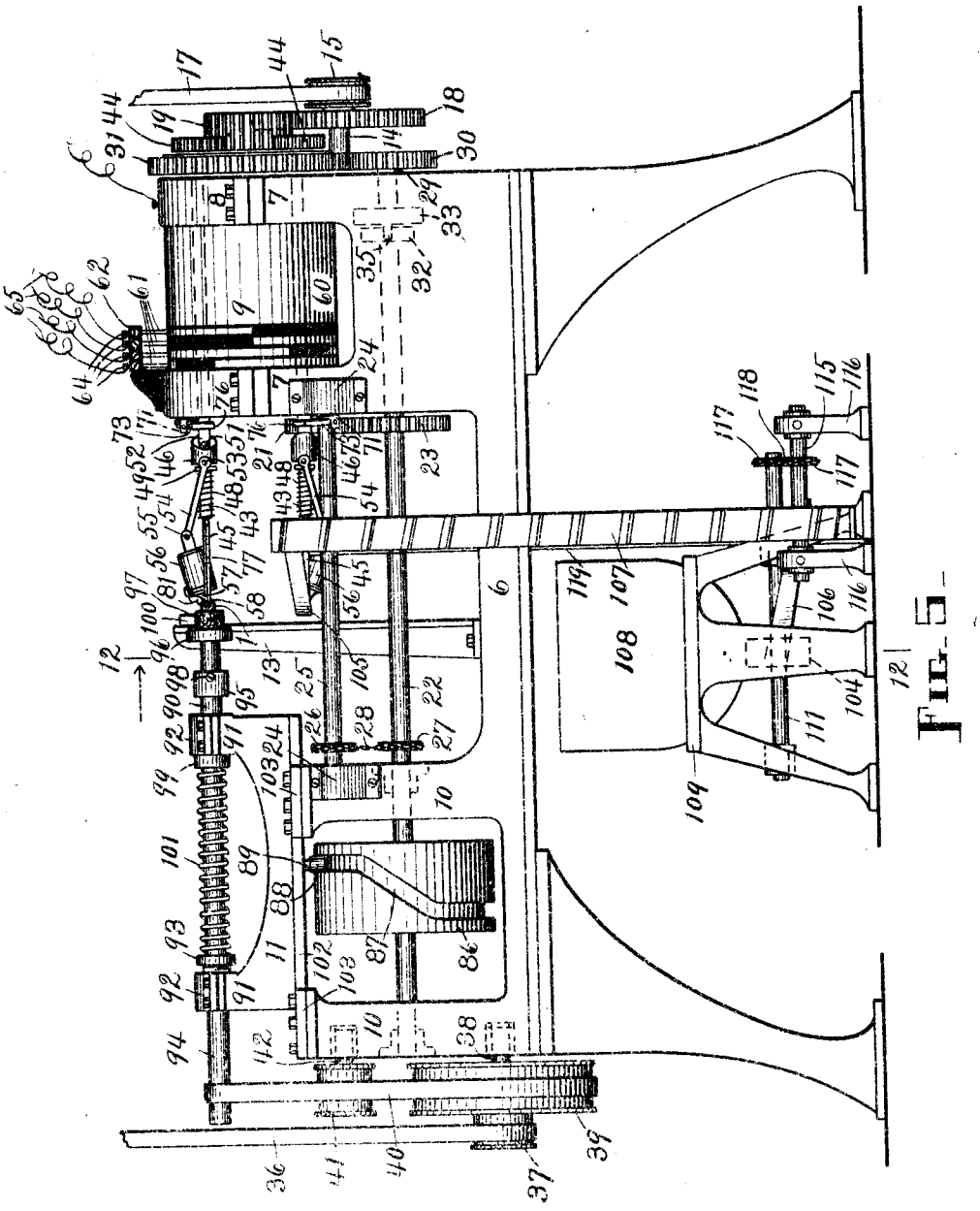

FIG. 5.

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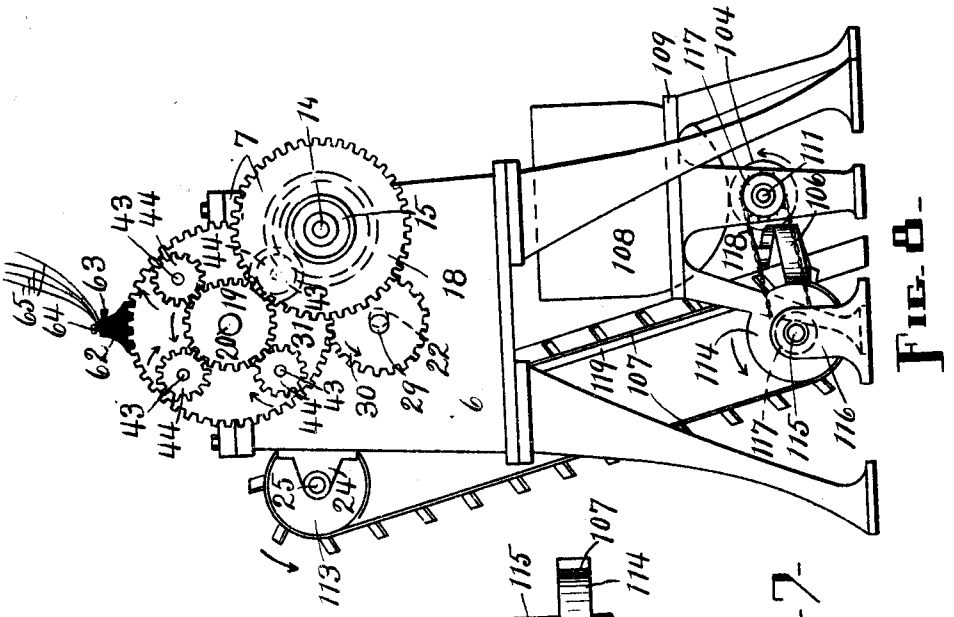

FIG. 8.

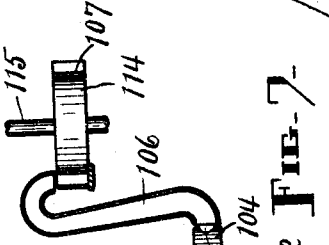

FIG. 7.

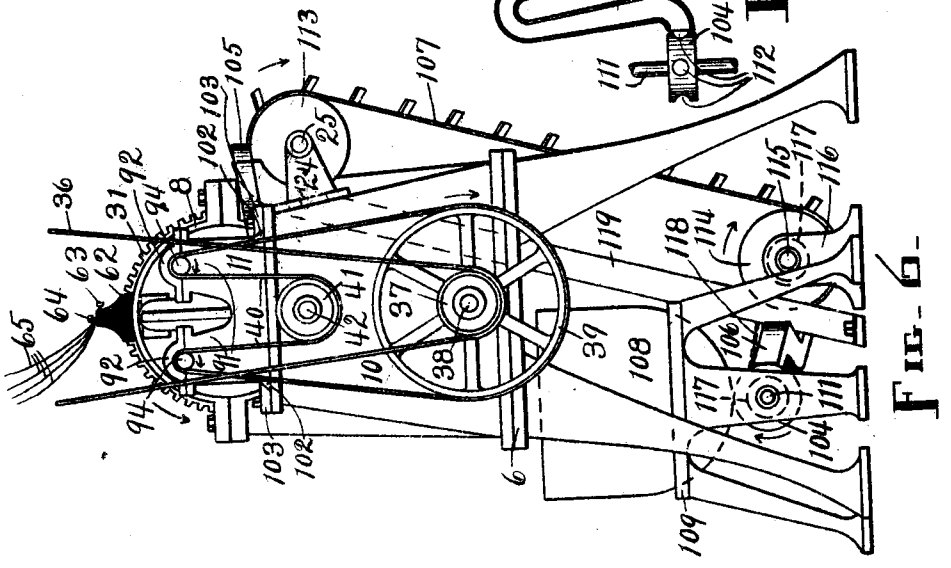

FIG. 6.

