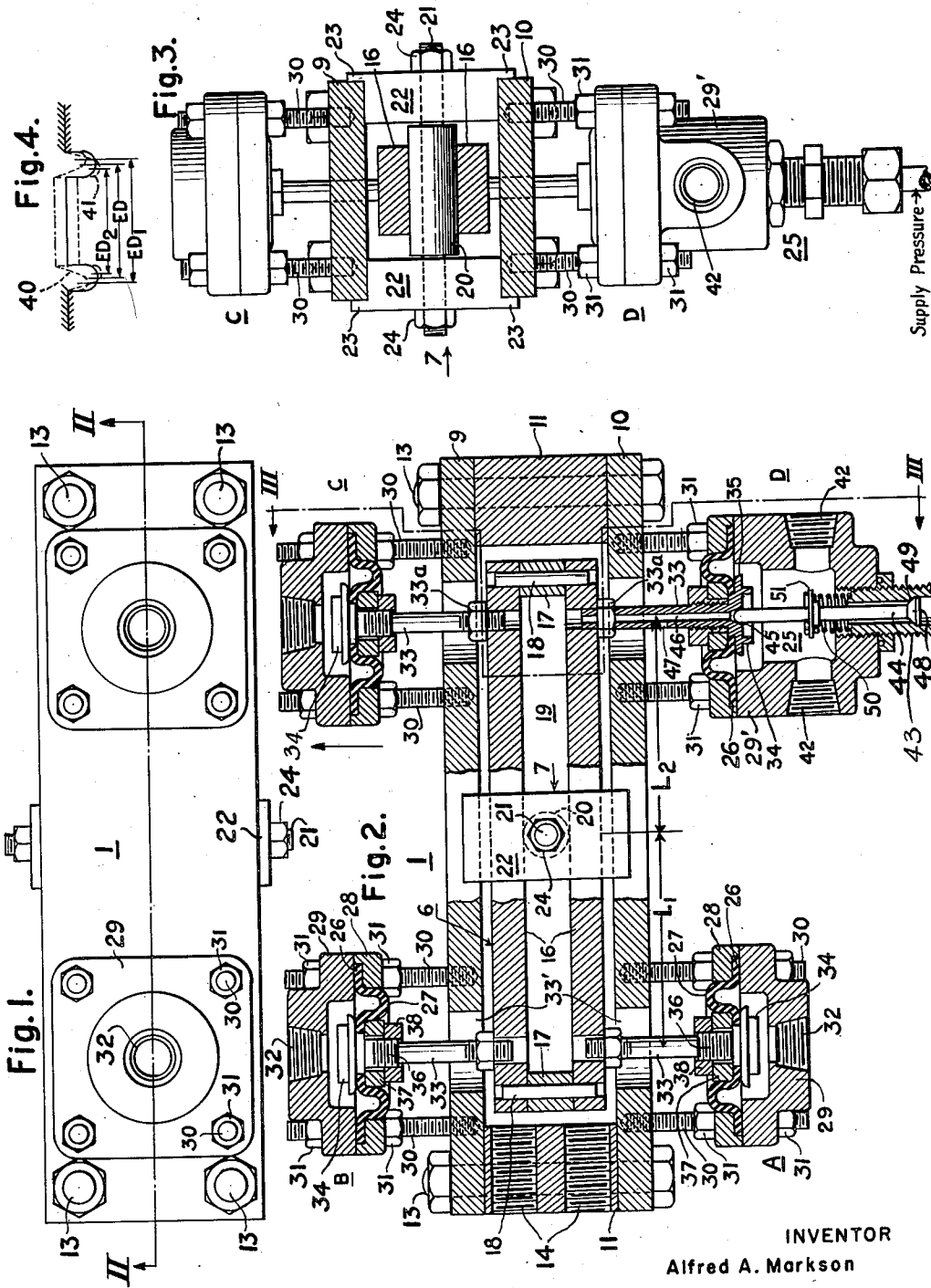


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DOUBLE-ACTION FULCRUMS
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TOTALIZING DEVICE PROVIDED WITH ADJUSTABLE DOUBLE-ACTING FULCRUMS

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This invention relates to force totalizing devices of the type embodying a plurality of pressure input units in which the pressure input to one of the units is proportional to the algebraic sum of the input pressures to the other units. More particularly, this invention relates to a totalizing device in which the ratio of the algebraic sum of the pressure inputs to certain of the units with respect to the pressure input to the other pressure units, may be adjusted.

