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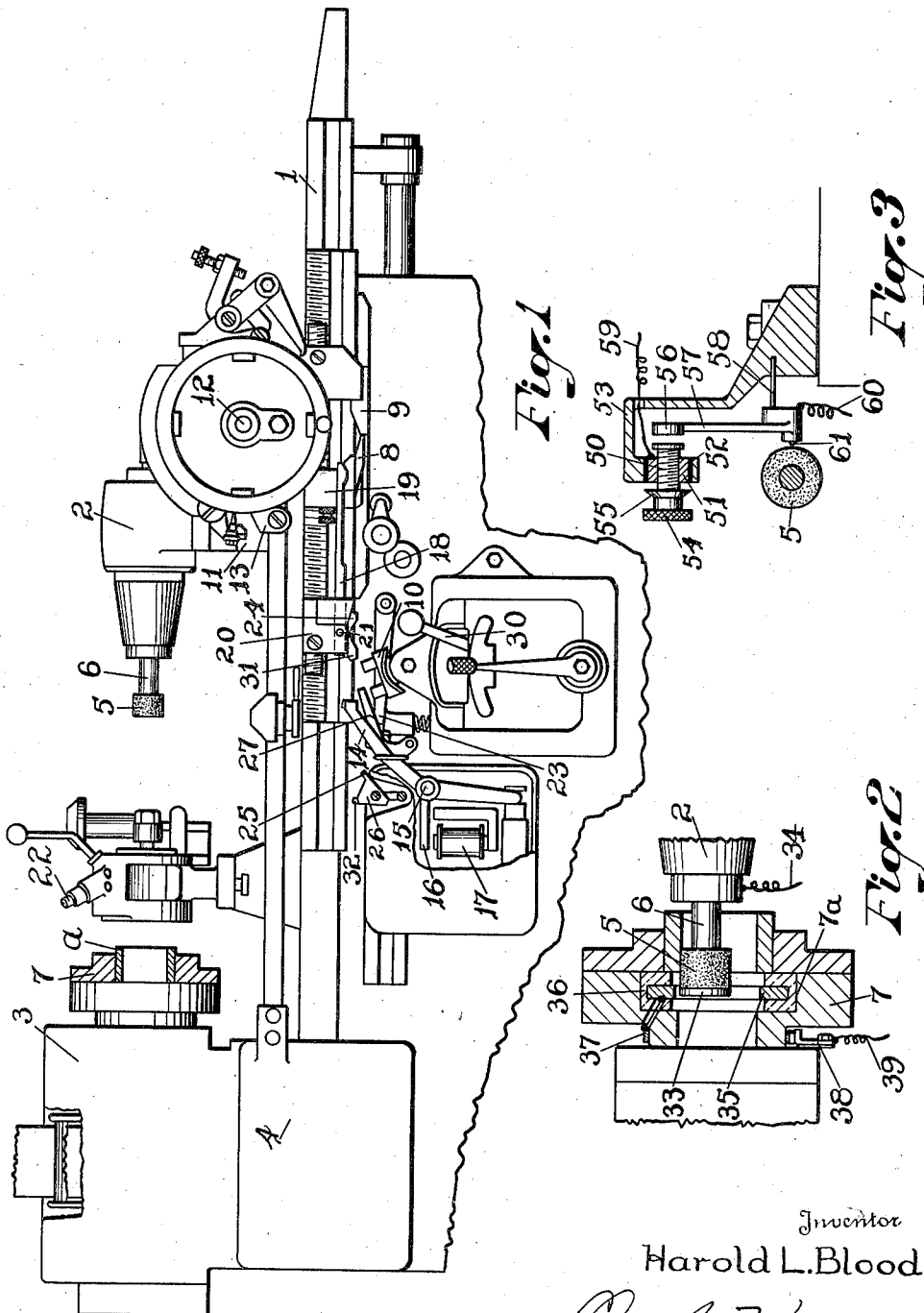
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2,116,232

