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2,889,109

PNEUMATIC DIGITAL TO ANALOG SUMMING DEVICE

Filed June 16, 1955

2 Sheets-Sheet 1

FIG-3

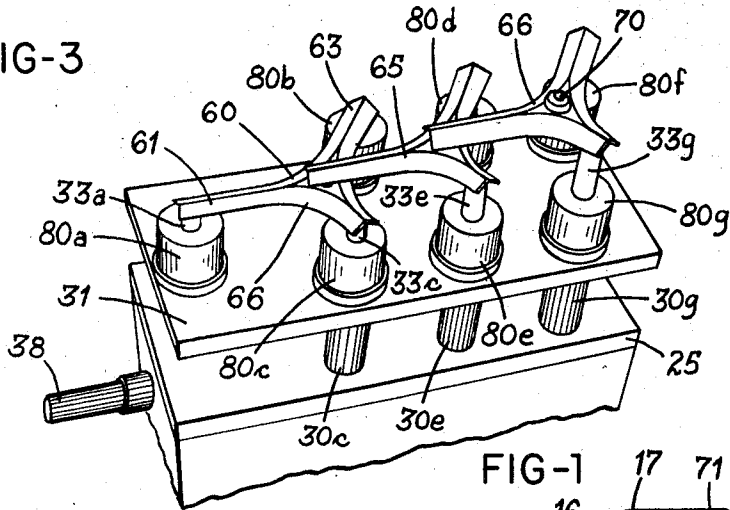


FIG-1

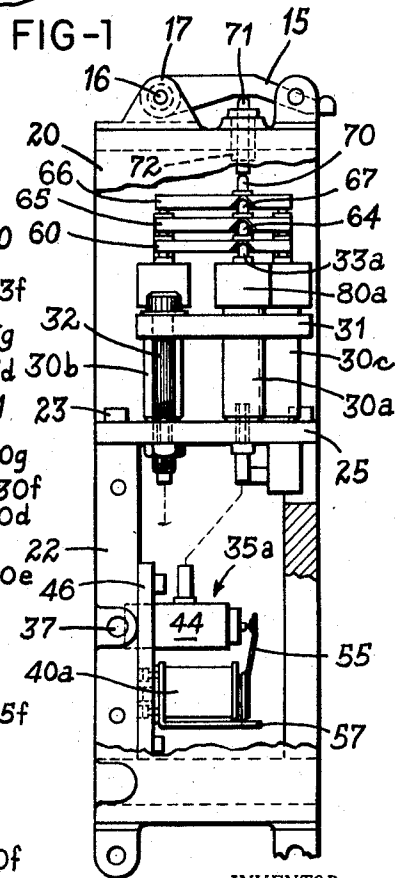
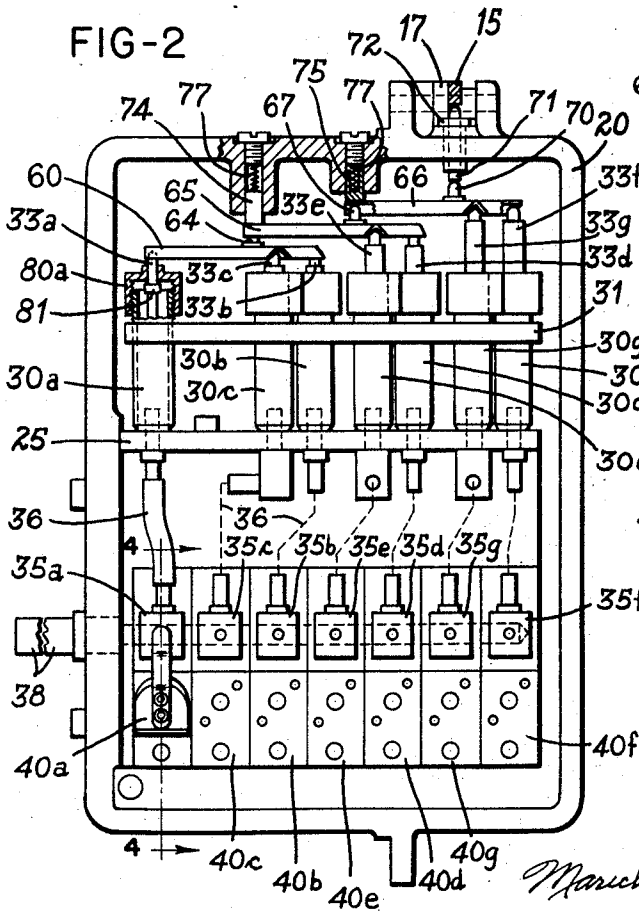