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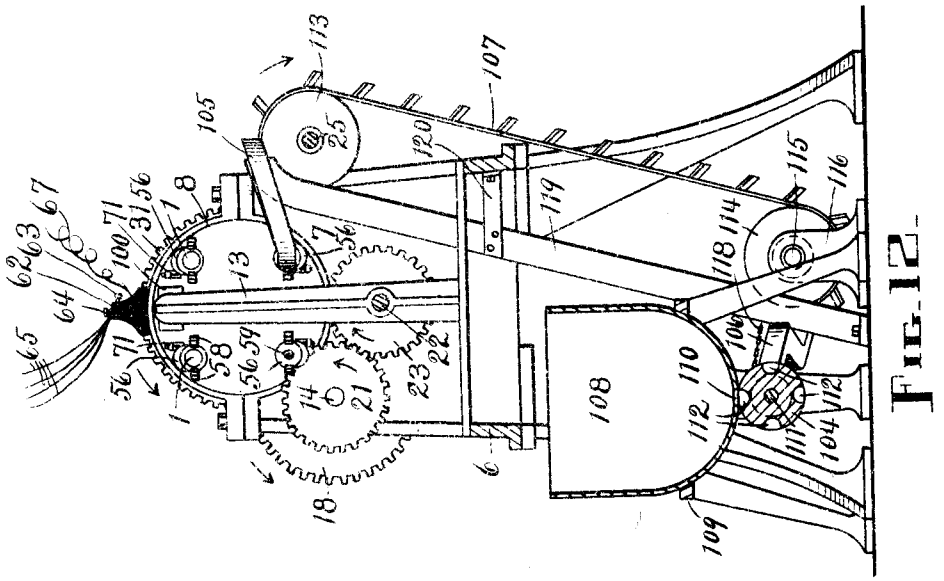

FIG. 12.

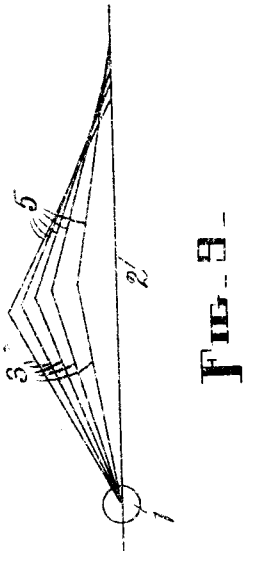

FIG. 9.

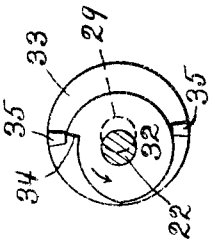

FIG. 11.

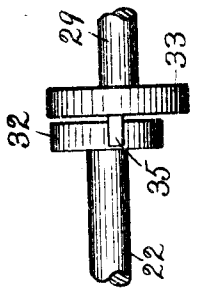

FIG. 10.

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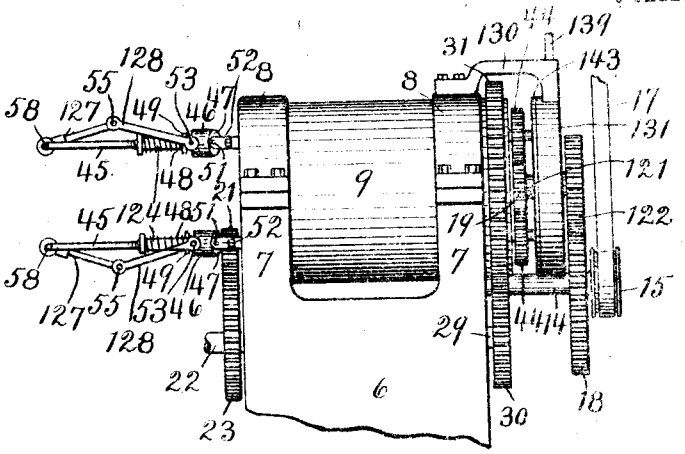

FIG. 13.

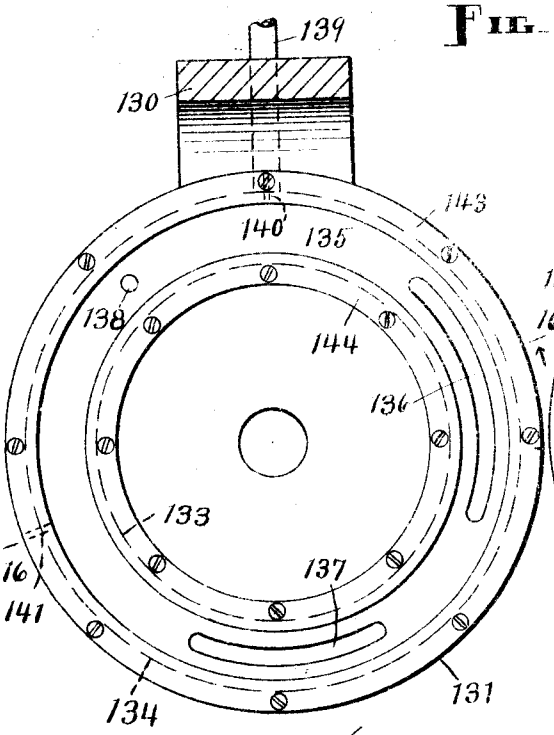

FIG. 14.

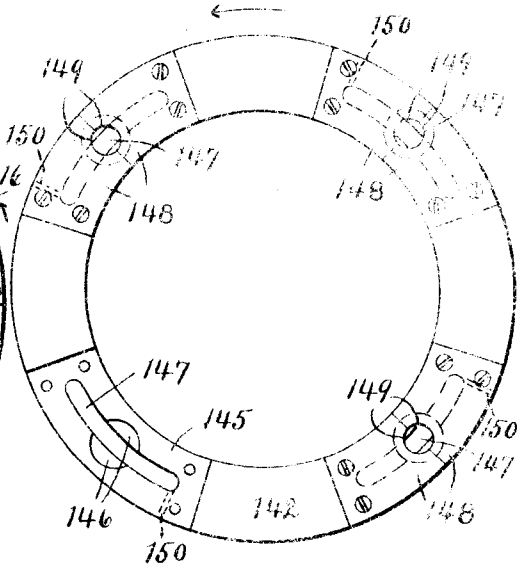

FIG. 15.

