June 17, 1958 | M. O. BASSETT | 2,839,733

TRACER HEAD

Filed May 13, 1954

Fig. 1.

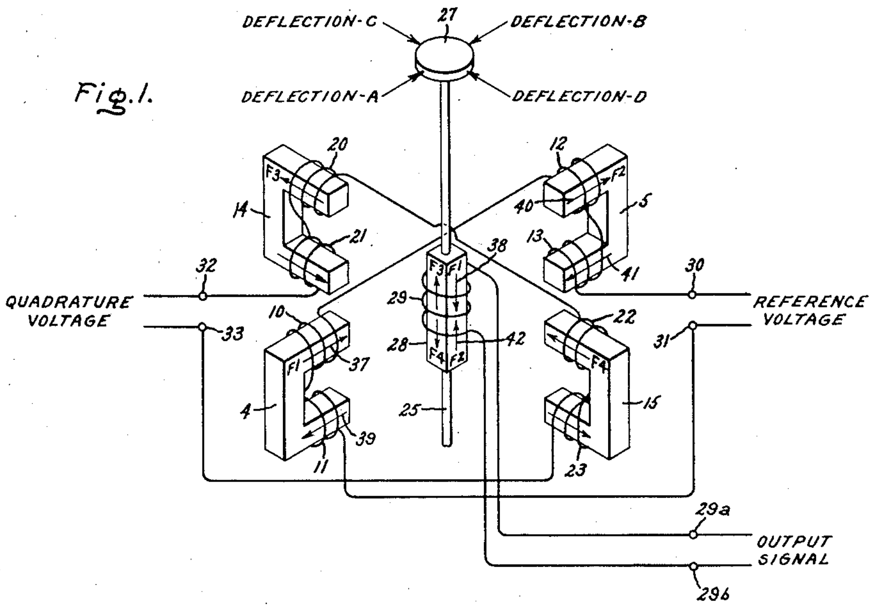


Fig. 2.

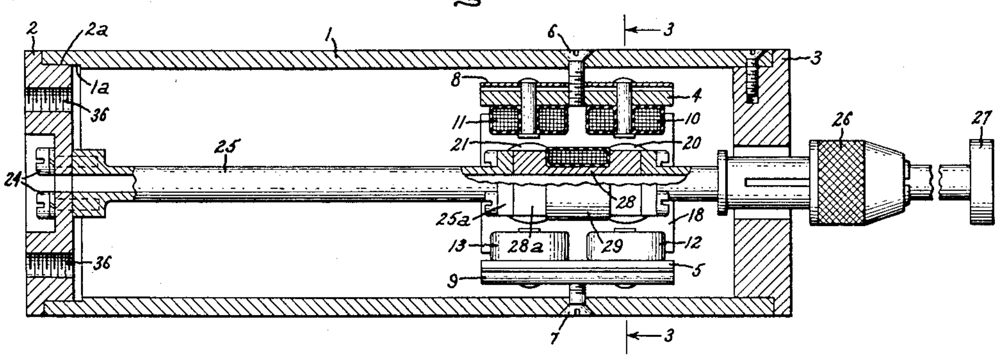
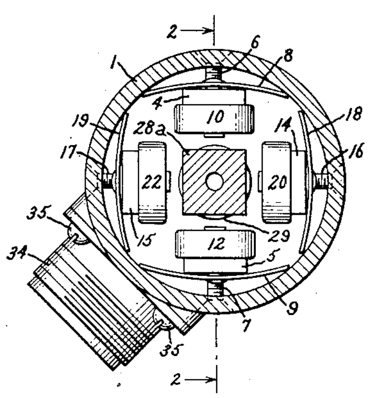


Fig. 3.



Inventor:
Merton O. Bassett,
by Irving H. Marshman
His Attorney.

United States Patent Office

2,839,733

Patented June 17, 1958

2,839,733

TRACER HEAD

Merton O. Bassett, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application May 13, 1954, Serial No. 429,627

5 Claims. (Cl. 336—30)

This invention relates to electric control systems, more particularly to electric tracer control systems and it has for an object the provision of a simple, reliable and improved tracer head unit for use in combination with or as a part of such system.

