Nov. 8, 1960 C. E. HAJNY 2,959,219

CONTROL APPARATUS

Filed March 28, 1957 2 Sheets-Sheet 1

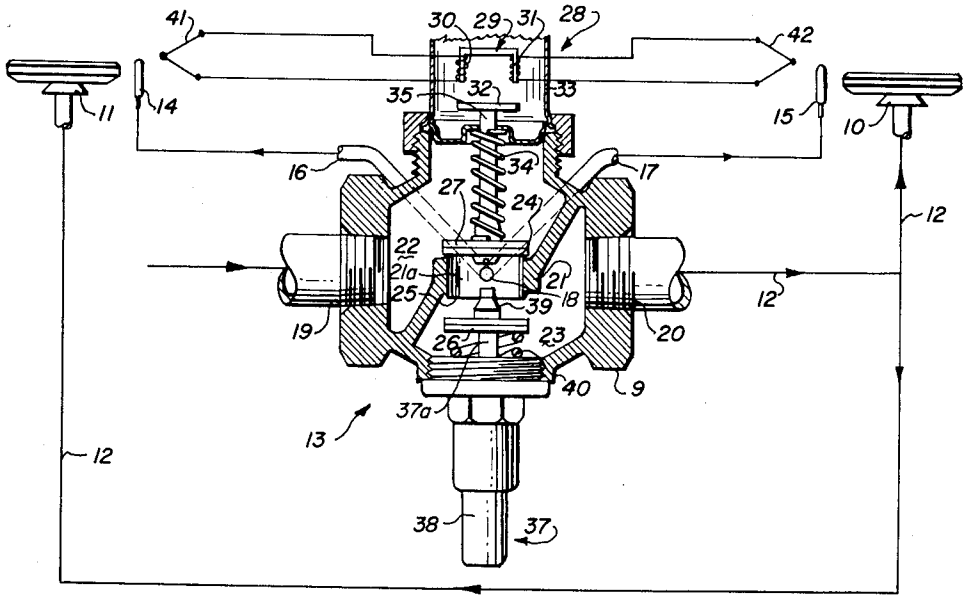


Fig. 1

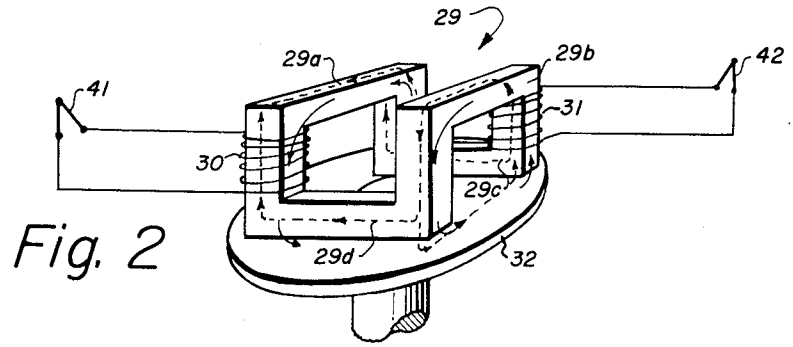


Fig. 2

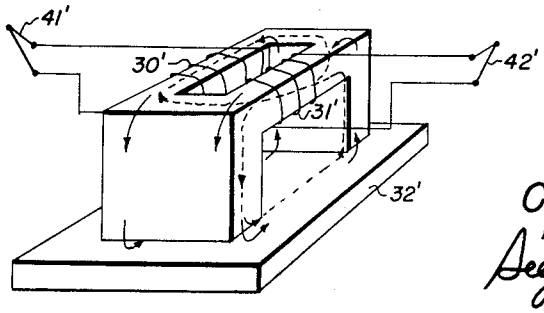


Fig. 2a

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CONTROL APPARATUS

Filed March 28, 1957 2 Sheets-Sheet 2

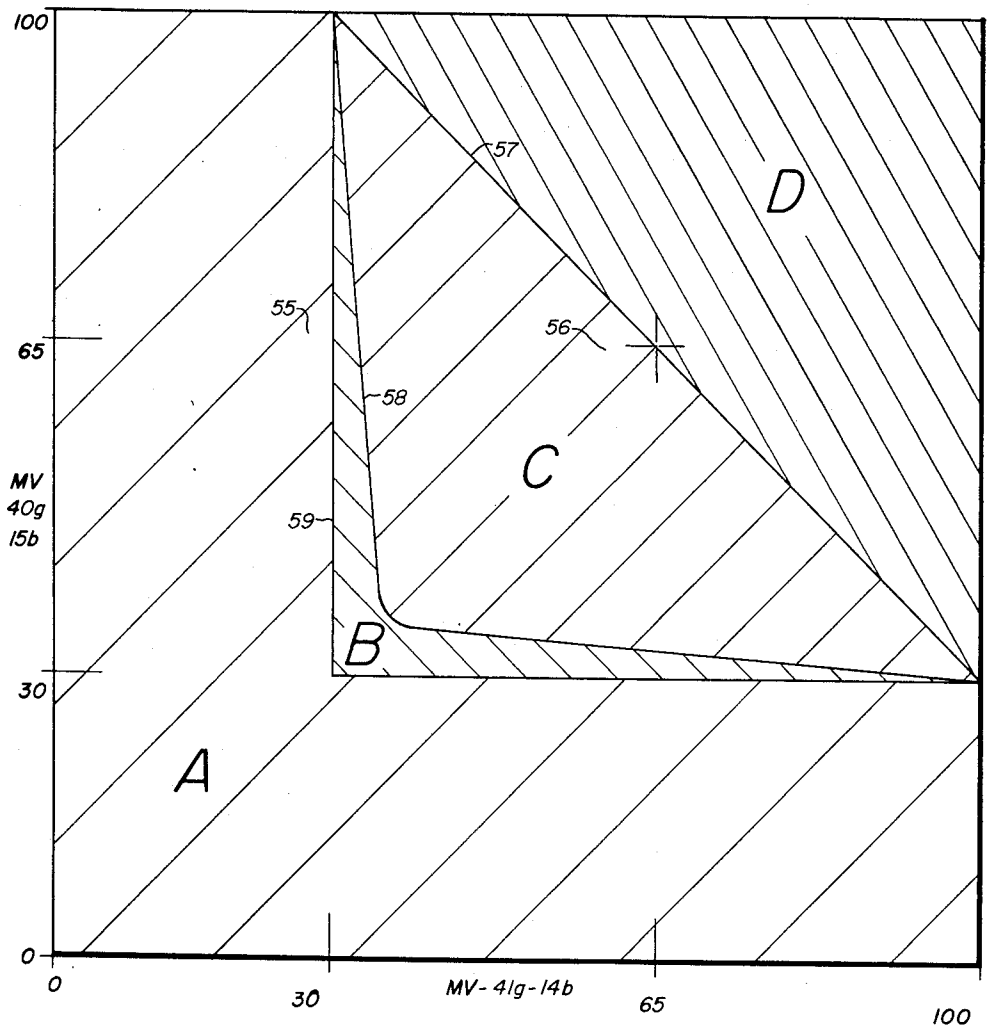


Fig. 3

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2,959,219

CONTROL APPARATUS

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10 Claims. (Cl. 158—130)

This invention relates in general to control apparatus and more particularly to a novel thermoelectrically powered safety shut-off apparatus for fluid fuel burning systems.

Heretofore, in the thermoelectric safety shut-off control of the fuel flow to a plurality of ignition or other burners, it has been necessary to employ separate fuel flow-control means such as valves or switches individually responsive to the outage of the respective individual burners. There have been various unsuccessful attempts in the past to provide a single, practical thermoelectrically powered electromagnetic fuel flow-control device capable of integrating the responses from a plurality of separate thermoelectric generators associated with individual burners in order to afford safety shut-off control for each of the burners.

It is a general object of this invention to provide an apparatus for controlling fuel flow to a plurality of burners through single magnetic control means which efficiently integrates response from two separate generators associated with two separate burner flames.

Another object of the present invention is to provide a control apparatus of the general type aforementioned permitting increased effective range of safe pilot burner operation, thereby reducing false field response.

Another object of the present invention is to provide an apparatus of the general type set forth wherein the safety shut-off control to a pair of burners is provided upon the faulty operation of one of the burners without substantially decreasing the versatility of application of said burners in fluid fuel burning systems.

Another object of the present invention is to provide an apparatus as above characterized including a novel electromagnet structure which effectively and efficiently utilizes the small amount of power available from a pair of thermoelectric generators associated respectively with a pair of ignition burners to provide safety shut-off control of the fuel flow to said burners.

A more specific object of the invention is to provide a novel electromagnetic device as aforementioned having a novel core structure and having a pair of flux-generating windings connected to the generators associated with said novel core structure in a manner to afford the improved safety shut-off control of the fuel to the burners.

