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TRACER CONTROL FOR TOOL MACHINES

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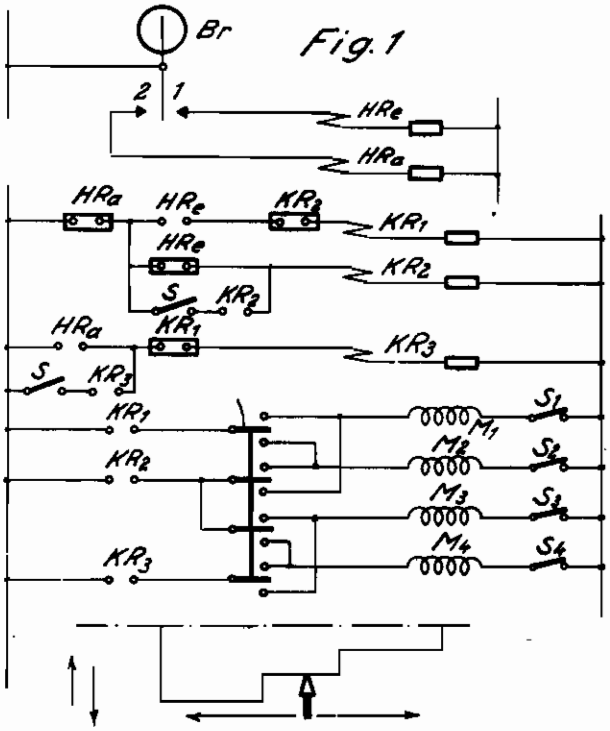

Fig. 1

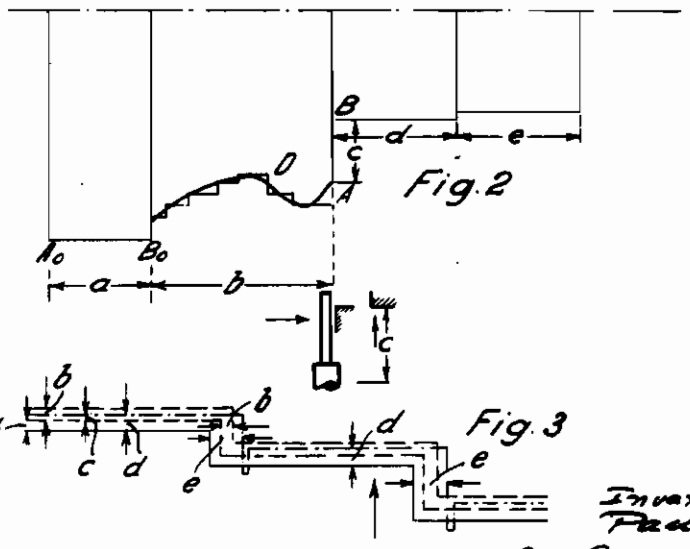

Fig. 2

Fig. 3

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TRACER CONTROL FOR TOOL MACHINES

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The present invention relates to a tracer control for tool machines, and more particularly for metal-cutting production machines.

For a better understanding of the following description the terms contained therein will first be briefly explained.

The tracer control of a tool machine scans a "guide line". By guide line is to be understood the trace which determines the corresponding operation. In the case of a tracer control of a lathe the guide line is the generatrix of the body to be produced. In the case of a milling machine the guide line is the corresponding layer line which is scanned by the tracer.

The tracer itself converts its movements into control impulses. The impulse transmitter may either be a simple contact making device as described in the U. S. patent to John C. Shaw No. 1,506,454 or it may be constructed in the form of a nozzle bolometer, for instance, as described in the U. S. patent to Rudolf Bingel et al. No. 2,046,013 or of a magnetic impulse transmitter as disclosed in the U. S. patent to Alfred v. Mershon No. 1,879,388.

The feed motion of the tool machine is effected in two directions, in the direction towards or away from the work piece and along the same. Since the movements in the direction of the work piece determine the path of the tracer, one motion shall hereinafter be called the tracing feed and the other feed motion the guide feed.

The tracer controlled machines may be subdivided into two large groups, one group serving for the preparation of production work and the other group for the production itself. A machine serving for the preparation of production work is, in general, the tracer controlled copy milling machine. It is employed in such cases where complicated dies for forging work or molds for molding presses are to be manufactured, i. e., parts serving as auxiliary means for the production proper. However, in the case of a tracer-controlled lathe, the matter is quite different. The bodies to be produced on these machines are not, as a rule, auxiliary means for the production proper, but are the work pieces to be produced. The tracer controlled lathe is, for instance, employed if a considerable number of complicated work pieces are to be made by merely trained workers or if a smaller number of work pieces is involved and if the use of automatic lathes does not pay owing to the small number of work pieces to be made.