SIZE DETERMINING MECHANISM FOR AUTOMATIC MACHINES

Original Filed Dec. 31, 1932

2 Sheets-Sheet 1



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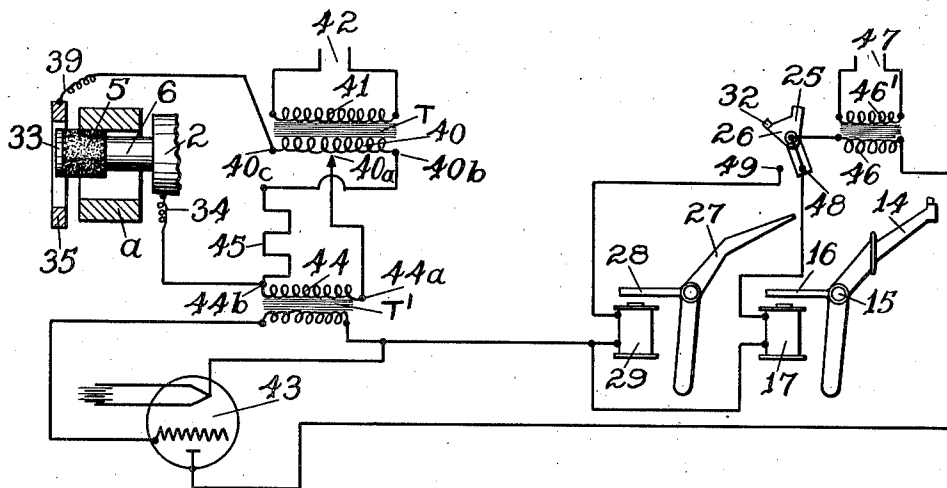


Fig. 4

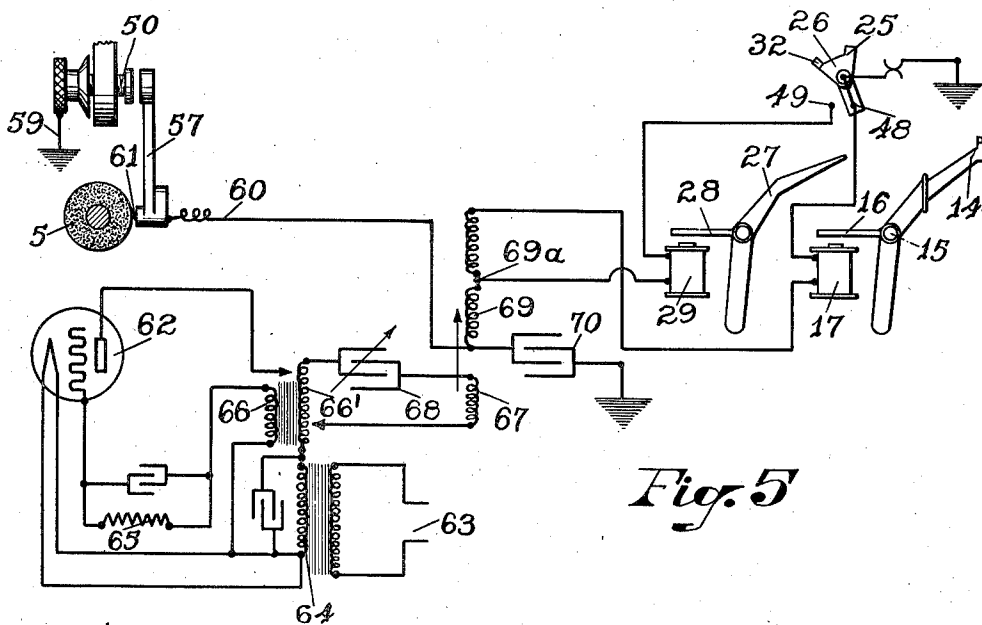


Fig. 5

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SIZE DETERMINING MECHANISM FOR
AUTOMATIC MACHINES

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Original application December 31, 1932, Serial
No. 649,701. Divided and this application De-
cember 11, 1933, Serial No. 701,776

5 Claims. (Cl. 51—165)

The present application is a division of my original application Serial No. 649,701 filed December 31, 1932 for a Size determining mechanism for automatic machines, since issued as Patent No. 2,050,261, dated August 11, 1936 and relates particularly to automatic machines for the reduction of work pieces to a predetermined size by a cutting operation, such as grinding.