FIG-2



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2 Sheets-Sheet 2

FIG-4

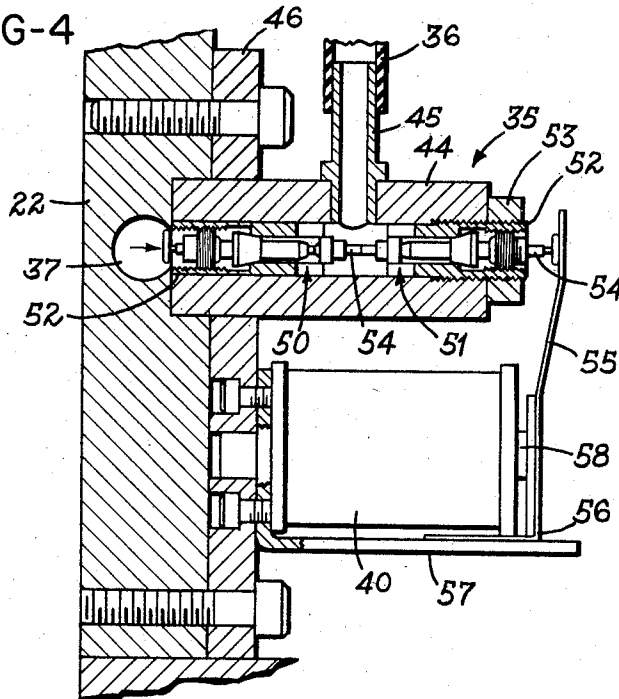


FIG-5

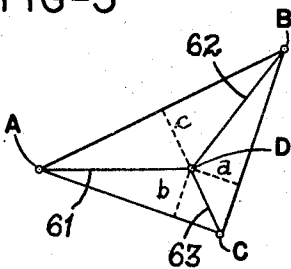


FIG-6

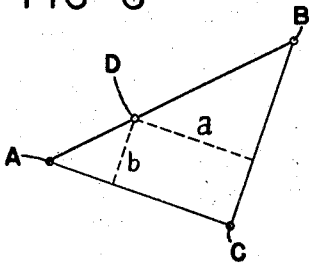


FIG-9

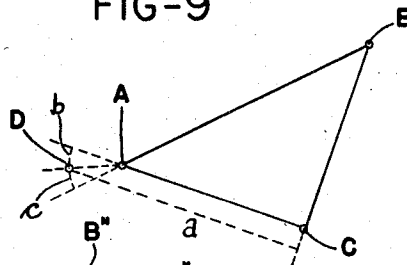


FIG-7

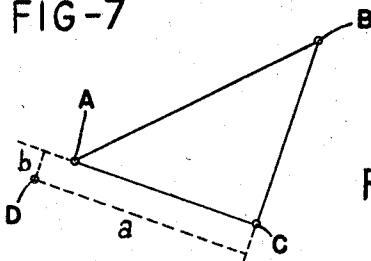


FIG-8

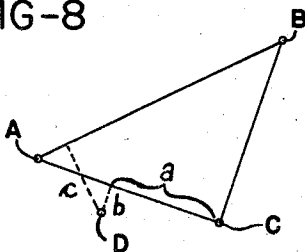
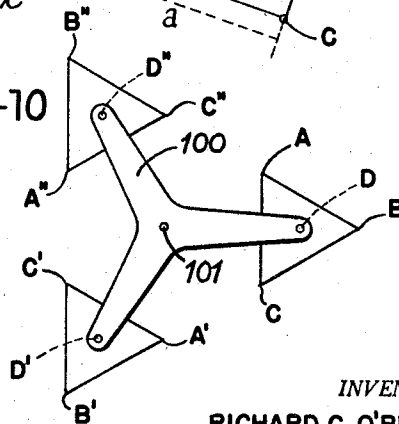


FIG-10



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2,889,109

PNEUMATIC DIGITAL TO ANALOG SUMMING DEVICE

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Application June 16, 1955, Serial No. 515,872

10 Claims. (Cl. 235—61)

This invention relates to transducers.

