March 29, 1960 R. S. WILLIAMS 2,930,524

ADJUSTABLE RATIO ROTARY TOTALIZERS

Filed Aug. 28, 1957 3 Sheets-Sheet 1

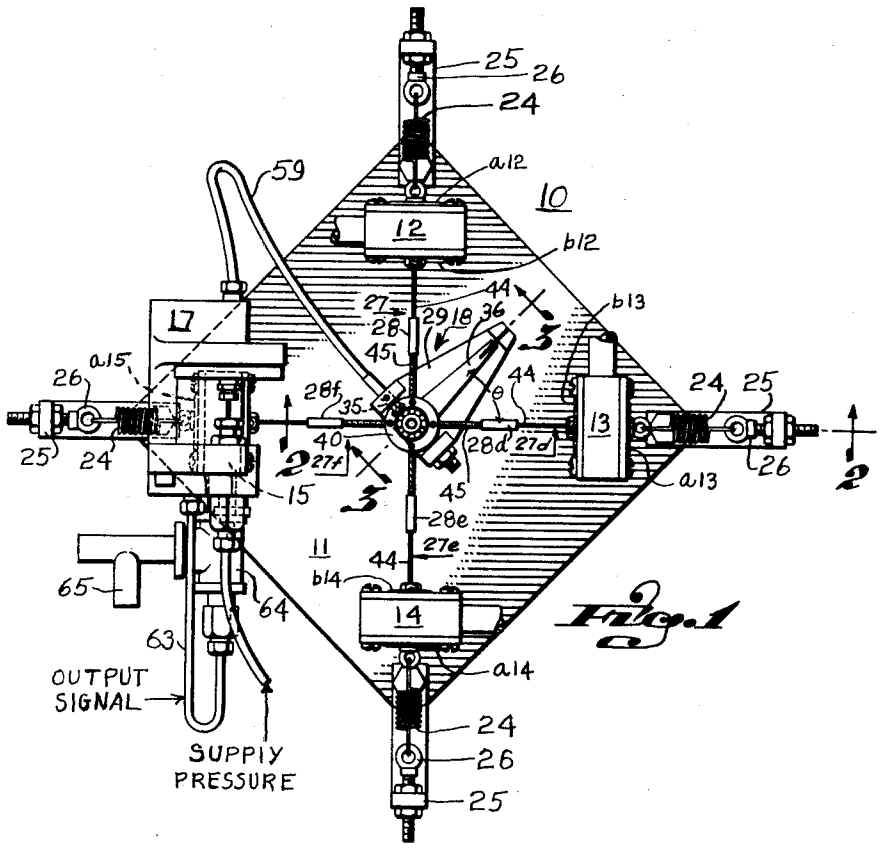


Fig. 1

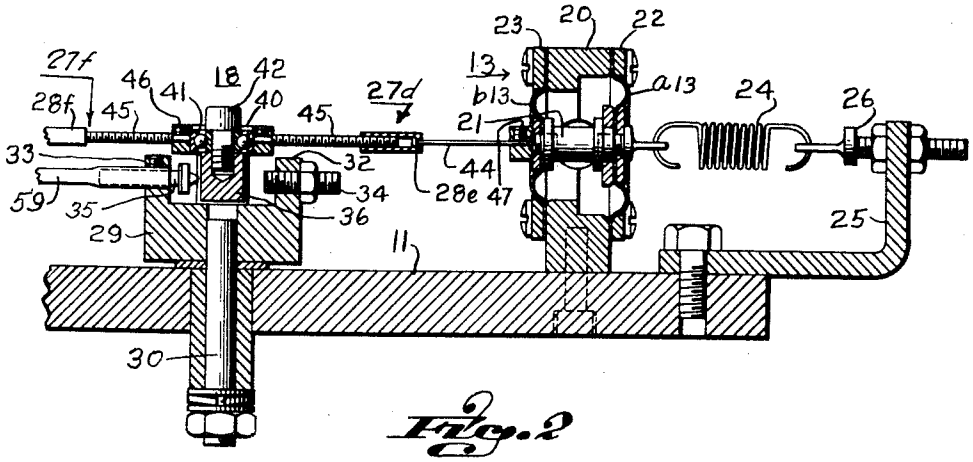


Fig. 2

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3 Sheets-Sheet 2

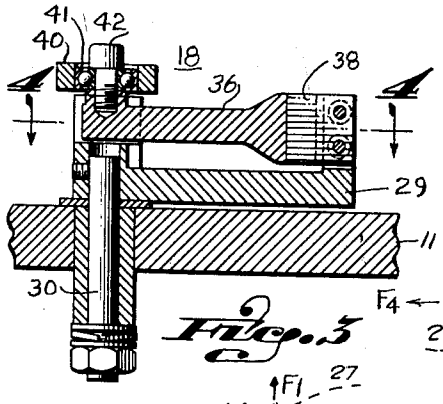


Fig. 3

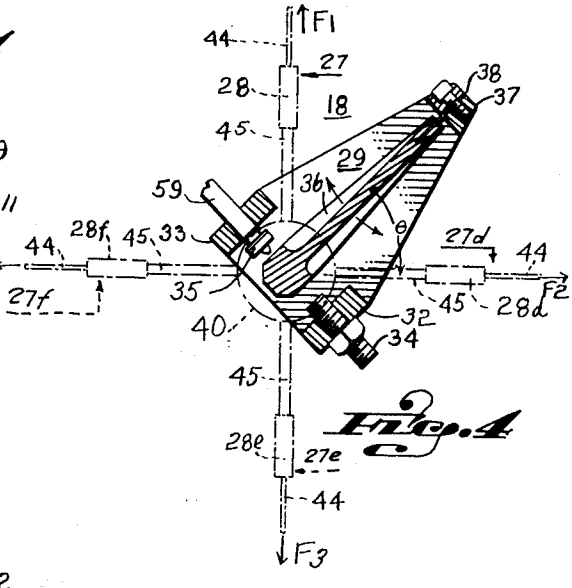


Fig. 4

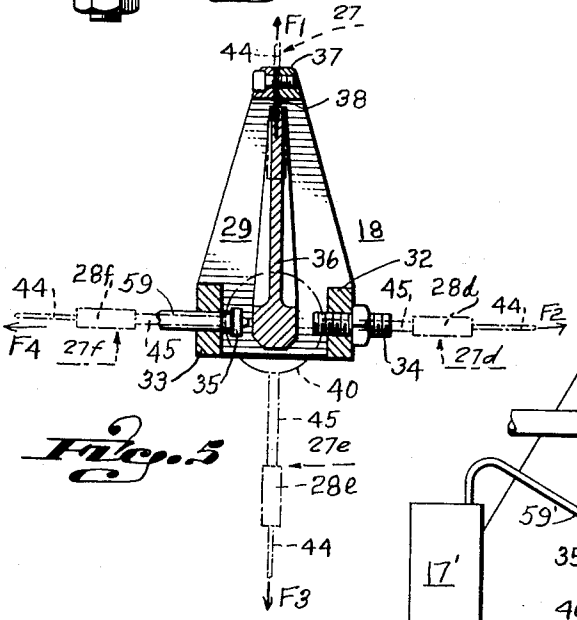


Fig. 5

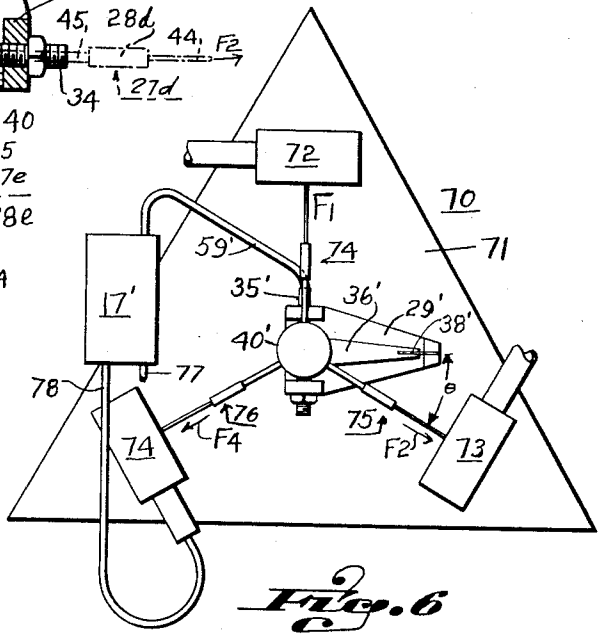


Fig. 6

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3 Sheets-Sheet 3

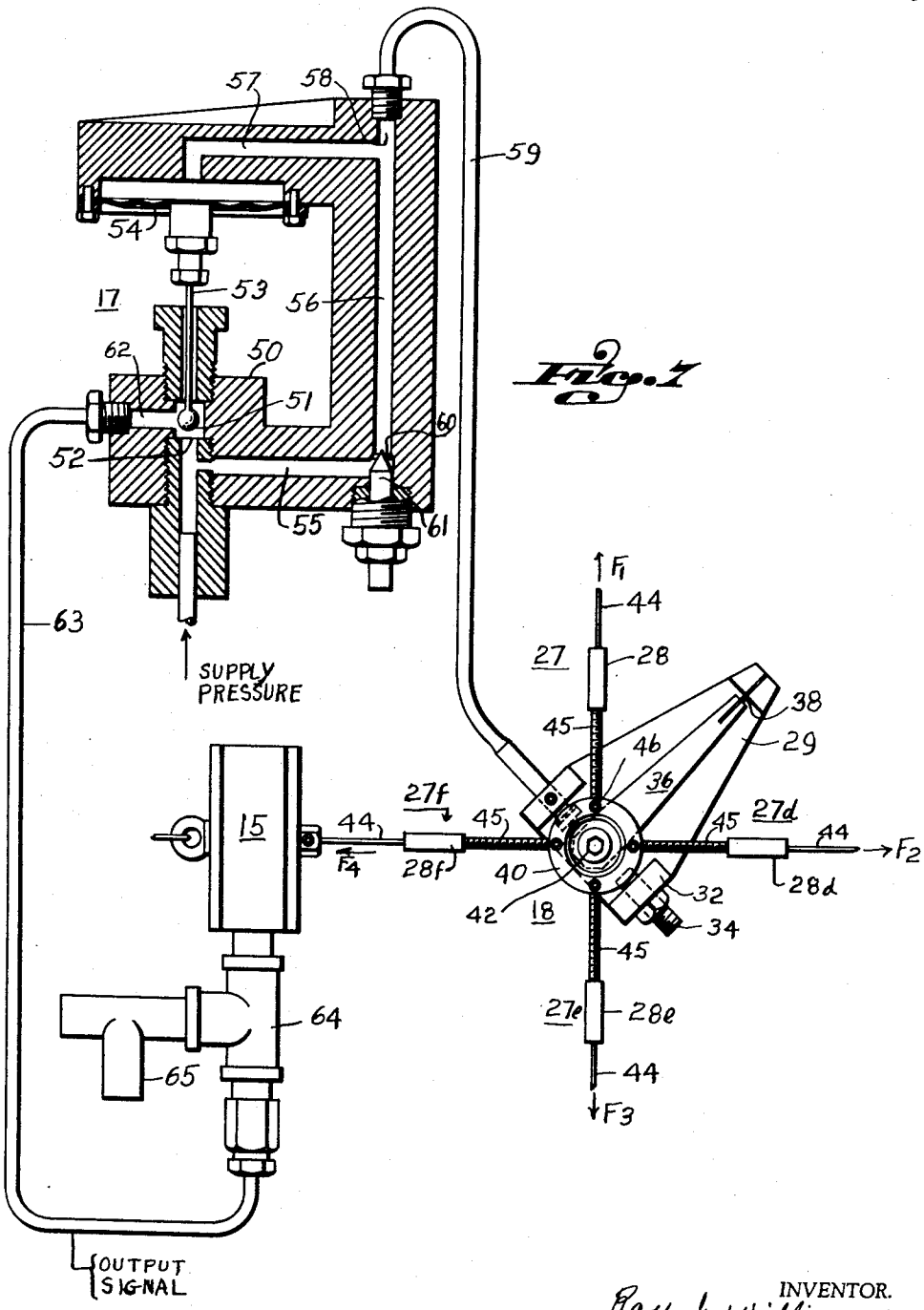


Fig. 1

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2,930,524

ADJUSTABLE RATIO ROTARY TOTALIZERS

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Application August 28, 1957, Serial No. 680,766

14 Claims. (Cl. 235—61)

This invention relates to devices for totalizing a plurality of force producing inputs and developing a control signal that is a function of the sum of the forces.

More particularly, the invention relates to an adjustable ratio rotary totalizer having a plurality of input units and a balancing output signal unit for developing a plurality of forces so arranged that the trigonometric sum of the forces of such units produce a motion that results in an output signal that is proportional to said sum.

