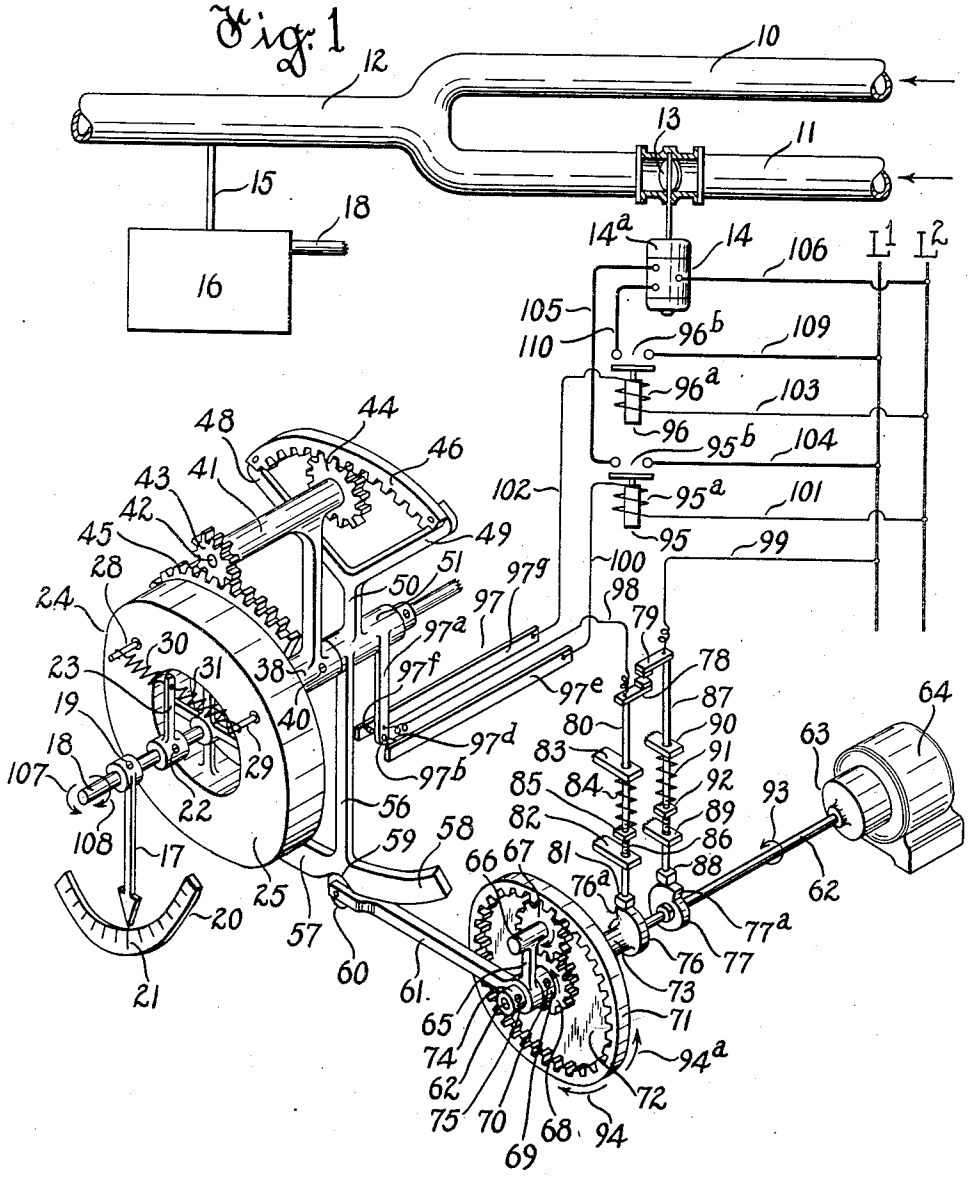
Feb. 18, 1947. E. X. SCHMIDT 2,415,913

APPARATUS FOR MAINTAINING A CONDITION OF SUBSTANTIALLY CONSTANT VALUE

Filed Feb. 9, 1944 4 Sheets-Sheet 1

Fig. 1



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Fig. 2

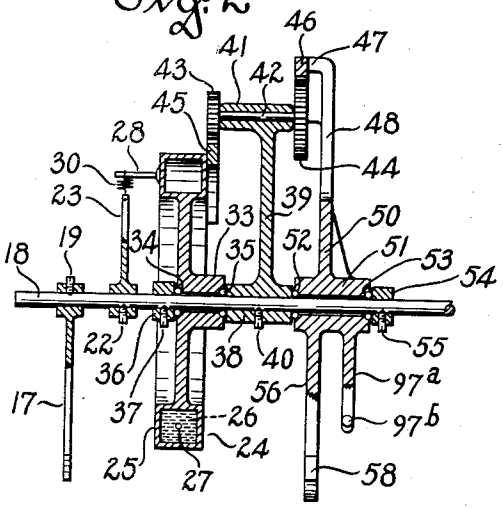


Fig. 3

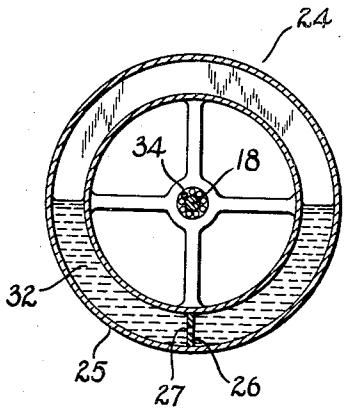


Fig. 4

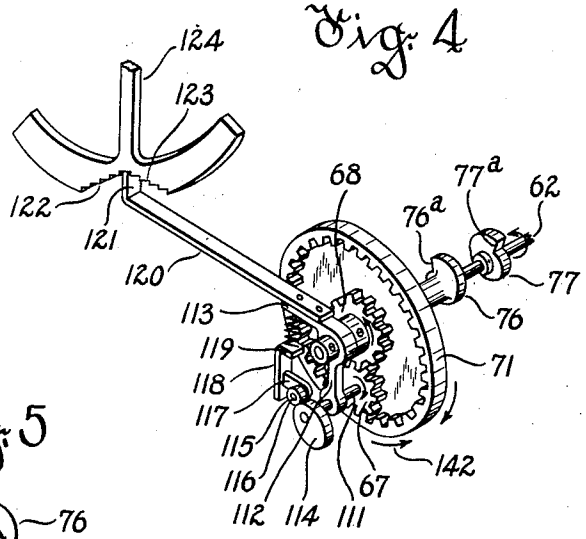
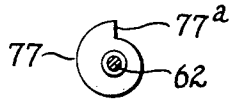


Fig. 5



Fig. 6



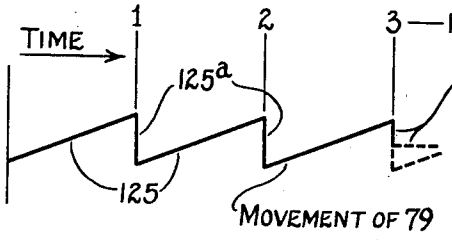
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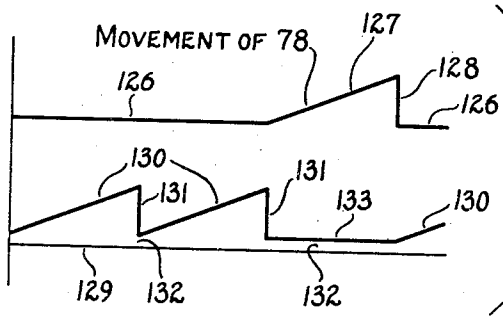
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Fig. 7



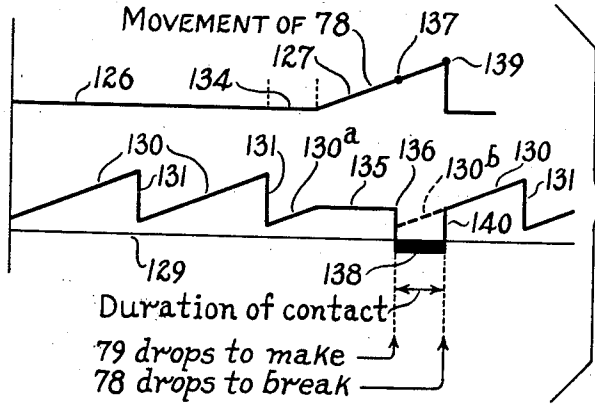
Movement of 79 when making contact due to conditions shown below. Lift of contact 78 prevents drop of 79, thus closing contacts 78 and 79.

Fig. 8



Lever 61 in normal position shown in Fig. 1.

Fig. 9



Lever 61 moved counterclockwise to and held in a given position.