It is a primary object of the invention to provide a mechanical transducer having a digital input and an analogue output representing the algebraic sum of the input digits.

An additional object is to provide a transducer which is capable of use with a plurality of discrete inputs having values coded as to position in accordance with the binary system of numbers and which will give an analogue output corresponding in extent to the sum of the selected inputs.

Another object is to provide a transducer as outlined above which is readily adapted to either addition or subtraction of its inputs and particularly which is readily adjustable to assure a high degree of accuracy.

It is also an important object of the invention to provide a transducer having the characteristics outlined above which is of simple basic construction embodying mechanical component parts of individually simple form for economical production and maintenance, which may be readily constructed, and assembled, and which gives fast and reliable results in use and is adapted for operation at high speed.

Further objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

Fig. 1 is a view partly in side elevation and partly broken away in section showing a transducer constructed in accordance with the invention;

Fig. 2 is a view looking from right to left in Fig. 1 with some portions broken away in section;

Fig. 3 is a fragmentary perspective view looking generally downwardly on a portion of the transducer of Figs. 1 and 2;

Fig. 4 is an enlarged fragmentary section on the line 4—4 of Fig. 2; and

Figs. 5 to 10 are diagrammatic views illustrating the principles of operation of the invention.

A preferred embodiment of the invention is shown in the drawings as comprising a movable finger 15 pivoted at 16 in a bracket portion 17 on one end of a housing or frame 20. Within the frame 20 is a base plate 22 having secured thereto as by bolts 23 an additional plate 25. These plates 22 and 25 together support a plurality of the working parts of the device which cooperate to provide a selective number of input strokes for causing movement of the finger 15 through an output stroke corresponding in extent to the sum of the input strokes.

The input units of the device supported by the plate 25 include seven air cylinders 30a—30g respectively, which are also supported in part by an additional plate 31 secured to the plate 25 by bolts 32. Each cylinder 30 is provided with a projecting plunger 33a—33g respectively which has a definite stroke in response to the application of air pressure to the associated cylinder 30, the normal position of all of the plungers 33 being down as viewed in Figs. 1 and 2. The several plungers 33 vary in length

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for reasons of mechanical convenience which will become apparent hereinafter, the plungers 33a—33c being the shortest, plungers 33d—33e being of intermediate height and the plungers 33f and 33g being of the maximum height.

The cylinders 30 are provided with individual control valve assemblies 35a—35g respectively connected with the several cylinders by tubes 36. These control valve assemblies 35 are in turn connected with a main air supply header passage 37 which is in the form of a bore within the base plate 22 and is connected at 38 to an outside air supply. The individual valve assemblies 35 are operated by individual solenoids 40a—40g respectively as illustrated in detail in Fig. 4.

Referring to Fig. 4, a tube 44 forms a valve housing and has a fitting 45 leading from an intermediate point thereon for connection to the associated tube 36. The housing 44 is supported on the plate 22 by an additional plate 46 which also forms the base for the associated solenoid 40. The valve housing 44 supports a pair of valves 50 and 51, shown as conventional tire valves, which are mounted in opposed relation by sleeves 52 threaded in opposite ends of housing 44, the mounting sleeve 52 for the valve 51 also being provided with a lock nut 53.

Each of the valves 50 and 51 includes the usual valve stem 54, and the valve 50 controls the flow from the air supply header 37 and would normally be open under the pressure effective thereon from within header 37. The valve 51 is the exhaust valve and would normally close under the pressure from header 37 through valve 50, and these positions of the two valves are shown in Fig. 4. The associated solenoid 40 controls valves 50 and 51 through an arm 55 hinged at 56 on an L-shaped bracket 57 mounted on plate 46. The arm 55 is secured to the armature 58 of the solenoid, and the arrangement is such that when the solenoid is energized, arm 55 will move to the left from the deenergized position shown in Fig. 4 to open valve 51 and at the same time through the stem 54 of valve 51 to force the valve 50 closed, thereby permitting the associated cylinder 30 to exhaust through valve 51.

Thus with this particular arrangement, each cylinder 30 will be operated to extend its plunger 33 when its associated solenoid is deenergized, but when the solenoid is energized, the cylinder will be exhausted and its plunger will be depressed. This arrangement has been found especially advantageous where great speed of operation is desired, since operation of a given cylinder will be substantially immediate whenever its associated solenoid is deenergized, due to the force of the air pressure which is constantly acting against the solenoid.