The novel features that are characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation together with additional objects and advantages thereof will best be understood by the following description of the specific embodiment when read in connection with the accompanying drawings, in which:

Figure 1 is a fragmentary vertical sectional view of a novel control apparatus constructed in accordance with the inventive concept and embodied in a system controlling gaseous fuel burners, portions of said apparatus and system being shown semi-diagrammatically;

Figure 2 is an enlarged fragmentary perspective view of a portion of the control apparatus shown in Figure 1;

Figure 2*a* is a perspective view similar to Figure 2 and showing an alternative magnet structure within the inventive concept; and

Figure 3 is a graph showing performance curves in terms of millivoltage produced by two separated pilot burner-thermoelectric generator assemblies in circuit therewith, of prior art safety shut-off devices and the improved safety shut-off device, and also showing an idealized performance curve.

While the fixed magnet and movable armature described in the following detailed description are embodied in a valve device for directly controlling the fuel flow to a pair of main and pilot burners, it is to be understood that it is with full awareness that controlling movement may be obtained by having both the armature or magnet movable with respect to each other, or the armature fixed and the magnet movable. It is to be further understood that the relative movement of the armature and magnet may be used to control a switch or other suitable or desired device, rather than to directly control a valve as shown.

With the foregoing in mind and proceeding to Figure 1 of the drawings, the reference numeral **13** indicates flow-control means in the form of an electroresponsive valve disposed in a supply conduit **12** to control the fuel flow to a pair of main burners conventionally illustrated at **10** and **11**. A pair of ignition burners **14** and **15** are associated with the burners **11** and **10** respectively to ignite the latter as is well understood in the art. As shown, the pilot burners **14** and **15** may be supplied with fuel through separate conduits **16** and **17** leading from the valve **13**.

The valve **13** comprises a valve body **9** having an inlet **19**, a main outlet **20** and a partition **21** intermediate said inlet and outlet separating the interior of the valve body into an inlet chamber **22** and an outlet chamber **23**. The partition **21** may be formed with an enlarged central portion having a bore **21***a* at the ends of which are formed a pair of oppositely disposed valve seats **24** and **25**. As shown, a pilot outlet **18** is formed in the bore **21***a* intermediate the valve seats **24** and **25** and has external connection to the pilot fuel supply conduits **16** and **17** as indicated. A pair of valve discs **26** and **27** are operable to coact respectively with seats **25** and **24**, disc **26** being referred to as a flow-interrupter disc and disc **27** being referred to as safety shut-off disc for reasons hereinafter appearing.

The position of safety shut-off valve disc **27** is controlled by an electromagnetic holding means **28** which may take the form of a generally tubular housing **33** enclosing a magnet **29** and a cooperable disc armature **32** movable to attracted and retracted positions with respect thereto. As shown, an armature stem **35** is fixed to the armature **32** at one end and extends through the housing **33** to carry the safety shut-off valve disc **27** at the other end. A coil spring **34** may surround the armature stem **35** with one end engaging the valve disc **27** and the other end engaging the housing **33** to bias the armature toward retracted position and valve disc **27** into engagement with seat **24**. The magnet **29** is operable, under conditions to be explained, to retain the armature **32** attracted thereto and the valve disc **27** in open position against the bias of the spring **34**. The electromagnet as generally indicated at **29** has separated though similar energizing windings **30** and **31**. The windings **30** and **31** each have the same number of turns and are respectively connected for energization by a pair of thermoelectric generators **41** and **42**, the latter being mounted so as to be heated by the pilot burners **14** and **15** respectively. The configura-

tion of the core of magnet 29 and the disposition of windings 30 and 31 with respect thereto will be described in detail hereinafter.

It is to be noted that the holding means 28 shown is of the resettable type in contradistinction to the automatic type, and therefore the force of biasing spring 34 on armature 32 is greater than the attractive force of magnet 29 thereon when said armature is in the retracted position shown in Figure 1. Stated another way, when magnet 29 is energized by both windings 30 and 31, it is inoperative to attract the armature 32 from its retracted position against the bias of the spring 34, but it is operative to retain said armature in attracted position once said position is attained (assuming that the windings are energized by a predetermined electromotive force as shall be explained).