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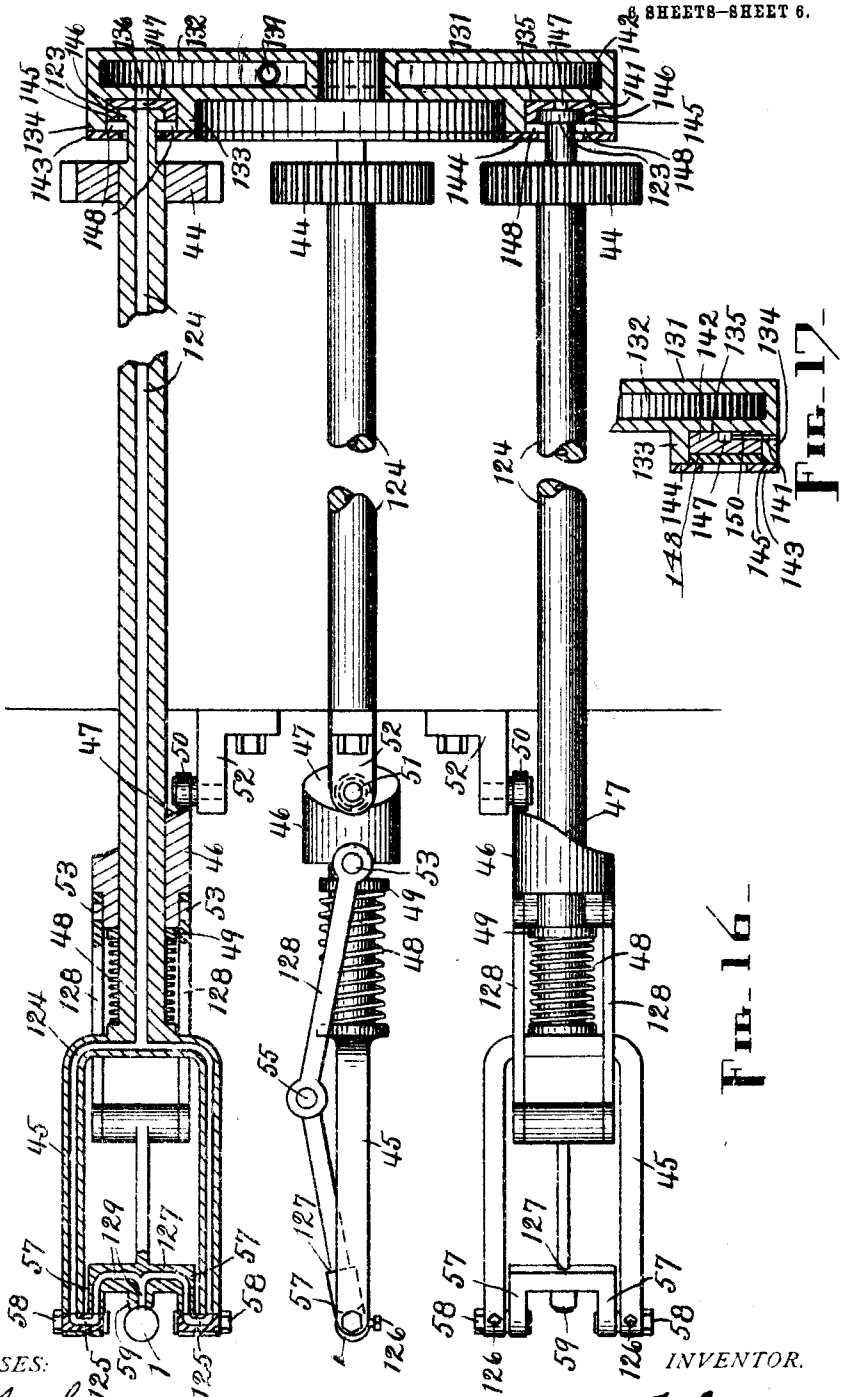

Fig. 17.

Fig. 16.

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UNITED STATES PATENT OFFICE.

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MACHINE FOR GRINDING BALLS.

1,026,350. Specification of Letters Patent. Patented May 14, 1912.

Application filed February 20, 1911. Serial No. 609,562

To all whom it may concern:

Be it known that I, AUGUSTINE E. GREENE, a citizen of the United States of America, residing at Hartford, in the county of Hartford and State of Connecticut, have invented a new and useful Machine for Grinding Balls, of which the following is a specification.

My invention relates to improvements in machines for manufacturing balls of various kinds or out of various materials and resides in mechanism, which, broadly and generally considered, is capable of imparting a varying conical rotation to a ball while in contact with a revoluble grinding or polishing wheel, the rotation of such ball being around a constant or unchanging though imaginary point which is in line with the axis of said wheel, in partially rotating or turning said ball independently to bring the so-called opposite side of the same into position for grinding or polishing, and in grinding or polishing this side in the same manner as in the first instance, the motion imparted to the ball during the aforesaid grinding or polishing operations being such that the time of contact between the ball and the wheel at any given point of contact on the ball is approximately the same as such time of contact at any other given point of contact on the balls. The aforesaid mechanism in its broad aspect possesses the above-mentioned capabilities and consists of certain peculiar mechanical and automatic means for holding, manipulating and releasing the ball, for controlling and regulating the grinding or polishing wheel, and for conveying or feeding the ball—all as hereinafter set forth.

One of the most important features of the aforesaid mechanism resides in the means whereby the member, at the end of which is held the ball while being subjected to the grinding or polishing wheel, hereinafter usually termed the abrading member or abrader, has imparted to its axis of rotation a varying conical rotation, varying because the angle of inclination of such axis to the non-oscillatory axis about which said first-mentioned axis revolves is changeable. This feature is important for the obvious reason that provision is thus made for abrading the ball evenly and uniformly and so producing a true sphere.

The object of my invention is to produce in an economical and expeditious manner balls which are uniform in size, shape and finish, being perfectly spherical, and this without impairing, injuring, or changing the properties or inherent characteristics or qualities of the material from which the balls are made, which material may be of any suitable character.

A further object is to produce an automatic machine and one that needs but little attention for abrading and finishing balls, turning them out in the form of true spheres, which machine has a high velocity and is capable of accomplishing a very large amount of work in a given time, as compared to other ball-making machines, seizes and holds a ball most rigidly or securely during the abrading operations, releases it first partially and then wholly as the operation of the machine continues, is adapted to take the ball or any number of the same through the machine as many times as may be deemed necessary, and in which the work is visible throughout the entire operation. With this machine, moreover, the pressure between the ball and the abrading wheel can be easily regulated so as to meet different grinding and polishing conditions or requirements.

Other important objects and advantages will appear in the course of the following description.

I am enabled to attain the objects and secure the advantages of my invention by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a top plan of a practical embodiment of my machine; Fig. 2, an enlarged side elevation of one of the magnetic chucks and associated parts, a portion of the drum which carries these members appearing in section; Fig. 3, a similar view to the preceding, as said chuck and associated parts appear from above; Fig. 4, a vertical section taken on lines 4—4, looking in the direction of the associated arrow, in Fig. 2; Fig. 5, a front elevation of said machine; Fig. 6, a left-hand end elevation of the same; Fig. 7, a detail, in top plan, of the bottom ball-feeding device; Fig. 8, a right-hand elevation of the machine; Fig. 9, a diagram illustrative of the action of the ball-holding mechanism; Fig. 10, an enlarged top plan of the clutch which controls the drum at the head of the machine; Fig.

11 an enlarged face view of such clutch, looking from the left; Fig. 12, a vertical section taken on lines 12—12, looking in the direction of the associated arrow, in Fig. 5; Fig. 13, a front elevation of a pneumatic, instead of an electro-magnetic as in the first case, machine head; Fig. 14, an enlarged inner face view of the stationary air or suction chamber case; Fig. 15, an enlarged face view of the revoluble ring which fits into said case and has the chuck spindles connected therewith, as viewed from the left, one pair of the spindle-holding plates being omitted; Fig. 16, an enlarged detail, in partial section, showing most of the principal parts of the pneumatic head, intermediate portions of the spindles being broken out, and the section through the air-chamber case being taken on lines 16—16, looking in the direction of the associated arrow, in Fig. 14, and, Fig. 17, an enlarged fragmentary detail, in section, of parts of the suction mechanism.

Similar figures refer to similar parts throughout the several views.

Before describing the machine I wish to call attention to the fact that, by making provision whereby either the electro-magnetic or vacuum head can be employed, said machine is rendered capable of handling balls of almost any description. Attention is further called to the fact that, while I have shown the machine in condition for handling balls of only one size, it is readily conceivable that without any departure, so far as essentials or the vital features of my invention are concerned, from the illustrated construction, such machine can be made to handle balls of a different size or of different sizes. In this connection it is pointed out that I do not desire or intend to limit myself or to be limited to the details of construction herein shown and described, since numerous departures, changes, or modifications from or in the construction or arrangement herein laid down and specified will occur to one skilled in the art to which this invention appertains, and all such should be and hereby are reserved for my benefit, provided they fall within the scope of my claims.

The machine naturally divides itself into four general divisions, namely, the supporting parts and driving mechanism, the ball-operating mechanism of which there are two types, the abrader-operating mechanism, and the ball-feed mechanism. These I will now take up in order, commencing with the supporting parts and driving mechanism.