The upper ends of the three plungers 33a—33c define a triangle and cooperate with a transmission member 60 to integrate their several individual input strokes. The configuration of the member 60 is not critical, as will become more apparent from the discussion hereinafter of the principles of operation of the invention, and this member is shown as having three legs 61, 62 and 63 of generally inverted V-trough section at their outer ends to seat on the upper ends of the associated plungers 33. On the upper side of member 60 is a stud 64 which forms a transmission point or output element for the movements of member 60 in response to the movements of one or more of plungers 33a—33c.

The stud 64 on member 60 cooperates with the upper ends of the plungers 33d and 33e to support a second transmission member 65 shown as identical with member 60, and a third identical transmission member 66 is similarly supported by the upper ends of plungers 33f and 33g together with a stud 67 on member 65 which corresponds to the stud 64. The transmission member 66 similarly carries a stud 70 connecting through a plunger

71 with the under side of the finger 15, plunger 71 being slidable in a bushing 72 mounted in frame 20. The several transmission members 60, 65 and 66 are normally biased downwardly as viewed in Figs. 1 and 2, as by a pair of plungers 74 and 75 mounted in the upper wall of frame 20 and provided with springs 77 as shown in Fig. 2, in order to maintain all these parts in working relation.

The operation of these input and transmission members will be more readily seen in the diagram of Fig. 5, wherein the points A, B and C correspond to the plungers 33a-33c respectively and define a triangle ABC in a reference plane. The point D corresponds to the stud 64 and lies within this triangle at distances a , b and c from the lines BC, AC and AB respectively. If now the point A is raised through a distance corresponding to the stroke of the plunger 33a, the triangle as a whole will pivot on the line BC as an axis, and the point D will rise through a distance whose ratio to the movement of point A will equal the ratio of the distance a to the perpendicular distance from A to BC. Similar movements of points B or C corresponding to the strokes of plungers 33b and 33c respectively will cause pivoting of the triangle about AC and AB with resulting movements of the points D through distances which bear relationships to the movements of points B and C equal respectively to the ratio of the distance b to the perpendicular distance from B to AC and the ratio of the distance c to the perpendicular distance from C to AB.

If in Fig. 5 more than one of the points A, B, and C are moved, the result will be a compound movement of the point D which will equal the sum of its individual movements. For example, if all plungers operated through equal strokes, the total movement of point D would be directly proportional to the sum of the strokes of all three plungers. If any selected pair of points A, B and C is moved, the movement of point D will equal the sum of its individual movements in response to the movement of the individual points in the selected pair. It will of course be apparent that the actual movement of all individual points in the triangle is along an arc rather than a straight line, but the ratios of the projections of the several distances on the original reference plane, and hence the ratios of the several inputs to the outputs will still remain constant. Similarly when the output element 64 is not in the same original plane with the input members, adequate accuracy is obtained for practical purposes if the angular movement of the triangle about each axis does not exceed about 2° .

As noted, the relation of the movements of the point D to the movements of the points A and B depends upon the location of D with respect to the other points. For example, considering the simple case of an equilateral triangle wherein the points A, B and C have strokes of equal distance and the point D is at the center of the triangle, the movement of any one point will cause one-third as much movement of point D. Movement of any pair of points will then cause point D to move two-thirds as far as any single point A, B or C, while movement of all three points A, B and C through the same distance will result in an equal movement of point D. Shifting of the location of point D while retaining equal strokes for points A, B and C will change the individual movements of D, but its total movement when all three points A, B and C move will still be the same. Change of the relative strokes of points A, B and C will correspondingly change both the individual and total range of movements of point D.

For the purposes of the present invention, desired results are obtained if the relationships between the locations and strokes of the plungers 33a-33g are such that the seven individual inputs represented by the possible movements of the stud 70 caused by operation of each single plunger 33 correspond to values in the binary system of members, namely the values 1, 2, 4, 8, 16, 32 and 64. It will be

apparent from the principles explained above that this result may be obtained by a variety of different arrangements of the input and transmission members, but it is convenient in manufacture to utilize identical component parts to the maximum practical extent, and accordingly an illustrative example will be given wherein such conditions are achieved.