An object of this invention is to provide a totalizer comprising a plurality of input units and an output unit arranged concentrically about a common center and connected by links to a signal developing element located at said common center but which is pivotally supported to rotate about a center removed from said common center, and having means for so rotating the pivotal support of the signal developing element that the motion thereof is a function of the angle between said element and an adjacent connecting link.

Another object is to provide a device having a plurality of force producing units, one of which may be responsive to a variable input signal and another to an output signal, the units being connected by links to a common center, and a control member having a fixed end rotatable about said common center and extending radially towards said center, whereby the angle between the control member and one of said links may be adjusted to thereby change the ratio of input to output signals.

A further object is to provide a totalizer as above set forth in which the control member may be adjusted to a position in which the forces of two opposed units may be nullified and the forces of another pair caused to vary as the sine and cosine of angle θ.

The above and other objects of the invention will be apparent to those of ordinary skill in the art to which the invention pertains from the following description taken in conjunction with the acompanying drawings.

In the drawings:

Figure 1 is a view in front elevation of a rotary ratio totalizer embodying a form of the invention;

Figs. 2 and 3 are views in section taken on lines 2—2 and 3—3, respectively, of Fig. 1;

Fig. 4 is a view in section taken on line 4—4 of Fig. 3;

Fig. 5 is a view showing the ratio adjustment of Fig. 4 rotated 45° counterclockwise from its position in Fig. 4;

Fig. 6 is a view of a modified form of ratio totalizer; and

Fig. 7 is a more or less schematic view of the ratio totalizer showing the signal transmitter of Figs. 1 and 6 in section.

In Figs. 1–5 and 7 of the drawings an adjustable ratio totalizer **10** and components thereof are shown that comprises a base **11** having mounted thereon a plurality of input responsive devices **12**, **13**, **14** and a signal output responsive device or unit **15**. As shown, units **12** and **14**, and **13** and **15**, respectively, are directly opposite each other. Lines connecting devices **12** and **14** and **13** and **15** intersect at right angles. Therefore, the geometric arrangement of these units forms 4 quadrants. While four units, **12–15**, are shown, it is to be understood that different number of odd or even numbered units may be employed.

Device **10** also includes a signal transmitter **17** (see details in Fig. 7) and a ratio mechanism and control valve assembly **18** actuated by the input units and the signal output responsive unit. The ratio mechanism and the assembly **18** develop the actuating pressure for the transmitter **17** and controls or determines its output pressure.

Devices **12–15** are similarly constructed and as one of them, namely device **13**, is shown in section, a description of the details of that unit will suffice for the description of the others.

In the arrangement of Fig. 1, the output pressure of transmitter **17** is delivered to unit **15** and the force developed by that unit balances the resultant of the forces developed by units **12–14** as will be explained infra.