The present invention relates above all to the second type of tracer controlled tool machines, i. e., to production machines. However, there are many cases where the invention may also be successfully used for machines serving for the preparation of production work.

The object of the invention is to provide an improved tracer control for working ranges in which the guide line runs in parallel relation to one of the two feed directions. This is, for instance, the case when machining a stepped shaft on the lathe. Depending upon the purpose of use such a shaft contains a greater or smaller number of cylindrical parts of a different diameter having the same axis and whose generatrix lies in parallel relation to the direction of the guide feed. The reverse case would, for instance, be when machining a multi-stepped face plate, in which case the generatrix of the flat surfaces is parallel to the direction of the tracing feed.

More specifically stated, the object of the invention is to machine, above all if production machines are involved, for instance, the cylindrical surfaces of the stepped shaft with the greatest possible accuracy, the best attainable surface quality and with the greatest cutting capacity. A template or a finished pattern serves as a guide line for the machining operation. As a result of the great sensitiveness which such a tracer control must present and which is the same in the two directions of feed, the control for the tracing feed owing to a slight unavoidable roughness and the like of the template is caused to operate also during the machining in the direction of the guide feed so that a smooth cylindrical surface cannot be obtained during the machining operation, but a grooved surface. Even if the grooves are very small, this is sufficient to impair the desired surface quality of the work piece. It is therefore also an object of the invention to provide a control which does not present these drawbacks. This may be accomplished according to the invention by providing an additional control member which reduces in the operating ranges in which the guide line runs in parallel relation to one of the two directions of feed the sensitiveness of the control in the other direction.

The means which are to be employed to reduce the sensitiveness depend upon the construction of the machine and upon the requirements to be fulfilled by the same. In the case of electrical impulse transmitters, reactors enable an electrical reduction of the sensitiveness. With other impulse transmitters the reduction of the sensitiveness may be brought about by elements which have a time constant so that instantaneous impulses remain ineffective. However, the matter is rendered particularly simple, if the control is rendered ineffective in the second feed direction by the auxiliary control member.

A control designed on the above principle is shown diagrammatically in Fig. 1. In this case a control is employed in which the impulse transmitter controlled by the tracer transmits impulses in the two feed directions through control relays. The control relay determining the feed

direction in parallel relation to the guide line is provided with a self-holding contact which renders ineffective the control impulses transmitted in the second feed direction until a control impulse is transmitted by the transmitter which releases the self-holding contact owing to variations in the guide line.

Since in a tracer control of the above-indicated character the two directions in which the feed is effected should be equivalent the corresponding operation must be preselected at the beginning of a machining operation. To this end, the selector switch W and the directional selectors S_1 . . . S_4 are employed. It is to be predetermined whether the tracer control should operate in the longitudinal direction or in the transverse direction and which direction of the movement (to the right—to the left; inwards; outwards) should be maintained and the selector switches and directional selectors are adjusted accordingly. It is assumed that the selector switch W has closed the upper contacts and that the directional selectors S_1, S_2 and S_4 are inserted in the circuit.

In this case it is assumed that a bolometer control is employed which acts upon a bolometer relay BR. In this case the control is so designed that as long as the tracer does not come into engagement with the work, the relay contact 1 is closed. The relay BR cooperates with the auxiliary relays HR_e, HR_a. The auxiliary relay HR_e controls the inward movement, i. e., the movement from the tracer and tool towards the work, the relay HR_a the outward movement, i. e., the movement from the tracer and tool away from the work piece.

If the machine is energized, the contact 1 should as described above be closed, whereby HR_e is attracted. Since the open-circuit contact HR_a is closed, the contactor KR_1 is energized through the closed open-circuit contact KR_2 upon the operation of HR_e, thus closing the closed-circuit contact KR_1 and initiating the feed movement "inwards". In the embodiment shown, it is assumed that the control employs, as is usual, magnetic clutches, as described in the above U. S. Patent 1,506,454 so that the closure of the closed-circuit contact KR_1 energizes the corresponding magnet coupling M_1.