A frame is represented at 6, which frame may be of any suitable construction, having head bearings 7—7 and caps 8—8 at the right-hand end, for a horizontal rotary ball-operating drum 9, supporting stands 10—10, at the left-hand end, for a horizontal abrader-operating carriage 11 which is reciprocable in a direction longitudinally of said machine, and a central standard 13.

Journaled in the frame 6, below but in the rear of the vertical plane of the axis of the drum 9, is a shaft 14. Secured to the outer end of the shaft 14 is a driving pulley 15 which is driven by a belt 17 from a main or countershaft (not shown). Secured also to the shaft 14, inside of the pulley 15, is a gear 18 that meshes with a small gear 19 loose on a stud 20 projecting from the outer end of the frame head and having its axis in line with the axis of the drum 9. Secured on the inner end of the shaft 14 is a gear 21. Journaled in the center of the frame 6, longitudinally, is a shaft 22 which is driven from the shaft 14 through the medium of the gear 21 and a gear 23 secured to said shaft 22 and meshing with said first-mentioned gear. Bearing brackets 24—24 are fastened to the front sides of the inner bearing 7 and stand 10, and journaled in these brackets is a shaft 25. The shaft 25 is driven from the shaft 22 by means of sprocket-wheels 26 and 27 respectively secured to said two shafts, and a sprocket-chain 28 connecting said sprocket-wheels. A short shaft 29 is journaled in the frame head and this shaft has a gear 30 secured on its outer protruding terminal to mesh with a large gear 31 on the outer end of the drum 9. Since the drum 9 must be driven intermittently and from the shaft 22, through the medium of the gears 31 and 30 and the shaft 29, I provide a clutch, which, in the present case, consists of a cam-like clutch proper 32 and a disk 33 secured to the adjacent ends of said shafts, respectively. These shafts are out of alinement, and the clutch 32 has a peripheral tooth 34 while the disk 33 has two oppositely disposed lugs 35 which extend to the left into the path of said tooth. Referring more particularly to Fig. 11, it will be seen how, as the clutch 32 revolves in the direction of the arrow there shown, the tooth 34 contacts with one of the lugs 35 and wedges its cam edge against the other lug 35 and so carries the disk 33 around until said disk makes one-half of a revolution, when, owing to the eccentricity of the axes of said clutch and disk, said clutch clears said lugs and makes the other half of its revolution without said disk. Thus at every revolution of the shaft 22 the shaft 29 makes a half revolution, and, since the gear 30 is only one-fourth the size of the gear 31, the drum 9 is caused to revolve one-fourth of the way around.

The abrader-operating mechanism is driven independently by means of a belt 36 which leads from a main or countershaft (not shown) to a pulley 37 loose on a stud 38 that projects from the left-hand end of the

frame 6. The pulley 37 is rigidly attached to a large pulley 39 which is also loose on the stud 38, and a belt 40 connects with the aforesaid abrader-operating mechanism in the manner hereinafter explained, an idler 41 being provided for said belt, which idler is mounted loose on a stud 42 projecting from the frame 6 above said stud 38. Inasmuch as the rest of the driving mechanism is more intimately associated with the other divisions of the machine, the same will be taken up in connection therewith as the descriptions thereof are reached.

The ball-operating mechanism comprises the drum 9 and the parts and members operated thereby and associated therewith which will now be described.

Revolubly mounted or journaled in the drum 9 and extending beyond both ends thereof are four spindles 43. These spindles are arranged at equal distances from the longitudinal center of the drum and at equal distances from each other, and have secured on their outer ends pinions 44 which mesh with the constantly revolving gear 19. Each spindle 43 is provided at its inner terminal with a yoke 45, and slidingly mounted on such spindle is a sleeve 46 formed into a cam 47 at the end adjacent to the drum 9. A spring 48 encircles each spindle 43 between its yoke 45 and a washer 49 which bears against projecting parts of the sleeve 46 on said spindle, and retains said sleeve with its cam 47 against an abutment in the form of a roll 50 which is in the path of said cam. There is a roll 50 for each cam 47, and such roll is mounted on a stud 51 carried by a supporting bracket 52 that is rigidly attached to the drum in proper relation to the adjacent cam. Pivotally attached at 53—53 to each sleeve 46 is a yoke 54, and pivotally attached at 55 to the left-hand terminal of said yoke is a chuck 56. Each chuck 56 has two arms 57, at the end opposite that which is pivoted to the supporting yoke 54 therefor, and these arms are pivoted at 58—58 to the free terminals of the associated yoke 45, inside of the arms or branches of the same. If the pivots 58 are of insufficient strength and rigidity to prevent the connected chuck, yoke and cam sleeve from turning on the supporting spindle, said sleeve can be keyed to said spindle in the usual manner, or any other suitable additional means may be employed to that end. Each chuck 56 has a core 59 which projects from the barrel or spool of said chuck between the arms 57 and constitutes the actual holder for the balls. When the chuck is of the electro-magnetic type, the core or holder 59 is made of soft iron so that only the minimum amount of residual magnetism will be retained by it. The exposed end of this core or holder is cupped or hollowed to fit the balls and form a good and sufficient contact or connection therewith. The roll 50 in each case is so situated that the contacting cam-sleeve 46 can never slide on its spindle 43 far enough toward the drum 9 to allow the axis of the associated chuck 56 to coincide with the axis of said spindle, and, since said chuck swings at one end on an axis, represented by the pivots 58, the angle of inclination of the chuck axis changes as the parts revolve with said spindle, because said sleeve is then reciprocated by reason of the contact between its cam 47 and said roll, and through the medium of the connecting yoke 54. Thus the point of intersection between the spindle axis, which is the principal or main axis corresponding with the line 2 in Fig. 9, and the secondary axis or the axis upon which the chuck oscillates, represented by the pivots 58, becomes the point about and upon which the revolution and the oscillation of the chuck takes place, and is the center of the perfect ball, it being understood that the distance from such point to the center of the holder 59 is equal to one-half the diameter of such ball. The axis of the chuck is represented by the lines 3 and the connecting or longitudinal axis of the yoke 54 by the lines 5, in Fig. 9, in five different possible positions given them by the cam acting against the roll and moving the adjacent end of said yoke axis along the spindle axis. By this means and in this manner a ball, as 1, in the holder receives the motion of which mention was made in the early part of this specification. To retain the ball firmly and securely in any holder 59, either electro-magnetism or suction is employed. I will here explain the means for applying the former, leaving the explanation of the means for utilizing the latter until later.

The drum 9 is provided with a commutator 60 for each chuck 56 when of the electro-magnetic type, and a brush 61 is provided for each commutator, such brush depending from an insulating bracket 62 mounted on the inner cap 8 and extending to the right over the commutators. Screws 63 are provided for the adjustment of the brushes 61, and binding-posts 64, as usual. Wires 65 lead from the binding-posts 64 to a suitable source of electrical energy, indicated at 66, in Fig. 1, and a wire 67 leads from such source to a non-insulated binding-post 68 on the outer cap 8. Each commutator is connected, in the customary manner, by a wire 69 with a binding-post 70 set in an insulated bracket 71 of insulating material attached to the drum adjacent to one of the spindles 43, and a short wire 72 connects such binding-post with a brush 73. Each brush 73 is adjustably held in one of the brackets 71 by a screw 74.