In my aforesaid copending original application, the size of the workpiece is automatically determined by utilizing variations in the impedance of an electrical circuit to control the grinding operation, such variations of impedance resulting from the varying inductive effect of the workpiece on the gaging or detecting circuit, as material is removed from the workpiece. In accordance with the invention of the present application, the size of the workpiece is automatically determined by utilizing variations in the capacity of an electrical circuit to control the grinding operation, such variations of capacity resulting from the approach of the grinding tool to a predetermined plane as material is removed from the workpiece. In carrying out the invention, the use of gages that actually contact with the piece is entirely eliminated, as is also the use of complicated mechanism associated with the grinding tool as heretofore, all as will hereinafter appear from the following description taken in connection with the accompanying drawings, in which:—

Fig. 1 is a front elevation of an internal grinding machine embodying the invention, with a portion of the work head in section.

Fig. 2 is a fragmentary plan view on an enlarged scale, illustrating the functioning of a gaging member associated with the work head.

Fig. 3 is a fragmentary view in side elevation showing a different form of gaging member.

Fig. 4 is a wiring diagram illustrating automatic control of the machine through variations of capacity when utilizing the gaging member of Fig. 2.

Fig. 5 is a wiring diagram illustrating a modified form of capacity control when utilizing the gaging member of Fig. 3.

Like reference characters refer to like parts in the different figures.

Referring first to Fig. 1, the machine provides the usual reciprocatory table 1 provided in an internal grinding machine; either the grinding wheel or the work to be ground may be carried on said table, the reciprocations of the latter operating in either case to produce a relative movement between said grinding wheel and work-

piece. In the construction shown, the table 1 supports and carries a wheelhead 2, and the work to be operated upon is held in a workhead 3, the latter being carried by a bridge 4 which spans the slideways, not shown, provided by the machine frame, for the back and forth movement of the table 1. A grinding wheel 5 is mounted on a spindle 6 journaled in the wheelhead 2 and a workpiece *a* is mounted in a suitable workholding chuck or other clamping device 7 journaled in the workhead.

The back and forth movement of the table 1 to cause the wheel 5 to make the required traverse of the workpiece *a* may be produced in any well known manner, as by the use of the fluid pressure controlling and reversing mechanism, forming the subject matter of the Heald and Guild Patent No. 1,582,468, granted April 27, 1926. Such mechanism forms no part of the present invention; it is sufficient to note that the driving means employed procures the reversal of the table at each end of its normal grinding stroke by the use of spaced adjustable dogs 8 and 9 carried by the table 1 and adapted alternately to engage and to move a reversing member 10. The latter during the grinding operation, when the grinding wheel 5 is moving back and forth within the workpiece *a* is situated between said dogs 8 and 9 in position to be alternately struck by said dogs and, by its consequent movement, effects the reversals of the table 1. The grinding wheel 5 is rotated at a high speed in any suitable manner and the workholding member 7 is also rotated at a somewhat slower speed by a belt drive, as indicated.

The wheelhead 2 of the machine is mounted on a cross-slide 11 which is arranged to have a transverse movement on suitable ways, not shown, on the reciprocatory table, movement of said cross-slide being procured by rotation of a threaded member, not shown, which is secured in any suitable way to the cross-slide. The cross-feed shaft 12 is rotated in a step-by-step movement by mechanism of the type disclosed in the Guild Patent No. 1,682,672, granted August 28, 1928, to procure a feeding movement of the grinding wheel 5 to cause said wheel to cut progressively deeper and deeper into the workpiece *a*; for the purpose of the present invention, it is sufficient to note that a ratchet wheel, not shown, is engaged by a pawl 13 which is actuated in response to the reciprocations of the carriage 1, thereby procuring rotation of said crossfeed shaft 12 carrying the grinding wheel transversely against the surface of the workpiece.