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Fig. 10

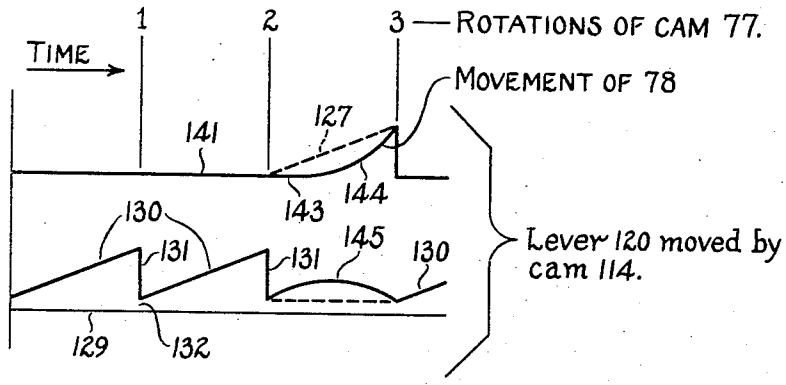
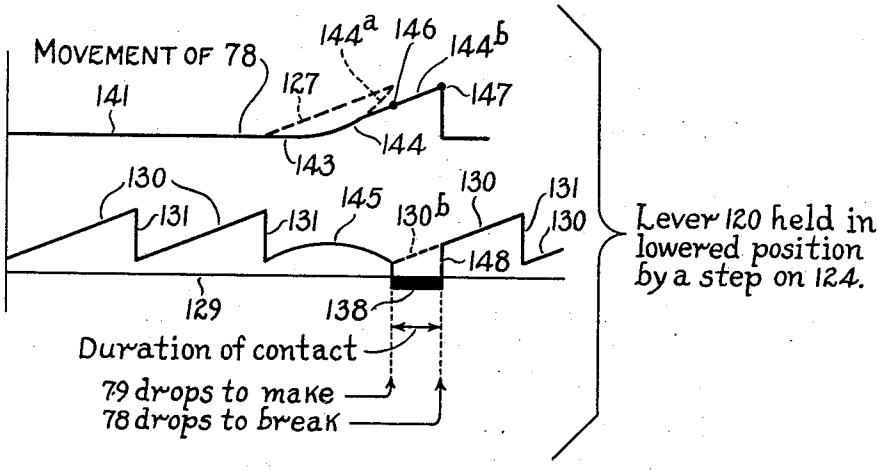


Fig. 11



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APPARATUS FOR MAINTAINING A CONDITION OF SUBSTANTIALLY CONSTANT VALUE

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Application February 9, 1944, Serial No. 521,700

12 Claims. (Cl. 137—78)

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This invention relates to apparatus for maintaining a condition of substantially constant value.

An object of the invention is to provide a simplified control apparatus of the aforementioned character.

Another object is to provide novel means for effecting adjustment of the rate of supply of a medium which provides the condition the value of which is controlled.

Another object is to provide novel means for controlling the direction of change in the rate of supply of the medium which supports said condition.

Another object is to provide for use of a ring-type liquid drag in apparatus of the aforementioned character.

Another object is to provide apparatus of the aforementioned character including a plurality of power-driven cams for electric circuit control; the operating means for one of said cams including a set of planetary gearing, and the operation of said gearing being subject to modification by the action of said liquid drag.

Another and more specific object of the invention is to provide novel apparatus for proportioning and mixing flowing combustible gases whereby the total heating value per unit volume of the mixture thereof is maintained substantially constant.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawings illustrate certain embodiments of the invention which will now be described, it being understood that the embodiments illustrated are susceptible of modification in respect of certain structural details thereof within the scope of the appended claims.

In the drawings, Figure 1 illustrates schematically and diagrammatically a gas mixing control system having my improved control elements embodied therein; said control system being adapted to maintain substantially constant the total heating value per unit volume of the combustible gaseous mixture provided thereby.

Fig. 2 is a view, partly in vertical section and partly in elevation, of certain of the control elements shown in Fig. 1.

Fig. 3 is a vertical sectional view of the ring-type liquid drag device shown in Figs. 1 and 2.

Fig. 4 is a fragmentary perspective view of a modified form of certain of the elements shown in Fig. 1.

Fig. 5 is a side elevational view of one of the cam members shown in Fig. 1.

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Fig. 6 is a similar view of the other cam member shown in Fig. 1, and

Figs. 7 to 11, inclusive, are graphs illustrating the cyclic movements of the contacts controlled by the respective cam members and showing the size of the arc gap provided therebetween under different conditions, and the manner in which the duration of engagement of the contacts is modified in each of the devices of Figs. 1 and 4, respectively.

Referring to Figs. 1 to 3, the numeral 10 designates a conduit through which a combustible gaseous fluid of relatively high quality or total heating value per unit volume is adapted to flow. It may be assumed that the gaseous fluid flowing in conduit 10 is subject to relatively wide variations both in its volumetric rate of flow and in the quality or total heating value per unit volume thereof. The numeral 11 designates a conduit through which air or other combustible gaseous fluid of relatively low quality or total heating value per unit volume is adapted to flow. The fluids flowing in conduits 10 and 11 are adapted to be combined within the relatively larger conduit 12 to provide a flowing combustible gaseous mixture; the total heating value per unit volume of which mixture it is desired to maintain substantially constant.

It is therefore necessary to provide some means for automatically controlling the rate of flow of fluid through one or the other of the conduits 10 and 11 in order that the quality or total heating value per unit volume of the gaseous mixture flowing in conduit 12 shall be maintained substantially constant. For this purpose I have shown a valve 13 of suitable form within conduit 11; said valve being movable toward its fully open or its closed position to control the volumetric rate of flow of fluid through conduit 11. It will be apparent to those skilled in the art, that, if desired, the valve 13 might be located within the conduit 10 (to control the volumetric rate of flow of the gaseous fluid of relatively high quality or total heating value per unit volume) instead of the arrangement illustrated.

Operation of valve 13 in one direction or the other selectively is subject to selective energization of the respective windings of a split-field reversible motor 14. Such energization of motor 14 is subject to control by the means hereinafter described.

In accordance with well known practice, a continuous and volumetrically constant sample of the combustible gaseous mixture in conduit 12 is conducted through pipe 15 to a suitable calori-

metric device 16 which is adapted to continuously ascertain the total heating value per unit volume of such mixture. Calorimeter 16 may be of the character disclosed in Patent No. 1,625,277, granted April 19, 1927, to Horace N. Packard. A calorimeter of the general character shown in said Patent No. 1,625,277 is likewise illustrated at the left-hand side of Fig. 2 of my prior Patent No. 2,002,279, granted May 21, 1935; said calorimeter in Patent No. 2,002,279 being designated by the numeral 120. It is to be understood that the calorimeter 16 shown diagrammatically in Fig. 1 hereof is provided with means, including a galvanometer needle such as shown at 137a in Fig. 3 of said Patent No. 2,002,279, which is operable in a direction and to a degree corresponding to the direction and degree of departure of the total heating value per unit volume of the gaseous mixture from the value preselected therefor. Calorimeter 16 also has means associated with said galvanometer needle (not shown) to provide for power operation of an indicating element, which is designated in Fig. 1 hereof by the numeral 17. Said power-operated means is of the character shown in Fig. 3 of Patent No. 2,002,279; the same being of the general character shown in Leeds Patent No. 965,824, granted July 26, 1910, and in Leeds Patent No. 1,125,699, granted January 19, 1915. Thus said power-operated means is adapted to effect operation of a rod or shaft 18, in Fig. 1 hereof, in a direction and to a degree corresponding to the direction and degree of deflection of the galvanometer needle.

The indicating element or arm 17 is rigidly attached to shaft 18 adjacent the forward end of the latter, and at a predetermined rotary angle with respect thereto, as by means of a set screw 19 or the like. A suitably calibrated scale 20 is adapted to be mounted in a fixed position with respect to the indicating arm 17, whereby the latter is adapted to indicate the instantaneous direction and degree of departure of the total heating value per unit volume of the gaseous mixture from the value preselected therefor.

Thus in Fig. 1 the shaft 18 and arm 17 are shown in their intermediate or neutral positions (as indicated by the radial alinement of arm 17 with the point designated 21 on scale 20; which point may have the proper or desired legend, such as a given predetermined total heating value, associated therewith) to indicate attainment or maintenance of the desired total heating value per unit volume of said mixture.

Also rigidly attached to shaft 18, as by means of a set screw 22, is an arm 23. Arm 23 is preferably arranged for positioning thereof in a vertical plane with respect to the axial center of shaft 18 in the neutral position of the latter, as illustrated. Mounted upon and rotatable with respect to shaft 18 is a toroid or ring-type liquid drag member designated in general by the numeral 24. As shown in Figs. 1 to 3, member 24 comprises an endless hollow or tubular ring or annulus 25, which is provided at a given point thereof with a fixed plate 26 (Figs. 2 and 3) having an opening or orifice 27 of predetermined size formed therein. Member 25 has a pair of projections or studs 28 and 29 rigidly attached to the exterior thereof and symmetrically positioned with respect to plate 26, whereby in the absence of liquid within member 25 the latter will be balanced with respect to shaft 18. A pair of like coiled tension springs 30 and 31 each

have one end attached to arm 23, and said springs have their opposite ends attached to the rods 28 and 29, respectively; whereby member 25 is biased to the intermediate or neutral position thereof with respect to arm 23 as illustrated in the neutral position of shaft 18.