An object of this invention is to provide a totalizing device comprising a beam having a double-acting adjustable fulcrum therefor and a plurality of pressure input units so grouped that some of the pressure input units act on one side of the fulcrum and the other of said units acts on the other side and means actuated in response to movement of the beam for adjusting the pressure in one of said units to such a value that the beam is in balance when the pressure P_X is equal to

$$\frac{L_1}{L_2}(P_1 - P_2) + P_3$$

where P_1 , P_2 , and P_3 are input pressures, and

$$\frac{L_1}{L_2}$$

is the ratio of the lengths of the lever arms L_1 and L_2 , respectively, as measured from the points of action of said units on the beam to the fulcrum.

Another object of the invention is to provide a device of the character referred to above in which the various pressure input units are provided with flexible diaphragms that are coupled to the beam, each of the diaphragms having slack portions, the several units being provided with means whereby the slack portions of the respective diaphragms and consequently their effective areas may be adjusted to equality with respect to one another.

These and other objects of the invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

Figure 1 is a top plan view of a totalizing device embodying a form of the invention;

Fig. 2 is a view in section, taken on line II—II of Figure 1, parts of the device being shown in full;

Fig. 3 is a view in section, taken along line III—III of Fig. 2; and

Fig. 4 is a more or less diagrammatic view showing how the adjustment of the slack portions of the diaphragms embodied in the pressure re-

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ceiving units affects the effective areas thereof.

Throughout the drawings and the specification like reference characters indicate like parts.

In the drawings, a totalizing device 1 is shown that comprises a plurality of pressure receiving units A, B, and C, D, coupled to a beam 6 provided with a double-acting adjustable fulcrum 7. As shown, units A and B act on the beam 6, at one side of the fulcrum 7 while units C and D act on the beam at the opposite side of the fulcrum.

In a preferred form of the invention, units A and B are disposed to act oppositely on the beam. Since they are arranged to exert opposing forces on the beam, it is preferred that they be placed as shown with one unit disposed above the beam and the other below. Similarly, since units C and D are arranged to exert forces on the beam that oppose each other, it is preferred that one of these units be so placed as to act on one side of the beam and the other unit in a location where it acts on the beam from the opposite side thereof. It is also preferred that units A and B be so placed that they have a common lever arm L_1 the length of lever arm L_1 being the distance between the point of action of units A and B on the beam and the center of fulcrum 7. Likewise, it is preferred that units C and D be so placed with respect to the fulcrum that they have a common lever arm of a length L_2 as measured from the center of the fulcrum to the line of action of units C and D on the beam.

As shown more clearly in Figs. 2 and 3, units A, B, C and D and the fulcrum 7 are mounted on a frame comprising spaced upper and lower plates 9 and 10. As shown, plates 9 and 10 are maintained in a spaced relationship by spacer blocks 11 disposed between and at the opposite ends of plates 9 and 10. Plates 9 and 10 and the spacer blocks 11 are rigidly secured together by means of bolts 13. If desired, one of the spacer blocks may be provided with means whereby the totalizing device 1 may be mounted on a suitable support (not shown). As shown, one of the blocks 11 is provided with a pair of spaced, threaded bores 14 by means of which the totalizing device may be secured to a support.

Beam 6 comprises a pair of spaced plates 16, the plates being spaced by means of spacer blocks 17 located at the opposite ends thereof. The beam plates may be secured together by means of dowel pins 18 that pass through the ends of plates and spacer blocks, as shown. By spacing the beam bars as shown, a slot 19 is provided

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between them in which the fulcrum 7 is disposed.

As shown, fulcrum 7 comprises a roller 20 through which an axle 21 extends. The axle is mounted in blocks 22 disposed on opposite sides of and between the frame plates 9 and 10. As shown more clearly in Fig. 3, the inside faces of blocks 22 are notched along their upper and lower edges to provide flanges 23 that bear against the sides of plates 9 and 10. Blocks 22 are slidable lengthwise of the frame plates 9 and 10, to adjust the lengths of lever arms L_1 and L_2 . The fulcrum 7 may be located at a point midway between the lines of action of units A and B and C and D on the beam, or on either side of the midpoint in any desired or required location. When the fulcrum has been located in the place desired it may be locked in place by means of nuts 24 threaded on the opposite ends of axle 21. By tightening the nuts 24, flanges 23 of blocks 22 are pulled up tightly against the opposite edges of plates 9 and 10, thereby locking fulcrum 7 in its adjusted position.