Unit **13** comprises a housing **20** having diaphragms *a***13** and *b***13** rigidly connected at their centers by a rigid coupling **21**. As shown, diaphragm *a***13** has a larger effective area than diaphragm *b***13**. Therefore, any pressure admitted to the interior of housing **20** will cause both diaphragms to move radially outward with respect to the center about which units **12–15** are located. The force developed is proportional to the value of the pressure and the difference between the areas of the diaphragms. The diaphragms *a***13** and *b***13** are clamped at their marginal edges by plates **22** and **23** having apertures for accommodating the active or deflecting portions of the diaphragms.

The rigid coupling **21** of diaphragms *a***13** and *b***13**, is connected to one end of a spring **24**, the other end of the spring being adjustably coupled to a support bracket **25** by an eye screw **26**. The inner end of coupling **21** is connected by a tension member **27***d* to the mechanism **18**.

The tension members **27**, **27***d*–**27***f* of the respective units **12–15** are so coupled to the mechanism **18** that the motion thereof will be a function of the net or resultant force on the same. The force developed by unit **15** is a function of the ratio adjustment of the mechanism **18**.

Ratio mechanism and control valve 18

The mechanism **18** comprises a member **29** preferably of triangular shape that is secured to the base **11** by a pivot pin **30**. The pin **30** extends through the base of the member **29** and the base **11**. The end of the pin **30** at the back side of the base **11** is designed to accommodate a ratio adjustment handle (not shown). At the opposite sides of the base of member **29** are upstanding lugs **32** and **33**. Lug **32** is provided with an adjustable stop screw **34** while the lug **33** supports a jet or nozzle **35** through which a pressure medium such as compressed air issues. The rate at which the air issues from the nozzle is controlled by a baffle **36**. The baffle or control element **36** is supported in a lug **37** at the apex of member **29** by a relatively thin resilient metal strip **38**. One end of the strip **38** is anchored in a slot in the pivoted end of baffle **36** and the other end is anchored in a slot in the lug **37** of member **29**. The strip **38** acts like a frictionless pivot.

The inner ends of the tension members **27**, **27***d*, **27***e* and **27***f* of the units **12–15** are connected to a ring **40**. That ring is pivotally or rotatably supported in a ball bearing **41** in which a stub shaft **42** is journaled. The shaft **42** is secured to the free end of the baffle **36**.

The tension members **27**, **27***d*–**27***f* are composed of two pieces connected by turn buckles **28**, **28***d*–**28***f*. One piece is a length of wire **44** and the other a threaded wire **45**. The wires **45** extend into the ring at 90° points with re-

spect to each other and are secured by set screws 46. The outer ends of the wires 44 are secured by set screws 47 in the diaphragm couplers 21. By means of the turn buckles 28, 28*d*–28*f* the tension members may be lengthened or shortened as required.

When the member 29 is rotated to a position where it lies directly under one of the tension members, say the tension member that connects unit 12 to the ring as in Fig. 5, pressure acting on the diaphragms of units 12 and 14 will not produce any motion in the baffle 36, because the baffle is on dead center, so to speak. However, pressure admitted to units 13 and 15 will produce motion either in the direction of unit 13 or in the direction of unit 15, depending upon which unit is developing the greater force. If the greater force is developed by unit 15, the baffle will move towards the jet 23 and decrease the rate at which air issues therefrom. When the force developed by unit 13 is the greater, the baffle is moved away from the jet, thereby increasing the rate of flow of air issuing from it.

When member 29 is turned to the 45° position in either the first or the third quadrants of Fig. 1, motion will be imparted to the baffle by all of the units in equal amounts for equal forces.

With the member 29 in the first quadrant as shown, the balancing force of unit 15 is derived as follows:

In the following equations the following assumptions are made:

Let θ be the angle between the baffle 36 and tension member 27*d*;

F_1, F_2 and F_3, the forces developed by units 12, 13, and 14 and F_4 the balancing force developed by unit 15;

Let the difference between the areas of diaphragms *a*12 and *b*12, *a*13 and *b*13, *a*14 and *b*14, and *a*15 and *b*15, be equal to unity;

The radius of baffle 36 be R; and

Clockwise and counterclockwise rotation of baffle 36 be designated (+) and (—), respectively.

