May 25, 1965 R. C. SMITH 3,185,106

SPARK PUMPS

Filed Aug. 28, 1963 2 Sheets-Sheet 1

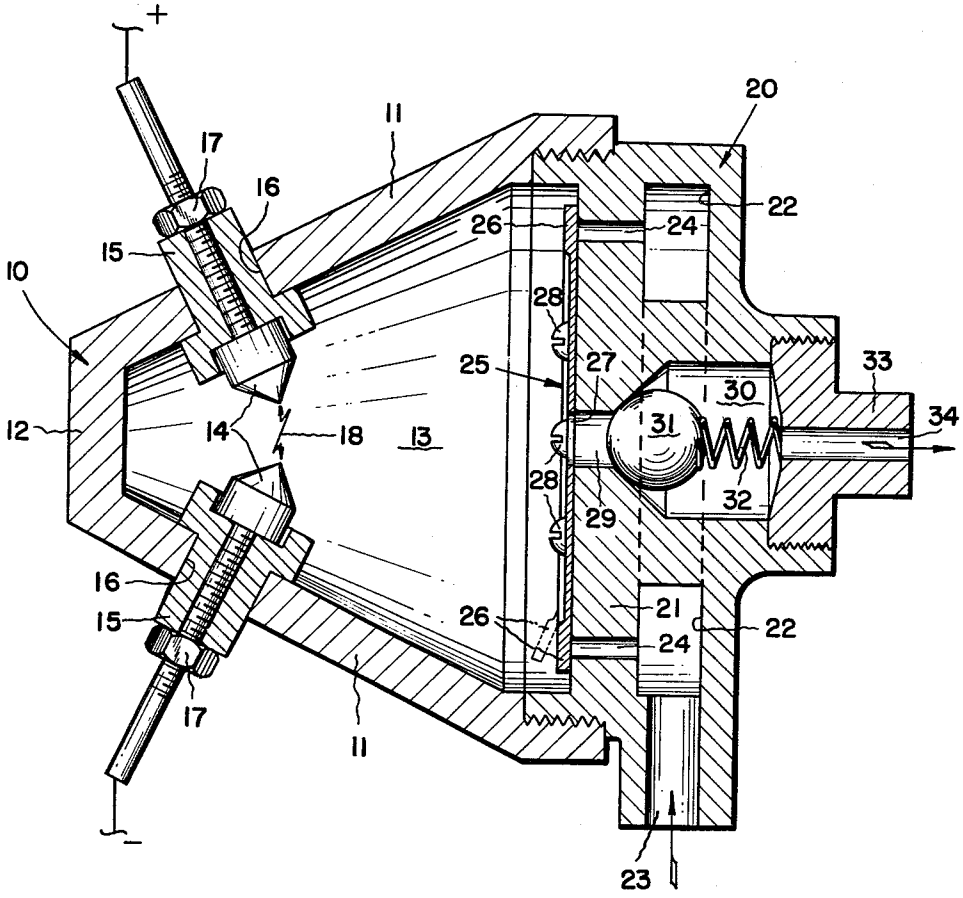

FIG. 1

INVENTOR.
RALPH C. SMITH
BY Charles J. Worth
AGENT

May 25, 1965 R. C. SMITH 3,185,106

SPARK PUMPS

Filed Aug. 28, 1963 2 Sheets-Sheet 2

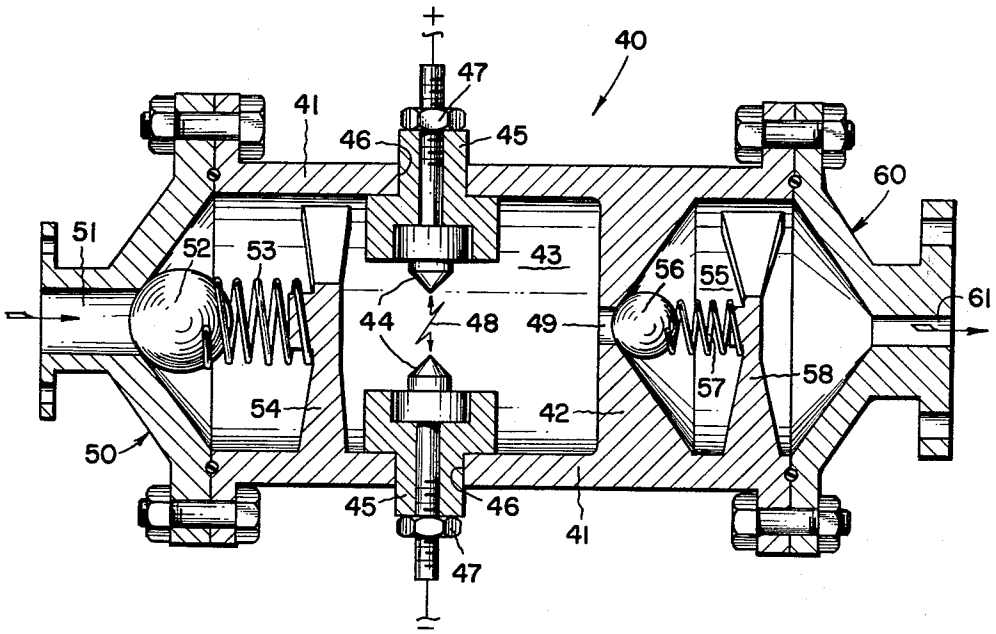

FIG. 2

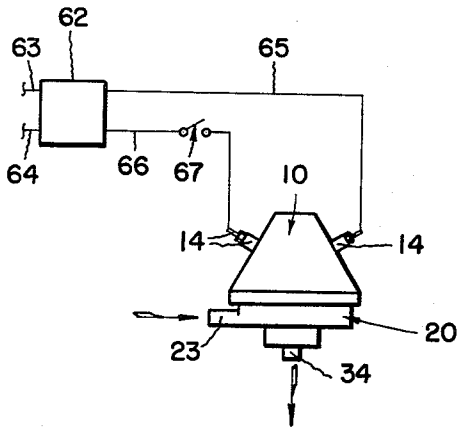

FIG. 3

INVENTOR.
RALPH C. SMITH
BY Charles J. Worth
AGENT

United States Patent Office 3,185,106 Patented May 25, 1965

3,185,106

SPARK PUMPS

Ralph C. Smith, Brooklyn, N.Y., assignor to Ingersoll-Rand Company, New York, N.Y., a corporation of New Jersey

Filed Aug. 28, 1963, Ser. No. 305,041
13 Claims. (Cl. 103—255)

This invention relates generally to pumps and more particularly to pumps wherein electrical energy is converted directly to pressure fluid delivery.

While the general concept of pressurizing fluid as is embodied in this invention, in itself is not new, utilizing electrical energy in the manner to be described to provide pressure fluid delivery is a new approach to providing very high pressure fluid source means.

Accordingly, an object of this invention is to provide a novel pump having no moving parts other than flow control portions thereof.

Another object of this invention is to provide the aforementioned pump wherein an electrical charge forms the pressurizing or pumping means.

Still another object of this invention is to provide a fluid pump having relatively no moving parts; and which is ruggedly constructed and is relatively economical to manufacture.

And another object of this invention is to provide a pump utilizing an electrical charge for depriving pressure fluid delivery.

This invention contemplates a pump comprising a housing defining a pump chamber provided with an inlet adapted to receive fluid to be pumped and an outlet for pumped liquid, a pair of electrodes supported by the housing having tips in spaced relation to one another within the chamber for forming a gap to be jumped by a spark to expand fluid in the chamber for pumping, the electrodes being adapted to be connected to a source of electrical energy to derive a spark across the formed gap, and check valve means in the housing biased to normally close the inlet and outlet, the check valve means being responsive to the reaction of a spark for opening the outlet to pass pumped fluid and to pressure differential between the inlet and the pump chamber after such pumping for opening the inlet to admit fluid to the pump chamber.

The foregoing and other objects and advantages will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein several embodiments of the invention are illustrated, by way of sample. It is to be expressly understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

FIGURE 1 is a sectional view diagrammatically illustrating a pump made in accordance with the present invention,

FIGURE 2 is a sectional view diagrammatically illustrating a modified pump, and,

FIGURE 3 is a schematic illustration of the pump of FIGURE 1 connected in circuit for operation.