In the previous operation of grinding machines of the type shown and described in the aforesaid Patent No. 1,682,672, the grinding operation is interrupted before the workpiece reaches predetermined finished size, the interruption occurring in response to the movement of the crossfeed mechanism to procure separation of the grinding wheel from the workpiece, in order that a dressing operation may be performed on the wheel. After the dressing operation has been performed on the wheel, the grinding operation is resumed until the workpiece is ground to a predetermined finished size, whereupon the grinding operation is brought to a close by a second separation of the grinding wheel from the work in response to the crossfeed mechanism. And since the present invention also contemplates both an initial separation of the grinding wheel from the workpiece for truing, followed by resumption of the grinding to complete the work, there is shown in Fig. 1 as an illustrative embodiment of the invention certain of the same wheel controlling mechanism described in the aforesaid Patent No. 1,682,672, to which mechanism automatic control through variations of electrical capacity has been applied.

As previously pointed out, in normal operation of the machine, back and forth movement is imparted to the table 1 by the cooperation of the spaced dogs 8 and 9 with the reversing member 10, and for the purpose of automatically interrupting the grinding operation on the workpiece and separating the wheel for the dressing operation, the machine provides a lever 14 pivotally mounted on a shaft 15, as shown in the broken away portion of Fig. 1. The lever 14 has integral therewith a magnetic armature 16 disposed in operative relation with respect to the core of an electromagnet 17, the unbalanced weight of the lever 14 tending to maintain the armature 16 spaced from the end of the electromagnet core as long as the electromagnet 17 remains in a deenergized condition. Upon energization of the electromagnet 17 in a manner hereinafter described, attraction of the armature 16 imparts upward movement to the lever 14 and causes the latter to lift a latch 18, assuming that the grinding wheelhead 2 is then in its left hand position with the grinding wheel 5 within the workpiece *a*.

The latch 18 extends between a block 19 carrying the left hand table dog 8, which block 19 is capable of free sliding movement on the table 1, and a stationary block 20 on which the latch 18 is pivotally mounted at 21. Under normal conditions, the block 19 is held in spaced relation to the stationary block 20 by the latch 18, but when the lever 14 is elevated as described above, the latch 18 releases the block 19 and subsequent right hand travel of the table 1 involves relative sliding movement between the table and the block 19, owing to the obstruction which the reversing member 10 imposes against the left hand table dog 8. Continued travel of the table 1 finally brings the stationary block 20 up against the then slidable block 19, whereupon the dog 8 becomes immovably supported for shifting the reversing member 10 to procure reversal of the table. The above described sliding movement of the block 19 on the table 1, when released by the latch 18, results in an amplified right hand stroke of the table to withdraw the wheel 5 from the workpiece *a* and the disposal in the temporarily amplified path of movement of the wheel 5 of a dressing device 22, in the manner fully described in the above noted Patent No. 1,682,672.

On the left hand movement of the table following the amplified dressing stroke, the reversing dog 8 is restored to its normal position by a resiliently supported lug 23 which engages the block 19, and as the table moves to the left, offers enough resistance to movement of the block 19 with the table to detain the block until the latch 18 is restored to its normal position in which it positively holds the block 19 separated from the block 20. On the above noted amplified right hand dressing stroke of the table 1, in order to prevent a repetition of the dressing stroke, an arm 24 mounted on the latch pivot 21 strikes a lug 25 of a switch member 26 pivotally mounted on an axis parallel to the shaft 15 of the lever 14, thereby turning the switch member 26 into the position shown to break the circuit through the electromagnet 17 and release the lever 14, as will be hereinafter more fully described with reference to Fig. 4.

Upon the resumption of the grinding operation after dressing of the wheel as described above, the normal back and forth movement of the table continues until the work is reduced to a predetermined finished size, whereupon the grinding operation is brought to a close by a second separation of the grinding wheel from the work in response to the electrical capacity control of the present invention. For the purpose of obtaining a final run out of the table 1 into the position shown in Fig. 1, there is provided a second lever 27 mounted on the same shaft 15 as the lever 14, the lever 27 having integral therewith an armature 28 responsive to an electromagnet 29, as shown in Fig. 4. Normally, the unbalanced weight of the lever 27 maintains the armature 28 away from the core of the electromagnet 29 while the latter is in a deenergized condition, and such is the condition of affairs during the grinding operation. Upon energization of the electromagnet 29 in the manner hereinafter described, the lever 27 is raised to move its upper end into the path of the left hand table dog 8, while the table is in its left hand position. Since the table dog 8 is pivotally mounted on its block 19, right hand movement of the table after elevation of the lever 27 results in lifting of the dog 8 so that it is carried clear of the reversing member 10.

