

Aug. 30, 1960

R. E. SPENCER

2,950,864

QUADRATIC INTERPOLATING DEVICES

Filed June 18, 1957

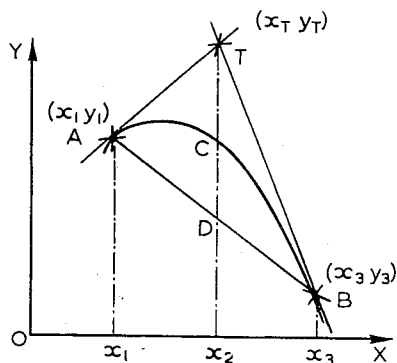


FIG. 1.

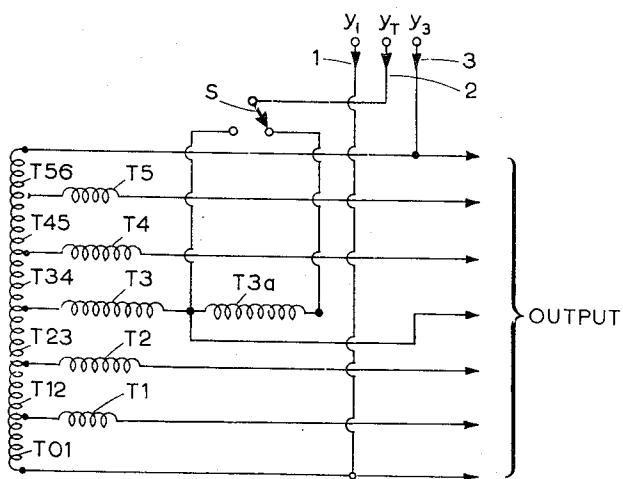


FIG 2

Inventor
R. E. Spencer
By Glascock Downing Tebbel,
Attys.

1

2,950,864

QUADRATIC INTERPOLATING DEVICES

Rolf Edmund Spencer, West Ealing, London, England, assignor to Electric & Musical Industries Limited, Hayes, England, a company of Great Britain

Filed June 18, 1957, Ser. No. 666,455

Claims priority, application Great Britain June 19, 1956

2 Claims. (Cl. 235—197)

This invention relates to interpolating devices, and constitutes an improvement in or modification of the invention described in co-pending United States application Serial No. 459,814.

In automatic control mechanisms, for machine tools for example, it may be desired to describe a particular locus with a high degree of accuracy and in the specification of the aforesaid patent application (hereinafter termed the main specification) an interpolating device is described which derives signals representing the co-ordinates of successive closely spaced points on a locus by a process of interpolation or extrapolation among representations of relatively widely spaced points, termed reference points.

In the main specification several examples of quadratic interpolating devices are described and Figure 1 in particular, in the main specification, illustrates a device which interpolates among three reference signals by providing further signals representing points lying on a parabola defined by the reference signals. This is achieved by interconnecting three input points by a multi-winding transformer which conforms to a quadratic law and another transformer which conforms to a linear law. The latter transformer is termed a chordal transformer and the windings of the first transformers are termed lift windings since the voltages induced across them correspond to the lifts required to pass from a chord of a parabola to points on the curve itself. The lift windings are connected at equal intervals along the chordal transformer winding, the number of turns on the lift windings bearing a quadratic relationship to their position of connection to the chordal winding. The reference signals are applied to one end of the chordal winding, the central lift winding and the other end of the chordal winding respectively, so that in general the reference points must be on the curve points on which are to be interpolated, or be similarly spaced from it.

In automatic machine tools, it is clearly beneficial to economise in the time and labour required in providing programme or instruction data as recorded, say on punched tape at the same time ensuring that a smooth transition at reference points is provided thereby ensuring a smoothly cut profile. This is the object of the present invention.

According to the present invention there is provided an improvement in or modification of the invention claimed in co-pending United States application Serial No. 459,814 comprising an interpolating or extrapolating device wherein three input points are intercoupled by two transformers so arranged that on application of cophasal alternating electrical signals representing a co-ordinate of two points on a parabolic curve and the intersection of the tangents at said points, a signal is set up at the or each output point having an amplitude representing a co-ordinate of a point or points on said curve.

In order that the present invention may be clearly understood and readily carried into effect, the invention

2

will be described with reference to the accompanying drawings, in which:

Figure 1 illustrates graphically the operation of the invention, and

Figure 2 illustrates part of the interpolator of Figure 1 of the main specification, modified in accordance with one example of the present invention.

Referring to Figure 1, A, B, and C are points on the parabolic curve ACB having corresponding x co-ordinates, x_1 and x_2 and x_3 . The intervals between x_1 and x_2 and x_2 and x_3 are equal. The tangents at A and B intersect at a point T denoted by (x_T, y_T) and it can be shown by geometrical consideration that the point T lies on the line through D, the mid-point of AB, which is parallel to the y axis. It is clear therefore that $x_T = x_2$. It is furthermore a geometrical property of the present diagram that $TC = CD$.