Since fulcrum 7 is located between bars 16 of beam 6, the fulcrum acts as such no matter whether the thrust on the beam acts downwardly or upwardly thereon.

In a preferred form of the invention, units A, B, and C may be identical in construction. Device D in the preferred form is different from units A, B and C because, as shown, it is a combined receiving and output unit, there being incorporated therein a valve 25 by means of which the pressure received by unit D is adjusted as required, to effect balance between the algebraic sum of the forces exerted by units A, B and C on beam 6 and also to provide an output pressure which is equal to the input pressure thereto.

Since devices A, B and C are identical in form a detailed description of one of them will suffice for the others.

As shown in Fig. 2, unit A comprises a flexible diaphragm 26 having a rigid central portion, a clamped marginal edge portion, and a slack portion 27 disposed between the edge and center portions. The marginal edge of the diaphragm is clamped between a clamp or base ring 28 and a cap or bonnet 29. The marginal edge of the diaphragm is disposed between the base ring 28 and the bonnet 29 and is clamped tightly therebetween by means of stud bolts 30 and clamping nuts 31. The bonnet 29 is provided with a tapped opening 32 to which a pipe or conduit may be connected and through which an input pressure P_i is delivered to the interior of bonnet 29.

The central portion of the diaphragm 26 is operatively connected to beam 6 by a push rod 33, the push rod passing through an opening 33' in the plate 10. The push rod is provided at one end with a flanged head 34 that bears on the pressure face of the central portion of the diaphragm, and a threaded stem 36. A backing ring 37 is placed against the outer face of the central portion of the diaphragm and is clamped tightly thereto by means of a clamp nut 38 threaded onto stem 36. Backing ring 37 and flanged head 34 thus form the rigid central portion of the diaphragm.

By adjusting the clamp nuts 31 on the studs 30 the diaphragm with its bonnet 29 and base ring 28 may be moved towards or away from the beam thereby adjusting the slack portion 27 of diaphragm 26 and consequently its effective diameter and area. If the bonnet and base ring are moved towards beam 6, for example, then the rigid central portion of the diaphragm is moved

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inwardly of the bonnet 29 thereby increasing the effective diameter, and consequently the effective area, of diaphragm 26. If the bonnet and base ring are moved outwardly or away from beam 6, the rigid central portion of the beam is moved outwardly with respect to the interior of the bonnet 29 whereby the slack portion of diaphragm 26 is adjusted in a direction to decrease the effective diameter, and consequently the effective area, of the diaphragm.

If desired, push rods 33 may be threaded at the beam ends thereof and provided with nuts 33a whereby further and finer adjustments of the effective areas of the diaphragms may be made.

Fig. 4 illustrates diagrammatically the effects that the above described adjustments of the position of unit A on the studs 30, have on the effective area of diaphragm 26. If unit A is so mounted that the diaphragm is in the position indicated by the solid lines of Fig. 4, the effective diameter of the diaphragm is ED. If unit A is moved on its studs towards the beam so that the diaphragm assumes a position such as indicated by the broken line 40, the effective diameter of the diaphragm is increased to a value ED₁. If unit A is moved outwardly or away from the beam to a position indicated by the dotted line 41, the effective diameter will be decreased to a value ED₂. Consequently, the effective area of the diaphragm will be decreased to a value corresponding to the decreased diameter.

By mounting units A, B, C and D on the studs as shown, the effective areas of the diaphragms of the respective units may be made effectively equal to each other so that the device will function without the error that might be introduced through the factor of unequal effective diaphragm areas.

Unit D comprises the same elements as units A, B and C as indicated by corresponding reference characters. Unit D differs from units A, B and C in that its bonnet 29' is deeper in order to accommodate valve 25. Valve 25 is so constructed and arranged that it is actuated in response to movement of beam 6 about fulcrum 7 to either increase or decrease the pressure delivered through the inlet of the valve to the interior of the bonnet.

