Nov. 14, 1950 S. K. MALEK 2,530,255

THERMOELECTRIC GENERATOR

Filed May 9, 1945

Fig. 1.

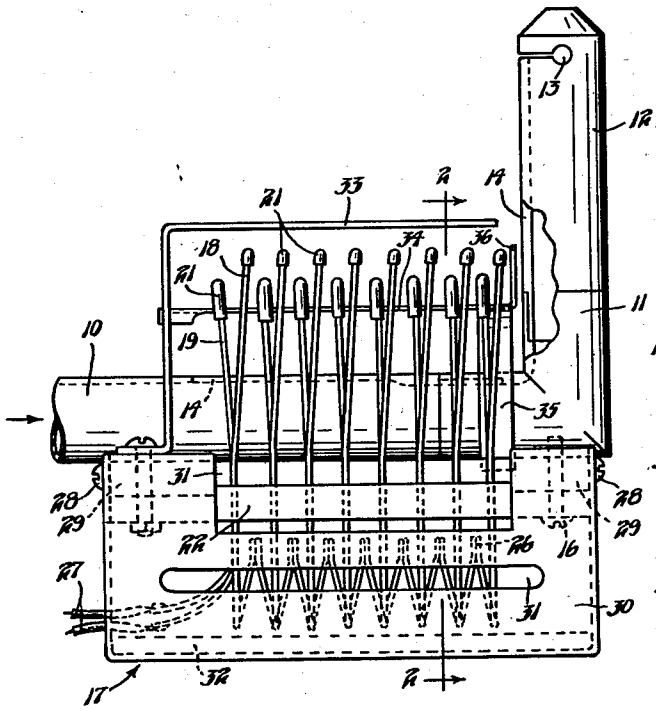


Fig. 2.

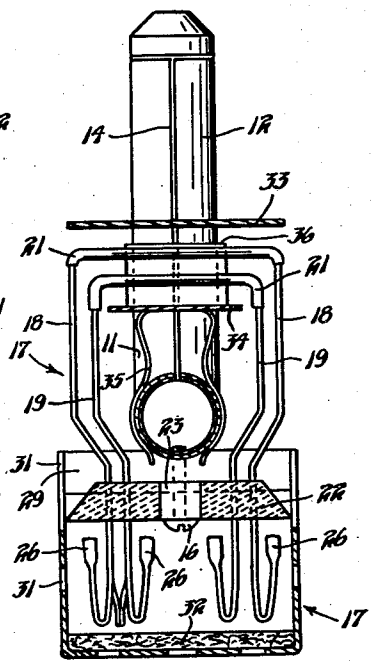


Fig. 3.

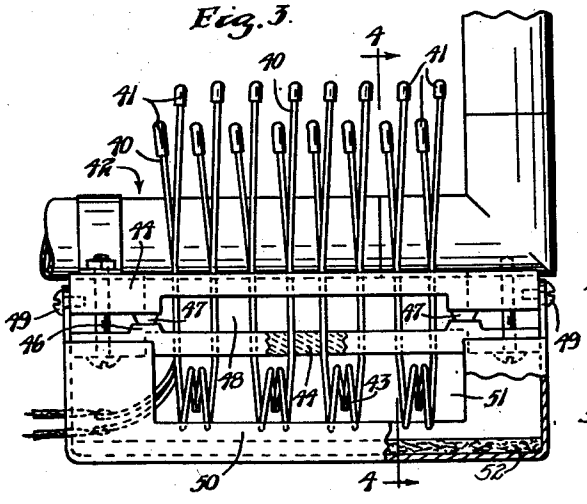
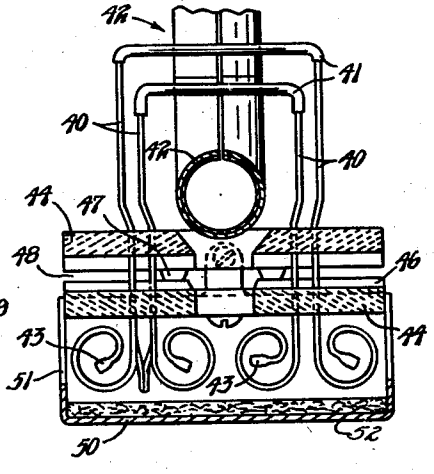


Fig. 4.