Manual reset means 37 is provided to move the valve disc 27 to open position and thereby to reset the armature 32 to attracted relation with respect to the pole faces of magnet 29. The illustrated reset means is shown as comprising a reciprocatable stem 37*a* having a manually engageable external knob or button 38 at one end and an enlarged tip 39 at its inner end. The stem 37*a* slidably carries the flow-interrupter disc 26 which is biased toward the tip 39 by a spring 40. Tht stem 37*a* is biased outwardly by a spring (not shown) which is stronger than the spring 40. Depression of the reset button 38 causes upward movement of the stem tip 39, as viewed in Figure 1, into actuating engagement with valve member 27 for movement of the armature 32 into engagement with the pole faces of magnet 31 as aforementioned and simultaneous lifting of safety shut-off valve 27 off seat 24, allowing fuel flow into bore 21*a*. During this movement of the reset stem, the flow-interrupter disc moves therewith under the bias of spring 40 into seating engagement with valve seat 25 to prevent flow of fuel to the main burners 10 and 11 during the resetting operation. The slidable mounting of the disc 26 on reset stem 37*a* permits further inward movement of the stem 37*a* after seating of the disc 26 in order to accomplish thereafter resetting of the armature 32 relative to the pole faces of magnet 29. It will thus be noted that fuel may flow through the pilot outlet 18 to the pilot burners 14 and 15 for safe lighting thereof once valve disc 27 is lifted from seat 24 during a resetting operation.

Referring now to the details of the magnet assembly as best shown in the perspective drawing comprising Figure 2, it is seen that the core of magnet 29 may comprise a pair of spaced inverted U-shaped core portions or members 29*a* and 29*b* and spaced connecting pole piece portions or members 29*c* and 29*d*. The connecting members 29*d* and 29*c* have coplanar surfaces facing the armature 32 which are adapted to function as the pole faces of the magnet 29 for coaction with said armature.

As shown, winding 30, which is connected for energization to thermoelectric generator 41, is wound on one leg of the U-shaped portion 29*a*, whereas the winding 31, which is connected for energization by thermocouple 42, is wound on one leg of the U-shaped portion 29*b*. This configuration of magnet core and position of the windings thereon afford, when generators 41 and 42 are energized in a particular manner to be explained, flow of flux along parallel paths which are set up in the core portions and armature substantially as shown by the solid line arrows in Figure 2.

More particularly, the flux produced by winding 31 tends to flow throughout the extent of the U-shaped portion 29*b*, across the first armature-magnet pole face air gap adjacent the connecting member 29*d* into the armature 32, through the second armature-pole face air gap adjacent the connecting member 29*c* and return to said winding. The lines of flux created by winding 30 tend to flow similarly throughout the extent of U-shaped portion 29*a*, across the first air gap into the armature 32, through armature 32 and returning through the second air gap to winding 30. (It is to be noted that the first and second air gaps between the armature 32 and the pole face pieces 29*d* and 29*c*, respectively, are relatively small when the armature is in the attracted position shown in Figure 2.)

The aforementioned parallel flow results from the fact that the windings 30 and 31 are so wound and disposed on the U-shaped members 29*a* and 29*b* that the flux created thereby is of an opposing or non-aiding type within the core itself, i.e., in the sense that the windings are not serially arranged on the magnet core structure in a manner to cause the flux to flow serially through the core portions within said windings. Thus, very little flux flows in the pole piece extents or connecting members 29*d* and 29*c* when both windings 30 and 31 are energized by substantially the same amount of electrical energy. However, when one winding, for example winding 31, is energized and the other winding, for example winding 30, is completely deenergized, the connecting portions 29*d* and 29*c* together with the core portion bearing the deenergized winding, i.e., core portion 29*a*, provide a closed path magnetic circuit between the ends of the other core portion, i.e., portion 29*b*, to afford a shunting effect which diverts a substantial portion of the flux from winding 31 away from the armature 32, the diverted portion of the flux traveling in the aforementioned closed path magnetic circuit.

The major reason why flux is diverted from the former path through the air gaps and to the aforementioned closed magnetic path is the absence of an opposing flux normally created by energization of the other winding and preventing flux from the one winding from entering this low reluctance path. For example, assuming winding 31 is energized and winding 30 is deenergized, a portion of the flux created by winding 31 will continue to flow through the core portion 29*b* and the armature in the path shown by the solid line arrows, but a diverted or shunted portion will flow through the entire magnet core which affords a closed magnetic circuit as shown by the dotted lines of Figure 2. The proportional amount of flux diverted away from the armature in this manner is a function of the properties of the materials used for the armature and the magnet core, the size or geometry of said magnetic members, the amount of generating force of the generators, the number of turns on the winding, and the size and hence reluctance of the armature-magnet air gap as related to the other factors. All of these factors are calculatable by men skilled in the electromagnetic art, so that the specific structure arrived at can best suit the requirements of the precise field application desired.