As shown in Fig. 3 member 25 is preferably half-filled with a suitable liquid, such as mercury, designated by the numeral 32; the orifice plate 26 being gradually movable (along with member 25) through the body of liquid 32 in one direction or the other to a given degree from the neutral position thereof best illustrated in Fig. 3 upon prior rotary movement of shaft 18 in a corresponding direction and to such given degree, as hereinafter set forth.

As shown in Fig. 2 the hub portion 33 of member 24 has a bore of greater diameter than shaft 18, and said hub is provided at its opposite ends with peripheral grooves forming races for sets of ball-bearings 34 and 35. The ball-bearings 34 are retained within their race by a member 36 which is rigidly secured to shaft 18, as by means of a set-screw 37; and the ball-bearings 35 are retained within their race by one end of the hub portion 38 of an arm member 39; said hub portion 38 being rigidly secured to shaft 18, as by means of a set-screw 40.

Arm member 39 preferably extends upwardly in a vertical plane with respect to the axis of shaft 18 in the neutral position of the latter; and said member is provided with an integral hollow bearing portion 41 which extends in a direction parallel to the axis of shaft 18. A shaft 42 is rotatably mounted within bearing portion 41; the forward end of shaft 42 having a relatively small spur gear 43 rigidly and non-rotatably attached thereto in any suitable manner (Figs. 1 and 2), and the rearward end of shaft 42 having a relatively larger spur gear 44 rigidly and non-rotatably attached thereto in a similar manner.

Rigidly secured to the rear face of member 25 in any suitable manner (as by spot-welding or riveting) is a gear segment 45, which is arranged concentrically with respect to the axis of shaft 18, and the teeth of which gear segment preferably extend radially a slight distance beyond the periphery of member 25. Gear 43 is arranged to mesh at all times with segment 45. Gear 44 is arranged below and adapted to mesh at all times with a concave gear segment 46, which is riveted or otherwise rigidly attached to the angularly offset upper ends (see 47, Fig. 2) of the pair of opposed arms 48 and 49 of a Y-shaped integral upward extension 50 of a member the hub portion of which is designated by the numeral 51. Said hub portion 51 is provided with an opening of larger diameter than shaft 18, and the former is provided at its opposite ends with grooves or races to accommodate sets of ball-bearings 52 and 53; ball bearings 52 being retained within their race by the adjacent end of hub portion 38; and ball bearings 53 being retained within their race by a member 54 which is rigidly secured to shaft 18, as by means of a set-screw 55.

Preferably formed integrally with and extending downwardly from hub portion 51 is an inverted substantially T-shaped element 56, the oppositely extending arms 57 and 58 of which have their lower edges arranged in the form of a relatively large arc concentric to the axis of shaft 18. The adjacent portions of the lower edges of arms 57 and 58 are curved upwardly toward each

other to provide the downwardly facing concave cam surface 59 (Fig. 1) which is adapted for cooperation with a roller or wheel 69 rotatably supported at the free end of the relatively long arm 61 of a substantially L-shaped lever which is supported by but freely rotatable with respect to the outer end of a shaft 62. Shaft 62 is driven, through suitable speed-reducing gearing 63, by an electric motor 64.

The relatively short arm 65 (Fig. 1) of said L-shaped lever is formed as shown at 66 to provide a bearing for a relatively small spur gear 67. Gear 67 is normally driven by a spur gear 68, of the same size as gear 67, the integral hub 69 of gear 68 being rigidly secured to shaft 62 for rotation thereby, as by means of a set-screw 70; and gear 67 meshes with a relatively large internally-toothed gear 71 to provide for driving of the latter at a predetermined speed which is substantially slower than the speed of rotation of shaft 62. In the particular form of the invention herein illustrated it may be assumed that gear 71 is provided with three times as many teeth as each of gears 67 and 68, wherefore gear 71 and cam 76 complete one rotation during each three complete rotations of shaft 62 and cam 77. Gear 71 has formed integrally therewith a disk portion 72 and a relatively long hub portion 73, the bore of which is of a size to permit rotation of shaft 62 with respect thereto while providing a proper bearing for gear 71. A bushing 74 may be attached to the forward end portion of shaft 62, as by means of a set-screw 75, to restrain lever 61 against displacement forwardly of said shaft; and a bushing (not shown) similar to that shown at 74 may be attached to shaft 62 at the rear end of hub portion 73 to retain gear 71 in properly assembled position.

Hub portion 73 has attached thereto a cam member 76 which is preferably shaped as illustrated. Although I have herein shown cam 76 formed integrally with hub 73, it will be understood by those skilled in the art that such cam may comprise an element formed separately from hub 73 and provided with means for removably and adjustably securing the same to said hub. Cam 76 is adapted to control the position of a downwardly spring-biased contact member 78.

Thus as shown there is associated with cam 76 a rod or plunger 80, having at its lower end the block or foot portion 81 which is adapted to bear at all times against the surface of said cam. Rod 80 is supported and guided for reciprocating movement thereof by a pair of perforated fixed bracket arms, fragments of which are shown at 82 and 83. Contact 78 is rigidly secured to the upper end of rod 80, as shown; a coiled compression spring 84 being interposed between the lower surface of bracket arm 83 and the upper surface of a nut or other shouldered member 85 adjustably positioned upon said rod through the medium of the threaded portion 86 on the latter. Suitable means (not shown) may be provided for locking nut 85 in its adjusted position. As best illustrated in Fig. 5, the surface of cam 76 is in the form of the segment of a circle throughout two-thirds of its periphery, and in the form of a true spiral throughout the remaining one-third of its periphery or angle of travel; the high and low portions of said cam being separated by a radially extending shoulder 76a relatively to which the block 81 is adapted to move with a snap action in a given rotary position of cam 76.

A cam 77 (reversely arranged with respect to cam 76) is rigidly secured to shaft 62 for rotation therewith and the same has associated therewith a rod 87 having a block 88 at the lower end thereof which is adapted to continuously bear against the surface of said cam 77. As will be noted the surface of cam 77 is in the form of a true spiral throughout its periphery; the high and low portions of which are separated by a radially extending shoulder 77a relatively to which the block 88 is adapted to move with a snap action in a given rotary position of cam 77. Rod 87 is supported and guided by bracket arms 89 and 90; a spring 91 being interposed between bracket 90 and an adjustable nut 92, in the manner aforedescribed, to provide for snap movement of contact 79 downwardly when block 88 moves relatively to radial shoulder 77a of said cam in a given rotary position of the latter. Contact 79 is adapted to overlie contact 78 as shown; and the arrangement is preferably such that both engagement and disengagement of contacts 78 and 79 is effected with a snap action.

It is to be understood that motor 64 is provided with electrical connections (not shown) to effect operation thereof at a predetermined constant speed. For instance, motor 64 may be connected with lines L^1, L^2, which are shown as the source of current supply for motor 14. Thus cam 77 will be driven at a predetermined reduced speed, through the medium of gearing 63, in the same direction as shaft 62; as indicated at 93 in Fig. 1; whereas cam 76 will be normally driven in the opposite direction (indicated by arrow 94) at a still further reduced speed (such speed of cam 76 corresponding to one-third of the speed of cam 77 in the particular arrangement herein illustrated), through the medium of planetary gearing 63, 67 and 71.

The arrangement is such that so long as element 56 remains in its neutral or intermediate position, illustrated, the contacts 78 and 79 will remain in disengaged relationship to each other. As an incident to movement of element 56 in one direction or the other from said neutral position the contactor arm 97a of a switch 97 is moved in a corresponding direction to effect engagement of one of the oppositely facing contact tips carried thereby with one of the contact tips 97d or 97f respectively carried by flexible or resilient stationary contact members 97e and 97g. Such engagement of a contact tip of arm 97a with one of the relatively stationary contact tips 97d or 97f presets a circuit for energization of the winding 95a or 96a of one or the other of the electromagnetically operable relays 95 and 96; such energization being subject to simultaneous engagement of the aforementioned contacts 78 and 79. As aforeindicated, movement of contactor arm 97a is in response to the direction of divergence of the value of the condition to be controlled (total heating value per unit volume of the combustible mixture, in the particular adaptation of the invention illustrated herein) with respect to a value preselected therefor. Inasmuch as arm 39 is rigidly attached to shaft 18, movement of the latter in one direction or the other will effect corresponding movement of arm 39. The gear 44 carried by arm 39 will tend to roll freely in mesh with the teeth of segment 46; and in view of the greater size of gear 44 with respect to gear 43 also carried by arm 39, the gear 43 will (by reason of its toothed connection with segment 45) bias the toroid or ring-type liquid drag member 25 to move in a direction and to a degree corresponding with the direction and degree of movement of shaft 18. The bias of member 25

under such conditions will be accentuated by the action of one or the other of the springs 30, 31. Such movement of member 25 will, however, be resisted by the restraint afforded by the orifice 27 in plate 26 to movement of the body of liquid 32. As a consequence member 25 will temporarily remain substantially stationary; the slow rate of rotary movement thereof permitted being controlled by the rate of flow of the liquid 32 in one direction or the other through the orifice 27 in plate 26.