Still more particularly, the invention relates to automatic tracer control systems for automatic pattern controlled machine tools which in operation are required to make cuts on a work piece throughout 360 degrees of a closed path, and a further object of the invention is the provision of a tracer head having a stylus for engaging the pattern or template which has a normal initial position and which may be deflected from such initial position in any radial direction throughout a range of 360 degrees. Another object of the invention is the provision of a tracer head having electric output terminals and a circuit for supplying to such terminals an alternating signal voltage of which the magnitude is proportional to the magnitude of the deflection of the stylus in any radial direction from such initial position and of which the phase with respect to a reference alternating voltage depends upon the radial direction; i. e., the angle of such deflection with respect to an initial reference direction.

In carrying the invention into effect in one form thereof, a first pair of magnetic core members are mounted in spaced apart relationship to provide an air gap and are mounted with their magnetic axes occupying a common plane. A second pair of magnetic core members are mounted in spaced apart relationship with their magnetic axes in a second common plane which is perpendicular with respect to the first and intersects it in a line which is parallel to the magnetic axes of all four magnetic members, and approximately equally distant therefrom. A stylus member is provided with a third magnetic core member and it is so mounted that its magnetic axis occupies an initial position approximately coincident with the intersection line of the planes occupied by the magnetic axes of the first and second pairs of magnetic core members, and may be deflected from such initial position in any radial direction in response to deflection of the tracer itself in a corresponding direction. Upon each of the first pair of core members is mounted a primary coil which is connected to a pair of alternating voltage supply terminals. These coils are poled so that they produce opposing magnetic fluxes in the movable third core member in the air gap. Similarly, a second pair of primary coils, each mounted on a different one of the second pair of magnetic core members are supplied from a pair of quadrature alternating voltage supply terminals and are poled so that they produce opposing magnetic fluxes in the third core member. A secondary coil is mounted on the third core member and it is connected to a pair of output terminals. When the stylus and the third core member are in their initial positions, the magnetic flux in the third core member is zero. Deflection of the stylus from this initial position causes to be induced in the secondary coil and supplied

to the output terminals an alternating signal voltage which is the resultant or vector sum of two component voltages of which one is proportional to the product of the deflection and the consine of the angle of deflection and the other is proportional to the product of deflection and the sine of the angle.

For a better and more complete understanding of the invention, reference should now be had to the following specification and to the accompanying drawing of which Fig. 1 is a simple schematical diagrammatical sketch in perspective of an embodiment of the invention; Fig. 2 is a sectional view of an elevation of the tracer head taken on the line **2—2** of Fig. 3 and showing an assembly of the elements of which the head is comprised, and Fig. 3 is a transverse sectional view taken on the line **3—3** of Fig. 2.

Referring now to the drawing, the tracer head comprises an outer tubular casing **1**, a top end cover plate **2** and a bottom end cover plate **3**. The casing **1** is preferably cylindrical in form and is made of a suitable, strong nonmagnetic material such as brass or aluminum.

Within the casing and mounted on its wall is a first pair of magnetic core members **4** and **5**. Preferably, these magnetic core members are U-shaped and are made of a material having good magnetic qualities such, for example, as silicon steel. The poles of one of the core members are separated from the opposing poles of the other member by an air gap. These core members are mounted on the wall of the casing by suitable means such as machine screws **6** and **7** and are securely held in position against rotational displacement by means of spring plates **8** and **9**, the extremities of which are pressed against the wall of the casing when the screws are tightened. The positioning of the core members is such that their magnetic axes occupy a common plane and the poles of the cores face each other in alignment.

On the upright leg of each U-shaped core member is mounted a primary coil. Thus, primary coils **10** and **11** are mounted on core member **4** and primary coils **12** and **13** are mounted on core member **5**.

A second pair of U-shaped magnetic core members **14** and **15** are mounted within the casing in spaced apart relationship to provide an air gap between their poles. The core members **14** and **15** are preferably identical with core members 4 and 5 and are mounted on the inner wall of the casing by means of screws **16** and **17** and are held securely in position by means of spring plates **18** and **19** respectively. They are positioned so that their magnetic axes occupy a common plane which is perpendicularly disposed with respect to the plane of the magnetic axes of the first pair of core members **4** and **5** and intersect it in a line which is substantially parallel to the magnetic axes of all four core members and substantially equally distant therefrom. In other words, the magnetic core members **4**, **5**, **14** and **15** are substantially symmetrically positioned with respect to the intersection of the planes in which their magnetic axes are included.

Mounted on the upright legs of U-shaped core members **14** are two primary coils **20** and **21**, and similarly two primary coils **22** and **23** are mounted on the upright legs of core member **15**.