Between one extreme wherein both of the windings 30 and 31 are producing exactly the same amount of flux to afford the aforedescribed paralleling of flux paths to produce the optimum attractive force relationship at the magnet-armature air gap; and another extreme wherein the situation of one winding being completely deenergized and the other energized obtains to cause a substantial amount of diversion of flux through the remainder of the core as also aforedescribed; are third situations wherein generators 41 and 42 are producing or generating uneven amounts of thermoelectric power putting windings 30 and 31 in imbalance. When this third or imbalanced situation occurs, there is a paralleling of flux through the armature and magnet air gaps in amount roughly proportional to the output of the weaker of the two generators, the excess of flux created by the stronger generator being used partially for armature-magnet pole face attraction and part for travelling through the closed path afforded by the magnet core.

For example, assume a fixed system as described and that the millivoltage output of the generators 41 and 42 may be translated directly into attractive forces at the armature and magnet pole faces when the armature is in attracted position. Assume further that the gen-

erator 41 is producing ninety millivolts and generator 42 is producing fifty millivolts. Under these conditions the attractive force produced at the air gaps is roughly equivalent to the amount produced by two balanced generators producing fifty millivolts each plus an increment of attractive force for the excess millivoltage of the stronger generator, i.e., forty millivolts. This force, however, is not the force generated by a single generator producing 40 millivolts, but rather, is that increment measured on the magnetization force curve and defined by the difference between the force generated by a single generator producing fifty millivolts and that generated by the same generator producing ninety millivolts with the other generator deenergized. A further example would be generator 41 producing sixty millivolts and generator 42 producing sixty-five millivolts. The attractive force produced in the armature-magnet air gap will be equivalent to that produced by two balanced generators generating sixty millivolts each, plus the increment of attractive force produced by a single generator measured on the force curve between the sixty and sixty-five millivolt levels with the other generator deenergized.

The advantages of the disclosed electromagnetic arrangement are perhaps most clearly portrayed when contrasted with an ordinary horseshoe or U-shaped core wherein windings similar to 30 and 31 are wound in series or aiding relationship on the legs thereof, everything else being identical with the structure thus far described. Let us assume, for illustration, the following values of a normal safety shut-off system. A pilot flame at 14 or 15 producing thirty millivolts at generators 41 and 42 is safe, i.e., will ignite the main burners 11 and 10, and a pilot flame producing 29 millivolts is unsafe, i.e., will not ignite the main burners. Thus, in order to effect shut off of fuel flow to the burners whenever there is an unsafe pilot flame, the system must be designed such that whenever one of the two generators falls below 30 millivolts, the spring 34 overcomes the attractive force between the magnet 29 and armature 32 and releases said armature to effect closure of the valve disc 27 for shut off of all fuel flow.

Since it is impossible to provide a practical pilot burner and generator that will produce a single safe millivoltage such a thirty millivolts without causing a lot of shut-downs or "drop-outs" in normal field use, a practical pilot burner and generator arrangement must be employed, which avoids such shut-downs by allowing for variations in fuel supply pressure, environment, composition of fuel, restrictions in the fuel orifices, distortions of parts occasioned by subjection to elevated temperature and changes in atmospheric humidity and pressure. In fact, in various commercial single thermoelectric generator and pilot burner arrangements in present use, it is generally accepted rule of thumb that the drop-out valve of a valve or switch in terms of millivoltage be at thirty percent of the optimum millivoltage that the pilot burner and generator can produce. For example, if burner and associated generator can produce, under optimum conditions, one hundred millivolts, then the drop-out value should be designed to be thirty millivolts. As another example, if a thermoelectric generator and associated pilot burner can produce thirty-three millivolts at optimum, the drop-out value should be nearly ten millivolts. So-called normal output of pilot burner-generator assemblies having an optimum output of one hundred millivolts is in the neighborhood of sixty to eighty millivolts, whereas the normal output of those having an optimum output of thirty-three millivolts is in the neighborhood of twenty to twenty-six millivolts.

With the foregoing millivoltages in terms of a pilot burner operation in mind, it will become apparent hereinafter that a safety shut-off apparatus utilizing a horseshoe type magnet having two series or aiding windings thereon separately connected to two separate pilot burners has a very limited range of so-called "safe" operating millivoltages. This obtains because in a series winding system, in order to have drop-out when any one of the two pilot burners becomes unsafe (i.e., causes generation of below 30 millivolts in the illustrative system), it is necessary that the minimum "drop-out" value of the dual system be the additive amounts of millivoltage of one burner at maximum unsafe value (at 29+) plus the maximum millivoltage possible at the other burner operating at optimum (100) or a total of 129+ millivolts. Since in a series system as described the millivoltage of the separate generators are additive in terms of flux generated, any combination of dual pilot operation which produces a total of 129+ millivolts or less causes drop-out of the armature and shut off of the fuel flow to the burners. To illustrate how limited the range of such a system is, assume the situation wherein both pilot burners and their associated generators are operating at well above the safe minimum, for example, at sixty-four millivolts. Even though the burners are operating in a safe range, the total of 128 millivolts generated is below the drop-out value, and therefore the attractive force produced at armature-magnet air gap is insufficient to retain the armature against the bias of spring 34. Fuel shut off thus results, even though the burners are operating safely.