Referring now to the drawings, and specifically to FIGURE 1, a pump made in accordance with the present invention has a chamber casing **10** and a valve end casing **20** providing a pump housing. Chamber casing **10** is of conical configuration providing an annular wall **11** which defines a pump chamber **13** therein that is closed at one end by a wall **12**. A pair of electrodes **14** are provided with tips that are in face to face spaced relation to one another within the pump chamber **13** thus forming a spark gap **18** therebetween. The electrodes **14** are mounted in insulators **15** which extend through openings **16** and the wall **11** and, for adjustment, may have threaded shanks as shown which engage the insulators **15** and are locked in place by nuts **17**.

The other end of the chamber casing **10** opposite from the end wall **12** may be threaded or otherwise formed to sealingly engage and hold the valve end casing **20** which provides a wall portion **21** to close that end of the pump chamber **13**. The valve end casing **20** has an annular inlet chamber **22** in communication with a pump inlet **23** adapted to be connected to a source of liquid, provided with a low head, to be pumped. A series of passages **24** through the end wall portion **21** of the valve end casing **20** connect the annular chamber **22** to the pump chamber **13** and are normally closed by reeds **26** of an inlet valve plate **25** connected to the valve end casing **20** by screws **28**, or other such similar conventional means well known in the art. Inlet valve plate **25** has a central opening **27** in alinement with a centrally disposed passage **29** in the end wall portion **21**, and together connect the pump chamber to an outlet valve chamber **30**. Opening **29** is normally closed by a ball check **31** that is biased to a closing position by a spring **32**. The outer end of the valve end casing **20** may also be threaded to receive and sealingly retain a plug **33** which has a passage **34** forming the pump outlet. Plug **33** also provides a seat for the biasing spring **32**.

In operation, with chamber **13** substantially filled with liquid to be pumped, a spark between the electrodes **14**, across gap **18**, will cause the liquid to expand and overcome the force of spring **32**, thus discharging pressure fluid through the openings **27** and **29** into the outlet valve chamber **30**, and thence through the pump outlet **34**. While the reeds **26** of inlet valve plate **25** normally close the inlet passages **24**, the rise of pressure of the liquid in pump chamber **13** further tends to seal the inlet passages.

When the effects of the spark across the gap **18** dissipates, the chamber **13** will be under a partial vacuum suffficient to draw liquid through the pump inlet **23**, which should have a positive head, the annular chamber **22**, and the passages **24**. This pressure differential across the inlet valve plate **25** is sufficient to urge the reeds **26** away from the wall portion **21** to open the passages **24** and provide inlet flow to the pump chamber **13**. With the pump chamber **13** again substantially filled with liquid, and the pressure across the valve plate **25** equalized, reeds **26** again will proceed to close passages **24**. A subsequent spark across gap **18** will again cause expansion of the liquid in the pump chamber **13** to derive further discharge.

It is not necessary in all cases to completely fill the pump chamber **13** with liquid, however, the electrodes **14** should be fully submersed in the liquid for efficient operation. In some instances entrapped air in the pump chamber **13** may be desirable to act as an air spring which would then tend to reduce pulsations of the discharge fluid. Although the pump shown in FIGURE 1 provides an inlet and outlet at a common end, a pump made in accordance with the present invention as shown in FIGURE 2 may provide axial flow therethrough. As shown in the drawings, the modified pump has a chamber casing **40** with an annular wall **41** defining a pump chamber **43** therein closed at one end by a wall **42**. A pair of electrodes **44** are provided, similar to the electrodes **14** of FIGURE 1, which are supported in insulators **45** extending through openings **46** in the annular wall **41**. Lock nuts **47** are also provided to act as do the lock nuts **17** of FIGURE 1. An inlet end cap **50** is connected to the chamber casing **40** by bolts, as shown or by any other conventional means, and has a pump inlet **51** adapted to be connected to a source of pressure fluid. A ball check **52** is provided to close the pump inlet **51** and is biased to its closing position by a spring **53** that abuts a seat provided by a spider **54** within the pump chamber **43**.