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THERMOELECTRIC GENERATOR

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15 Claims. (Cl. 136—4)

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This invention relates to an improved thermoelectric generator of a kind adapted to be used in conjunction with a fluid fuel burner. Another generator embodying some of the structural details of this invention is illustrated in my copending application, Serial No. 590,836, filed April 28, 1945.

It is one of the chief objects of the present invention to provide a highly efficient compact unit which may be economically produced and readily installed in existing burner installations or incorporated in new constructions.

It is well known in the thermoelectric art that the e. m. f. generated by a thermopile is proportional to the number of thermocouples employed and the temperature gradient between the hot and cold junctions of the couples, all of course, within limits adherent in such devices. It is also known that when the hot junction of a thermocouple is subjected to an open flame the metal at the junction oxidizes or deteriorates, thus decreasing the effective cross-sectional area of the metal. This reduces the electrical conductance of the member, impairs the efficiency of the device and sometimes results in complete failure or break-down.

Accordingly, another object of advantage and importance of this invention is to incorporate a relatively large number of couples in a unit wherein a high resistance to heat conductivity and a low electrical resistance is obtained without unduly increasing the overall dimensions of the device.

Another object of importance is the provision of novel means for increasing the life of the improved device by protecting the hot junctions thereof from direct contact with the energizing flame and the products of combustion thereof. Additionally, means are also provided for holding the heat of the energizing flame on the hot junctions, but permitting its rapid dissipation when the flame is extinguished.

A further object of advantage resides in the means for interposing a shielding element intermediate the hot and cold junctions of the thermopile and also for utilizing the shielding element in directing heat away from the cold junctions of the device.

Still another object of advantage and importance of the improved thermoelectric device of this invention resides in the means for forming the intermediate and cold junction portions of the thermocouples to provide a high resistance to heat conductivity between the hot and cold junctions, and to provide novel means for removing heat from the cold junctions and the intermediate portions of the thermocouples.

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A further object of advantage and importance is the provision of means for increasing the resistance to thermal convection by lengthening the legs of the thermocouples without increasing the overall dimensions of the unit.

An additional object of the present invention is to provide means for creating and directing a current of air over the cold junctions and toward the hot junctions of the device. The cold junctions are formed and disposed to present a considerable surface area to the air currents moving through the device.

Additional objects of advantage and importance will become apparent as the following detailed description progresses, reference being had to the accompanying drawing, wherein

Figure 1 is an elevational view of a thermoelectric device which embodies the invention, parts thereof being broken away.

Figure 2 is a vertical section taken on line 2—2 of Figure 1 looking in the direction indicated by the arrows.

Figure 3 is an elevational view of a slightly modified form of the invention, parts thereof being shown in section, and

Figure 4 is a sectional view taken on line 4—4 of Figure 3 looking in the direction indicated by the arrows.

The reference numeral 10 indicates generally a pilot supply line which has a horizontal portion and a vertical portion 11. The vertical portion 11 terminates in a pilot burner 12 as is best shown in Figures 1 and 2. Formed in the horizontal portion of the supply line 10 and extending along the vertical portion 11 thereof to the outlet 13 of the pilot burner 12 is a fuel emitting slot 14. Accordingly, when the pilot burner is ignited, a runner flame extends from the pilot flame along the vertical portion of the supply pipe and also along a portion of the horizontal section hereof. The portion of flame extending along the horizontal section is hereafter referred to as the thermopile flame.

Secured to the horizontal portion of the supply line 10 by screws 16 (only the right-hand one being shown) or other suitable means, is a thermopile which in its entirety is indicated by the reference numeral 17. The thermopile 17 comprises a plurality of thermocouples 18 and 19. The thermocouples 18 and 19 are substantially the same with the exception that thermocouples 19 are somewhat smaller in size as is best shown in Figure 2. The thermocouples 18 and 19 are substantially U-shaped and each is