Therefore, the table 1 is not reversed, but continues its movement to the right carrying the grinding wheel 5 out of the workpiece *a*, the table being brought to a full stop by any suitable means, such as is shown in the aforesaid Heald and Guild Patent No. 1,582,468. The return of the table 1 to the working position from the fully withdrawn position of Fig. 1 is effected by the shifting of a hand lever 30 operatively connected to the reversing member 10 and on the left hand movement of the table an arm 31 also mounted on the pivot 21 strikes a second lug 32 on the movable switch member 26, thereby turning the switch member in a position to disconnect the electromagnet 29 from its source. This turning movement of the switch member 26 upon the initiation of another grinding cycle restores the switch member to the position shown in Fig. 4 in readiness for the energization, at the proper time in the grinding of the next workpiece, of the electromagnet 17 controlling the wheel dressing operation.

The above described mechanism for mechanically controlling the movements of the table 1 carrying the grinding wheel is more fully described in the above mentioned Guild Patent No. 1,682,672, and therefore forms no part of the

present invention per se; the present invention as previously pointed out, involving the attainment in connection with the above described or similar grinding machine instrumentalities, of automatic size determining mechanism primarily responsive to variations of the capacity of an electrical circuit resulting from the approach of the grinding wheel to a predetermined plane. In other words, the table controlling mechanism described above with reference to Fig. 1 is merely an illustrative embodiment of the manner in which any one of the several forms of control, next to be described, can be applied to a grinding machine of the character shown.

Referring to Fig. 2, the grinding wheel spindle 6 is shown as carrying a disk 33 of conducting material, such as carbon, the disk 33 being of exactly the same diameter as the wheel 5. The wheelhead 2 is insulated as indicated, with a lead 34 extending therefrom, the purpose of which will shortly appear. The work-holding chuck 7 provides a recess 7a in which is received gage ring 35 of conducting material, the gage ring 35 being insulated from the chuck 7 at 36. The gage ring 35 is connected to a collector ring 37 turnable with the chuck 7, and a brush 38 bearing on the collector ring 37 has a lead 39 extending therefrom, the purpose of which will shortly appear.

Referring now to Fig. 4, the leads 34 and 39 from the disk 33 and gage ring 35 respectively, are shown as being connected across the terminals of the secondary winding 40 of a supply transformer T, the primary winding 41 of which is energized from a suitable alternating current source 42. Consequently, the disk 33 and gage ring 35 are continuously charged, and as the disk 33 moving with the grinding wheel 5 enters within the ring at the end of the grinding stroke, there will be a condenser effect between the disk 33 and gage ring 35. At the beginning of the grinding operation, the internal diameter of the unreduced workpiece *a* is considerably less than the internal diameter of the gage ring 35, as indicated in Fig. 4, so that the capacity of the condenser in the circuit, including the disk 33 and gage ring 35, is at a relatively low value. Obviously, as material is removed from the workpiece by the grinding operation accompanied by traversing of the grinding wheel 5 itself, the air gap between the disk 33 and gage ring 35 will decrease, with a resulting increase of capacity between these members at the end of each cutting stroke of the wheel 5.