By reason of such resistance to movement of member 25, gear 43 will be compelled to roll over the gear segment 45 in mesh with the teeth of the latter. The consequent rotation of shaft 42 (Fig. 2) will cause rotation of gear 44, and because gear 44 is substantially larger than gear 43 the teeth of gear 44 will cooperate with gear segment 46 to effect a given degree of angular movement of hub member 51 in one direction or the other with respect to shaft 18. Such movement of hub 51 will effect movement of arm 97^a whereby one of the contact tips carried thereby is engaged with one or the other of the contact tips 97^d or 97^f. At the same time element 56 is moved from the neutral position shown in Fig. 1 so that the cam surface 59 will act to effect depression of roller 60 and counterclockwise movement of lever arms 61 and 65 as a function of the degree of deflection of the indicating arm 17 with respect to the neutral point 21 on scale 20. Thus the arm 97^a cooperates with one or the other of the contact arms 97^e or 97^g in response to the direction of variation in the total heating value per unit volume of the combustible fluid flowing in conduit 12 (as determined by calorimetric device 16); whereas element 56 acts upon lever 61 to an extent determined both by the degree or amount of variation in the total heating value per unit volume of such fluid with respect to the value preselected therefor and by the rate at which such variation takes place.

Upon such counterclockwise movement of lever arms 61 and 65 (Fig. 1) gear 67 will be caused to move bodily toward the left over gear 68, thus effecting a corresponding degree of rotation of gear 71 in a counterclockwise direction, as indicated by the arrow 94^a. The corresponding counterclockwise movement of cam 76 (which is superimposed upon or differentially related to the normal movement thereof in a clockwise direction, as aforedescribed) has the net result of delaying the time at which the block 81 will drop from the high point of said cam. Due to such delay the block 88 will drop from the high point of cam 77 prior to dropping of block 81 from the high point of cam 76. This will result in engagement of contact 79 with contact 78 to complete a circuit for one or the other of the coils 95^a or 96^a, depending upon which of the contact tips 97^d or 97^f has been engaged by arm 97^a. The duration of engagement of contact 79 with contact 78 will, of course, depend upon the degree of reverse movement or retardation of cam 76, which as aforeindicated is in accordance with the degree of angular movement of element 56.

More particularly, arm 97^a is adapted upon movement thereof toward the right (from the neutral or intermediate position thereof illustrated in Fig. 1) to effect engagement of contact tip 97^b with a tip 97^d carried by the flexible or resilient stationary contact member 97^e. Contact member 97^e is electrically connected by conductor 100 with one terminal of the operating winding 95^a of switch 95, the other terminal of which winding is electrically connected by conductor 101 with line L^2. Thus upon engagement of top 97^b with top 97^d an energizing circuit for winding 95^a is preset for completion upon engagement of the aforementioned contacts 78 and 79.

Similarly, upon movement of arm 97^a toward the left (Fig. 1) the contact tip (not shown) upon the opposite face thereof is adapted to engage the contact tip 97^f carried by the other flexible stationary contact member 97^g. Contact member 97^g is electrically connected by conductor 102 to one terminal of the winding 96^a of switch 96, the other terminal of which winding is electrically connected by conductor 103 with line L^2. Thus upon engagement of said last mentioned tip of arm 97^a with tip 97^f an energizing circuit for winding 96^a is preset for completion upon engagement of said contacts 78 and 79.

It may be assumed that upon an increase in the total heating value per unit volume of the combustible mixture flowing in conduit 12, with respect to the value preselected therefor, the calorimetric device 16 will effect movement of shaft 18 in a direction to cause movement of indicating element 17 and contact arm 97^a toward the right. The consequent engagement of tip 97^b with tip 97^d will preset the energizing circuit of winding 95^a for completion upon engagement of contacts 78 and 79, as aforedescribed; and upon energization of winding 95^a the contacts 95^b thereof will be closed to complete a circuit for the split-field reversible motor 14 to effect operation of the latter in a direction to cause movement of valve 13 toward its fully opened position. Such circuit of motor 14 extends from line L^1 by conductor 104 through contacts 95^b of switch 95, thence by conductor 105 through one of the split-field windings of said motor 14, and by the common conductor 106 to line L^2.

As will be understood, such movement of valve 13 toward its fully opened position will be effected in a step-by-step manner; due to the operation of cams 76 and 77 (the former having been reversed or retarded to a given degree in the manner aforedescribed) to effect engagement of contacts 78 and 79 after each three complete rotations of cam 77, whereby contact 79 is dropped into engagement with contact 78 at a given instant of time prior to disengagement thereof due to dropping of contact 78 by the action of cam 76. In practice the motor 14 may be provided with a built-in series of speed-reducing gears, as represented by the numeral 14^a; or any other suitable means may be employed to insure a relatively slow rate of adjustment of valve 13 during engagement of contacts 78 and 79.

It will be apparent that upon movement of shaft 18 in the direction indicated by arrow 107, as just described, the arm 23 will be moved to a corresponding degree; said arm acting through coiled tension spring 31 to tend to effect movement of the ring-type liquid drag member 25 to a like degree. However, due to the presence of orifice plate 26 (Figs. 2 and 3) at the mid-point of the body of liquid 32, such as mercury, within the closed ring 25, said ring will lag behind arm 23 to a degree controlled by the rate of passage of the liquid through the orifice 27 in said plate. As will be apparent, such movement of arm 23 relatively to ring 25 will effect a corresponding increase in the tension of spring 31, with a resultant decrease in the tension of spring 30. Inasmuch as arm member 39 is constrained to move jointly with arm 23 (both being rigidly attached

to shaft 18); whereas the movement of ring 25 is restrained, or limited to a relatively slow rate, by the coaction of orifice 27 with the body of liquid 32; it is obvious that gear 43 will be caused to ride over the teeth of segment 45, thus causing counterclockwise rotation of shaft 42 (Fig. 1).

Gear 44, which is rigidly connected with shaft 42, is likewise constrained to move in a counterclockwise direction, thus effecting movement of the upward extension 50 toward the left to a degree which is substantially greater than the degree of movement of arm member 39. As a result the inverted T-shaped extension 56 is moved toward the right (Fig. 1) to a degree greater than the degree of angular rotation of shaft 18. At the same time the arm 97^a of switch 97 is moved to effect engagement of its tip 97^b with the tip 97^d of contact arm 97^e; thereby presetting the aforementioned energizing circuit for winding 95^a for completion upon engagement of contacts 78 and 79. The degree of movement of extension 56 toward the right serves, as aforedescribed, to insure engagement of contacts 78 and 79 during each complete rotation of cam 76, to effect movement of valve 13 toward its fully opened position. The degree of opening adjustment of valve 13 upon each complete rotation of cam 76 under the conditions just mentioned is proportional to the degree to which arm 61 is rotated in a counterclockwise direction. The amount which arm 61 is rotated in a counterclockwise direction depends upon the shape of depression 59 and the angular position of arm 56 which is related to the position of indicating arm 17 in a useful, but complicated, manner due to the action of restraining ring 25 and the associated gearing.

As will be understood, the ring 25 is biased by springs 30 and 31 in a manner to establish a fixed relationship between the angular position of arm 17 and ring 25. When this condition is established, a fixed angular relationship between arm 17 and arm 56 will be established. Due to the retarding action of the liquid in ring member 25 to movement in either direction, the corresponding movement of ring 25 is delayed, thus causing a greater degree of angular movement of arm 56 than the degree of angular movement of arm 17.

Such angular displacement of arm 56 is (in effect) added to the angular displacement of arm 17, and in the absence of any further change in the angular position of arm 17, the angular displacement of arm 56 with respect to arm 17 gradually decreases to zero as the flow of liquid through the orifice 27 in plate 26 (Fig. 3) permits ring 25 to assume its normal angular position with respect to arm 17.

After valve 13 has been intermittently adjusted toward its fully open position to such a degree as to bring the combustible mixture flowing in conduit 12 back to the total heating value preselected therefor, it is obvious that the calorimetric device 16 will cause rotation of shaft 18 in a clockwise direction (as indicated by numeral 100 in Fig. 1), whereby the contact tip 97^b will be disengaged from tip 97^d to insure against further adjustment of valve 13 toward its fully opened position. Such clockwise movement of shaft 18 will result in an increase in the tension of spring 30, with a corresponding decrease in the tension of spring 31, thereby causing the gearing 45, 42, 44, and 43 to operate in a manner similar to but in the opposite direction from that aforedescribed, to gradually reset the various parts 56, 61, 65, etc., to the normal positions thereof shown in Fig. 1. When the contact arm 97^a is thus moved to its intermediate or neutral position, both of the possible circuits for motor 14 will be interrupted, and hence, the automatic resetting operation of the other parts of the device will take place without any effect upon the adjustment of valve 13.