With the above assumed conditions, the ring 40 is stationary when the sum of the moments of the forces about the baffle pivot 38 are equal to zero. The following equations illustrate the proposition:

$$(1)\quad F_1R\cos\theta-F_2R\sin\theta-F_3R\cos\theta+F_4R\sin\theta=0$$

Dividing through by R and solving for F_4.

$$F_4=F_2+F_3\frac{\cos\theta}{\sin\theta}-F_1\frac{\cos\theta}{\sin\theta}$$

$$F_4=F_2+(F_3-F_1)\cot\theta$$

When

$$\theta=0,\ \cot\theta=\infty.\ \therefore F_4=\infty \text{ and } F_1=F_3$$

When

$$\theta=90°,\ \cot\theta=\frac{0}{\infty} \text{ and } F_4=F_2$$

and both produce motion proportional to the difference, but F_1 and F_3 are incapable of producing motion.

When the baffle 36 is in the 4th quadrant, the forces are summed to zero as follows:

$$F_1R\cos\theta+F_2R\sin\theta-F_3R\cos\theta-F_4R\sin\theta=0$$

$$F_4R\sin\theta=F_1R\cos\theta+F_2R\sin\theta-F_3R\cos\theta$$

Dividing through by R and sin θ.

$$F_4=F_1\frac{\cos\theta}{\sin\theta}+F_2-F_3\frac{\cos\theta}{\sin\theta}$$

$$F_4=(F_1-F_3)\cot\theta+F_2$$

By adjusting the angle θ, it will be apparent that the balancing force F_R will be modified in accordance with the cotangent of that angle.

When the baffle 36 is in the first quadrant, the motion and force applied to the baffle by unit 12 is in a direction tending to move the baffle towards the jet 35, whereas the motion and force developed by unit 13 is such as to shift the baffle away from the jet and increase the flow out of it. The force developed by unit 14 is such as to move the baffle away from the jet while the force developed by unit 15 actuates the baffle towards the jet.

The operation of the totalizer when the baffle 36 is in the 4th quadrant is illustrated by the following equations, in which the same assumptions are made as in the equations for the first quadrant supra.

$$F_1R\cos\theta+F_2R\sin\theta-F_3R\cos\theta-F_4R\sin\theta=0$$

$$F_4R\sin\theta=F_1R\cos\theta+F_2R\sin\theta-F_3R\cos\theta$$

$$F_4=F_1\frac{\cos\theta}{\sin\theta}+F_2-F_3\frac{\cos\theta}{\sin\theta}$$

$$F_4=(F_1-F_3)\cot\theta+F_2$$

If the member is moved into the 4th quadrant, the forces developed by units 12 and 13 act to move the baffle toward the jet, while the units 14 and 15 act to move the baffle away from the jet.

Variations in the flow of compressed air out of the jet by the baffle causes the operating pressure on the transmitter 17 to change. As the jet is throttled, the pressure on the transmitter mechanism 17 increases and as it is unthrottled, so to speak, the operating pressure on the transmitter 17 is decreased. Thus the output pressure of transmitter 17 either increases or decreases as the jet is restricted more and more or uncovered more and more.

In the arrangement shown, units 12, 13 and 14 are used as pressure signal input units and unit 15 as a signal output responsive balancing unit. In other words, when used as the balancing unit, unit 15 receives the output pressure of transmitter 17 so that the output pressure of the transmitter will in every case develop a force on the baffle 24 that balances the forces exerted thereon by the other three units.