Still referring to Fig. 4, there is shown a circuit for utilizing variations of the capacity in the circuit of the secondary winding 40 to directly determine the degree of energization of the electromagnets 17 and 29 controlling the grinding wheel operating mechanism. As shown, the grid circuit of a thyratron tube 43 is energized from a transformer T', the primary winding 44 of which has one terminal 44a connected to an intermediate point 40a of the secondary winding 40. The other terminal 44b of the primary 44 is connected, in parallel, to the respective terminals 40b and 40c of secondary 40, with a resistance 45 in circuit between terminal 44b and the terminal 40b of secondary 40. The terminal 44b is also connected through lead 34 to the disk 33 and gaging ring 35 in the circuit to the secondary winding terminal 40c. Thus, the potential across the primary winding 44, and hence between the grid and cathode, is made up of two components having different phase angles. That is to say,

one component is dependent upon the unvarying value of the resistance 45, while the other component is dependent upon the varying values of capacity in the circuit including the disk 33 and gaging ring 35. Therefore, variations of capacity in the circuit including the gaging ring 35 will directly affect the phase angle of the grid potential, which in turn will determine the amount of current passing through the tube 43.

The plate circuit of the tube 43 includes the secondary winding 46 of a transformer, the primary winding 46' of which is energized from a suitable source 47. One terminal of the secondary winding 46 is connected to the table controlled switch member 26, so that either the electromagnet 17, or the electromagnet 29, is also included in the plate circuit, depending on the position of the switch member 26 with respect to its stationary contacts 48 and 49, as previously described. Assuming that the circuit of Fig. 4 is in the condition shown, with the grinding wheel 5 just starting to remove material from the workpiece *a*, it is evident that the capacity of the circuit including the disk 33 and gaging ring 35 is then at a negligible value, and the phase angle of the grid potential is then such that the amount of current passing through the tube 43 is not great enough to energize the electromagnet 17. Furthermore, at the initiation of the grinding operation on a new workpiece, the air gap between the disk 33 and ring 35, even with the disk 33 entirely within the ring at the end of the grinding stroke, is so great that there is no appreciable passage of current by the tube 43.

As the grinding operation proceeds, each feed of the wheel 5 brings the disk 33 closer to the ring 35 at the end of a stroke, thereby increasing the capacity of the circuit including the disk 33 and gaging ring 35. As previously pointed out, the increased capacity of this circuit directly affects the phase angle of the grid potential so as to increase the amount of current passed by the tube 43, and when the workpiece *a* has been reduced to a predetermined roughing size, the current passing through the plate circuit is sufficient to energize the electromagnet 17. Thereupon, lifting of the lever 14 causes the wheel 5 to be withdrawn from the work for truing, in the manner previously described with reference to Fig. 1.

Upon the return of the wheel 5 to the workpiece following the truing operation, the electromagnet 29 is thrown into the plate circuit by engagement of the switch member 26 with the contact 49. However, the electromagnet 29 is so wound that it will not attract its armature 28 until the current in the plate circuit reaches a slightly higher value than the current which previously caused energization of the electromagnet 17. Therefore, the wheel 5 will take one or more cuts so as to further increase the capacity of the circuit including the disk 33 and ring 35. Finally when the workpiece has been ground to its predetermined finished size, the phase angle of the grid potential is such that sufficient current is passed by the tube 43 to fully energize the electromagnet 29, the resulting upward movement of lever 27 causing final separation of the grinding wheel 5 from the workpiece *a*, in the manner previously described with reference to Fig. 1.

Referring now to Fig. 3, there is shown a modified form of gaging condenser utilizing the actual approach of the periphery of the grinding wheel to a predetermined plane, by the crossfeed move-

ment, to obtain the desired variations in the capacity of the gaging circuit. In Fig. 3, a gaging stud 50 is threaded into a bushing 51, which in turn is insulated at 52 from a bracket 53 extending upwardly from a fixed portion of the machine frame. The stud 50 provides a head 54 carrying a micrometer scale 55, and turning of the head in the bushing 51 determines the air gap between the enlarged end of the stud and a disk 56 carried by the upper end of an arm 57. The disk supporting arm 57 is carried by one end of a resilient member 58 shown as a leaf spring, with the other end of the member received in the bracket 53. The stud 50 and the arm 57 provide leads 59 and 60 suitably insulated from the bracket 53, and these leads are adapted to be connected in the circuit of the secondary winding 40 of the supply transformer in Fig. 4 in the same manner as previously described with reference to the gaging condenser leads 34 and 39.