End wall **42** has a central outlet opening **49** which connects the pump chamber **43** to an outlet of chamber **55** in the end of chamber casing **40** opposite from inlet end cap **50**. Another ball check **53** is provided for closing the outlet passage **49** and is biased by a spring **57** to its closing position. A second spider **58** provides a seat for the spring **57**.

An outlet end cap **60** is connected to the chamber casing **40**, in a manner similar to the connection of the inlet end cap **50**, and has an outlet passage **61** for the pressure fluid being pumped.

In operation, with pump chamber **43** substantially filled with liquid, a spark between the electrodes **44**, across a spark gap **48** formed therebetween, causes the liquid to expand. The force of expansion overcomes the bias of spring **57** thus urging the ball check **56** off of its seat for opening passage **49** to provide discharge flow of pressure fluid through the outlet valve chamber **55** and, thence, the pump outlet **61**. Again, the force of expansion of the fluid in pump chamber **43** acts on ball check **52** to further seal the inlet **51**. When the effects of a spark across gap **48** terminates and pressure fluid has finally been discharged, spring **57** will again urge ball check **56** onto its seat closing the outlet passage **49**. Similar to the action of the pump of FIGURE 1, the pressure differential across the inlet valve will overcome the bias of spring **53** thus, urging ball **52** from its seat and providing inlet flow of fluid through the pump inlet **51** to the pump chamber **43**. With the pump chamber **43** substantially filled and the pressure differential across the inlet ball check **52** being equalized, spring **53** will again urge ball **52** to its closing position. A subsequent spark across the gap **48** will again cause expansion of the liquid in the chamber **43** thus providing pressure fluid discharge as previously described.

FIGURE 3 diagrammatically illustrates means for connecting the pump of FIGURE 1 to a source of electrical energy. As shown, the two electrodes **14** are connected to a source of high voltage **62** by lines **65** and **66**. A switch **67** may be disposed in one of the lines, in this instance being line **66**. By controlling the opening and closing of switch **67** voltage flow may be controlled to the electrodes **14** to control sparking within the chamber casing **10**.

The source of electrical energy **62** may be a storage bank, such as an RC complex which is well known in the art, connected to an A.C. source by leads **63** and **64**. It should also be understood that switch **67** may be omitted from the circuit and sparking controlled by adjusting the gap **18** between the electrodes **14** and the rate of charge build-up sufficient to jump the gap as required. Still another control means (not shown) is to provide a variable primary or control gap in one of the lines **65** and **66**. In this manner, the variable gap (not shown) controls voltage flow by requiring a higher charge than does gap **18**. It should be realized that the resistance of the liquid to be pumped must be considered.

By the foregoing, it should be understood that a pump having a valved inlet and a valved outlet, is provided with a pair of spaced electrodes forming a spark gap submerged in liquid to be pumped. A controlled spark across the formed gap causes expansion of liquid within the pump chamber which overcomes the outlet valve to provide pump discharge. By terminating the spark and after discharge is complete, the discharge valve closes and the pressure differential across the inlet valve causes it to open to again fill the pump chamber with liquid.

Although several embodiments of the invention have been illustrated and described in detail, it is expressly understood that the invention is not limited thereto. Various changes may also be made in the design and arrangement of parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

I claim:

1. A pump comprising:
(*a*) a housing defining a conical pump chamber with an inlet adapted to receive liquid to be pumped and an outlet for pumped liquid at the larger end of the pump chamber;
(*b*) a pair of electrodes supported by the housing having tips within the chamber in spaced relation to one another for forming a gap to be jumped by a spark for pumping;
(*c*) the pair of electrodes being adapted to be connected to a source of electrical energy to provide a spark;
(*d*) check valve means disposed in the housing being biased to normally close the inlet and outlet; and
(*e*) the check valve means being responsive to the reaction of a spark across the formed gap for opening the outlet to pass pumped liquid and to a pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