As shown in the drawing, the top cover plate **2** has a portion **2*a*** of reduced diameter which is press fitted into the casing **1** and rests against a shoulder **1*a***. Secured to this inwardly projecting portion **2*a*** by means of screws **24** is the supporting post **25** of a stylus member which extends longitudinally of the casing. The opposite end of the stylus projects out through a circular opening in the bottom cover plate and is provided with a chuck nut **26**. A template follower **27** for making physical contact with a template or pattern is securely clamped in the chuck jaws when the nut is tightened. The supporting post 25 is preferably made of a resilient high stress material such as chrome molybdenum steel. Owing to its resiliency, the stylus may be deflected in any radial direction from its initial central position. At its free end, the post 25 is provided with an enlarged portion 25a of square cross section and secured to it by means of screws is the flange 28a of a core member 28 which at its opposite end is provided with another flange to which the chuck nut 26 is attached. The core member is made of a material having magnetic permeability such, for example, as silicon steel. Mounted upon this magnetic core member is a secondary coil 29.

The primary coils 10, 11, 12 and 13 which are mounted on the first pair of stationary core members 4 and 5 are connected to reference alternating voltage supply terminals 30 and 31 which are arranged to be connected in turn to a source of reference alternating voltage such as represented by the two supply conductors designated "Reference Voltage." As shown, these coils are connected in series relationship to the terminals 30 and 31 although this is not essential. However, the series connection is advantageous since the current in each coil is the same as the current in the other coils. Also, it is not essential that there should be two primary coils on each of the stationary core members. The two may be combined in a single coil. The use of the two coils, one on each of the upright legs does make economic use of available space and thus results in compactness.

Similarly, the primary coils 20, 21, 22 and 23 are connected in series relationship to a pair of quadrature alternating voltage supply terminals 32 and 33 which in turn are supplied from a source of an alternating voltage such as represented by the two supply conductors designated "Quadrature Voltage" which is in quadrature with the reference alternating voltage from which terminals 30 and 31 are supplied. The output signal voltage terminals 29a, 29b and the reference and quadrature supply voltage terminals 30, 31, 32 and 33 are mounted in a cable connector 34 which is mounted on the casing 1 to which it is secured by suitable means such as screws 35.

The top cover plate 2 has tapped holes 36 for receiving screws for mounting the tracing head on a part of the machine or apparatus with which it is to be used. The coils 10, 11, 12 and 13 are so poled that when an alternating voltage is impressed upon reference voltage terminals 30 and 31 the flux F1 which is induced in stationary core 4 and passes through movable core 28 at a predetermined instant is represented by the arrows 37, 38 and 39, and the flux F2 which is induced in stationary core 5 and passes through movable core 28 at the same instant is represented by arrows 40, 41 and 42. With the movable core 28 in its initial central position the fluxes F1 and F2 are equal and of opposite polarity so that the net flux in the movable core member produced by fluxes F1 and F2 is zero. Similarly, as a result of the quadrature voltage which is supplied to primary coils 20, 21, 22 and 23, fluxes F3 and F4 are induced in stationary core members 14 and 15 and pass through movable core member 28 in opposite directions and with the movable core member in its initial position, the net flux in the movable core member resulting from fluxes F3 and F4 is zero. Consequently, zero voltage will be induced in the secondary winding and supplied to the output terminals 29a and 29b.

If, however, the stylus is deflected in the plane of stationary core members 4 and 5 in a direction indicated by the arrow associated with the legend deflection A, the air gap between stationary core 4 and movable core 28 is increased and that between core 5 and core 28 is decreased. The changes in reluctance in these two magnetic circuits cause flux F1 to decrease and flux F2 to increase. The net flux in movable core 28 is the difference between the two fluxes, i. e., F2—F1, and since this flux is alternating, a corresponding alternating voltage is induced in secondary coil 29. A deflection in the opposite direction, which in the drawing is denoted deflection B, causes a voltage of opposite polarity, i. e. 180 degrees out of phase therewith, to be induced in coil 29. The magnitudes of these voltages are proportional to the deflections.

In a similar manner, deflections C and D in the plane of cores 14 and 15 cause voltages of opposite polarity to be induced in secondary coil 29. Similarly, the magnitudes of these voltages are proportional to the deflections and the voltage which is supplied to the output terminals is either in phase with the quadrature voltage or 180 degrees out of phase therewith.