Normally with the parts shown in the position of Fig. 3, that is at the start of the grinding operation, the resilient member 58 extends substantially horizontally so that the vertical arm 57 maintains the disk 56 at an appreciable distance from the opposed end of the stud 50. Assuming then that the leads 59 and 60 are connected in circuit with the secondary winding 40 as shown in Fig. 4, the capacity between the stud 50 and the disk 56 will then have such a small value that not enough current will be passed by the tube 43 to energize the electromagnet 17. This condition of affairs obtains at the start of the grinding operation and continues as long as there is a gap between the periphery of the grinding wheel 5 and the rounded surface of a diamond 61, or other inset of hard material, carried by the lower extremity of the arm 57 below the plane of the resilient supporting member 58.

As the grinding proceeds, each operation of the crossfeed mechanism brings the periphery of the grinding wheel 5 nearer to the surface of the diamond 61, and the bracket 53 carrying the arm 57 is so set that when the workpiece *a* has been reduced to the roughing size, the next succeeding crossfeed of the wheelhead will cause the periphery of the wheel 5 to engage the rounded surface of the diamond 61. When this occurs, the lower end of the arm 57 is depressed, due to the flexure of the member 58, thereby swinging the upper portion of the arm toward the stud 50. Due to the relatively much greater distance between the disk 56 and the resilient member 58, as compared to the distance between the diamond 61 and the member 58, a very slight deflection of the member 58 will move the disk 56 a considerable distance toward the end of the stud 50. When this occurs, the reduced air gap between the disk 56 and the end of the stud 50 increases the capacity of the gaging circuit to such an extent as to automatically cause first, separation of the grinding wheel from the workpiece, for truing of the wheel in response to energization of the electromagnet 17, and finally, the run out of the table in response to energization of electromagnet 29 when the wheel 5 reaches its position for the final cut. In other words, the tube 43 will function in substantially the same manner as previously described with reference to Fig. 4, with either the gaging ring 35 and its shiftable disk 33, or the gaging stud 50 and its shiftable disk 56 connected across the secondary 40 of the supply transformer T.

Referring now to Fig. 5, there is shown a modified arrangement in which the gaging condenser

is included in a receiving circuit adapted to energize the electromagnets 17 and 29, variations in the capacity of the gaging condenser being employed to bring the frequency of the receiving circuit in tune with that of an oscillatory exciting circuit when the work is reduced to a predetermined diameter. An oscillatory exciting circuit suitable for this purpose comprises a thyratron tube 62 energized from a suitable source 63 by a supply transformer, the secondary winding 64 of which is divided into two parts adapted to impress suitable voltages on the plate and on the filament of the tube 62. The grid circuit of the tube 62 includes a grid leak 65 in series with a feed back coil 66 inductively related to a coil 66' in the plate circuit.

The receiving circuit is coupled to the exciting circuit through a primary winding 67 connected across the terminals of the coil 66' through an adjustable condenser 68, the primary winding 67 being inductively related to a secondary winding 69 in the receiving circuit. One terminal of the winding 69 is connected, in parallel, to a grounded condenser 70 and to the gaging condenser represented by the previously described gaging stud 50 and disk 56. The other terminal of the secondary winding 69 is connected to the electromagnet 17, while an intermediate point 69a of the winding 69 is connected to the electromagnet 29.

With the table controlled switch member 26 in the position shown, that is, connected to the electromagnet 17, it is evident that the natural frequency of the receiving circuit is determined by the combined capacity of the condenser 70 and of the gaging condenser, and the inductance of the entire secondary winding 69 combined with that of the electromagnet 17. However, with the switch member 26 in its other position to connect the electromagnet 29 in the receiving circuit, it is evident that the natural frequency of the receiving circuit will have a different value, due to the fact that only a portion of the secondary winding 69 is then included in the receiving circuit. Furthermore, variations in the capacity of the gaging condenser will also vary the frequency of the receiving circuit.