As a result of adjustment of valve 13 in the manner aforedescribed, the arm 17 may tend to return to its normal position (shown in Fig. 1) before ring 25 has attained its normal angular relationship to said arm, in which relationship the bias effects of both spring 30 and 31 upon ring 25 will be equal to each other. Under such conditions the degree of deflection of arm 39 with respect to arm 56 will be gradually decreased until ring 25 has attained such normal angular relationship to arm 17. Further movement of arm 17 toward its normal position (Fig. 1) would then cause angular displacement of arm 39 toward arm 48 or 49 (as the case may be), and as a result of the displacement lever 56 will reach the normal position (wherein that contact on arm 97^a which was last active is disengaged from its associated stationary contact and roller 60 is positioned at the inner end of the double cam surface 59) before arm 17 reaches the normal position thereof shown in Fig. 1. It is thus apparent that the position of arm 56 is related not only to the total heating value per unit volume of the mixture as indicated by arm 17, but the position of arm 56 is also affected by the rate and direction of change in the position of said arm 17. This feature is of great practical importance in that it substantially prevents "hunting" operation of valve 13.

In the event of a decrease in the total heating value per unit volume of the combustible gaseous mixture flowing in conduit 12, with respect to the value preselected therefor, the device will operate in a manner similar to that aforedescribed (but in the opposite sense) to effect the required degree of closing adjustment of valve 13. Thus if it be assumed that the various parts of the device are in the neutral or stabilized positions thereof illustrated in Fig. 1; it is obvious that upon a decrease in the total heating value per unit volume of the combustible mixture from the preselected value, the calorimetric device 16 will cause a corresponding degree of clockwise rotation of shaft 18, with resultant substantially immediate engagement of the tip (not shown) on arm 97^a with contact tip 97^f on the flexible arm 97^g. This will preset an energizing circuit for the operating winding 96^a of switch 96, for completion upon engagement of contacts 78 and 79; said circuit when completed extending from line L^1 by conductor 99 through contacts 79 and 78, by conductor 98 through the tip (not shown) on the left-hand face of arm 97^a to tip 97^f and flexible contact arm 97^g, by conductor 102 through said winding 96^a, and by conductor 103 to line L^2.

The movement of shaft 18 in a clockwise direction from its neutral position will have caused corresponding movement of arm member 39 toward the right; and due to the restraint or resistance to movement offered by ring 25, the gear 43 will ride toward the right over segment 45; the consequent rotation of shaft 42 in a clockwise direction likewise effecting clockwise rotation of gear 44 whereby the upward extension 50 is moved toward the right and the downward extension 56 is moved toward the left. The right-

hand side of concave cam surface 59 therefore acts upon roller 60 in substantially the same manner as aforedescribed to effect a given degree of counterclockwise movement of lever 61, with the result aforementioned; namely, a given degree of retraction of cam 76 in a counterclockwise direction to insure a given period of engagement of contacts 78 and 79 during each complete rotation of cam 76; it being understood that the length of such period is gradually decreased as the total heating value per unit volume of the mixture in conduit 12 is brought back to normal by the adjustment of valve 13.

Upon energization of winding 96a the contacts 96b of switch 96 are closed, thus completing an alternative energizing circuit for motor 14, which circuit may be traced from line L^1 by conductor 109 through said contacts 96b, by conductor 110 through the other section of the split-field winding of motor 14, and by the common conductor 106 to line L^2. Such circuit provides for operation of motor 14 in a direction to effect movement of valve 13 toward its fully closed position; the cams 76 and 77 cooperating to insure intermittent completion of such reverse circuit for the motor; whereas the aforedescribed degree of automatic adjustment of cam 76 provides the desired control of the period of engagement of contacts 78 and 79 during each complete rotation of cam 76; which period is directly proportional to the degree of departure (decrease) of the total heating value per unit volume of the combustible mixture from the value preselected therefor and the rate and direction of change.

Upon re-attainment of the desired total heating value per unit volume of the mixture the shaft 18 will be rotated toward its intermediate or neutral position illustrated; and in consequence both circuits for motor 14 will eventually be interrupted. As aforeindicated, upon neutral or intermediate positioning of contact arm 97a the other parts of the device, if displaced, will be automatically returned to their preset or neutral positions illustrated without affecting the adjustment of valve 13.

It will be understood by those skilled in the art that if desired the relative size of the orifice 27 in plate or barrier 26 within ring 25 may be increased or decreased, to thereby vary the time required for the follow-up action of said ring 25 and the parts associated therewith.

Attention is called to the fact that the driving means for shaft 18 (within calorimetric device 16) includes a well known form of friction clutch. Hence if shaft 18 should tend to rotate in either direction at the instant when, or shortly after, block 81 has dropped from the high point of cam 76, the radial shoulder 76a on cam 76 may abut against said block 81 to temporarily prevent the desired reverse or retarding movement of cam 76. Such reverse movement of cam 76 will, of course, be effected gradually as the shoulder 76a tends to move away from block 81, as an incident to the normal direction of rotary movement of said cam; such temporary resistance to adjustment of the parts being accommodated by slipping of the clutch which drives shaft 18. Excessive strain upon any of the parts of the device is therefore avoided.

As will be understood by those skilled in the art, in certain installations the control instrument which effects positioning of shaft 18 (Fig. 1) may have insufficient power to effect proper operation of the other elements of the device. More particularly, the available power may be

insufficient to provide for operation of the lever arm 61 of Fig. 1. Under these conditions I prefer to provide a modified device of the character illustrated in Fig. 4. In Fig. 4 the stub shaft 111 is rigidly attached to gear 67 and rotates in the bearing formed adjacent the free end of arm 112 of a lever which is pivotally supported by shaft 62; the other arm 113 of said lever being arranged at a predetermined angle (preferably a right angle) to arm 112. Shaft 111 has rigidly attached thereto a cam or eccentric 114. Cam 114 is adapted to continuously engage a roller 115 rotatably supported upon a bearing shaft 116 fixed to a part 117 of a stationary bracket another part of which is designated by numeral 118. Bracket part 118 has a portion 119 bent at substantially a right angle thereto, and a coiled compression spring is interposed between portion 119 and lever arm 113 to insure the aforementioned continuous engagement of cam 114 with roller 115.

Lever arm 113 has riveted or otherwise rigidly attached thereto a resilient extension 120 the free end 121 of which is bent upwardly at substantially a right angle thereto. As will be understood, the continuous rotation of shaft 62 causes continuous rotation of gear 67, with the result that cam 114 cooperates with roller 115 to effect cyclic up and down movement of the free end 121 of extension 120. The arrangement is such that when the cam 77 attached to shaft 62 is in a position where cam follower 88 (see Fig. 1) is about to drop and for a given period thereafter the end 121 of extension 120 can assume the position thereof shown in Fig. 4. During the remainder of the period represented by (or corresponding to) one revolution of shaft 62 the lever extension is gradually moved downwardly from the position thereof illustrated, thus moving the end 121 downwardly from the middle or intermediate one of the opposed sets of steps 122 and 123 formed upon the lower edge of a specially formed approximately T-shaped member 124.

The shape of cam 114 is such that end portion 121 will be moved entirely out of engagement with member 124 during each complete rotation of cam 114. It is therefore apparent that the end portion 121 of extension 120 does not interfere to any substantial degree with the normal functioning of shaft 18 and the parts associated therewith for effecting movement of said member 124. As cam 77 approaches the rotary position thereof at which the follower 88 drops to its lower extreme position the end 121 of lever 120 (through the action of cam 114) tends to move to the position thereof illustrated (Fig. 4), so that when the aforementioned follower 88 drops, said end 121 will be in the position shown and there will be no rotary displacement of cam 76 with respect to cam 77; unless member 124 has been moved toward the right or left from its normal or neutral position, to correspondingly limit the degree of upward movement of lever end 12. With said end 121 restrained against movement to its upper extreme position illustrated by engagement thereof with one of the steps of the groups 122, 123 on either side of said end 121, cam 76 will be retarded to an extent depending upon the angular or rotary position of lever 120.

Referring now to Figs. 7, 8 and 9 which graphically illustrate the various positions assumed by cam operated switch contacts 78 and 79 under different conditions, in respect of the device of Fig. 1. Thus in Fig. 7 the zigzag line illustrates

the relatively slow upward movement 125 and quick downward movement 125a of contact 79 resulting from each complete rotation of cam 77 with respect to the block or follower 88; the effect of three complete rotations of cam 77 being illustrated.

In Fig. 8 the horizontal portion 126 of the upper line illustrates the substantially stationary positioning of contact 78 afforded by engagement of block 81 (Fig. 1) with the concentric portion of cam 76 (see Fig. 5) during two thirds of a complete rotation of the latter. The upwardly inclined portion 127 of said line illustrates the upward movement of contact 78 effected by cooperation of the true spiral formation of one-third of the periphery of cam 76 with the block 81; cam 78, as aforestated, being normally driven at one-third of the speed of cam 77.