For deflections which are at some angle x to the plane of stationary cores 4 and 5, the component of such deflection in such plane is equal to the deflection times the cosine of angle x and the component of deflection in the plane of cores 14 and 15 will be equal to the deflection times the sine angle x. Thus two component voltages are induced in secondary coil 29 of which one is proportional to the original deflection times the cosine of the angle x and in phase with the reference voltage, and the other is proportional to the original deflection times the sine of angle x and in phase with the quadrature voltage. Since the quadrature voltage is 90 degrees out of phase with the reference voltage, the net voltage which is induced in the secondary coil 29 is the vector sum of the two component voltages and is thus proportional in magnitude to the original deflection and has a phase relationship with respect to the reference voltage equal to the angle x.

An important advantage of this invention is that the signal components produced by a deflection of the stylus in any radial direction are combined magnetically within the head and thus only a single output signal voltage is produced and only a single amplifier is required in contrast with prior tracer heads in which two separate signal voltages are produced and two amplifiers are required for amplifying and combining the voltages into a single signal voltage of which the magnitude is proportional to the deflection and the phase is dependent upon the angle of the deflection.

Another advantage of this invention is that cross axis pickup has no adverse effect upon the output signal since the operation of the device is dependent upon a single signal voltage being induced in a single coil by separate magnetic fluxes having perpendicularly disposed magnetic axes.

Although in accordance with the provisions of the patent statutes this invention is described as embodied in concrete form and its principle has been described together with the best mode in which it is now contemplated applying that principle, it will be understood that the apparatus shown and described is merely illustrative and that the invention is not limited thereto since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of this invention or from the scope of the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A tracer head for a tracer control system comprising in combination, a pair of alternating voltage supply terminals, a first pair of magnetic core members mounted in spaced-apart relationship to provide an air gap and with their magnetic axes occupying a first common plane, a pair of primary coils each mounted on a different one of said core members and connected to be supplied from said terminals, a pair of quadrature alternating voltage supply terminals, a second pair of magnetic core members mounted in spaced-apart relationship to provide an air gap and with their magnetic axes occupying a plane intersecting said first plane at right angles and passing through said first air gap, a second pair of primary coils

each mounted on a different one of said second pair of core members and connected to be supplied from said quadrature voltage supply terminals, a stylus member provided with a third magnetic member disposed in said air gaps at the intersection of said planes for vectorially combining the net magnetic fluxes from both said pairs of magnetic members, a pair of output terminals, a secondary winding mounted on said third magnetic member and electrically connected to said output terminals, and means pivotally mounting said stylus member to provide for a deflection of the magnetic axis of said third magnetic member in any radial direction from an initial position in response to different radially directed deflections of said stylus member thereby to cause to be induced in said secondary winding and supplied to said output terminals a resultant voltage of which the phase varies with the direction of said deflection.

2. A tracer head for a tracer control system comprising in combination, a pair of alternating voltage supply terminals, a first pair of magnetic core members mounted in spaced-apart relationship to provide an air gap and with their magnetic axes occupying a first common plane, a pair of primary coils each mounted on a different one of said core members and serially connected to be supplied from said terminals, a pair of quadrature alternating voltage supply terminals, a second pair of magnetic core members mounted in spaced-apart relationship to provide an air gap and with their magnetic axes in a second plane perpendicular to said first plane and passing through said first air gap to intersect said first plane in a line centrally disposed between the magnetic members of said first pair, a second pair of primary coils each mounted on a different one of said second pair of core members and serially connected to be supplied from said quadrature voltage supply terminals, a stylus member provided with a third magnetic member disposed in said air gaps with its magnetic axes parallel to the magnetic axes of said pairs to complete their magnetic circuits and vectorially combine their net magnetic fluxes, a pair of output terminals, a secondary winding mounted on said third magnetic member and electrically connected to said output terminals, and means pivotally mounting said stylus member to provide for a deflection of the magnetic axis of said third magnetic member in any radial direction from an initial position in response to different radially directed deflections of said stylus member thereby to cause to be induced in said secondary winding and supplied to said output terminals a resultant voltage of which the magnitude varies with the deflection and the phase varies with the direction of said deflection.