Secured to each spindle 43, with a ring 75 of insulating material between, is a contact ring 76 against which one of the brushes

73 bears. A wire 77 leads from each contact ring 76 to a binding-post 78 at the inner end of one of the arms or branches of the yoke 45 which is at the inner terminal of the spindle 43 upon which such ring is mounted, said wire passing from said ring through radial openings in the associated insulating ring 75 and spindle to a central longitudinal passageway 79 in said spindle, as shown in Fig. 4, thence through such passageway to said yoke, out through a suitable opening therein, and along the outside of the yoke arm which supports said binding-post to the latter, as best shown in Fig. 3, the aforesaid opening in the yoke being represented by dotted lines at 80. A short wire 81 connects the binding-post 78 with a binding-post 82 on the chuck 56 in this combination, and the circuit to the frame is completed through a short wire 83 which connects two binding-posts 84 and 85 also on said chuck, but the binding-post 85 being non-insulated. The binding-posts 82 and 84 are the terminals of the electro-magnet which forms a part of the chuck 56 in this instance. Thus the circuit from the source of energy at 66 to any chuck 56 and back to such source is formed by the proper wire 65, brush 61 and commutator 60, and the wires 69 and 72, brush 73, ring 76, and the wires 77, 81 and 83 in the combination, the frame of the machine, and the wire 67. The arrangement of the commutators 60 and the timing of the drum 9 are such that each chuck 56 or its holder 59 is magnetized and demagnetized four times at every revolution of said drum, but all of said holders are not magnetized and demagnetized together. When any holder 59 is magnetized it attracts to itself and holds securely any ball that is a good subject for magnetic attraction when brought into the field of such attraction emanating from such holder, and releases said ball upon being demagnetized.

For the purpose of imparting the necessary independent rolling motion to the ball when it passes from one abrader to the other, as yet to be more fully explained, so that the unabraded portion or side will be presented to the second abrader, a piece of felt or other suitable material to form a friction member 100 is attached to the right-hand face of the standard 13 near the top. The friction member 100 occupies a position so that the center of its exposed face approximately coincides with the top of the vertical diameter of the circle described by the left-hand end of the horizontal diameter of a ball held by any one of the chucks 56, but encroaches somewhat on the vertical plane of such circle. Such being the case, a ball held by one of the chucks 56, if such chuck were energized, would be carried past although frictionally engaging the member 100 without being affected thereby, but if the energy be cut off from said chuck after it has brought said ball into rubbing contact with said friction member, the latter will impart a rolling motion to said ball. This is exactly what is done in practice, and, since the ball is held so tightly by the friction member in the cupped end of the operating holder 59 that said ball cannot get out of said holder, the ball rolls or is rolled in the holder, and when it has been turned half over or half way around therein the chuck is energized again and carries the ball without further independent motion off of and away from said member 100. Although the chuck does not stop rotating while the ball is being carried past the member 100, the motion of the chuck in no wise interferes with the rolling over of the ball, but rather facilitates such action.

Passing on to the abrader-operating mechanism, which includes the carriage 11, it will be observed that such carriage is reciprocated by means of a cam 86 secured on the shaft 22 between the stands 10. This cam has a cam-groove 87 therein to receive an anti-friction roll 88 mounted on a stud 89 set in the bottom of the carriage 11. The form or shape of the cam-groove 87 is such that at every revolution of the cam 86 the carriage, through the medium of the roll 88 and stud 89, is caused to travel from one end of its course to the other and back again. The other members of the abrader-operating mechanism consist of two parallel spindles 90 arranged to revolve side by side in two pairs of bearings 91 and under two pairs of caps 92 at opposite ends of the carriage 11, and of the attached and associated elements described below. In this case the spindles 90 do not rest directly in the left-hand bearings 91 and caps 92, but in collars 93—93 which are tapped into said bearings and caps. The spindles 90 are not only capable of revolving in their bearings, but they may also be reciprocated therein. Said spindles extend beyond the left-hand bearings 91, and the belt 40 passes under the pulley 39, over these extending portions of the spindles, and under the idler 41, so that the spindles are driven in the same direction at a great speed by said belt and rotary members and by the belt 36 and the pulley 37. These pulley extensions, as they may be called, shown at 94—94, of the spindles 90, are of sufficient length to permit of the required amount of longitudinal movement without the belt 40 running off. Attached to the inner terminal of each spindle 90 is a head 95 which receives the stem of a suitable holder 96 for an abrader 97, a set-screw 98 being employed in the customary manner to assist in securing said stem in said head and to afford adjustment for said stem. The abraders 97 are made of any suitable grinding or polishing ma-

terial. A collar 99 is secured to each of the spindles 90 in position to bear against the contiguous right-hand bearing 91 and cap 92 when urged toward them by a spring 101 interposed between such collar and the companion collar 93. The two collars 99 limit the inward movement of the spindles 90 independently of the carriage 11, and the two springs 101 retain said spindles in their innermost independent positions with a force that may be increased or decreased by screwing the collars 93 in or out accordingly. The springs 101 are sufficiently strong and stiff to hold the abraders 97 to their work, when the carriage 11 is in its advanced position, yet such springs afford yielding means for the spindles 90 whereby said abraders cannot be forced too hard against the balls, as might otherwise happen occasionally in the event the balls should be too large. As previously noted, the pulley extensions 94 are long enough to enable the carriage 11 to make its full travel in either direction without disconnecting the motive power, also, of course, to permit of whatever little independent movement there may be longitudinally on the part of the spindles 90. The base of the carriage 11 is provided with two lateral flanges 102 and these are arranged to slide in guide-ways on the tops of the stands 10, such guide-ways consisting in part of two pairs of removable plates 103. The cam-groove 87 is so shaped that a dwell is produced at each end of the throw of the cam 86, so that, at each revolution of said cam, the carriage 11 is actuated forward and backward and held during parts of such revolution in both of its extreme positions.

The abraders 97 are hollowed in the centers of their working faces to receive the balls, in much the same manner as are the holders 59, and when the abrader holders 96 are properly adjusted in the heads 95 and the collars 99 are against the contiguous bearings 91 and caps 92, the cam 86 as it revolves advances the parts, until the centers of the cupped portions of said abraders coincide or approximately coincide with the circular path at the left-hand ends of the horizontal diameters of the finished balls carried by the chucks 56. In other words, the point of intersection between the oscillatory axis of rotation and the main or principal axis around which such oscillatory axis revolves, of any chuck in abrading position is the same distance from the center of the concavity in a juxtaposed abrader, that is, of an abrader 97 the axis of which if continued would coincide with said main or principal axis, as it is from the center of the concavity of the holder 59 of said chuck.

The mechanism for feeding the balls comprises in general a feed-wheel 104, upper and lower troughs or raceways 105 and 106, respectively, and an elevator 107. With these and other parts described below is furnished a receptacle 108 for the balls, such receptacle being located under the rear center of the frame 6 on a stand 109 which sets on the floor. The bottom of the receptacle 108 on the inside is concave so that the balls in said receptacle gravitate toward the center of such bottom and toward a central opening 110 therein, which opening is of a size to permit a single ball only to pass through. Secured directly under the opening 110, on a shaft 111 which is journaled in the legs of the stand 109 and extends lengthwise of the machine, is the feed-wheel 104. This feed-wheel has four pockets 112 arranged at regular intervals in the periphery thereof and each large enough to receive a ball as it escapes through the opening 110 and convey the ball away from the receptacle. The raceway 106 is inclined and the higher end of the same is situated adjacent to the front part of the feed-wheel 104, while the lower end opens into the rear line of pockets which form the elevator 107, hence at every quarter revolution of said feed-wheel, assuming that one of the pockets 112 is beneath the opening 110 at the start, a ball drops into said pocket, it being then the uppermost one, is carried forward until in a position to roll out of such pocket, which it does and passes into said raceway, and then said ball rolls down said raceway and around into the elevator bucket which is in position to receive it. In this connection see more particularly Figs. 7 and 12.