Signal transmitter 17

The transmitter 17 (see Fig. 7) comprises a body 50 having a valve 51 therein that controls a seat 52. Valve 51 is attached to one end of a stem 53. The opposite end of the stem is connected to a metallic diaphragm 54 that normally actuates the valve away from the seat 52. Pressure on the diaphragm 54 moves the ball valve 51 towards the seat. The inlet side of the seat 52 is connected by interconnecting passageways 55 and 56 to the pressure side of diaphragm 54 and to the jet or nozzle 35, respectively. As shown, the passageway 55 is connected by a passageway 57 to the pressure side of diaphragm 54 and by a passageway 58 and a flexible tube 59 to the jet 35. In the passageway 56 is a needle valve seat 60 controlled by a needle valve 61, whereby the restriction at the seat may be adjusted.

The valve body is also provided with a passageway 62 leading from the output side of the inlet seat 52 to an output connection 63. The connection 63 may be connected by a T-fitting 64 to the diaphragm chamber of unit 15 and to a sending line 65 leading to apparatus to be regulated or controlled. The sending line may also be connected to gauges or recording instruments for indicating the output of the totalizer or recording the same.

When the output of transmitter 17 is applied to the diaphragm chamber of unit 15, the pressure established in that unit will be of such magnitude that the force exerted by it on the baffle ring 40 will balance the forces exerted thereon by the diaphragms of units 12, 13 and 14.

When the baffle support member 29 is on dead center with units 12 and 14, the output pressure of unit 15 will be proportional to the pressure in unit 13. With the member 29 in dead center position with units 13 and 15, the output pressure of the latter is not proportional to the pressure in unit 13. If support member 29 is moved from the dead center position to the 45° position, the torque arms on the baffle ring will be equal for all of the units.

In any case, the output pressure of transmitter 17 will

be a function of the position of the baffle **36** with respect to the tip of the jet or nozzle **35**.

In Fig. 6, a modified form of totalizer **70** is shown. It embodies an odd numbered arrangement of force producing units instead of an even number as in Fig. 1. Totalizer **70** comprises a base **71** on which are mounted pressure input units **72** and **73** and a signal responsive balancing unit **74**. These units are schematically illustrated; however, it is to be understood they may be of the same construction as the units embodied in device **10**.

Units **72—74** are connected by adjustable length tension members **74***a*, **75** and **76** to a baffle ring **40'** which is connected to baffle **36'** in the same manner as in Fig. 1 and the other applicable views. The baffle is pivotally supported on a member **29'** which in turn is pivotally supported by the base in the same manner as in Fig. 1. Thus the pivoted end of the baffle may be rotated about a center coinciding with the center of the ring **40'** as in the case of device **10**.

The units **72—74** are so positioned that the angles between the respective adjacent tension members **74—76** are equal to 120°.

Totalizer **70** includes a jet **35'**, and a signal transmitter **17'** of the type shown at **17** in Fig. 7. The input supply to the transmitter **17'** is at **77**, its output is at **78** and leads to the diaphragm chamber of unit **74** and the supply connection to the jet **35'** is at **59'**.

The angle θ between the baffle **36'** and tension member **75** may be varied or adjusted whereby the ratio of input signals to output or transmitter signal may be preset.

The equations illustrating the operation of totalizer **70** are as follows, the same assumptions and designations of forces being the same as those applied to the equations for totalizer **10**.

$$F_1R\cos\theta - F_2R\sin\theta - F_4R\sin\theta = 0$$

$$F_4 = F_1\frac{\cos\theta}{\sin\theta} - F_2 = F_1\cot\theta - F_2$$

The totalizer **70** has dead center positions of the baffle as when it is in line with any one of the three tension members **74—76**.

From the foregoing, it will be apparent to those of ordinary skill in the art to which the invention pertains, that various modifications and changes may be made in the illustrated embodiments without departing from either the spirit or the scope of the invention.