Referring to Figure 2 the transformer windings T01, T12, T23, T34, T45 and T56, together comprise the chordal transformer of the interpolator and T1, T2, T3, T4 and T5 comprise parabolic lift windings of the other transformer of the interpolator. The input points, are denoted by the references 1, 2 and 3. As described in the main specification the numbers of turns on the parabolic lift windings are quadratically related to the intervals between their connections to the chordal winding and assuming the switch S is set to the position opposite to that shown in Figure 2, so that 2 is connected to the terminal of T3 remote from the chordal windings and that reference signals representing y_1, y_2, y_3 are applied to the input points 1, 2 and 3, the interpolator operates to provide further signals representing points on the curve defined by the signals y_1, y_2 and y_3 . The intervals between successive points along the x co-ordinate direction are determined by the characteristics of the interpolator in conjunction with the input data which may for example be recorded on a punched tape. In Figure 2, however for the purposes of the invention there is connected to T3 a further lift winding T3a having an equal number of turns to T3 and mounted on the same core thereas. When therefore the switch S which connects 2 either to the junction T3 and T3a or to the other terminal of T3a, is set to the position shown, from the considerations given above with reference to Figure 1, it is clear that on application of a signal to the point 2, which represents the y co-ordinate of the point T, the intersection of the tangents at A and B, the interpolator operates to provide the same reference output signal as those it provides if the point 2 receives a reference signal representing the y co-ordinate of C together with the y co-ordinates of A and B at input points 1 and 3 respectively and the switch S is set to its alternative position. This is so since the winding T3a provides the additional lift equal to the lift produced by T3, corresponding to the lift CT which is equal as mentioned above to the lift DC from the chord AB to the arc ACB in Figure 1.

By virtue of the present invention a significant amount of computing time may be saved compared with the computing time required for the unmodified mechanism such as is described in co-pending U.S. application Serial No. 459,814 for in practice it may be simpler to compute the values of the co-ordinates of the intersection of the tangents at the points A and B when A and B are known than to compute the co-ordinates of the intermediate point C on the parabolic arc. Alternatively, the values of the slopes of the required curve may be programmed and the control mechanism may be arranged to provide the co-ordinates X_t, Y_t of the point T in response to these and the values of the co-ordinate at A and B. Clearly moreover since D is the mid-point of AB, only the slope at A or B is required in the case described above.

In an interpolator employing the present invention, if a switch such as S indicated in Figure 2 is provided this switch may comprise a relay which is operated in response to auxiliary signals provided on the programme record and when for example a punched tape is used they can comprise extra perforations. Thus a change from a programme comprising data according to the invention to data as employed in the main specification or vice versa is made automatically by the control mechanism.

The present invention has a principal advantage in that it provides continuity of the first differential coefficient at reference points along a profile to be cut in machine tool control so that a smooth transition is obtained at reference points and this may be of primary importance especially if the surface to be cut is that of an aerofoil or turbine blade.

Although the present invention has been described with reference to an interpolator interpolating values of a function of a dependent variable such as x it may equally well be applied to a control mechanism or interpolator for determining the different co-ordinates of points on a locus whose co-ordinates are functions of a common independent parameter. This type of interpolation requires separate interpolation means for each co-ordinate and is termed parametric interpolation. One form of apparatus for providing parametric interpolation is described in co-pending United States Application Serial Number 581,038 and parametric interpolation has an advantage in machine tool control mechanisms in that the inclination of the axis of the parabolic arc which is described may be varied and much greater latitude of control is provided.

What I claim is:

1. An interpolating device comprising an autotransformer, two input terminals connected respectively to spaced points on said autotransformer, a third input terminal, a further transformer winding connected from said third input terminal to a point on said autotrans-

former electrically midway between said first two input terminals, and an output terminal connected midway along said further transformer winding, whereby on application of alternating signals representing ordinates of points on a quadratic curve to said first two input terminals and an alternating signal representing the ordinate of the intersection of the tangents to said curve at said points to said third input terminal, a signal is set up at said output terminal representing the ordinate of a further point on said quadratic curve.

2. An interpolating device having an autotransformer, two input terminals connected respectively to spaced points on said autotransformer, a third input terminal, a plurality of output terminals, a further transformer having a winding connected from said third input terminal to a point on said autotransformer electrically midway between said first two input terminals, and a plurality of further windings respectively connected from said output terminals to spaced points on said autotransformer, which points represent different abscissae, the numbers of turns of said further windings being proportioned to cause voltages to be induced across them which represent lifts along the respective ordinates from points on a chord of a quadratic curve to points on said curve on the scale that half the voltage induced across said first mentioned winding represents the lift along an ordinate from the mid point of said chord to the curve whereby on application of alternating signals representing ordinates of two points on a quadratic curve to said first two input terminals and an alternating signal representing the ordinate of the intersection of the tangent to said curve at said two points to said third input terminal, signals are set up at said output points representing the ordinates of further points on said curve.

References Cited in the file of this patent

UNITED STATES PATENTS

2,781,967 Spencer et al. Feb. 19, 1957