2. A pump comprising:
(*a*) a housing defining a pump chamber with an inlet adapted to receive liquid to be pumped and an outlet for pumped liquid;
(*b*) the pump chamber consisting of a conical wall that is larger at its one end closer to the outlet than its other end;
(*c*) a pair of insulators extending through the housing and being supported thereby;
(*d*) a pair of electrodes each extending through one of the insulators and being supported thereby;
(*e*) the electrodes having tips within the pump chamber in spaced relation to one another for forming a gap to be jumped by a spark for pumping and being adapted to be connected to a source of electrical energy to provide a spark;
(*f*) check valve means disposed in the housing being biased to normally close the inlet and outlet; and
(*g*) the check valve means being responsive to the reaction of a spark across the formed gap for opening the outlet to pass pumped liquid and to a pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

3. A pump comprising:
(*a*) a housing defining a pump chamber with an inlet adapted to receive liquid to be pumped and an outlet for pumped liquid;
(*b*) the pump chamber consisting of a conical wall that is larger at its one end closer to the outlet than its other end;
(*c*) a pair of electrodes supported by the housing having tips within the chamber in spaced relation to one another for forming a gap to be jumped by a spark for pumping;
(*d*) the pair of electrodes being adapted to be connected to a source of electrical energy to provide a spark;
(*e*) a check valve disposed in the housing being biased to normally close the outlet and being responsive to the reaction of the spark for opening the outlet to pass pumped liquid therethrough; and
(*f*) another check valve disposed in the housing being biased to normally close the inlet and being responsive to pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

4. A pump comprising:
(*a*) a housing defining a pump chamber with an inlet adapted to receive liquid to be pumped and an outlet for pumped liquid;
(*b*) the pump chamber consisting of a conical wall that is larger at its one end closer to the outlet than its other end;

(c) a pair of insulators extending through the housing and being supported thereby;
(d) a pair of electrodes each extending through one of the insulators and being supported thereby;
(e) the electrodes having tips within the pump chamber in spaced relation to one another for forming a gap to be jumped by a spark for pumping and being adapted to be connected to a source of electrical energy to provide a spark;
(f) a check valve disposed in the housing being biased to normally close the outlet and being responsive to the reaction of the spark for opening the outlet to pass pumped liquid therethrough; and
(g) another check valve disposed in the housing being biased to normally close the inlet and being responsive to pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

5. A pump comprising:
(a) a housing defining a pump chamber with an inlet at one end thereof adapted to receive liquid to be pumped and an outlet at the same end as the inlet for pumped liquid;
(b) the pump chamber having a conical wall that is larger at its one end closer to the outlet than its other end;
(c) a pair of insulators extending through the housing and being supported thereby;
(d) a pair of electrodes each extending through one of the insulators and being supported thereby;
(e) the electrodes having tips within the pump chamber in spaced relation to one another for forming a gap to be jumped by a spark for pumping and being adapted to be connected to a source of electrical energy to provide a spark;
(f) a check valve disposed in the housing being biased to normally close the outlet and being responsive to the reaction of the spark for opening the outlet to pass pumped liquid therethrough; and
(g) another check valve disposed in the housing being biased to normally close the inlet and being responsive to pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

6. A pump comprising:
(a) a housing defining a pump chamber with an inlet at one end thereof adapted to receive liquid to be pumped and an outlet at the end opposite from the inlet for pumped liquid;
(b) the pump chamber consisting of a conical wall that is larger at its one end closer to the outlet than its other end;
(c) a pair of insulators extending through the housing and being supported thereby;
(d) a pair of electrodes each extending through one of the insulators and being supported thereby;
(e) the electrodes having tips within the pump chamber in spaced relation to one another for forming a gap to be jumped by a spark for pumping and being adapted to be connected to a source of electrical energy to provide a spark;
(f) a check valve disposed in the housing being biased to normally close the outlet and being responsive to the reaction of the spark for opening the outlet to pass pumped liquid therethrough; and
(g) another check valve disposed in the housing being biased to normally close the inlet and being responsive to pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

7. A pump comprising:
(a) a housing defining a pump chamber with an inlet adapted to receive liquid to be pumped and an outlet for pumped liquid;
(b) the pump chamber consisting of a conical wall that is larger at its one end closer to the outlet than its other end;
(c) a pair of insulators extending through the housing and being supported thereby;
(d) a pair of electrodes supported by the insulators and being adapted to be connected to a source of electrical energy to provide a spark;
(e) the electrodes having tips within the pump chamber in spaced relation to one another for forming a gap to be jumped by a spark, and each being movable relative to its supporting insulator and the other electrode to adjust the gap formed between the spaced tips;
(f) a check valve disposed in the housing being biased to normally close the outlet and being responsive to the reaction of the spark for opening the outlet to pass pumped liquid therethrough; and
(g) another check valve disposed in the housing being biased to normally close the inlet and being responsive to pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