constructed of two thermoelectrically dissimilar metals such as Copel and Chromel. The two pieces of metal are joined as by welding, fusing, or the like, to form the closed end of the U and the joint is then covered by a protective sleeve 21 of stainless steel or similar material, which also covers a considerable portion of the metal adjacent the joint. This portion of the thermocouple will hereinafter be referred to as the hot junction. The open ends of the U-shaped thermocouples are threaded through a plurality of perforations in a ceramic insulating member 22. The ceramic insulating member 22 is centrally apertured as at 23 and the side edges thereof are tapered for purposes hereinafter more fully explained. The ceramic member 22 maintains the thermocouples 18 and 19 in spaced alignment with the thermocouples indicated by the reference numeral 19 telescoped within the larger thermocouples 18. The portions of the thermocouples 18 and 19 above the ceramic member 22 are offset outwardly to increase their spacing from the burner and also to bring them into an updraft created by the thermopile flame. The depending ends of the thermocouples 18 and 19 which extend below the insulating member 22 are joined as by welding, or the like, to connect the thermocouples of both groups electrically. The joined ends of the thermocouples 18 and 19 are hereinafter referred to as cold junctions 26. The cold junctions 26 and wire closely adjacent thereto are turned upwardly as is clearly shown in Figures 1 and 2 to form U-shaped ends so that the length of the wires of the couples may be increased without increasing the overall dimensions of the unit and also to position large portions of the thermocouples in the path of air entering the device as hereinafter more fully explained. Electric conductors 27 are extended from the electrically connected thermocouples as is best shown in Figure 1.

Secured to the thermocouple assembly 17 as by means of screws 28 is a casing member 30. The casing member 30 is preferably rectangular in shape and portions of the sides thereof are cut away as at 31 to reduce the heat conductivity of the material and also to provide air passages to the interior thereof. It is to be noted that the lower cut-away portions 31 of casing member 30 are in alignment with the upwardly turned cold junctions of the thermocouples. Accordingly, air passing through the cut-away portions comes directly into contact with the U-shaped ends and the cold junctions 26. An insulating member 32 preferably of asbestos, or the like, is positioned between the bottom of the casing member and the downwardly projecting portions of the thermocouples as is best shown in Figure 2.

Secured to a block 29 on the upper portion of the casing member 30 closely adjacent one end thereof is a substantially L-shaped baffle member 33 made of stainless steel or similar material. One portion of the baffle member 33 extends vertically and the other portion thereof extends horizontally and slightly above the hot junctions of the thermocouples 18. Secured to the vertical portion of the baffle 33 and extending horizontally therefrom and thence upwardly is a second L-shaped baffle 34 made of like material. A clip member 35 adjacent the vertical portion 36 maintains the baffle 34 parallel to and beneath the hot junctions of the thermocouples 19. The vertical portion 36 of baffle 34 protects the sleeves 21 and hot junctions from direct contact with the runner flame. There is thus provided a

shielding baffle plate at both ends and above and below the aligned double bank of hot junctions. The upper baffle 33 functions to protect the flame beneath the hot junctions from combustion chamber disturbances such as concussions, back flashes, and the like and radiant heat from the main burner. This baffle also serves to retard the flow of heat from the hot junction and thus tends to maintain a relatively constant temperature in the space between the two baffles during fluctuation in the temperature generated by the heating source. The lower baffle 34 which is positioned between the flame and the under portion of the hot junction prevents direct contact by the flame and tends to dissipate the heat evenly over all of the hot junctions. During operation of the device, the baffles tend to maintain a constant and even temperature on the hot junctions, but when the thermopile flame is extinguished, the heat of the hot junctions and in the space between the two baffles is rapidly dissipated through the open side portions thereof.

Operation of the improved thermoelectric generator of this invention is substantially as follows: upon ignition of the fuel at the pilot outlet 13 a runner flame extends along the slot 14 to ignite fuel emanating from the horizontal portion thereof to establish a thermopile actuating flame. This actuating flame impinges on the baffle 34 which thereupon becomes heated and the heat therefrom traveling upwardly contacts and heats the hot junctions of the thermocouples 19 and 18. The heat from the baffle 34 is disrupted in its upward travel by the baffle 33, and as a result a relatively constant temperature is established in the space between the two baffles. The upwardly directed thermopile flame and the heat therefrom creates an updraft which is fed by air passing through the cut-away portions 31 of the casing member 30 and the aperture 23 in the central portion of the ceramic member 22. The flow of air through the opening 31 bathes the U-shaped ends and the cold junctions of the thermopile and conducts heat therefrom upwardly through the central aperture 23. Thus, means are provided for maintaining a relatively high temperature gradient between the hot and cold junctions of the improved device. When the thermopile and pilot flame are extinguished, the up-draft created thereby diminishes as the device cools and the heat of the hot junctions is carried away through the side opening between the two baffles. Energy generated by the improved device is conducted therefrom through the leads indicated by the referenec numeral 27. The energy thus created may be utilized for operating a valve, or the like, in controlling the supply of fuel to a main burner with which the device may be associated.