The first three input members 33a-33c are arranged to define an isosceles right triangle as shown in Fig. 5, and the point D is located on the perpendicular from C to AB at a position such that the ratio of

$$\frac{c}{CD+c}$$

15 is approximately twice the ratio

$$\frac{a}{AC}$$

and also the ratio

$$\frac{b}{BC}$$

If the strokes of plungers 33a-33c were all the same with this location for the point D, it is apparent that the movement of point D would be the same in response to operation of either of plungers 33a and 33b, but this is readily compensated for by limiting the stroke of plunger 33a to one-half that of plunger 33b, as by means of the adjustable collar 80a which is threaded on the cylinder 30a and cooperates with a stop collar 81 on the plunger 33a. Similar adjusting collars 80b-80g are shown on the other plungers, and such arrangement may be found desirable particularly as providing a ready adjustment for maximum accuracy. The actual shape of the transmission member may be varied as desired as pointed out above, but the illustrated configuration, utilizing legs 61 and 62 approximately twice the length of leg 63, is convenient and simple to manufacture.

With this arrangement, therefore, when the plunger 33a is caused to execute its stroke, the stud 64 will move through a distance x determined by the location of point D and the actual length of the plunger stroke. The corresponding strokes of stud 64 in response to individual actuation of plungers 33b and 33c respectively will then be $2x$ and $4x$, corresponding to the next successive positions in the binary scale. Similarly by operation of selected pairs of the three plungers, movements of stud 64 through distances of $3x$, $5x$ and $6x$ may be obtained, and if all three plungers are operated, stud 64 will move through a distance of $7x$.

In the complete device of Figs. 1-3, the movements of stud 64 will be converted into an input stroke of transmission member 65 about an axis line connecting the tops of plungers 33d and 33e, and corresponding in function directly to the line BC in Fig. 5. The resulting movement of plunger 67 will in turn cause ultimate movement of transmission member 66 about an axis line connecting the tops of plungers 33f-33g and similarly corresponding to line BC in Fig. 5. This final movement of the stud 70 is transmitted through plunger 71 to the pivoted finger 15, and since transmission members 65 and 66 thus cooperate to form a reducing transmission system with respect to member 60, the ultimate movement of plunger 70 may be designated as from 1 to 7 output units in accordance with the selective operation of plungers 33a-33c.

The plungers 33d and 33e have the same relation to the transmission member 65 that the plungers 33b and 33c bear to the member 60. Thus operation of plunger 33d through the same stroke as either of plungers 33b and 33c will cause movement of stud 67 through the same distance $2x$ as for stud 64 when plunger 33b is operated, and similarly operation of plunger 33e will cause stud 67 to move a distance of $4x$. These movements will in turn cause movement of transmission member 66, and the resulting movements of the stud 70 will equal 8 and 16 output units respectively. Thus by selective combined

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operation of plungers 33a-33e, the stud 70 can be caused to move any distance in the range up to 31 output units, all such distances always being equal to a whole number of such discrete output units.

The plungers 33f and 33g operate in the same manner with respect to transmission member 66 as for the plungers 33d and 33e and the transmission member 65, respectively, but since member 66 directly carries the stud 70, the effect of its movements on the stud 70 are increased by a factor of 2 as compared with the stud 67 for the same input stroke of corresponding plungers. Thus if plunger 33f is individually operated through the same input stroke as any of plungers 33b-33e, the stud 70 will move through a distance of $2x$ equaling 32 output units, and the movement of stud 70 will cover a distance of 64 output units for the same input stroke of plunger 33g. The entire combination may accordingly be operated selectively to move stud 70 over the complete range of output units up to a total of 127.

It will be apparent that additional input and transmission members may be incorporated with the device of Figs. 1 to 3 if it is desired to obtain a still greater range of movements of the finger 15, and the principles of the invention as already described will apply to and control such extension of the system. In addition, the same general principles are applicable to modifications other than a device for producing an analogue output corresponding to the arithmetical sum of its inputs, and a variety of such modifications are illustrated schematically in Figs. 6-9 in essentially the same manner as already described in connection with Fig. 5.