The elevator 107 is of the ordinary endless-belt variety and is carried on upper and lower pulleys 113 and 114, respectively; the former being secured on the shaft 25 and therefore driving the elevator, and the latter being secured on a shaft 115 journaled in two bearings 116, which rest on the floor. The shaft 115 is parallel with the shaft 111 and drives the latter, as said shaft 115 is revolved through the medium of the pulley 114 and the elevator, by means of sprocket wheels 117—117 secured to the two shafts, and a sprocket-chain 118 connecting said sprocket-wheels. The elevator buckets are arranged so that those in the rear line are given a downward slant to the left as they travel upward, and a long plate or siding 119 is arranged against the left-hand edge of said rear line of buckets to prevent the balls therein from rolling out until just before the top of the pulley 113 is reached. Here the siding 119 ends and the upper front end of the raceway 105 is situated, the latter being in front of the upper end of said siding, as best shown in Fig. 1, and the balls rolling from the elevator into said raceway as they pass clear of the siding. The siding 119 rests at the bottom on the floor and is braced from the frame 6 at 120,

Fig. 12, and the raceways 105 and 106 are attached to and supported from said siding. From its open front end which is immediately adjacent to the elevator near the top, the raceway 105 curves rearwardly and slants downwardly to open at its back end toward the orbit of the holders 59 and at a point which is below the advanced position of the forward abrader 97 or of the working face of such abrader.

This completes the description of the several mechanisms, with the exception of the suction devices of or for the ball-operating mechanism, and, although the operations of the several mechanisms described in detail above have been rather fully explained, I will introduce a brief explanation of the machine having the electro-magnetic control for the balls as a whole, following with a description of the aforesaid suction devices.

Having connected both ends of the machine with the power, the revolving members are set in motion, rotating in the directions indicated by the arrows associated therewith, some of such members revolving constantly and some intermittently, as already made plain, and as about to be further explained. The gear 18, on the shaft 14 with the pulley 15, through the medium of the intermediate gear 19 and the pinions 44, causes the four spindles 43 to revolve constantly; and the gear 21, also on said shaft and through the medium of the gear 23, causes the shaft 22 to revolve constantly with the cam 86 thereon, and to actuate with it the elevator 107, through the medium of the sprocket-wheels 27 and 26 and the sprocket-chain 28, the shaft 25, and the pulley 113. The elevator transmits motion to the feed-wheel 101 through the medium of the pulley 114, the shaft 115 the sprocket-wheels 117 and the sprocket-chain 118, and the shaft 111. Concurrently, the spindles 90 are driven constantly by the belts 40 and 36, but generally in the opposite direction to that of the spindles 43. The feed-wheel 101 is now receiving balls one at a time from the receptacles and delivering them in the same manner to the elevator 107 by way of the raceway 106. When the first ball 1 arrives at the mouth or entrance to the raceway 105 it enters said raceway and runs down to the discharge end thereof. By this time there is a chuck 56 in position adjacent to the open rear end of the raceway 105, with its holder 59 energized, to pick the ball from said raceway and securely hold it, the electric circuit to and through such chuck being now closed by reason of the fact that the commutator 60 which belongs in said circuit has one of its electric contact segments in contact with its brush 61. Although the spindle 43 with which the aforesaid chuck is connected is revolving the circuit is not interfered with because of the presence of one of the contact rings 76 on such spindle, and the connection afforded by the brush 73 which bears on said ring. While held securely by the energized chuck 56, which for convenience will be called the first chuck, the ball is carried thereby from the receiving position to the first abrading position in line with the forward abrader 97, which abrader meanwhile is in its retracted position. The first chuck with the ball is moved into the new position by reason of the fact that the clutch 82 on the constantly revolving shaft 22 engages the lugs 35 and imparts to the disk 33 and the shaft 29 one-half of a revolution, and said shaft 29 in turn with its gear 30 imparts one-fourth of a revolution to the gear 31 and the drum 9 which carries said chuck; and said chuck with the ball is left in such position because, by the time or at the time it arrives there, said clutch clears said lugs and the movement of said drum ceases. Immediately the cam 86 advances the carriage 11 and thrusts the forward abrader 97 against the ball now held and rotated by the first chuck in the first abrading position, the ball being rotated in the peculiar manner previously set forth at length. One side of the ball is subjected to the action of the forward abrader until the latter is withdrawn, when the clutch operates to give the drum another quarter turn. Meanwhile the second chuck has picked the second ball from the raceway 105 at the receiving position, the balls being fed to and carried up by the elevator in numbers and at the speed necessary to supply them at such position as and when required. Just before the clutch acts to cause the first chuck to be moved from the first abrading position adjacent to the forward abrader to the second abrading position adjacent to the rear abrader, the cam 86, which retains the forward abrader in advanced position during the abrading operation, retracts the carriage 11 and so takes the abraders from their field of action, and said cam keeps them out of such field until the first chuck arrives at the second abrading position, when, of course, the second chuck will be in the first abrading position. Upon the second quarter of the revolution of the drum 9, the first ball is caused to traverse the friction member 100, and just after said ball reaches said member the first chuck is demagnetized, so as to enable the ball to roll in its holder or to be rolled therein by frictional contact with said member, and just before said ball leaves said member said chuck is magnetized again. The first ball, thus turned half way over or around so as to present the undressed side to the rear abrader, is next left at the second abrading position, when for the second time the chuck

32 frees the disk 33, and the abraders are advanced and operate this time on two balls, the rear abrader operating on the first ball attached to the first chuck and the forward abrader operating on the second ball attached to the second chuck. It is thus seen that one side of each ball is dressed by the forward abrader, and that the other side of each ball is dressed by the rear abrader. For the second time the abraders are retracted, and then the drum makes the third quarter of its revolution, with the result that the first ball is dropped from the now demagnetized chuck into the receptacle 108 below, the second ball is carried to the second abrading position, being turned half way around on the way, and the third ball, which the third chuck has already picked, is brought to the first abrading position. With the completion of the revolution of the drum, during the last quarter of which the second ball is dropped, the third ball is carried to the second abrading position and the fourth ball held by the fourth chuck to the first abrading position, and the first chuck is again magnetized so that it can and does pick the fifth ball, one cycle of the machine is complete, provided such cycle start with the picking of the first ball by the first chuck, in accordance with the foregoing description. During this cycle the clutch actively operates at four regular intervals, the carriage 11 advances and retreats four times, and each chuck is demagnetized twice, once when it passes the friction member 100, and once again when it drops the ball after the second abrading.

Under the present arrangement, the balls are run through the machine a number of times until they are reduced to the exact size desired or are finished or polished to the desired degree of nicety, but this procedure may not always be necessary.

It may be well to note in passing that the pivots 58 and the rolls 50 afford ample resistance to the impact of the abraders when advanced on the balls between them and the chuck holders 59, then there are the springs 101 to relieve any excessive shock at these points, as well as to yield, when the abraders encounter balls that are too large, and so allowing the abraders to stop short of their normal advanced positions.

Taking up, finally, the suction device or devices illustrated on the last two sheets of drawings, it will be seen that means for handling the balls with air take the place of electromagnetic means for that purpose, and that the drum 9 without the commutators, the driving mechanism for such drum, the spindles 43 with their yokes, the spring-pressed cam sleeves 46 and the rolls 50 therefor, and the holders 59, of the other construction are all retained and do not greatly differ, wherever they differ at all, from corresponding parts and members in the other construction.