The electromagnetic core and winding structure shown in Figures 2 and 2*a* affords a much greater range of dual pilot burner operation than a series system of the type described. For example, the magnet and windings of the improved structure may be designed so that two generators such as 40 and 41 producing 36 millivolts each will provide the same attractive force in the armature-magnet air gap as one of said generators operating at 100 millivolts and the other generator operating at 30 millivolts.

This relationship will be more readily apparent upon considering the performance curves shown on the graph of Figure 3 wherein the millivoltage output of one pilot burner-generator assembly, for example, the pilot burner 15 and generator 40, provides the ordinate or vertical axis, and the millivoltage output of a second pilot burner-generator assembly, for example, the pilot burner 14 and generator 41, provides the abscissa or horizontal axis. As shown, the optimum output of each of the generators represented is one hundred millivolts.

On the graph, the line 57 represents the drop-out line of a dual type safety shut-off device utilizing a conventional horseshoe magnet core with the windings energized by generators 40 and 41 disposed in series-aiding relation. The line 58 represents the drop-out line of a dual type safety shut-off control constructed in accordance with the present invention, and the line 59 represents the drop-out line of an idealized dual type safety shut-off control.

In Figure 3 the L-shaped area represented by the capital letter "A" indicates a range of unsafe operation by one or both of the two pilot burner-generator assemblies. Thus, any point within the area A, at least one of the pilot burner-generator assemblies is producing less than the 30 millivolts arbitrarily assumed to be the minimum safe millivoltage for either pilot burner-generator assembly. For example, point 55 in area A represents condition in which generator 41 is producing approximately 28 millivolts and generator 40 is producing approximately 65 millivolts. This is unsafe in the sense that pilot burner 14 associated with generator 41 will not safely ignite the main burner 11 under these conditions.

The combination of areas represented by the capital letters B, C, and D represents the safe operating range for pilot burners 14 and 15, i.e., each of the assemblies is producing at least thirty millivolts and therefore any combination of pilot burner operations producing millivoltages falling within the areas B, C, and D afford safe ignition of the burners 10 and 11. For example, point 56 in area C represents generator 40 producing 65 millivolts and generator 41 producing 60 millivolts both of which are produced by safe pilot flames.

As aforementioned, line 57, which divides the area D from areas B and C, represents the cure for a horseshoe type magnet series-aiding windings as described hereinbefore. Any point along line 57 is representative of an additive total of just below 130 millivolts produced by the two pilot burner-generator assemblies. The area in the graph indicated by the capital letter D represents the range of safe pilot burner operation in a series type device, the extremes of said range being those situations wherein one pilot burner-generator assembly is operating at maximum, i.e., 100 millivolts, and the other is operating at the safe minimum of 30 millivolts. Thus, the areas B and C which also represent part of the safe operating range of the pilot burners are lost to the dual pilot burner systems using a horseshoe magnet and series-aiding windings.

Line 58 which divides areas B and C represents the drop-out curve of the magnet structure shown in Figures 2 and 2*a* wherein the windings 30 and 31 are energized by generators 41 and 42. Thus, when the improved structure is used, a very substantially increased range of pilot burner operation represented by area C plus the area D is attained. The area C, represents the range increase afforded by the improved structure over the range D afforded by series type magnet structure. It will be observed that the performance curve 58 of the improved structure closely approaches the ideal represented by the curve 59.

The improved magnetic structure makes it possible to now provide a single control device affording safety shut-off fuel control responsive to the operation of a pair of pilot burners, the system embodying said single control having, for all practical purposes, substantially the same operating characteristics as the much more expensive present systems utilizing a separate safety shut-off control for each pilot burner-generator assembly.

Figure 2*a* shows a slightly modified magnet structure as compared with that shown in Figure 2. The difference being that the area between the legs of the U-shaped extents 29*a* and 29*b* is filled in, and the windings 31′ and 30′ are shifted to the closed end portions of said U-shaped extents. This structure operates substantially identically with the structure shown in Figure 2.