Thus in Fig. 6, the point D is located on one of the sides of the triangle ABC, shown as the side AB. With this particular arrangement, an input stroke of the point A will produce a positive stroke of the point D in the same manner as described in connection with Fig. 5, the extent of this stroke being determined by the ratio of the distance a to the distance AC. The same is true for an input stroke of the point B and the ratio

$$\frac{b}{BC}$$

Movement of the point C, however, will not affect the point D since it is lying on the axis on which the triangle will pivot in response to movement of point C. In other words, the system shown in Fig. 6 will integrate the movements of the points A, B and C by addition for points A and B, and by ignoring movement of point C.

In Fig. 7, the point D lies outside the triangle ABC but is located on the projection of the line AB. This arrangement will cause point D to move in the same direction as point A but in a direction opposite to that of point B, and it will be unaffected by movement of point C. In other words, the integrating effect of this system will be by addition with respect to point A but by subtraction with respect to point B.

Fig. 8 shows a further modification in which the point D lies outside the triangle ABC in an area bounded in part by the projections of two diverging sides of the triangle, namely AB and BC. The integrating effect of this system will be by addition with respect to the movements of A and C but by subtraction with respect to B. This may be compared with the arrangement of Fig. 9 in which point D lies outside the triangle but in an area bounded in part by the projections of the converging lines AB and AC. The integrating effect of this system is by addition with respect to point A but by subtraction with respect to both the points B and C.

It is thought that both the versatility and the mechanical simplicity of the apparatus of the invention will now be apparent. In particular, the component parts of the apparatus may be of simple individual construction, requiring no great degree of precision of manufacture, and they are easily assembled and adjusted in accordance with the desired use and purpose of the completed appa-

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ratus. The invention is especially applicable to a device for producing movement of a part such as the finger 15 as an analogue through a range of accurately controlled discrete units of space. Thus in the specific example described above, the movements of the output element 70 will be through the range from $1/128$ to $127/128$ of a distance equal to the stroke of any single one of the plungers 33b-33g, and the movements of the finger 15 are correspondingly determined in accordance with the relative positions of the plunger 71 and the pivot point 16.

Many other applications of the present invention will be apparent to those skilled in the art in the light of the foregoing disclosure, and Fig. 10 shows diagrammatically an arrangement employing four individual units of the type described in connection with Figs. 5-9. In Fig. 10, the triangle ABC corresponds to the similar triangles in Figs. 5-9 except that it is equilateral and has its output element D at its center, and the triangles A'B'C' and A''B''C'' are identical with triangle ABC.

In the system of Fig. 10, the individual strokes of all of the nine input members corresponding to the corners of the three triangles are assumed to be the same. Therefore as previously pointed out, the point D for example will move selective distances equal to one-third, two-thirds and three-thirds of the stroke of each individual input member A, B or C, and the same is true for the output elements D' and D'' and their respective input members. These three output elements in turn support and act as input members for a transmission member 100 as shown as having three legs of equal length and an output element 101 at the center thereof. With this system, therefore, actuation of any single input member will cause movement of the output element 101 through a distance equal to one output unit. Similarly, actuation of any two input members will cause the output element 101 to move through a distance equal to two output units, and so forth up to a total of nine output elements. It will be readily apparent that this system may be similarly extended to give a greater range in accordance with the same operating principles.

While the forms of apparatus herein described, constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A mechanical transducer having a digital input coded as to position on a binary basis and an analogue output displaceable in discrete units corresponding to the input, comprising a plurality of air cylinders positioned in predetermined spaced and substantially parallel relation, a piston in each said cylinder including a plunger projecting from said cylinder to form an input element, means establishing strokes of predetermined extent for said plungers respectively between a non-actuated and an actuated position, means for supplying pressure air to all of said cylinders, individual valve means for each said cylinder movable between an operated position effective to admit pressure air to the associated said cylinder for actuation of said plunger thereof and a release position connecting said associated cylinder to exhaust for return of said plunger to the non-actuated position thereof, a transmission member mechanically interconnecting said plungers in different positions such that movement of any actuated said plunger produces a response in an amount corresponding to a different position on a binary scale, means biasing said transmission member in the direction to urge all of said plungers to said non-actuated position, and an output element for actuation by said transmission member and displaceable in discrete units in an amount representing the integrated value of all actuated said plungers.