Pointing out in detail the differences alluded to in the preceding paragraph, attention is first called to the substitution of a shaft 121 for the stud 20, the narrowing of the intermediate gear 19 thereon, and the presence of an additional intermediate gear 122 secured to said shaft, with said gear 19, to mesh with the gear 18, Fig. 13; and then to a flange or head 123 at the outer end of each spindle 43, an air passage 124 which, unlike the wire passageway 79 in the first instance, extends the entire length of said spindle, branches at the yoke 45 which forms a part of the spindle, and extends to the openings in the arms of such yoke at the ends for the pivots 58, and air passages 125—125 in said pivots. Each pair of pivots 58 is here prevented from turning by means of two bolts 126 tapped into the free ends of the supporting yoke 45 into engagement with said pivots. Mounted on the inner terminals of each pair of these pivots, in practically the same way as the electro-magnetic chucks are mounted, is an air or vacuum chuck 127 pivotally connected at 55 with two arms 128, these members being arranged and adapted to operate mechanically in the same way as do the chucks 56 and the yokes 54. Like the chucks 56, the chucks 127 have ball holders 59, and there is a branching air passage 129 in the head of each of said chucks 127, which passage leads from the center of the chuck holder to the openings in the chuck arms 57 for the pivots 58. The passage 125 in each pivot 58 connects with the branch of the passage 124 which is in the supporting yoke arm for such pivot, and also connects with the branch if the passage 129 which is in the arm 57 that is mounted on said pivot, so that there is a clear air passageway from the left-hand open end of the holder of each air chuck, through said chuck and by way of the connecting pivots to and through the supporting yoke 45 and the entire length of the supporting spindle 43. At the junctions of the passages 124 and 125 such passages must be large enough, of course, to enable the air chucks to rock, when the mechanism is in operation, without closing the same. The axis of each spindle 43, in the suction or vacuum mechanism, corresponds with the line 2, in Fig. 9, and the chuck 127 and arms 128 assume the same positions while revolving as those indicated by the lines 3 and 5, in said view.

Suitably supported by a bracket 130 from the outer cap 8 is a case 131 having an annular air or suction chamber 132 therein, Figs. 13, 14, 16 and 17. The case 131 is suspended between the gears 19 and 122, and the shaft 121 extends through the center thereof. The inner wall of the case 131 is

provided exteriorly with two annular flanges 133 and 134, the former being smaller than the latter. The flange 134 is an extension laterally of the periphery of the case 131. There is thus formed a circular channel 135. The chamber 132 opens into the channel 135 through two arcuate slots 136 and 137 and a round opening 138 in the wall between. A pipe 139 leads from the chamber 132, at any convenient point, to a pump (not shown) for exhausting the air from said chamber. Two radial ports 140 and 141 are made in the flange 134 to establish communication with the channel 135 from the outside. A coupling ring 142 fits and is adapted to revolve freely in the channel 135, being secured in place on the open side of said channel by means of outer and inner rings 143 and 144 fastened to the edges of the flanges 134 and 133, respectively. Thus said flanges form a journal for the coupling ring. Equi-distant from each other in the coupling ring 142 are four recesses 145 formed in the left-hand face of said ring, and these recessed portions are farther recessed, in the center of each at 146, to provide journals for the spindle heads 123, and slotted at 147, the slots being concentric with the slots 136 and 137 and the hole 138 and opening through the plain right-hand side of said ring and through the recessed side thereof. Each head 123 is held in its recess 146 by means of a pair of abutting segmental plates 148 fastened in the recess 145 provided for their reception. The plates 148 have openings 149 in their abutting edges of a size to accommodate the necks of the spindles 43 or the portions of such spindles that are between the heads 123 and the parts of said spindles upon which the pinions 44 are mounted, but not large enough for the passage of said heads. There are four radial ports 150, in the coupling ring, each of which opens at its inner end into one of the slots 147 at one end of the same, and at the other end through the periphery of said ring. The ports 140, 141 and 150 are all in the same vertical plane in order to enable any one of the latter to be brought into alinement with either of the two former.

Clearly from the above the drum 9 in its rotation carries with it the spindles 43, as before, and rotates the coupling ring 142 which is securely attached to the outer terminals of said spindles by the plates 148, such ring traveling around in the channel 135, consequently each slot 147 is brought into open communication with the slots 136 and 137 and with the opening 138, and each port 150 is brought into alinement with the ports 140 and 141. Assuming that there is a partial vacuum in the chamber 132, and that the machine is running and the ring 142 has been turned so as to locate one of the slots 147 in open communication with the slot 137, air is being sucked through into said chamber from the holder 59 which is in communication through the connecting passages with said slot 147, or there is a suction at said holder, and such suction has sufficient force to hold a ball while being abraded. This suction commences as soon as the aforesaid slot 147 passes into open relation with the slot 137, and continues while a ball is picked at the receiving position, which is the delivery station of the ball-feeding mechanism, taken to the first abrading position, abraded on one side and passed on to the friction member 100, said drum and ring having meanwhile made two quarter turns and carried said slot 147 into open relation with the slot 136, such relation being established before said slot 147 leaves said slot 137, and finally taken to the slot 147 beyond said slot 136, and brought the communicating port 150 into line with the port 140. The suction is thus cut off and air admitted at the alining ports or through the alining ports to break the vacuum, and the ball freed in this manner is rolled over or given a half revolution as it is carried past the member 100 and before the slot 147, which is now being followed in its course, arrives at the opening 138. When said slot does arrive at said opening, which is just as the ball is about to leave the member 100, the vacuum is reëstablished and said ball is advanced to the second abrading position, abraded, and carried on to discharging position before said slot leaves said opening. Very soon after communication with the chamber 132 is cut off a second time, connection is had with the port 141, as shown in Fig. 17, the vacuum is again broken, and the ball in consequence permitted to drop from its now powerless holder. By the time said holder is in position to pick another ball, however, its associated slot 147 will have once more come into open relationship with the slot 137. The operation of the air or vacuum controlling parts and members is alike in the case of each vacuum chuck, the same being energized twice and twice rendered powerless by the breaking of the vacuum at each complete revolution of the drum and coupling ring; and the constant and intermittent rotary and the constant oscillatory motions of the parts, including the drum, spindles and chucks, are the same as has been fully explained in connection with the electro-magnetic chucks and associated parts.

The vacuum chucks 127, as they appear in Fig. 16, while relatively in correct positions, are not as they would be if in the machine and occupying corresponding positions, because the case 131 is sectioned on

lines 16—16, Fig. 14. The top and middle chucks 127 are energized and holding balls, and the bottom chuck 127 is "dead", in Fig. 16. Were these three chucks in the same relative positions in the machine and in operation, the uppermost chuck would be without energy and traversing the friction member 100 with a loose ball, the lowermost chuck would be energized and about to pick a ball, and the middle chuck would be without energy and would have just dropped a ball, while the fourth chuck, which does not appear in this view, would be energized and in the act of carrying a ball just taken at the receiving position to the first abrading position.

The suction mechanism, including the vacuum chucks, is designed to handle balls of wood, ivory, and other substances and materials which, unlike steel balls for example, cannot be handled successfully or at all by the electro-magnetic chucks. My invention comprehends, therefore, the grinding and polishing of balls of practically any description, as I have previously stated, and the work is done with a degree of uniformity, accuracy and thoroughness and with a celerity that have been unequaled heretofore.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination, in a machine for abrading spherical objects, with an abrader, of means to hold an object while in contact with such abrader and at the same time impart an orbital gyratory motion to said object on its own center.

2. The combination, in a machine for abrading spherical objects, with an abrader, of means to hold an object while in contact with such abrader and at the same time impart an orbital gyratory motion to said object on its own center and means partially to rotate said object also on its own center independently of its holding means.

3. The combination, in a machine for abrading spherical objects, with abraders, of means to hold an object while in contact with either of such abraders and at the same time impart a gyratory motion to said object, means to carry said object from one of said abraders to the other, and means partially to rotate said object independently of its holding means during the transfer from one abrader to the other.

4. The combination, in a machine for abrading balls, with an abrader, of an intermittently rotating member, a plurality of ball-holding chucks carried by such member, and means to impart a gyratory motion to said chucks.

5. The combination, in a machine for abrading balls, with an abrader, of an intermittently rotating member, a plurality of ball-holding chucks carried by said member, means to impart a gyratory motion to said chucks, and means partially to rotate balls while connected with said chucks independently of the latter.