In the modified form of the invention shown in Figures 3 and 4, the structure is similar to the construction shown in Figures 1 and 2. In this embodiment, the thermoelectric generator comprises a plurality of substantially U-shaped thermocouples 40 connected in series, and mounted in two banks as in the preferred embodiment. One bank of thermocouples 40 is telescoped within the other bank as is best shown in Figure 4 and the hot junctions 41 thereof are in spaced parallel alignment with those of one group on a plane above those of the other group and both groups positioned above a thermopile burner 42. The portions of the thermocouples immediately below the hot junc-

tions are offset in respect to the portions immediately above the cold junctions to increase their spacing from the generating flame and also to permit up-draft caused by the flame to conduct heat therefrom. Formed at the open end of the U-shaped thermocouple members 40 are cold junctions indicated by the reference numeral 43. The cold junctions 43 and the portions of the thermocouples adjacent thereto are curled or turned, as is best shown in Figures 3 and 4, for a purpose hereinafter more fully explained. Interposed between the hot and cold junctions is a ceramic shielding member 44. The shielding member 44 serves the double purpose of maintaining the thermocouples in spaced alignment and also of protecting and shielding the cold junctions 43 from heat generated by the burner 42. Opposed faces of the ceramic shielding member are provided with ribs 46 and 47 as is clearly shown in the drawing. These ribs 46 and 47 provide a relatively small contacting surface between the sections, thus greatly reducing the conductance of heat therethrough, and also maintain the balance of the surfaces of the section in spaced apart relation to form an air passage 48 therebetween.

Secured to the sectional ceramic member 44 as by screws 49 is a casing member 50. The casing member 50 is substantially rectangular in form and the side portions thereof are cut away as at 51 to provide an air passage into the interior of the casing member and also to reduce the heat conductivity of the material. The casing member 50 is disposed to encase the cold junctions 43 of the thermocouples as is best shown in Figures 3 and 4. An insulating member 52, preferably of asbestos, or the like, is interposed between the cold junctions 43 and the bottom of the casing member 50.

In the embodiment shown in Figures 3 and 4, the baffle plates shown in the other embodiment have been omitted for the purpose of more clearly showing other features of the modified embodiment.

Operation of the embodiment here described is substantially the same as is the operation of the preferred embodiment. However, it is to be noted that air drawn through the opening 51 in the casing member 50 to feed the up-draft created by the flame from the furner 42 passes over and removes heat from greater portions of the thermocouples adjacent the cold junctions thereof than in the first described embodiment. This is made possible without increasing the over-all dimension of the casing member 50 by turning or curling the cold junctions as shown in Figure 4. The current of air passing through the opening 51 into the interior of the casing member 50 is directed upwardly through the central aperture in the shielding unit 44. As the current passes through the central aperture additional air is fed thereinto through the air passage 48. As the air is discharged from the central aperture it is deflected outwardly so as to bathe and remove heat from the portions of the thermocouples immediately above the shielding member 44. Thus the interior of the shielding unit as well as the intermediate and cold junction portions of the couples are cooled by air currents set in motion by the thermopile flame.

It will be apparent from the foregoing that herein is provided an improved thermoelectric generator wherein means are provided for maintaining the hot junctions thereof at a substantially constant temperature during operation of the device regardless of fluctuation in the thermopile flame caused by variations of pressure in the fuel supply. Moreover, upon extinguishment of the thermopile flame, the hot junctions of the improved device may quickly cool to a temperature substantially the same as that of the cold junctions.

It will also be apparent that various changes in construction and design may be made without departing from the spirit or scope of the invention. Accordingly, the patent granted hereon is not to be limited to the precise embodiments here shown or in any other manner except as may be necessitated by the terminology of the appended claims when given the range of equivalents to which they may be entitled.