3. A tracer head for a tracer control system comprising in combination a first pair of U-shaped magnetic core members mounted with their axes in a common plane and with the poles of one of said members spaced from the poles of the other to provide an air gap, a second pair of U-shaped magnetic core members mounted with the poles of one of said members spaced from the poles of the other to provide an air gap and with their magnetic axes in a common plane passing through said first air gap and perpendicularly disposed with respect to said first plane and intersecting it in a line approximately centrally disposed between the core members of said first pair, a stylus member provided with a third magnetic core member for vectorially combining the net magnetic fluxes of each of said pairs and having an initial position in which its magnetic axis and said intersection line are substantially co-linear, a pair of alternating voltage supply terminals, a pair of primary coils each mounted on a different one of said first pair of core members and connected to said terminals with said coils poled to produce opposing magnetic fluxes in said third core member, a pair of quadrature alternating voltage supply terminals, a second pair of primary coils each mounted on a different one of said second pair of core members and connected to said quadrature voltage supply terminals and poled to supply opposing magnetic fluxes in said third core member, a pair of output terminals, a secondary winding on said third core member connected to said output terminals, and means pivotally mounting said stylus member to provide for a deflection of the magnetic axis of said third core member in any radial direction from said initial position in response to different radially directed deflections of said stylus member thereby to be caused to be induced in said secondary winding and supplied to said output terminals a resultant voltage of which the phase relationship is dependent on the direction of said deflection.

4. A tracer head for a tracer control system comprising in combination, a pair of alternating voltage supply terminals, a first pair of U-shaped magnetic core members mounted with their magnetic axes occupying a common plane and with the poles of said core members facing each other in spaced apart relationship to form an air gap, a pair of primary coils each mounted on a different one of said core members and connected in series relationship to said terminals to produce poles of opposite polarity on opposite sides of said air gap, a pair of quadrature alternating voltage supply terminals, a second pair of U-shaped magnetic core members mounted with their magnetic axes occupying a common plane perpendicularly disposed with respect to said first plane and intersecting said first plane in a line approximately centrally disposed between said magnetic axes of said first and second magnetic core members and with the poles of said second magnetic core members facing each other in spaced apart relationship to form an air gap, a second pair of primary coils each mounted on a different one of said second core members and connected in series relationship to said quadrature voltage supply terminals to produce poles of opposite polarity on opposite sides of said second air gap, a stylus member provided with a third core member disposed in said air gaps with its magnetic axis in an initial position approximately parallel to said magnetic axes of said first and second pairs and approximately centrally disposed with respect thereto for vectorially combining the net fluxes of both said pairs of core members, a pair of output terminals, a secondary winding mounted on said third core member and electrically connected to said output terminals, and means pivotally mounting said stylus member to provide for a deflection of the magnetic axis of said third core member in any radial direction from said initial position in response to different radially directed deflections of said stylus member thereby to cause to be induced in said secondary winding a resultant voltage of which the magnitude is proportional to the deflection of said stylus member and the phase relationship is dependent on the direction of said deflection.

5. A tracer head for a tracer control system comprising in combination, a tubular housing member having a supporting base at one end, a first pair of magnetic core members mounted on an inside wall of said housing with their magnetic axes in a first common plane and in spaced apart relationship to provide an air gap, a second pair of magnetic core members mounted on an inside wall of said housing with their magnetic axes in a second common plane perpendicularly disposed with respect to said first plane and passing through said first air gap to intersect said first plane in a line approximately centrally disposed between the magnetic axes of said first pair, a pair of alternating voltage supply terminals mounted in said housing, a first pair of primary coils each mounted on a different one of said core members of said first pair and electrically connected to be supplied from said terminals, a pair of quadrature voltage supply terminals mounted in said housing, a second pair of primary coils each mounted on a different one of the core members of said second pair and electrically connected to be supplied from said quadrature voltage supply terminals, an elongated resilient stylus member provided with a third magnetic core member disposed in said air gaps for vectorially combining

the net magnetic fluxes of each of said pairs of core members and having its magnetic axis in an initial position approximately parallel to the magnetic axes of said first and second pairs and approximately centrally disposed with respect thereto, a pair of output terminals, a secondary coil mounted on said third core member and means mounting one end of said stylus member on said base member to provide for a deflection of said third magnetic core member in any radial direction from said initial position in response to different radially directed deflections

of the opposite end of said stylus member, to cause to be induced in said secondary winding and to supply to said output terminals a resultant alternating voltage of which the phase varies with the direction of said deflection.

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