At the start of the grinding cycle, the position of the parts of the gaging condenser is such that there will be a considerable air gap between the disk 56 and the gaging stud 50, and the capacity of the gaging condenser will have a very low value. Under this condition, the natural frequency of the receiving circuit is different from that of the exciting circuit, so that not enough current flows in the receiving circuit to energize the electromagnet 17. As the grinding proceeds, the capacity of the gaging condenser remains unchanged until the feed of the wheel causes its periphery to engage the diamond 61. When this occurs, the capacity of the condenser suddenly increases, due to the reduction of the air gap between the stud 50 and disk 56, and this increase of capacity causes the frequency of the receiving circuit to approach that of the exciting circuit. The frequency of the exciting circuit is initially set so that when the workpiece has been reduced to the roughing diameter, the increased capacity of the gaging condenser brings the receiving circuit substantially in tune with the exciting circuit, whereupon energization of the electromagnet 17 by the increased flow of current in the receiving circuit causes the grinding wheel to be withdrawn for truing.

When the trued grinding wheel 5 is returned to

the work for the finishing cut in the manner previously described, the switch member 26 is then in position to connect the electromagnet 29 in the receiving circuit. Therefore, the natural frequency of the receiving circuit has a different value than at the start of the grinding operation, due to the fact that only a portion of the secondary winding 69 is included in the receiving circuit. As a result, the receiving circuit is again out of tune with the exciting circuit when the grinding wheel returns to the work after truing, and not enough current is passed by the receiving circuit to energize the electromagnet 29. Further feed of the wheel 5, however, with the corresponding increase in the capacity of the gaging condenser compensates for the reduced inductance of the secondary winding 69, and brings the receiving circuit again in tune with the exciting circuit when the workpiece has been reduced to a predetermined finished diameter. This results in full energization of the electromagnet 29 and the final run out of the table to complete the grinding cycle. Obviously, the type of gaging condenser shown in Fig. 2 can also be utilized in connection with the circuit arrangement just described with reference to Fig. 5.

From the foregoing, it is apparent that by the present invention there is provided means whereby the size of a workpiece is automatically determined by utilizing variations in the capacity of an electrical circuit to control the grinding operation, such variations of capacity resulting directly from the approach of the grinding tool to a predetermined plane as material is removed from the workpiece.

I claim:

1. In a mechanism providing a tool for performing a cutting operation on a workpiece by a relative movement, an electrical circuit and means for automatically controlling the progress of the cutting operation in accordance with variations in the capacity of said electrical circuit, including a condenser comprising a stationary element and a cooperating element movable directly by said tool.

2. In a mechanism providing a tool for performing a cutting operation on a workpiece by a relative movement, an electrical circuit and means for automatically controlling the progress of the cutting operation in accordance with variations in the capacity of said electrical circuit, including a condenser comprising a stationary element and a cooperating element movable directly by said tool.

3. In a machine of the class described, the combination with a cutting tool, a work holder, and means to procure a cutting operation between said tool and a workpiece carried by said holder, of a gage movable with said tool, an electrical circuit having a condenser therein, including said gage, and means responsive to the value of the capacity of said condenser to interrupt the cutting operation when said gage reaches a position in which the workpiece has been reduced to a predetermined size.

4. In a machine of the class described, the combination with a cutting tool, a work holder, and means to procure a cutting operation between said tool and a workpiece carried by said holder, of a gage adjustable with respect to said workpiece without contacting the same, an electrical circuit having a condenser therein, including said gage, and means responsive to the value of the capacity of said condenser to interrupt the cutting operation when the workpiece reaches a predetermined size, said value of capacity being determined by the approach of said tool to a predetermined plane, to alter the air gap of said condenser.

5. In a grinding machine the combination with a work holder, a grinding wheel, and means to procure a grinding cycle on a workpiece carried by said holder, of an electrical circuit having variable capacity and means responsive to variations in the capacity of said circuit to automatically control the progress of the grinding cycle, with such variations in capacity being determined directly by the approach of said tool to a predetermined plane as material is removed from the workpiece, one value of capacity causing temporary separation of the wheel from the workpiece for wheel truing, when the workpiece is reduced to roughing size and a second value of capacity causing final separation of the wheel from the workpiece when the latter is reduced to predetermined finished size.

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