The two lines in the lower portion of Fig. 8 graphically illustrate the variations in spacing of, or arc gap between, the contacts 78 and 79 under normal conditions; that is to say, so long as element 56 remains in the intermediate or neutral position thereof shown in Fig. 1. Assuming that the variable distance between base line 129 and lines 130, 131 represents the positions attained by contact 78 with respect to contact 79, it will be noted that the arc gap is initially increased, as represented by the upwardly inclined line 130, then rapidly reduced, as indicated by the vertical line 131 (which represents the drop-off of block 88 from the high portion of cam 77) to provide the normal minimum arc gap represented by the space 132. The rise 130 and fall 131 of contact 79 is repeated during the second complete rotation of cam 77. During the third complete rotation of cam 77 the spiral one-third portion of cam 76 cooperates with block 81 to effect upward movement of contact 78 at the same speed as the rise of contact 79, wherefore the aforementioned normal minimum arc gap 132 is maintained, as shown by the parallel relationship of line 133 to line 129. Under normal conditions both contacts 78 and 79 will drop to the lower extreme positions at the same time to maintain such normal minimum arc gap, whereupon cam 77 will act to lift contact 79 upwardly away from contact 78 in the manner illustrated by the fragment of the upwardly inclined line 130 to repeat the aforedescribed cycle of operations.

In the upper portion of Fig. 9 the horizontal portion 129 of the line represents the substantially stationary positioning of contact 78 during two-thirds of a complete rotation of cam 76, as in Fig. 8. However, in Fig. 9 it is assumed that during engagement of the aforementioned concentric portion of cam 76 with block 81 the element 56 has been moved to a given degree in one direction or the other from the neutral position thereof illustrated in Fig. 1. As a result the cam 76 will have been reversed, or retarded from its normal clockwise direction of movement for a period represented by the horizontal portion 134 (between dotted vertical lines), so that the beginning of the upward movement of 78 (represented by the upwardly inclined line 127, as in Fig. 8) is delayed.

With reference to the lower portion of Fig. 9 it will be noted that the variations in value of the arc gap between contacts 78 and 79 are the same as those illustrated in the lower portion of Fig. 8, during two complete rotations of cam 77. Due to the retarding or setting back of cam 76 as just described the arc gap will be gradually increased for the period represented by the relatively short upwardly inclined line 130a (which represents the rise of contact 79 while contact 78 remains substantially stationary). Then upon upward movement of contact 78 (as represented by line 127 in the upper portion of Fig. 9) said arc gap will be maintained constant at the value represented by the distance between horizontal lines 135 and 129, until the point in time represented by 136 is reached, whereupon block 88 will drop off the high point of cam 77 to provide for engagement of contact 79 with contact 78; the latter then being at that point in its rise designated by numeral 137 (Fig. 9). The period of engagement of contacts 78 and 79 is represented by the thick horizontal line 138; such period, of course, being directly proportional to the degree of lateral movement of element 56 in either direction from its normal position.

More particularly, the rise of contact 78 will continue beyond point 137 throughout the remainder of the length of the spiral one-third portion of the periphery of cam 76, and contact 78 will drop at the point in time represented by numeral 139 (Fig. 9), to disengage the same from contact 79. In the meantime the engagement of contact 79 with contact 78 will withhold block 88 from engagement with cam 77, so that the normal increase in the arc gap represented by dotted line 130b is not possible. However, such rotation of cam 77 insures that upon dropping of contact 78 as aforedescribed the cam 77 positively limits the degree of downward movement of contact 79 to thereby provide a relatively large arc gap, as represented by the vertical line 140, between the separated contacts 78 and 79.

Referring again to Fig. 7 and to Figs. 10 and 11, which jointly illustrate graphically the various positions assumed by cam operated switch contacts 78 and 79 under different conditions, in respect of the modified form of device shown in Fig. 4. Thus as aforestated the cam 77 of Fig. 4 is identical with the cam 77 of Fig. 1 and is adapted to effect the aforedescribed cyclic up and down movements of contact 79, as indicated by the series of upwardly inclined lines 125 and the vertically downwardly extending lines 125a in Fig. 7.

In the upper portion of Fig. 10 the horizontal portion 141 of the solid line indicates the substantially stationary positioning of contact 78 during the initial two-thirds of the complete rotation of cam 76 (Fig. 4); said portion 141 corresponding exactly with the horizontal portion 126 of the line shown in Fig. 8. The upwardly inclined dotted line 127 in Fig. 10 corresponds with the full line 127 in Fig. 8, and indicates the rate and degree of upward movement of contact 79 which would be effected during the final one-third of a complete rotation of cam 76 if there were no movement of lever 120 and the parts associated therewith. As aforesaid, however, it is necessary in the device of Fig. 4 to intermittently effect counterclockwise movement of lever 120 to its lower extreme position to permit substantially free movement of element 124 (Fig. 4) to any position to which it may be biased by rotary movement of shaft 18 (see Fig. 1) in one direction or the other. As aforedescribed such movement of lever 120 is effected by cooperation of cam or eccentric 114 (Fig. 4) with roller 115; the necessary counterclockwise movement of lever arm 112 being transmitted to shaft 111 and to gear 67 to tend to effect counterclockwise movement of gear 71 as shown by the arrow 142

in Fig. 4. The result of such tendency to reverse the direction of driving of gear 71 is to temporarily substantially neutralize or nullify the normal driving thereof in a clockwise direction, wherefore little or no upward movement of contact 78 is provided, as indicated by the horizontal continuation 143 of the line 141 in Fig. 10. Inasmuch as cam 114 makes three complete revolutions during each rotation of gear 71 it will be understood that said cam permits return of gear 67 to its illustrated normal position prior to the time when a complete rotation of gear 71 has been effected; and accordingly the rate of upward movement of contact 78 is accelerated, as indicated by the upwardly extending curved portion 144 of the line.

As shown in the lower portion of Fig. 10 the upwardly inclined lines 130 and the vertical lines 131 illustrate the variations in distance (or arc gap) between contacts 78 and 79 during the initial two-thirds of a complete rotation of cam 76 (Fig. 4), in the same manner as shown in the lower portion of Fig. 8. However, as shown at 145 in the lower portion of Fig. 10 the effect of the bodily movement of gear 67 (due to the action of cam 114) is to temporarily gradually increase above the normal minimum and then gradually decrease to said normal minimum the arc gap between contacts 78 and 79 during the final one-third of a complete rotation of gear 71 and cam 76. The net result is that under normal conditions engagement of contacts 78 and 79 is positively prevented.

In the upper portion of Fig. 11 the lines corresponding with those shown in the upper portion of Fig. 10 have been given like numerals of reference. In Fig. 11, however, it is assumed that lever 120 is restrained against movement to its upper extreme position, shown in Fig. 4, by engagement of lever end 121 with one of the steps 122 or 123, due to movement of element 124 in one direction or the other from its neutral or intermediate position. As a result the normal movement of contact 78 represented by the upper portion 144a of curved line 144 will not take place, but line 144 will merge into the upwardly inclined line 144b, which is parallel with the aforementioned dotted line 127. The contact 79 will drop to engage contact 78 at the point marked 146 on line 144b, thus completing the circuit as indicated at 138 in Fig. 11. Engagement of contacts 78 and 79 is maintained until contact 78 drops, at point 147, thus providing the arc gap represented by line 148 in Fig. 11; the contact 79 having been lifted in the meantime, as indicated by the dotted line section 139b of upwardly angled line 139. As will be understood, the duration of engagement of contacts 78 and 79, as represented by heavy line 138 in Fig. 11 will vary in accordance with the degree of divergence of element 124 from the neutral position thereof illustrated. The substantial similarity of the manner of operation of the device of Fig. 4 with respect to that of Fig. 1 will be apparent from the foregoing descriptions of these devices.

Although I have herein disclosed my invention as applied to control of the total heating value per unit volume of a mixture of combustible gaseous fluids, it is to be understood that the invention is adaptable for use in the control of various other conditions, such as water-level control, pressure control, temperature control, etc.; that is to say, in those devices wherein the particular condition is to be controlled by adjustment of the rate of supply of a medium which supports the condition.

I claim:

1. In apparatus for maintaining substantially constant the value of a condition, in combination, adjustable means for effecting a flow of a medium supporting the condition, means continuously responsive to the instantaneous value of said condition, means subject to control by said second mentioned means and including a rotatable liquid drag device responsive to both the instantaneous value and the rate of change in value of said condition with respect to a value preselected therefor for intermittently effecting adjustment of said first mentioned means, said third mentioned means also including a pair of continuously operable power driven cams and a pair of switch contacts respectively operable thereby, the drive of one of said cams including a set of planetary gearing, and means for subjecting said planetary gearing to control in accordance with the rotary position of said liquid drag device to thereby vary the degree of adjustment per unit of time of said first mentioned means throughout a relatively wide range, to thus increase or decrease the rate of flow of said medium in accordance with both the instantaneous value and the rate of change in value of said condition with respect to said preselected value.