Although two specific embodiments have been shown and described, it is with full awareness that many modifications thereof are possible. The illustrated forms of the invention have been selected for purposes of disclosure only and are not intended to limit the forms which the invention may take or to confine the invention to particular use, all of such other forms, modifications or changes being contemplated as may come within the scope of the invention as set forth in the appended claims.

I claim:

1. In a control device, a magnet core comprising a pair of spaced U-shaped portions having the leg portions thereof magnetically connected by first and second pole pieces to form a closed low reluctance magnetic path, first and second winding means associated with said U-shaped portions and operable when energized to produce a flow of magnetic flux therethrough, first and second electric energy source means connected to said first and second winding means respectively for energization of the latter, said first and said second winding means when either is energized singly being adapted to produce a flux flow in said closed path serially through both of said U-shaped portions and said pole pieces, and said first and said second winding means when both are energized simultaneously being adapted to produce flux flow through said U-shaped portions in direction to establish parallel flux paths each including one only of said U-shaped portions.

2. In a control device, magnet means comprising a pair of spaced side members magnetically connected by first and second end pieces to form a closed low reluctance magnetic path, first and second winding means associated with said side members and operable when energized to produce a flow of magnetic flux therethrough, first and second low power source means connected to said first and second winding means respectively for energization of the latter, said first and said second winding means when either is energized singly being adapted to produce a flux flow a portion of which flows in said closed path serially through both of said side members and said end members, and said first and said second winding means when both are energized simultaneously, being adapted to produce flux flow through said side members in direction to establish parallel flux paths each including one only of said side members.

3. In a control device, electromagnetic means comprising core means including a pair of spaced U-shaped members the leg portions of which are magnetically connected by first and second pole pieces to form a closed low reluctance magnetic path, armature means associated with said core means for relative movement therewith, first and second winding means associated with said U-shaped members and operable when energized to produce a flow of magnetic flux therethrough, a first and second source means connected to said first and second winding means respectively for energization of the latter, said first and said second winding means when either is energized singly being adapted to produce a flux flow a portion of which flows in said closed path serially through both of said U-shaped members and said pole pieces, and said first and said second winding means when both are energized simultaneously being adapted to produce flux flow through said U-shaped members and said armature means in a direction to establish parallel flux paths each including one only of said U-shaped members.

4. In a control device, a magnet core comprising first and second spaced U-shaped portions the leg portions of which are magnetically connected by first and second pole pieces to form a closed low reluctance magnetic path, first and second winding means associated with said first and second U-shaped portions respectively and operable when energized to produce a flow of magnetic flux therethrough, first and second thermoelectric source means connected to said first and second winding means respectively for energization of the latter, said first winding means when energized singly being adapted to produce a flux flow a portion of which flows in said closed path serially in a given direction through both of said U-shaped portions and said pole pieces, said second winding means when energized singly being adapted to produce a flux flow a portion of which flows in said closed path serially in the opposite direction through both of said U-shaped portions and said pole pieces, and said first and said second winding means when both are energized simultaneously being adapted to respectively produce a flux flow through said first and second U-shaped portions in direction to establish first and second separate parallel flux paths, the first only of said flux path including said first U-shaped portions, and the second only of said flux path including said second U-shaped portions.

5. In a control device, electromagnetic means including a magnet core comprising a pair of spaced U-shaped members the leg portions of which are magnetically connected by first and second pole pieces to form a closed magnetic path, a relatively movable armature associated with said core and providing an air gap therewith, first and second winding means associated with said U-shaped members and operable when energized to produce a flow of magnetic flux therethrough, first and second source means connected to said first and second winding means respectively for energization of the latter, said first and said second winding means when either is energized singly being adapted to produce a flux flow a portion of which is shunted to flow serially through the closed magnetic path including both of said U-shaped members and said pole pieces and another portion which flows through said air gap and said armature, and said first and said

second winding means when both are energized simultaneously and equally being adapted to produce a flux flow through said air gap, said armature, and U-shaped members in a direction to establish parallel flux paths each including one only of said U-shaped members.