If the tracer is in engagement with the guide line, the contact 1 is opened, thus energizing HR_e, the closed-circuit contact HR_e is opened and the open-circuit contact HR_e is closed. Upon the opening of the closed-circuit contact KR_1 the movement of the tracing feed is shut off. As soon as the closed-circuit contact HR_a has been opened, the open circuit contact HR_e is closed, thus energizing the contactor KR_2 and consequently the closed-circuit contact KR_2 of the magnetic clutch M_2 which initiates the longitudinal movement "to the left" is bridged. Consequently, the tracing feed is now shut off, whereas the guide feed is switched in. If owing to a slight inaccuracy in the template, i. e., owing to a small indent, the contact of the bolometer relay BR should be again closed, the tracing feed would nevertheless be brought about although as was assumed, the guide line runs in parallel relation to the direction of the guide feed and a transverse feed is consequently impossible. However, this is prevented by the novel control, i. e., by the self-holding contact of the contactor KR_2 mentioned above, since a self-holding contact is provided in the circuit which may be closed or opened by the switch S. It is assumed that the switch S is closed, i. e., by hand. However, it is, of course, also possible to control this switch automatically by stops, above all if the production of work pieces is involved in which cylindrical parts alternate with parts shaped at will. By the operation of the contactor KR_2 and by the closing of its self-holding contact caused thereby, the open-circuit contact is now rendered ineffective. If therefore HR_e should operate upon the closing of the contact 1, the contactor KR_2 would not be thereby influenced, since the open-circuit contact HR_e is bridged. However, if KR_2 cannot be released, also the open-circuit contact of KR_2 cannot also be closed that is to say, the contactor KR_1 cannot be operated. By this measure which therefore brings about a reduction of the sensitiveness of the control in the tracing feed to the zero value, control impulses are prevented in working ranges in which the guide line runs in parallel relation to one of the two feed directions, from being transmitted in the other feed direction.

It is now assumed that the tracer approaches the shoulder of a stepped shaft. Here the tracer is deflected to such an extent that the contact 2 of the bolometer relay BR is closed. HR_a is now operated, whereby its open-circuit contact is opened. KR_1 and KR_2 are thereby released, i. e., the magnetic couplings M_1 and M_2 for the guide feed and tracing feed inwards become de-energized. Owing to the release of KR_1, its open-circuit contact is closed which is in series with the closed-circuit contact of HR_e. The contactor KR_3 is now caused to operate and inserts in the circuit through its closed-circuit contact the magnetic clutch M_3 for "tracing feed outwards", i. e., it retracts the tool from the work piece.

Also KR_3 is provided with a self-holding contact which is connected to a second contact of the switch S, that is to say, the contactor KR_3 is also held attracted, even if HR_a is released upon the opening of the contact 2. This is due to the fact that each gear has a certain unavoidable play. A given accuracy may then be only attained, if during the entire machining operation the same unaccuracy fault may be reckoned with, whose magnitude is known. However, in the moment in which the play in the gear may be varied depending upon the direction of the machining operation, an accuracy factor is added which is very difficult to take into consideration. Consequently, the control according to the invention is so designed that in every case the same play is present in the gear, i. e., an overcontrol is effected to a certain extent in the manner that one of the two movements, i. e., in this case the tracing feed is caused to be continued more than is necessary and then reverses its direction so that at the beginning of a further machining operation, the gear is again in the same initial position. The magnetic coupling M_3 for the tracing feed outwards remains as previously mentioned energized owing to the self-holding device, even if the contact 2 has been opened. Only when the tracer has moved away from the template to such an extent that the contact 1 again closes, HR_a is caused to operate and switches in the inward movement, since HR_a and KR_2 have been released. Consequently, as regards the second portion of the stepped shaft exactly the same movement has been initiated as at the beginning of the machining, for in this case it has been assumed that the contact 1 should be closed. If KR_1 is caused to operate, its open-circuit contact opens the circuit of the

contactor KR_3, whereupon its closed-circuit contact switches in the clutch M_1 for the inward movement which is again immediately interrupted, if the tracer comes again into engagement with the template. By the reduction of the sensitiveness of the control as previously described it is therefore possible to machine a cylindrical body in a manner as accurate as on a usual lathe operating without tracer control.