Bonnet 29' may be provided with one or more tapped openings 42 to which an output pressure line may be connected for transmitting the output pressure to some other device, such as a regulator or indicator. As shown, valve 25 comprises a body 43 threaded into the bonnet 29' and a stem 44 that is housed in body 43 and extends into the chamber of the bonnet. The inner end of stem 44 is disposed to seat in an exhaust port seat 45 formed in flanged head 34. Push rod 33 of unit D is drilled lengthwise to provide a passageway 46 that communicates with a lateral passageway 47, whereby fluid under pressure may be exhausted from the interior of bonnet 29' to the atmosphere when the diaphragm moves in a direction in which the exhaust port seat 45 is disengaged from the end of stem 44. The opposite end of the valve stem 44 is provided with a valve element 48 that seats on an inlet port seat 49 in valve body 43. A light compression spring 50 may be placed on stem 44 between a collar 51 secured to the stem and the inner end of body 43, whereby the valve stem is urged in a direction to seat valve element 48 on the inlet port seat 49. When beam 6 is in balance with the forces acting thereon, that is when the sum of the moments of the forces exerted by devices

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A, B, C and D about the fulcrum 7 is zero, valve stem 44 closes both the inlet port 49 and the exhaust port 45. When beam 6 is in a position where both the inlet and exhaust ports of valve 25 are closed, the beam is in neutral position.

When the sum of the moments of the forces exerted by units A, B, C and D on beam 6 is greater than zero and the direction of unbalance is such that beam 6 tends to turn counter-clockwise, the exhaust port seat 45 is uncovered, whereby the pressure in bonnet 29' is decreased until the sum of the moments of these forces is again zero, at which time both the exhaust port and the inlet port are closed. If the sum of these moments is greater than zero and the unbalance is in a direction to cause the beam to turn clockwise about fulcrum 7, diaphragm of unit D will move in a direction to unseat the inlet port seat whereby the pressure in bonnet D acting on the diaphragm thereof, is increased to a value at which the sum of the moments of the forces on beam 6 about fulcrum 7 are again zero, at which time both the inlet ports are closed and the beam is in balance.

If the length of the lever arms for units A and B, and C and D, are L_1 and L_2 , respectively, and if it be assumed that the effective areas of the diaphragms of units A, B, C and D are equal, that the input pressures to units A, B and C are P_1 , P_2 , P_3 , respectively, and that the input balancing pressure to unit D is P_4 (or P_X where there are more than four units acting on the beam and X represents the higher number thereof), then the input pressure P_4 to unit D and consequently the output pressure therefrom, will be equal to

$$\frac{L_1}{L_2}(P_1 - P_2) + P_3$$

This equation is derived as follows:

$$(P_1 \cdot L_1) + (P_3 \cdot L_2) = (P_2 \cdot L_1) + (P_4 \cdot L_2)$$

Simplifying and resolving this equation for P_4 it follows that

$$P_4 = \frac{L_1}{L_2}(P_1 - P_2) + P_3$$

If

$$L_1 = L_2$$

then

$$P_4 = (P_1 - P_2 + P_3)$$

If

$$\frac{L_1}{L_2}$$

is greater than 1, then P_4 will be proportionately greater than is the case where

$$\frac{L_1}{L_2} = 1$$

and if

$$\frac{L_1}{L_2}$$

is less than 1, then P_4 will be proportionately less.

If P_2 and P_3 are zero, then it follows that

$$P_4 = P_1 \cdot \frac{L_1}{L_2}$$

If P_1 is zero, and P_2 and P_3 are greater than zero, then it follows that

$$P_4 = (P_3 - P_2) \times \frac{L_1}{L_2}$$

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and when $L_1 = L_2$, $P_4 = P_3 - P_2$. If P_4 and P_2 are equal, then

$$P_4 = \frac{(P_1 + P_3)}{2} \times \frac{L_1}{L_2}$$

and if L_1 and L_2 are equal,

$$P_4 = \frac{(P_1 + P_3)}{2}$$

If P_1 is constant, P_3 is zero, and P_2 is variable,

$$P_4 = K - P_2$$

where K is a constant. Therefore, if P_2 increases from, say, zero to 60 lbs. per sq. inch gage, P_4 will decrease from 60 lbs. per sq. inch to zero gage. In this example, the range of values of P_4 is determined by the ratio of

$$\frac{L_1}{L_2}$$

By reversing the input pressures P_2 and P_1 , the sense of motion or change of P_4 is reversed. If P_2 is zero, then

$$P_4 \text{ equals } (P_3 + P_1) \times \frac{L_1}{L_2}$$

and when $L_1 = L_2$, $P_4 = P_1 + P_3$.

The above examples of combinations of input pressures with resulting output pressures are illustrative of but a few of the many practical combinations that are possible with the above described device.