2. A mechanical transducer for integrating a series of digital inputs coded in value on a binary basis and pro-

ducing an analogue output, comprising three air cylinders positioned in predetermined spaced and substantially parallel relation, a piston in each said cylinder including a plunger projecting from said cylinder to form an input element, means establishing strokes of predetermined extent for said plungers respectively between a non-actuated and an actuated position, means for supplying pressure air to all of said cylinders, individual valve means for each said cylinder movable between an operated position effective to admit pressure air to the associated said cylinder for actuation of said plunger thereof and a release position connecting said associated cylinder to exhaust for return of said plunger to the non-actuated position thereof, a framework mechanically interconnecting said plungers in different positions such that movement of any actuated said plunger produces deflection of a point on said framework in an amount corresponding to a different position on a binary scale, means biasing said framework in the direction to urge all of said plungers to said non-actuated positions, and an output element movable by said point in proportion to the deflection thereof and displaceable in discrete units in an amount representing the integrated value of all actuated said plungers.

3. A mechanical transducer having a digital input coded as to position on a binary basis and an analogue output displaceable in discrete units corresponding to the input, comprising a plurality of air cylinders positioned in predetermined spaced and substantially parallel relation, a piston in each said cylinder including a plunger projecting from said cylinder to form an input element, means establishing strokes of predetermined extent for said plungers respectively between a non-actuated and an actuated position, means for supplying pressure air to all of said cylinders, individual valve means for each said cylinder movable between an operated position effective to admit pressure air to the associated said cylinder for actuation of said plunger thereof and a release position connecting said associated cylinder to exhaust for return of said plunger to the non-actuated position thereof, a solenoid associated with each said valve means and arranged to hold said valve means in said release position when said solenoid is energized, a transmission member mechanically interconnecting said plungers in different positions such that movement of any actuated said plunger produces a response in an amount corresponding to a different position on a binary scale, means biasing said transmission member in the direction to urge all of said plungers to said non-actuated position, and an output element for actuation by said transmission member and displaceable in discrete units in an amount representing the integrated value of all actuated said plungers.

4. A transducer of the character described comprising three air cylinders positioned in predetermined spaced and substantially parallel relation, a piston in each said cylinder including a plunger projecting from said cylinder for cooperation with the other said plungers to define a triangle located in a reference plane and having legs corresponding to the relative spacing of said cylinders, means establishing an input stroke of predetermined extent for each said plunger relative to said reference plane, means for supplying pressure air to all of said cylinders, individual valve means for each said cylinder movable between an operated position admitting pressure air to the associated said cylinder to effect said input stroke of the associated said plunger and a release position connecting said cylinder to exhaust for retraction of said plunger, a transmission member connected with said plungers for displacement about axes corresponding to said triangle legs in response to actuation of said plungers respectively, means biasing said transmission member in the direction to urge all said plungers to the retracted positions thereof, and an output element on said transmission member located in predetermined spaced relation with said plungers to cause an output stroke thereof rela-

tive to said reference plane corresponding in extent to the integral of said input strokes of actuated said plungers.

5. A transducer as defined in claim 4 including an additional pair of air cylinders positioned in spaced and substantially parallel relation with said three air cylinders, a piston in each said pair of cylinders including a plunger projecting therefrom for cooperation with the other said plunger and said output element to define a second triangle in a second reference plane, means including individual valve means for each of said pair of cylinders for supplying pressure air thereto for selective strokes of the associated said plungers and retraction thereof, a second transmission member connected with said pair of plungers and said output element for displacement about axes corresponding to the legs of said second triangle in response to actuation of any of said five plungers, and a second output element on said second transmission member movable therewith relative to said second reference plane in accordance with the integral of the input strokes of actuated said plungers.

6. A transducer of the character described comprising three air cylinders positioned in predetermined spaced and substantially parallel relation, a piston in each said cylinder including a plunger projecting from said cylinder for cooperation with the other said plungers to define a triangle located in a reference plane and having legs corresponding to the relative spacing of said cylinders, means establishing an input stroke of predetermined extent for each said plunger relative to said reference plane, means for supplying pressure air to all of said cylinders, individual valve means for each said cylinder movable between a first position admitting pressure air to the associated said cylinder to effect said input stroke of the associated said plunger and a second position connecting said cylinder to exhaust for retraction of said plunger, a solenoid associated with each said valve means, means mechanically connecting each said valve means with its associated said solenoid to cause said solenoid to retain said valve means in said second position in the energized position of said solenoid and to release said valve means for movement to said first position thereof with the energy of said pressure air upon deenergizing of said solenoid, a transmission member connected with said plungers for displacement about axes corresponding to said triangle legs in response to actuation of said plungers respectively, means biasing said transmission member in the direction to urge all said plungers to the retracted positions thereof, and an output element on said transmission member located in predetermined spaced relation with said plungers to cause an output stroke thereof relative to said reference plane corresponding in extent to the integral of said input strokes of actuated said plungers.