I claim as my invention:

1. In a thermoelectric generator adapted to be used in conjunction with an energizing source of heat, a first group of thermocouples in spaced alignment, each of said thermocouples comprising an inverted substantially U-shaped member, a second group of substantially similar thermocouples telescoped within and spaced from said first aligned group, said thermocouples being electrically connected, the closed upper ends of said U-shaped thermocouples comprising the hot junctions and the open lower ends therof comprising the cold junctions, a protective sleeve positioned over the hot junction of each thermocouple and secured thereto, a centrally apertured insulating member positioned intermediate said hot and cold junctions and providing means for maintaining said thermocouples in spaced apart alignment, the portions of said thermocouples beneath said insulating member being turned to form a plurality of loops, said insulating member and said thermocouples being positioned to provide heat generator receiving means intermediate said insulating member and said hot junctions, a case secured to said insulating member and enclosing said cold junctions, said case being apertured to provide a circulation of air over said cold junctions and upwardly through the centrally located aperture of said insulating member when the device is in operation, and a heat retaining protective member positioned above and spaced from said hot junctions.

2. In a thermopile, a first group of thermocouples in spaced alignment, each of said thermocouples comprising an inverted substantially U-shaped member, a second group of substantially similar thermocouples positioned within and spaced from the thermocouples of said first group, said thermocouples being electrically connected, the closed upper ends of said U-shaped thermocouples comprising the hot junctions and the open lower ends thereof comprising the cold junctions, a centrally apertured insulating member positioned intermediate said hot and said cold junctions, the portions of said thermocouples extending below said insulating member being turned to form a plurality of loops, an apertured member secured to said insulating member and encasing said cold junctions, the apertures in said encasing member and the aperture in said insulating member providing inlet and outlet means respectively for the passage of air over said cold junctions, and baffle means positioned above and below said hot junctions and spaced therefrom.

3. In a thermoelectric generator adapted to be used in conjunction with an energizing source of heat, a plurality of electrically connected thermo-

couples, each of said thermocouples comprising an inverted substantially U-shaped member, the closed upper end of each U-shaped member comprising the hot junction and the spaced lower end thereof comprising the cold junction, a centrally apertured heat insulating member positioned intermediate said hot and cold junctions, the portions of said thermocouples beneath said heat insulating member being turned to form a plurality of loops, heat generator receiving means formed within said U-shaped members and intermediate said insulating member and said hot junctions, shielding means positioned beneath and above said hot junctions and spaced therefrom, an apertured member secured to said heat insulating member and encasing said cold junctions, and means formed by the apertures of said encasing member and said heat insulating member for directing air over said looped cold junctions.

4. In a thermoelectric generator, a plurality of electrically connected thermocouples, each of said thermocouples comprising an inverted substantially U-shaped member, the closed upper end of said member comprising a hot junction and the spaced lower end thereof comprising a cold junction, means interposed between said hot and cold junctions for protecting said cold junctions from heat applied to said hot junctions, said cold junctions being curled to form a plurality of loops, a member encasing said loops, openings in said encasing member permitting the passage of air therethrough and over said loops, means for directing heated air from said loops and toward said hot junctions, heat generator receiving means formed within said U-shaped members and intermediate said hot junctions and said protecting means, and means preventing the rapid passage of heat from said hot junctions when the generator is in operation.

5. In a thermoelectric generator adapted to be used in conjunction with an energizing source of heat, a plurality of electrically connected thermocouples, each of said thermocouples comprising an inverted substantially U-shaped member, the closed upper end of each member comprising the hot junction and the open lower end comprising the cold junction thereof, heat insulating means positioned intermediate said hot and cold junctions, the portions of said thermocouples beneath said heat insulating means being turned to form a plurality of loops, heat generator receiving means formed intermediate said insulating means and the hot junctions of said thermocouples, and a heat retaining protective member positioned above and spaced from said hot junctions.

6. In a thermoelectric generator adapted to be used in conjunction with an energizing source of heat, a plurality of electrically connected thermocouples, each of said thermocouples comprising an inverted substantially U-shaped member, the closed upper end of each member comprising the hot junction and the open lower end comprising the cold junction thereof, heat insulating means positioned intermediate said hot and cold junctions, the portions of said thermocouples beneath said heat insulating means being curled to form a plurality of loops, heat generator receiving means formed intermediate said insulating means and the hot junctions of said thermocouples, shielding means positioned closely adjacent and beneath said hot junctions, and a heat retaining protective member positioned above and spaced from said hot junctions.