Therefore, what is claimed as new and desired to be secured by Letters Patent is:

1. A rotary ratio totalizer comprising a signal transmitter having a valve and a diaphragm for actuating the same to control the magnitude of the transmitter output signal, an air issuing jet and a pivotally supported baffle movable to and from the jet to control the actuating pressure on said diaphragm, a plurality of signal input units having diaphragms deflectible by signal pressures, and a balancing unit responsive to the signal pressure of the transmitter, said input and balancing units being disposed about the jet and spaced equally in degrees with respect to each other, means connecting the diaphragms of each of said units to said baffle, whereby the baffle is actuated by said units about its pivot to control the rate of flow of air from the jet, the transmitter signal thus established causing the balancing unit to develop a force that balances the resultant of the forces exerted on the baffle by the signal input responsive units.

2. A totalizer as in claim 1 having a support member on which the baffle is mounted at its pivoted end, the support member being rotatably supported at a location adjacent to the free end of the baffle, and the jet is carried by said support member at a location in the path of motion of the free end of the baffle, the support member being rotatable to a position where the angle θ is included between the baffle and connecting means of one of said signal units whereby the output signal of the transmitter is in part a function of the co-tangent of said angle.

3. A totalizer as in claim 1 in which a member is pivotally supported adjacent the free end of the baffle and the respective diaphragms of the signal input and output units are connected to said member.

4. A totalizer as in claim 3 in which the baffle support member is rotatably supported on a pivot whose axis substantially coincides with the axis of rotation of the baffle supported rotary member.

5. A totalizer as in claim 1 in which the sum of signal input units and the output signal unit is an even number.

6. A totalizer as in claim 1 in which the sum of the signal input units and the output signal unit is an odd number.

7. A totalizer as in claim 1 in which the diaphragms of the signal input and signal output responsive units exert forces on the baffle that are directed radially outward from their points of connection thereto.

8. A totalizer as in claim 1 in which the diaphragms of the signal input and signal output responsive units are provided with means yieldingly urging them radially outward.

9. A totalizer as in claim 1 in which each of the means connecting the diaphragms of the signal input and output signal responsive units comprises tandem tension members connected by a turnbuckle whereby the lengths thereof may be adjusted.

10. The combination of a pneumatic signal transmitter having a valve body provided with a pressure supply and output ports, a valve for controlling the magnitude of the pressure signal at the outlet port, a diaphragm connected to the valve and normally urging the same toward one of its signal control positions, a jet, a passageway leading from the valve supply port to said diaphragm and to said jet and a restriction in the passageway for varying the pressure on the diaphragm in accordance with variations in flow through the jet, with a rotatably mounted member for supporting the jet, a baffle pivotably carried by said rotatably mounted member for controlling the flow of air out of said jet, the pivot being at a location relatively remote from the point of rotation of said jet supporting member, and a plurality of signal input units and a balancing unit responsive to the output pressure of the transmitter, and links connecting the signal input and balancing units to the baffle at a location adjacent to its free end, whereby the output signal is caused to be proportional to the magnitude of the input forces and the co-tangent of the angle between said baffle and an adjacent one of said links.

11. The combination as in claim 1 in which the transmitter valve is normally urged by its diaphragm toward open position and towards closed position by the pressure established by the baffle and said jet.

12. A rotary ratio totalizer comprising a signal transmitter having a valve and a diaphragm for actuating the same to control the magnitude of the transmitter output signal, an air issuing jet and a pivotally supported baffle movable to and from the jet to control the actuating pressure on said diaphragm, a plurality of signal responsive units having diaphragms deflectable by signal pressures, at least one of said signal responsive units being responsive to an input signal and another being responsive to the signal pressure of the transmitter, said input and balancing units being disposed about the jet and spaced equally in degrees with respect to each other, means connecting the diaphragms of said units to said baffle, whereby the baffle is actuated by said units about its pivot to control the rate of flow of air from the jet, the transmitter signal thus established causing the balancing unit to develop a force that balances the force exerted on the baffle by the signal input responsive unit.

13. A rotary ratio totalizer as in claim 12 in which a member is pivotally supported adjacent the free end of the baffle and the respective diaphragms of the signal input and output units are connected to said member.

14. A totalizer as in claim 13 in which the baffle support member is rotatably supported on a pivot whose axis substantially coincides with the axis of rotation of the baffle supported rotary member.

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