7. A transducer of the character described comprising three air cylinders positioned in predetermined spaced and substantially parallel relation, a piston in each said cylinder including a plunger projecting from said cylinder for cooperation with the other said plungers to define a triangle located in a reference plane and having legs corresponding to the relative spacing of said cylinders, means establishing an input stroke of predetermined extent for each said plunger relative to said reference plane, means for supplying pressure air to all of said cylinders, individual valve means for each said cylinder movable between an operated position admitting pressure air to the associated said cylinder to effect said input stroke of the associated said plunger and a release position connecting said cylinder to exhaust for retraction of said plunger, a transmission member associated with said plungers and including three legs of generally trough shape seating on the ends of respective said plungers, means biasing said transmission member into said seated relation with said plungers for displacement about axes corresponding to said triangle legs in response to actuation of said plungers respectively, and an output element on said transmission member located at substan-

tially the point of intersection of said three legs thereof to cause an output stroke thereof relative to said reference plane corresponding in extent to the integral of said input strokes of actuated said plungers.

8. A transducer of the character described comprising a first group of three input members arranged in equispaced relation to define an equilateral triangle located in a reference plane, second and third groups of three input members similarly arranged to define second and third equilateral triangles in equispaced relation with said first triangle in said reference plane and of the same size as said first triangle, means for selectively actuating said input members through an input stroke of the same predetermined extent relative to said reference plane, a transmission member associated with each said group of input members and mounted for displacement in response to actuation of said associated input members respectively about the axes corresponding to the legs of said triangle defined by said associated input members, an output element on each said transmission member located in equispaced relation with said associated three input members to define a fourth triangle, and a fourth transmission member mounted for displacement in response to displacement by the first named said transmission members about the legs of said fourth triangle.

9. A transducer of the character described comprising a first group of three input members arranged in equispaced relation to define an equilateral triangle located in a reference plane, second and third groups of three input members similarly arranged to define second and third equilateral triangles in equispaced relation with said first triangle in said reference plane, each of said input members including an air cylinder and a piston having thereon a plunger projecting from said cylinder, means establishing an input stroke of the same predetermined extent relative to said reference plane for all of said plungers, means for supplying pressure air to all of said cylinders, individual valve means for each said cylinder movable between an operated position admitting pressure air to the associated said cylinder to effect said input stroke of the associated said plunger and a release position connecting said cylinder to exhaust for retraction of said plunger, a transmission member associated with each said group of input members and mounted for displacement in response to actuation of said associated plungers respectively about the axes cor-

responding to the legs of said triangle defined by said associated plungers, an output element on each said transmission member located in equispaced relation with said associated three plungers, and a fourth transmission member mounted for displacement in response to displacement by the first named said transmission members.

10. A mechanical transducer having a digital input and an analogue output displaceable in discrete units corresponding to the input, comprising a plurality of pressure fluid operated cylinders positioned in predetermined spaced and substantially parallel relation, a piston in each said cylinder including a plunger projecting from said cylinder to form an input element, means establishing strokes of predetermined extent for said plungers respectively between a non-actuated and an actuated position, means for supplying pressure fluid to all of said cylinders, individual valve means for each said cylinder movable between an operated position effective to admit pressure fluid to the associated said cylinder for actuation of said plunger thereof and a release position connecting said associated cylinder to exhaust for return of said plunger to the non-actuated position thereof, a solenoid associated with each said valve means and connected to operate the associated said valve means, a transmission member mechanically interconnecting said plungers in different positions such that movement of any actuated said plunger produces a predetermined response movement related to the stroke of said actuated plunger, means biasing said transmission member in the direction to urge all of said plungers to said non-actuated position, and an output element for actuation by said transmission member and displaceable in discrete units in an amount representing the integrated value of all actuated said plungers.

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