6. A control device for a pair of separated pilot burners comprising, a magnet and movable armature having a retracted position and resettable toward attracted position, biasing means biasing said armature with predetermined force toward retracted position, said magnet having spaced connected portions operable to form a closed magnetic path, first and second energizing winding means on said spaced portions of said magnet for creating in response to a safe condition an attractive force to retain said armature in attracted relation after movement thereto, a first thermoelectric generator associated with one of said pilot burners for energizing said first winding, and a second thermoelectric generator associated with the other of said pilot burners for energizing said second winding, said first and second thermoelectric generators each being operable to deliver an electromotive force to its winding corresponding to the flame condition at its respective pilot burner, when the generator for one winding is heated by a maximum safe pilot burner flame and the generator for the other winding is heated by a pilot burner flame of a size just less than a minimum safe flame the energization of said windings thus afforded creates an attractive force between said armature and magnet that is just less than the force of said biasing means, and when the generators for both windings are heated by pilot burner flames which are slightly larger than a minimum safe flame and therefore substantially smaller than a maximum safe flame, the energization of said windings thus afforded creates an attractive force between said armature and magnet that is greater than the opposing force of said biasing means and is therefore capable of retaining the armature in attracted position when moved thereto.

7. A control device for fuel burning apparatus having a pair of separated burners comprising, a magnet, movable armature having a retracted position and resettable toward attracted position with respect to said magnet, biasing means biasing with a predetermined force said armature toward retracted position, fuel flow-control means associated with said armature for movement therewith between flow-controlling positions, said magnet having spaced connected U-shaped portions, first and second energizing winding means on said spaced connected U-shaped portions of said magnet, a first flame responsive source of electrical energy associated with one of said burners for energizing said first winding and a second flame responsive source of electrical energy associated with the other of said burners for energizing said second winding, said first and second flame responsive sources of electrical energy each being operable to deliver an electromotive force to its winding corresponding to the flame condition at its respective burner, the configuration of said core and the arrangement of said winding thereon being such that when the flame responsive source for one of said windings senses a burner flame of a size just less than a minimum safe flame, attractive force created between said armature and magnet by the energization of said windings thus afforded is just less than the force of said biasing means, and when the flame responsive sources for both windings sense burner flames which are only slightly larger than a minimum safe flame therefore substantially smaller than a maximum safe flame, the attractive force created between said armature and magnet by energization of said windings thus afforded is greater than the opposing force of said biasing means and is therefore capable of retaining the armature in attracted position and hence said flow-controlling means in one of its controlling positions when moved thereto.

8. In a control device, a magnet core comprising a pair of core portions magnetically connected by spaced first and second pole piece members to form a closed low reluctance flux path, and first and second winding means associated with said first and second core portions respectively intermediate the connections thereto of said pole piece members, either of said first and second winding means when energized alone producing a flux flow through the closed flux path serially through said core portions and pole piece members, and said first and second winding means, when energized simultaneously, producing flux flow through said core in a manner affording parallel flux paths each including one only of said core portions.

9. In a control device, a magnet core comprising a pair of core portions magnetically connected by spaced first and second pole piece members to form a closed low reluctance flux path, an armature having an attracted position with respect to said pole piece members, and first and second winding means associated with said first and second core portions respectively intermediate the connections thereto of said pole piece members, either of said first and second winding means when energized alone producing a flux flow through the closed flux path serially through said core portions and said pole piece members, and said first and second winding means, when energized simultaneously, producing flux flow through said core and armature in a manner affording parallel flux paths each including one only of said core portions.

10. Fuel flow control apparatus comprising a pair of burners, first and second thermoelectric generators respectively disposed in heating relation to said burners, and a fuel flow control device comprising electromagnet means having core means including a pair of U-shaped members magnetically connected by first and second pole pieces to form therewith a closed low reluctance magnetic path, an armature movable to attracted and retracted positions with respect to said pole pieces, means biasing said armature toward retracted position, a flow control member operatively associated with said armature and movable from one to another controlling position by movement of said armature from attracted to retracted position, first and second winding means on said U-shaped members connected for energization by said first and second generators respectively and operable when energized singly to produce a flow of magnetic flux a portion of which flows serially in both of said U-shaped members and in said pole pieces, said first and second winding means when both are energized simultaneously being operable to produce flux flow through said U-shaped members and said armature in a direction to establish parallel flux paths each including one only of said U-shaped members, linking of said armature by the flux in said parallel flux paths affording sufficient attractive force to retain said armature in attracted position and said flow control member in said one controlling position when moved thereto against said biasing means.

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CERTIFICATE OF CORRECTION

Patent No. 2,959,219 November 8, 1960

Charles E. Hajny

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 28, strike out "the"; column 5, line 44, for "a", first occurrence, read -- as --; line 54, for "valve", first occurrence, read -- value --; column 7, line 2, for "cure" read -- curve --; column 8, line 22, strike out "a", second occurence; column 9, line 67, after "flame" insert -- and --.

Signed and sealed this 14th day of November 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents

USCOMM-DC

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