By the switch S it is possible to scan with the same control guide lines whose inclination varies. If in this case the machining of bodies is involved whose generatrix extends in parallel relation to the guide line, this switch is inserted in the circuit during a portion of the machining operation, but is opened during the other portion, in which case the control of the switch S may be either effected automatically or manually. In this connection, Fig. 2 shows an example. Along the path *a* between the points A_0 and B_0 the generatrix of the pattern is parallel to the guide feed direction. The switch S is closed so that the sensitiveness of the control is reduced in a direction perpendicular to the guide feed motion. It is assumed that at the point B_0 the switch S is opened by hand. As long as the tracer does not come into engagement with the template, the contact 1 of the bolometer relay is closed. The auxiliary relay HR_e is caused to operate and energizes through the open-circuit contacts of the relays KR_2 and HR_2 which have been released the relay KR_1 which in turn energizes the magnetic clutch M_1 for the inward movement. If then the tracer comes into engagement with the template, the contact 1 of the relay BR is opened. The auxiliary relay HR_e is released and therefore also the relay KR_1 for the inward coupling M_1. The open-circuit contact of the relay HR_2 upon the release of the latter energizes the relay KR_2 which in turn energizes the coupling M_2 for the longitudinal motion. The tracer moves in the guide feed direction away from the template so that the contact 1 of the bolometer relay BR closes again. The auxiliary relay HR_e is thus operated, whereby upon the opening of its open-circuit contact the relay KR_2 is deenergized and the guide feed motion is shut off. At the same time the inward movement, i. e.; the movement towards the pattern is again switched in. At the point D owing to a considerable angular displacement of the tracer, the contact 2 of the bolometer relay BR is closed, thus causing an operation of HR_e and an interruption through its open-circuit contact of the longitudinal movement upon the opening of the circuit of KR_2. The closed-circuit contact of HR_a energizes KR_3 which in turn energizes the clutch M_3 for the outward movement. Consequently, the angular displacement of the tracer becomes smaller, thus opening the contact 2 of the bolometer relay BR and releasing HR_a. KR_3 is released and the clutch M_3 becomes deenergized. The open-circuit contact of HR_a then switches in through the open-circuit contact of the relay HR_e upon the release of the latter, the relay KR_2 so as to energize the magnetic clutch M_2 for the longitudinal movement. If the tracer reaches the point A, the machining is effected within the operating range A—B, where the guide line runs in parallel relation to a machining direction; however, in this case not in parallel relation to the guide feed direction, but to the tracing feed direction. By changing over the selector switch W, the effect of the tracer upon the control is reversed. If the switch S is inserted in the circuit, the sensitiveness of the control is reduced in the guide feed direction so that a facing operation is effected in the usual manner within the range *c*.

In the drawing is schematically shown that the reversal may be effected automatically. At point B the selector switch W is again brought back into its initial position. The switch S remains closed so that the operation described above is effected along the stepped shaft portions *d* and *e*.

The theoretical faults as to the reproduction depend (Fig. 3)

(1) Upon the path *e* of the tracer point which is necessary for opening the contact of the bolometer relay (statical position of diameter)

(2) Upon the additional path *b* of the tracer point for closing the contact 2 of the bolometer relay

(3) Upon the accuracy of the operating values of the bolometer (operating leakage)

(4) Upon the running out *c* and *c'* of the drive which depends upon the time between the transmission of the signals and the operation of the magnetic clutch.

In the case of a constant feed speed (transverse and longitudinal feed may be different) the faults under 4 are constant. The paths for the movement under 1 to 2 are also constant, apart from the leakage losses under 3. Consequently, there results a theoretical fault curve which is shown in Fig. 3. The total fault *d* for the diameter is therefore constant in the case of each shaft diameter. The fault *e* in the variation of the length is likewise always constant. If the template is therefore displaced in the longitudinal direction with respect to the work piece by the amount *e* and in the transverse direction by the amount *d*, there results an accuracy of reproduction, the faults of which apart from the mechanical faults of the lathe depend only upon the leakage values of the bolometer tracer.

As a consequence of the self-holding contact in the embodiment shown the following is attained:

(1) The longitudinal movement is always switched in after the inward movement.

(2) Control impulses as a result of slight motions (vibrations) are ineffective during the longitudinal motion so that a perfect cylindrical surface may be machined, the accuracy of which depends upon the tracer control.

(3) The outward motion remains longer switched in than is actually necessary when passing from the outward motion to the longitudinal motion.

Consequently, when passing from the outward motion to the longitudinal motion an inward motion is necessary. This measure renders ineffective the play in the gear not to be avoided as well as the hysteresis of the tracer as a result of the friction.

(4) The fault curve coincides with the template. The faults as to the operating and running out accuracy may therefore be compensated for by simply displacing the template so that the work may be machined to a highly accurate size or shape.

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