2. In apparatus for control of a condition, in combination, means for continuously delivering a medium to support said condition, means for controlling the rate of delivery of said medium whereby said condition is maintained at a predetermined substantially constant value, said last mentioned means including means responsive to the direction, degree and rate of variation in such value with respect to said predetermined value, means controlled by said variation responsive means to control the direction of variation in the rate of delivery of said medium supporting said condition, cam operated switching means included in circuit with said direction control means for effecting adjustment of the rate of delivery of said medium to maintain said condition at said predetermined substantially constant value, said switching means including a pair of cams having a common drive, one of said cams being driven at a constant speed and the other cam being normally driven at a different speed through the medium of planetary gearing, said planetary gearing including an oscillatable retarding arm whose variable operative position is subject to control by said variation responsive means, said arm in any operative position thereof being adapted to correspondingly control the degree of adjustment per unit of time of the rate of delivery of said medium, said arm being so related to said cams as to provide for inoperation of said switching means when said condition is of said predetermined substantially constant value, a double-inclined cam member operable by said variation responsive means, a ring type liquid drag member also operable by said variation responsive means and spring-biased to move in either direction to a degree corresponding to the movement of the latter, gear segments connected with said drag member and said double-inclined cam member respectively, an element rigidly connected with a part of said variation responsive means for movement with the latter, a gear continuously engaged with the gear segment on said drag member, a second gear continuously engaged with the other gear segment, a shaft to which said gears are non-rotatably connected,

and said last mentioned element having means for supporting said shaft for rotation with respect thereto.

3. In apparatus for control of a condition, in combination, means for continuously delivering a medium to support said condition, means for controlling the rate of delivery of said medium whereby said condition is maintained at a predetermined substantially constant value, said last mentioned means including means responsive to the direction, degree and rate of variation in such value with respect to said predetermined value, means controlled by said variation responsive means to control the direction of variation in the rate of delivery of said medium supporting said condition, cam operated switching means included in circuit with said direction control means for effecting adjustment of the rate of delivery of said medium to maintain said condition at said predetermined substantially constant value, said switching means including a pair of cams having a common drive, one of said cams being driven at a constant speed and the other cam being normally driven at a different speed through the medium of planetary gearing, said planetary gearing including an oscillatable retarding arm whose variable operative position is subject to control by said variation responsive means, said arm in any operative position thereof being adapted to correspondingly control the degree of adjustment per unit of time of the rate of delivery of said medium, said arm being so related to said cams as to provide for inoperation of said switching means when said condition is of said predetermined substantially constant value, a double-inclined cam member operable by said variation responsive means, a ring type liquid drag member also operable by said variation responsive means and spring-biased to move in either direction to a degree corresponding to the movement of the latter, gear segments connected with said drag member and said double-inclined cam member respectively, an element rigidly connected with a part of said variation responsive means for movement with the latter, a gear continuously engaged with the gear segment on said drag member, a second year continuously engaged with the other gear segment, a shaft to which said gears are nonrotatably connected, said last mentioned element having means for supporting said shaft for rotation with respect thereto, a switch contactor movable with said second mentioned gear segment in one direction or the other according to the direction of movement of said variation responsive means, and a pair of resilient stationary contacts with which said contactor is adapted to engage selectively to preset one or the other of a pair of alternative circuits for completion upon closure of said cam operated switching means.

4. In a condition controlling system, in combination, a member adapted to assume a given position upon attainment of a predetermined value of the condition, said member being movable in one direction or the other with respect to said position in accordance with variations in the value of said condition, an element rigidly attached to said member for movement with the latter, a pair of gears rigidly connected with each other and supported by said element for rotation jointly with respect thereto, a ring type liquid drag member rotatably supported by said member first mentioned, spring means interposed between said first mentioned member and said drag member whereby the latter is biased to move in a direction and to a degree corresponding to the movement of the former, an orifice plate fixed within said drag member cooperating with the liquid to limit such movement of the drag member to a predetermined relatively slow rate, a gear segment rigidly attached to said drag member with which one gear of said pair is adapted to continuously engage, a second gear segment rotatably supported by said first mentioned member with which the other gear of said pair is adapted to continuously engage, a cam member rigidly attached to said last mentioned gear segment, a substantially L-shaped lever with one arm of which said cam member is adapted to engage, a planet gear rotatably supported by the other arm of said lever, planetary gearing of which said last mentioned gear forms a part, a switch contactor operating cam associated with said planetary gearing, a shaft for normally driving said planetary gearing at a predetermined speed, a second switch contactor operating cam rigidly attached to said shaft, said cams being jointly operable under normal conditions to maintain said switch contactors disengaged from each other, means including said cam member and said lever acting upon movement of said first mentioned member from its given position to effect intermittent engagement of said contactors for periods of time corresponding to the instantaneous relative positions of said first mentioned member and said cam member, said last mentioned means also including a switch contactor movable in one direction or the other according to the direction of movement of said first mentioned member, a pair of resilient stationary contacts with which said contactor is adapted to selectively engage to preset one or the other of a pair of alernative circuits for completion upon engagement of said cam-operated contactors, an adjustable valve the position of which is adapted to control the rate of delivery of a medium whereby the value of said condition is maintained substantially constant, a reversible electric motor for controlling the position of said valve, and means for subjecting said motor to control by said alternative circuits respectively.

5. In a gas mixing control system, in combination, a pair of branch conduits through which gaseous fluids of substantially different total heating value per unit volumes are respectively adapted to flow, a main conduit into which said branch conduits are adapted to discharge for mixture of said fluids, a calorimetric device which withdraws a continuous sample of the mixture from said main conduit and continuously ascertains the total heating value per unit volume thereof, power operated means including an oscillatable shaft associated with said calorimetric device for continuously indicating the instantaneous total heating value per unit volume of said mixture, an adjustable valve in one of said branch conduits, means responsive to movements of said power operated means for effecting adjustments of said valve whereby said total heating value per unit volume is maintained substantially constant, said last mentioned means including a ring type liquid drag member and a double-inclined concave cam member supported upon said shaft for rotation with respect thereto, spring means interposed between said shaft and said drag member to bias the latter to move in a direction and to a degree corresponding to the movement of said shaft, gear segments respectively attached to said drag member and said cam member, an arm rigidly attached to said shaft, a second shaft having bear-

ing engagement with said arm, a gear continuously engaged with the segment on said drag member, a relatively larger gear continuously engaged with the segment on said cam member, said gears being rigidly connected to opposite ends of said second shaft, a substantially L-shaped lever one arm of which is adapted for cooperative engagement with said cam member, a planet gear rotatably carried by the other arm of said lever, planetary gearing of which said planet gear forms a part, means including a motor operated shaft for normally driving said planet gear at a substantially constant speed, a cam associated with said planetary gearing, a switch contactor operable by said cam, a second cam rigidly attached to said motor operated shaft and normally rotatable at a substantially higher speed than said cam first mentioned, a second switch contactor operable by said second cam, said cams under normal conditions being adapted to insure against engagement of said switch contactors, said lever when operated to a given degree by said concave cam member being adapted to effect adjustment of the cam associated with said planetary gearing to thereby effect a corresponding period of engagement of said contacts per unit of time, a reversible electric motor for effecting adjustment of said valve, and means subject to control by said switch contactors for completing a circuit for said motor for operation of the latter in one direction or the other.

6. In a gas mixing control system, in combination, a pair of branch conduits through which gaseous fluids of substantially different total heating values per unit volume are respectively adapted to flow, a main conduit into which said branch conduits are adapted to discharge for mixture of said fluids, a calorimetric device which withdraws a continuous sample of the mixture from said main conduit and continuously ascertains the total heating value per unit volume thereof, power operated means including an oscillatable shaft associated with said calorimetric device for continuously indicating the instantaneous total heating value per unit volume of said mixture, an adjustable valve in one of said branch conduits, means responsive to movements of said power operated means for effecting adjustments of said valve whereby said total heating value per unit volume is maintained substantially constant, said last mentioned means including a ring type liquid drag member and a double-inclined concave cam member supported upon said shaft for rotation with respect thereto, spring means interposed between said shaft and said drag member to bias the latter to move in a direction and to a degree corresponding to the movement of said shaft, gear segments respectively attached to said drag member and said cam member, an arm rigidly attached to said shaft, a second shaft having bearing engagement with said arm, a gear continuously engaged with the segment on said drag member, a relatively larger gear continuously engaged with the segment on said cam member, said gears being rigidly connected to opposite ends of said second shaft, a substantially L-shaped lever one arm of which is adapted for cooperative engagement with said cam member, a planet gear rotatably carried by the other arm of said lever, planetary gearing of which said planet gear forms a part, means including a motor operated shaft for normally driving said planet gear at a substantially constant speed, a cam associated with said planetary gearing, a switch contactor operable by said cam, a second cam rigidly attached to said motor operated shaft and normally rotatable at a substantially higher speed than said cam first mentioned, a second switch contactor operable by said second cam, said cams under normal conditions being adapted to insure against engagement of said switch contactors, said lever when operated to a given degree by said concave cam member being adapted to effect adjustment of the cam associated with said planetary gearing to thereby effect a corresponding period of engagement of said contacts per unit of time, a reversible electric motor for effecting adjustment of said valve, means subject to control by said switch contactors for completing a circuit for said motor for operation of the latter in one direction or the other, said last mentioned means including a switch contactor rigidly attached to said first mentioned shaft, and a pair of resilient stationary contacts with which said contactor is engageable selectively to effect completion of a circuit for said motor for operation of the latter in one direction or the other.