6. The combination, in a machine for abrading balls, with abraders, of an intermittently rotating member, a plurality of ball-holding chucks carried by said member, means to impart a gyratory motion to said chucks, and means partially to rotate each ball connected with a chuck independently of the latter as said intermittently rotating member operates with said chuck to take said ball from one of said abraders to the other.

7. In a machine for abrading spherical objects, an intermittently rotating member, a chuck carried by said member, means to energize said chuck at predetermined intervals, and means partially to rotate an object connected with said chuck while the latter is non-energized.

8. In a machine for abrading spherical objects, an intermittently rotating member, a chuck carried by said member, means to energize said chuck at predetermined intervals, means to impart a gyratory motion to said chuck, and means partially to rotate an object connected with said chuck while the latter is non-energized.

9. Ball-holding means, for an abrading machine, comprising a revoluble non-oscillatory spindle provided with an orbital oscillatory chuck.

10. Ball-holding mechanism, for an abrading machine, comprising a revoluble spindle provided with an orbital oscillatory chuck, and energizing and non-energizing means for such chuck.

11. Ball-holding mechanism, for an abrading machine, comprising a revoluble spindle provided with a yoke, a collar slidingly mounted on such spindle, a chuck pivotally attached to said yoke, pivotal connections between said chuck and said collar, and means to reciprocate said collar.

12. Ball-holding mechanism, for an abrading machine, comprising a revoluble spindle provided with a yoke, a spring-pressed cam member slidingly mounted on such spindle, a chuck pivotally attached to said yoke, pivotal connections between said chuck and said cam member, and an abutment for the latter.

13. The combination, in ball-holding mechanism for an abrading machine, with an intermittently rotatable member, of a plurality of independently revoluble spindles carried by such member, such spindles being provided with oscillatory chucks.

14. The combination, in ball-holding mechanism for an abrading machine, with an intermittently rotatable member, a plurality of independently revoluble spindles

carried by such member, such spindles being provided with oscillatory chucks, and energizing and non-energizing means for such chucks.

15. The combination, in ball-holding mechanism for an abrading machine, with an intermittently rotatable member provided with abutments, a plurality of independently revoluble yoke-provided spindles carried by such member, spring-pressed cam members slidingly mounted on such spindles and bearing against said abutments, chucks pivotally attached to the spindle yokes, and pivotal connections between said chucks and said cam members.

16. The combination, in ball-holding mechanism for an abrading machine, with a plurality of constantly revolving spindles provided with oscillatory chucks, and means to rotate intermittently said spindles about a common axis, of means to energize and non-energize each of said chucks according to its position in the orbit around said common axis.

17. The combination, in ball-holding mechanism for an abrading machine, with a constantly revolving chuck, intermittent means to rotate said chuck orbitally, and means to energize and non-energize said chuck according to its position in the orbit which it describes, of a friction member in operative relation to a ball, connected with said chuck, to hold said ball to said chuck and partially rotate the ball during a period while the chuck is non-energized.

18. The combination, in ball-holding mechanism for an abrading machine, with a constantly revolving and oscillating chuck, intermittent means to rotate said chuck orbitally, and means to energize and non-energize said chuck according to its position in the orbit which it describes, of a friction member in operative relation to a ball, connected with said chuck, to hold said ball to said chuck and partially rotate the ball during a period while the chuck is non-energized.

19. The combination, in an abrading machine for balls, with a chuck, and means to revolve said chuck on its principal or main axis and oscillate it orbitally about said axis, of an abrader having an axis extending in the same direction with the aforesaid principal or main chuck axis, and means to actuate said abrader axially into and out of the field of action of said chuck and the ball carried thereby.

20. The combination, in an abrading machine for balls, with a chuck, and means to revolve said chuck on its principal or main axis and oscillate it orbitally about said axis, of an abrader having an axis extending in the same direction with the aforesaid principal or main chuck axis, and means to actuate said chuck with a ball carried thereby into the field of action of said abrader and out of such field.

21. The combination, in an abrading machine for balls, with a chuck, and means to revolve said chuck on its principal or main axis and oscillate it orbitally about said axis, of an abrader having an axis extending in the same direction with the aforesaid principal or main chuck axis, and means to actuate said chuck with a ball carried thereby and said abrader into and out of each other's fields of action, said abrader being actuated axially.

22. The combination, in an abrading machine for balls, with a pair of abraders, means to advance and retract such abraders, and a friction member between the positions occupied by such abraders when advanced, of a chuck, and means to actuate such chuck with a ball from one of such positions to the other, traversing said friction member on the way.

23. The combination, in an abrading machine for balls, with a ball-holding chuck, means to impart an intermittent orbital movement to such chuck, and means to revolve such chuck on its principal or main axis and oscillate it orbitally about said axis, of an abrader having an axis extending in the same direction with said principal or main chuck axis, and means to impart an intermittent travel axially to said abrader, such travel occurring while said chuck is in line with the abrader axis.

24. The combination, in an abrading machine for balls, of a plurality of ball-holding chucks intermittently rotatable about a common axis, a pair of abraders separated on centers by a distance equal to the separation on centers of two adjacent chucks, means to stop said chucks in their orbital movement with any pair in line with said abraders, and means to advance and retract said abraders while said chucks are in a condition of orbital rest.

25. The combination, in an abrading machine for balls, of a plurality of constantly revolving and oscillating ball-holding chucks intermittently rotatable about a common axis, a pair of abraders separated on centers by a distance equal to the separation on centers of two adjacent chucks, means to stop said chucks in their orbital motion with any pair in line with said abraders, and means to advance and retract said abraders while said chucks are in a condition of orbital rest.

26. The combination, in a machine for abrading balls, with ball-holding means, of a suitably mounted carriage, a member slidingly supported by said carriage, yielding means to retain said member normally in a forward position relative to the carriage, an abrader carried by said member, and means to reciprocate said carriage, to ad-

vance said abrader against a ball held by said ball-holding means, and to retract it from such ball.

27. The combination, in a machine for abrading balls, with ball-holding means, of a suitably mounted carriage, a revoluble spindle supported by said carriage, an abrader carried by said spindle, and means to reciprocate said carriage, to advance said abrader against a ball held by said ball-holding means, and to retract it from such ball.

28. The combination, in a machine for abrading balls, with ball-holding means, of a suitably mounted carriage, a revoluble spindle slidingly supported by said carriage, yielding means to retain said spindle normally in a forward position in the carriage, an abrader carried by said spindle, and means to reciprocate said carriage, to advance said abrader against a ball held by said ball-holding means, and to retract it from such ball.

29. The combination, in a machine for abrading balls, with a ball-holding chuck rotatable in an orbit, of a ball-feed having a delivery station adjacent to said orbit at one side.

30. The combination, in a machine for abrading balls, with a ball-holding chuck rotatable in an orbit, and means to energize and non-energize such chuck, of a ball-feed having a delivery station adjacent to said orbit at one side.

31. The combination, in a machine for abrading balls, with a constantly revoluble ball-holding chuck intermittently rotatable in an orbit, and means to energize and non-energize such chuck, of a ball-feed having a delivery station adjacent to said orbit.

32. The combination, in a machine for abrading balls, with a plurality of ball-holding chucks mounted for intermittent rotation in an orbit, and a ball-feed having a delivery station adjacent to such orbit, of energizing means for such chucks while each is at such station, and non-energizing means for such chucks while each is at some point remote from such station.

33. The combination, in a machine for abrading balls, with ball-holding means having an orbital motion, of a receptacle for balls below such ball-holding means, an elevator having a delivery station adjacent to the orbit of said ball-holding means, and means to deliver balls from said receptacle to said elevator.

34. The combination, in a machine for abrading balls, with ball-holding means having an orbital motion, of a receptacle for balls, an elevator having a delivery station adjacent to the orbit of said ball-holding means, and a revoluble feed member arranged to receive balls singly from said receptacle and deliver them to said elevator.

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