7. In a thermoelectric generator adapted to be used in conjunction with an energizing flame, a plurality of thermocouples, each of said thermocouples comprising an inverted substantially U-shaped member, the closed upper end of each member comprising the hot junction and the open lower end thereof comprising the cold junction, heat insulating means positioned between said hot and said cold junctions, the portions of said thermocouples below said heat insulating means turned upon themselves and spaced therefrom to form a plurality of loops, said cold junctions being electrically connected, and flame deflecting means positioned beneath said hot junctions.

8. In a thermopile adapted to be used in conjunction with an energizing flame, a plurality of electrically connected thermocouples, each of said thermocouples comprising an inverted substantially U-shaped member, the closed end of said U-shaped member comprising the hot junction and the open end the cold junction thereof, a flame deflecting member positioned beneath said hot junctions and spaced therefrom, and a heat retaining member positioned closely above said hot junctions.

9. In a thermopile adapted to be used in conjunction with an energizing flame, a plurality of electrically connected thermocouples, each of said thermocouples comprising an inverted substantially U-shaped member, the closed end of said member comprising the hot junction and the open end thereof the cold junction, a centrally apertured heat insulating member positioned intermediate the hot and cold junctions of said thermopile, said aperture being disposed to permit the passage of air between said cold junctions and toward said hot junctions, a flame deflecting member positioned beneath said hot junctions and spaced therefrom, and a heat retaining member positioned closely above said hot junctions.

10. In a thermoelectric generator, a first group of thermocouples in spaced alignment, each of said thermocouples comprising an inverted substantially U-shaped member, a second group of substantially similar thermocouples telescoped within and spaced from said first aligned group, heat deflecting means interposed between the open and closed ends of said inverted U-shaped thermocouples, and a baffle plate positioned beneath the closed ends of said inverted U-shaped thermocouples.

11. In a thermoelectric generator, a first group of thermocouples in spaced alignment, each of said thermocouples comprising an inverted substantially U-shaped member having hot and cold junctions, a second group of substantially similar thermocouples telescoped within and spaced from said first group, the thermocouples of said first and said second groups being electrically connected, and means producing a relatively high heat conduction resistance between the hot and cold junctions of said thermocouples.

12. In a thermoelectric generator, a first group of thermocouples having hot and cold junctions positioned in spaced alignment, each of said thermocouples comprising an open end loop, a second group of similarly shaped thermocouples positioned within and spaced from said second group, heat shielding means interposed intermediate said hot and cold junctions and providing means for maintaining said thermocouples electrically insulated one from another, and

means for electrically connecting said thermocouples one to another.

13. In a thermoelectric generator, a first group of thermocouples disposed in spaced alignment, each of said thermocouples comprising a pair of wires of dissimilar thermoelectric characteristics joined to provide hot junctions, the remainder of said wires being spaced apart and terminating in cold junctions, a second group of similar thermocouples telescoped within and spaced from said first group and disposed with their hot junctions on a plane below the hot junctions of said first group, and means electrically connecting said first and said second groups of thermocouples.

14. In a thermoelectric generator to be used in conjunction with an energizing flame, a thermocouple, said thermocouple comprising an inverted substantially U-shaped member, the closed end of said U-shaped member comprising the hot junction and the open end thereof comprising the cold junctions, heat insulating means positioned on said thermocouple intermediate said hot and cold junctions, means for cooling the interior of said heat insulating means, and protective baffle means positioned above and below said hot junction and spaced therefrom.

15. In a thermoelectric generator, a first group of thermocouples in spaced alignment, each of said thermocouples comprising an inverted substantially U-shaped member having hot and cold junctions, and a second group of substantially similar thermocouples telescoped within and spaced from said first group, the thermocouples of said first and second groups being electrically connected.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,648,899	Hayman	Nov. 15, 1927
1,952,550	Kerr	Mar. 27, 1934
1,977,340	King	Oct. 16, 1934
2,181,843	Wantz	Nov. 28, 1939
2,291,812	Kliever	Aug. 4, 1942
2,310,026	Higley	Feb. 2, 1943
2,311,785	Sparrow	Feb. 23, 1943
2,322,410	Alfery	June 22, 1943
2,372,506	Mantz	Mar. 27, 1945
2,407,517	Ray	Sept. 10, 1946

OTHER REFERENCES

General Controls Catalog (1940) page 16.