Having thus described the invention, it will be apparent to those skilled in this art, that various modifications and changes may be made in the arrangement and construction of details without departing from either the spirit or scope of the invention. Therefore, what I claim as new and desire to secure by Letters Patent is:

1. An adjustable ratio multi-force totalizer comprising a rigid frame, a beam disposed in said frame, a fulcrum slidably supported on said frame and arranged to exert a resisting force on said beam in either direction transversely thereof, a pair of pressure receiving units disposed on one side of said fulcrum and secured to said frame, another pair of pressure receiving units on the opposite side of said fulcrum and secured to said frame, each pressure receiving unit being provided with a flexible diaphragm connected to said beam, the diaphragms of the respective pairs of units acting on said beam in opposition to each other and at the same distance from the fulcrum, a valve actuated by movement of said beam about its fulcrum for controlling the admission of a totalizing fluid pressure to one of said pressure units, the pressure in said chamber being proportional to the algebraic sum of the moments of the forces about said fulcrum exerted on said beam by the respective diaphragms of said other pressure receiving units as expressed by the equation

$$P_4 = \frac{L_1}{L_2}(P_1 - P_2) + P_3$$

where P_4 is the totalizing pressure whose magnitude is proportional to the algebraic sum of the pressures P_1 , P_2 , and P_3 acting on said beam and

$$\frac{L_1}{L_2}$$

- is the ratio of the lengths of the lever arms as measured from the fulcrum to the points where the diaphragms of the respective pairs of units act on said beam.

2. A totalizer according to claim 1, characterized by the fact that the beam is provided with

a slot extending lengthwise of the beam, that the fulcrum extends through said slot, and that the ends of the fulcrum are supported in support members which are adjustably secured to the frame whereby the fulcrum may be located at the center of the beam or on either side thereof and secured in place at such location.

3. An adjustable ratio multi-force totalizer comprising a beam, a fulcrum about which said beam is disposed to rock, said fulcrum being disposed to engage said beam at spaced coplanar points so that said fulcrum is double-acting and disposed to exert oppositely acting reaction forces on said beam, a pressure receiving unit having a diaphragm coupled to said beam at a fixed point located on one side of the center of said beam, a second pressure receiving unit located on the same side of said beam center as the first pressure receiving unit, said second unit being provided with a flexible diaphragm coupled to said beam in opposition to said first mentioned unit, a third pressure receiving unit located on the opposite side of the center of said beam at a fixed distance therefrom, and a fourth pressure receiving unit located adjacent the third unit, said third and fourth pressure receiving units each having a flexible diaphragm so coupled to said beam that they act thereon in opposed relation to each other, and a valve actuated by movement of said beam for establishing a pressure in one of said pressure receiving units whose magnitude P_4 is equal to

$$\frac{L_1}{L_2}(P_1 - P_2) + P_3$$

where P_4 , the established pressure, and P_3 are the pressures delivered to said third and fourth units, respectively, and acting on said beam at a lever arm length L_2 from said fulcrum and P_1 and P_2 are the pressures received by the first and second units which act on said beam at a lever arm length L_1 from said fulcrum, and

$$\frac{L_1}{L_2}$$

is the ratio of said lever arms.

4. A device according to claim 1, characterized by the fact that each of said pressure receiving units is provided with means for adjusting the effective area of its diaphragm.

5. A device according to claim 1, characterized by the fact that each pressure receiving unit is provided with a bonnet having an open side facing said beam, that the flexible diaphragm thereof is disposed across said open side and clamped at its marginal edge to said bonnet, that the central portion of said diaphragm is rigidly connected by a thrust member to said beam, there being a slack portion in said diaphragm between the rigid central portion and the clamped marginal edge of the diaphragm and that the bonnet is provided with means for adjustably supporting the same on said frame, whereby the housing and diaphragm may be moved towards or away from said beam to adjust the slack portion and consequently the effective area of the diaphragm.

6. A device according to claim 1, characterized by the fact that said valve is embodied in the pressure chamber whose pressure is P_4 , said valve comprising an exhaust port member carried by the diaphragm, a valve stem having one end disposed to seat in the exhaust port, and a valve element at the other, said pressure receiving unit having an inlet port on which said valve element seats, the inlet port being adapted for connection to a source of supply of fluid under constant pressure, both valve ports being closed when the beam is in neutral position, the exhaust port being open when the diaphragm deflects away from the stem and the inlet port being open when the force of pressure P_4 is less than

$$\frac{L_1}{L_2}(P_1 - P_2) + P_3$$

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