7. In apparatus for maintaining substantially constant the value of a condition, in combination, means including an adjustable valve for effecting a flow of a medium supporting the condition, means for continuously ascertaining the instantaneous value of said condition, means including a rotatable liquid drag device, movable by said last mentioned means in response to the direction, amount and rate of variation in value of said condition with respect to a value preselected therefor, movable means responsive to the direction of movement of said second mentioned means for presetting one or another of a pair of alternative electric circuits adapted when closed respectively to control the direction of adjustment of said valve to thereby change the rate of flow of said medium supporting the condition, a set of electrical contactors common to said alternative circuits, a corresponding number of rotary cams individual to the respective contactors to effect operation of the latter relatively to each other, common driving means for said cams, the rate of speed of one of said cams being maintained substantially constant, another of said cams being driven at a different speed through the medium of a planetary transmission, said planetary transmission including a pivoted L-shaped lever whose movement is subject to control by said first mentioned movable means whereby such movement of said lever is made proportional to the degree and rate of movement of said movable means in either direction from a given position of the latter, and said lever when so moved acting through said planetary transmission to retard or accelerate the movement of said last mentioned cam, for the purpose set forth.

8. In apparatus for control of a condition, in combination, means including a plurality of branch conduits and a main conduit leading therefrom for continuously delivering a medium to support said condition, means including an adjustable valve in one of said branch conduits for controllng the rate of delivery of said medium through said main conduit whereby said condition is maintained at a predetermined substantially constant value, said last mentioned means including means responsive to the direction and degree of variation in such value with respect to said predetermined value, electrical switching means controlled by said variation responsive means to control the direction of adjustment of

said valve to thereby vary the rate of delivery of said medium supporting said condition, cam operated electrical switching means included in circuit with said direction control switching means for effecting variation in the rate of adjustment of said valve to thereby assist in maintaining said condition at said predetermined substantially constant value, said cam operated switching means including a pair of cams having a common power drive, one of said cams being driven at a constant speed and the other cam being normally driven at a slower speed through the medium of planetary gearing, and said planetary gearing including a movable arm whose position is subject to control by said variation responsive means, to thereby vary the degree of adjustment of said valve per unit of time, whereby the rate of delivery of said medium is subject to control in accordance with the instantaneous position of said arm.

9. In apparatus for control of a condition, in combination, means including a plurality of branch conduits and a main conduit leading therefrom for continuously delivering a medium to support said condition, means including an adjustable valve in one of said branch conduits for controlling the rate of delivery of said medium through said main conduit whereby said condition is maintained at a predetermined substantially constant value, said last mentioned means including movable means responsive to the direction, degree and rate of variation in such value with respect to said predetermined value, electrical switching means controlled by said variation responsive means to control the direction of adjustment of said valve to thereby vary the rate of delivery of said medium supporting said condition, cam operated electrical switching means included in circuit with said direction control switching means for effecting variation in the rate of adjustment of said valve per unit of time to thereby assist in maintaining said condition at said predetermined value, said cam operated switching means including a pair of cams having a common power drive, one of said cams being driven at a substantially constant speed and the other cam being normally driven at a predetermined slower speed through the medium of planetary gearing, said planetary gearing including a movable lever whose position is subject to control by said variation responsive means, said lever when moved to any one of a number of its operative positions being adapted to correspondingly adjust said planetary gearing to thereby control the degree of adjustment per unit of time of the rate of delivery of said medium, and said lever being so related to said cams as to provide for inoperative positioning of the former when said condition is of said predetermined value.

10. In apparatus for control of a condition, in combination, means including a plurality of branch conduits and a main conduit leading therefrom for continuously delivering a medium to support said condition, means including an adjustable valve in one of said branch conduits for controlling the rate of delivery of said medium through said main conduit whereby said condition is maintained at a predetermined substantially constant value, said last mentioned means including movable means responsive to the direction, degree and rate of variation in such value with respect to said predetermined value, electrical switching means controlled by said variation responsive means to control the direction of adjustment of said valve to thereby vary the rate of delivery of said medium supporting said condition, cam operated electrical switching means included in circuit with said direction control switching means for effecting variation in the rate of adjustment of said valve per unit of time to thereby assist in maintaining said condition at said predetermined value, said cam operated switching means including a pair of cams having a common drive, one of said cams being normally driven at a predetermined slower speed through the medium of planetary gearing, said planetary gearing including a movable lever whose position is subject to control by said variation responsive means, said lever when moved to any one of a number of its operative positions being adapted to adjust said planetary gearing to thereby control the degree of adjustment per unit of time of the rate of delivery of said medium, said lever being so related to said cams as to provide for inoperative positioning of the former when said condition is of said predetermined value, said second mentioned means also including a double-acting cam member adapted for cooperation with said lever, said cam member being operable by said variation responsive means, a ring type liquid drag member also operable by said last mentioned means and spring-biased to move in either direction to a degree corresponding to movement of the latter, gear segments connected with said drag member and said cam member respectively, an element rigidly connected with said variation responsive means for movement with the latter, a gear continuously engaged with the gear segment on said drag member, a second gear continuously engaged with the other gear segment, a shaft to which said gears are non-rotatably connected in spaced relationship to each other, and said last mentioned element having means for supporting said shaft for rotation with respect thereto.

11. In a condition controlling system, in combination, means including a plurality of branch conduits and a main conduit leading therefrom for continuously delivering a medium to support the condition, means including an adjustable valve in one of said branch conduits for controlling the rate of delivery of said medium through said main conduit whereby said condition is maintained at a predetermined substantially constant value, said last mentioned means also including a member adapted to assume a given position upon attainment of said predetermined value of said condition, said member being movable in one direction or the other with respect to said position in accordance with variations in the value of said condition, an element rigidly attached to said member for movement with the latter, a pair of gears rigidly connected with each other and supported by said element for rotation jointly with respect thereto, a ring type liquid drag member rotatably supported by said member first mentioned, spring means interposed between said first mentioned member and said drag member whereby the latter is biased to move in a direction and to a degree corresponding to the movement of the former, an orifice plate fixed within said drag member cooperating with the liquid therein to limit such movement of the drag member to a relatively slow rate, a gear segment rigidly attached to said drag member with which one gear of said pair is adapted to continuously engage, a second gear segment rotatably supported by said first mentioned member with which the other gear of said pair is adapted to continuously engage, a cam member rigidly attached to

said last mentioned gear segment, a substantially L-shaped lever with one arm of which said cam member is adapted to engage, a planet gear rotatably supported by the other arm of said lever, planetary gearing of which said last mentioned gear forms a part, an electric switch contactor, an operating cam therefor associated with said planetary gearing, a shaft for normally driving said planetary gearing and said cam at a predetermined speed, a second electric switch contactor, an operating cam for the latter rigidly attached to said shaft, said cams being jointly operable under normal conditions to maintain said switch contactors disengaged from each other, means including said cam member and said lever acting upon movement of said first mentioned member from its aforementioned given position to effect intermittent engagement of said switch contactors for periods of time corresponding to the instantaneous relative positions of said first mentioned member and said cam member, and associated power operated adjusting means for said valve subject to control by said contactors when engaged with each other.

12. In a condition controlling system, in combination, means including a plurality of branch conduits and a main conduit leading therefrom for continuously delivering a medium to support the condition, means including an adjustable valve in one of said branch conduits for controlling the rate of delivery of said medium through said main conduit whereby said condition is maintained at a predetermined substantially constant value, said last mentioned means also including a member adapted to assume a given position upon attainment of said predetermined value of said condition, said member being movable in one direction or the other with respect to said position in accordance with variations in the value of said condition, an element rigidly attached to said member for movement with the latter, a pair of gears rigidly connected with each other and supported by said element for rotation jointly with respect thereto, a ring type liquid drag member rotatably supported by said member first mentioned, spring means interposed between said first mentioned member and said drag member whereby the latter is biased to move in a direction and to a degree corresponding to the movement of the former, an orifice plate fixed within said drag member cooperating with the liquid therein to limit such movement of the drag member to a relatively slow rate, a gear segment rigidly attached to said drag member with which one gear of said pair is adapted to continuously engage, a second gear segment rotatably supported by said first mentioned member with which the other gear of said pair is adapted to continuously engage, a cam member rigidly attached to said last mentioned gear segment, a substantially L-shaped lever with one arm of which said cam member is adapted to engage, a planet gear rotatably supported by the other arm of said lever, planetary gearing of which said last mentioned gear forms a part, an electric switch contactor, an operating cam therefor associated with said planetary gearing, a shaft for normally driving said planetary gearing and said cam at a predetermined speed, a second electric switch contactor, an operating cam for the latter rigidly attached to said shaft, said cams being jointly operable under normal conditions to maintain said switch contactors disengaged from each other, means including said cam member and said lever acting upon movement of said first mentioned member from its aforementioned given position to effect intermittent engagement of said switch contactors for periods of time corresponding to the instantaneous relative positions of said first mentioned member and said cam member, said last mentioned means also including a switch contactor movable in one direction or the other according to the direction of movement of said first mentioned member, a pair of resilient stationary contacts with which said last mentioned contactor is adapted to selectively engage to preset one or another of a pair of alternative circuits for completion upon engagement of said cam-operated switch contactors, and associated power operated adjusting means for said valve subject to control by all of said switch contactors jointly.

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