8. A pump comprising:
(a) a first casing having an annular wall defining a conical pump chamber and an end wall for closing one end of the chamber;
(b) a pair of insulators extending through the annular wall and supported thereby;
(c) a pair of electrodes supported by the insulators being adapted to receive electrical energy for providing a spark to jump a gap through the liquid to be pumped;
(d) the pair of electrodes having tips within the pump chamber in spaced relation to one another to provide a spark gap therebetween;
(e) a second casing connected to the first casing and providing a wall portion closing the end of the pump chamber opposite from the end wall of the first casing;
(f) the second casing having an inlet adapted to receive liquid to be pumped and an outlet for pumped liquid each extending through the wall portion and in communication with the pump chamber;
(g) a pair of check valves operatively associated with the second casing being biased to normally close the inlet and outlet;
(h) one of the pair of check valves being responsive to the reaction to a spark for opening the outlet to pass pumped liquid; and
(i) the other of the pair of check valves being responsive to pressure differential between the inlet and the pump chamber for opening the inlet after pumping to admit liquid to be pumped to the pump chamber.

9. The pump in accordance with claim 8, wherein the inlet comprises:
(a) an annular chamber encircles the outlet; and
(b) a plurality of ports extending through the wall portion of the second casing providing communication between the annular chamber and the pump chamber.

10. The pump in accordance with claim 9, wherein:
(a) the other of the pair of check valves is a plate connected to the wall portion of the second casing within the pump chamber and provided with a plurality of reeds disposed in series around its periphery each overlying and normally closing one of the plurality of ports to flow between the annular chamber and the pump chamber.

11. A pump comprising:
(a) a first casing defining a pump chamber open at one end and having an end wall for closing the other end of the chamber;

(*b*) the pump chamber having a conical wall that is larger at its one end closer to the open end of the chamber than its other end;

(*c*) a pair of insulators extending through the first casing and supported thereby;

(*d*) a pair of electrodes supported by the insulators being adapted to receive electrical energy for providing a spark to jump a gap through the liquid to be pumped;

(*e*) the pair of electrodes having tips within the pump chamber in spaced relation to one another to provide a spark gap therebetween;

(*f*) a second casing connected to the first casing and providing a wall portion closing the end of the pump chamber opposite from the end wall of the first casing;

(*g*) the second casing having an inlet adapted to receive liquid to be pumped and an outlet for pumped liquid each extending through the wall portion and being in communication with the pump chamber;

(*h*) a pair of check valves operatively associated with the second casing being biased to normally close the inlet and outlet;

(*i*) one of the pair of check valves being responsive to the reaction to a spark for opening the outlet to pass pumped liquid; and

(*j*) the other of the pair of check valves being responsive to pressure differential between the inlet and the pump chamber for opening the inlet after

pumping to admit liquid to be pumped to the pump chamber.

12. The pump in accordance with claim 11, wherein the inlet comprises:

(*a*) an annular chamber encircles the outlet; and

(*b*) a plurality of ports extending through the wall portion of the second casing providing communication between the annular chamber and the pump chamber.

13. The pump in accordance with claim 12, wherein:

(*a*) the other of the pair of check valves is a plate connected to the wall portion of the second casing within the pump chamber and provided with a plurality of reeds disposed in series around its periphery each overlying and normally closing one of the plurality of ports to flow between the annular chamber and the pump chamber.

References Cited by the Examiner

UNITED STATES PATENTS

1,719,572	7/29	Stoll	230—231
1,871,285	8/32	Tursky	230—231
3,014,428	12/61	Kimberly	103—255
3,103,783	9/63	Smith	103—1
3,106,169	10/63	Prosser et al.	230—231
3,114,326	12/63	Yaindl	103—230
3,141,296	7/64	Jacobs	103—1

LAURENCE V. EFNER, *Primary Examiner.*