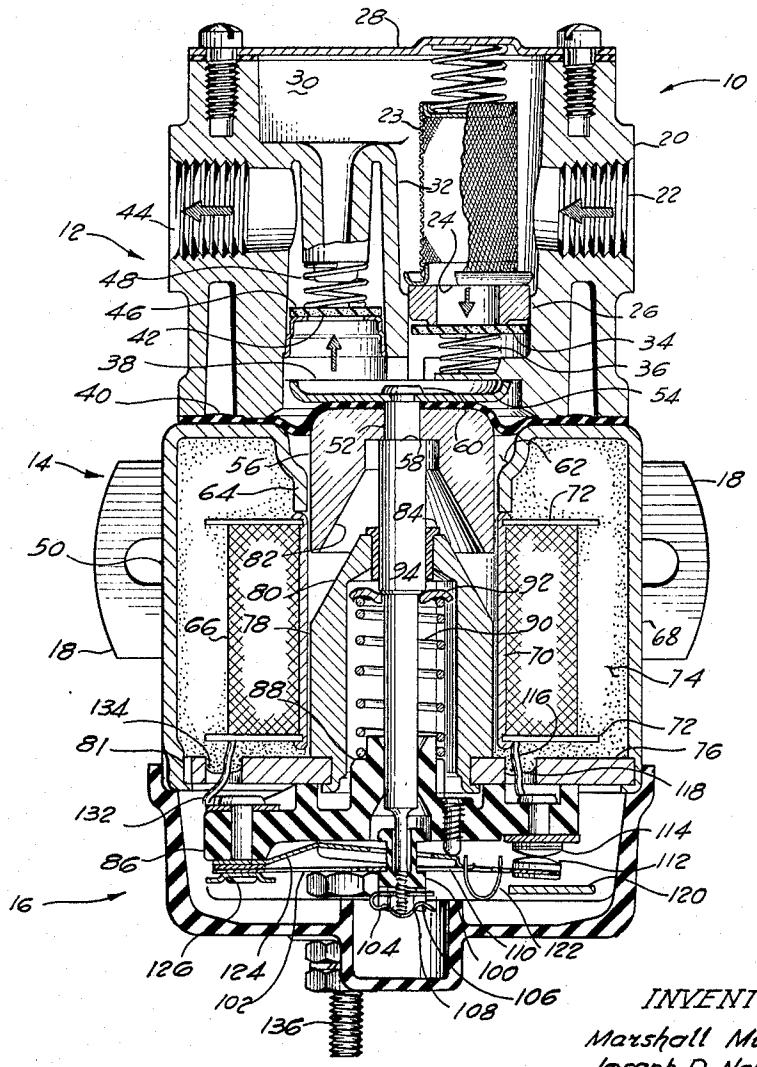
Sept. 20, 1966 M. MILES ETAL 3,273,505

ELECTRICALLY OPERATED FUEL PUMP

Filed Nov. 10, 1964 2 Sheets-Sheet 1

FIG. 1.



INVENTORS
Marshall Miles
Joseph D. Northrup
Edward T. Prell.

By Norton Lewis
Attorney

Sept. 20, 1966 M. MILES ETAL 3,273,505

ELECTRICALLY OPERATED FUEL PUMP

Filed Nov. 10, 1964 2 Sheets-Sheet 2

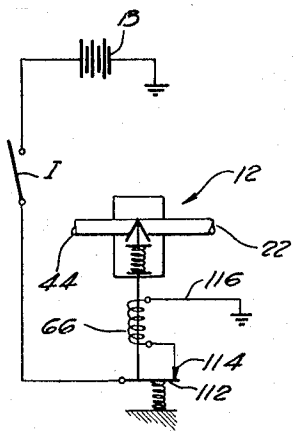


FIG. 6.

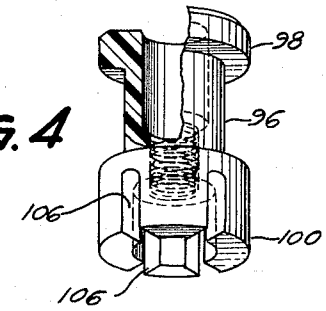


FIG. 4

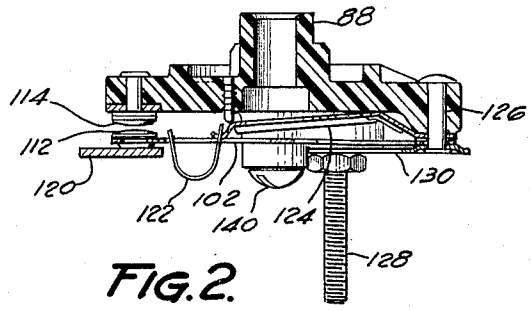


FIG. 2.

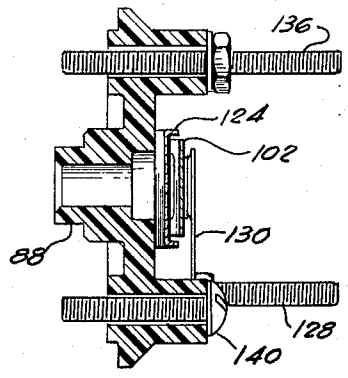


FIG. 5.

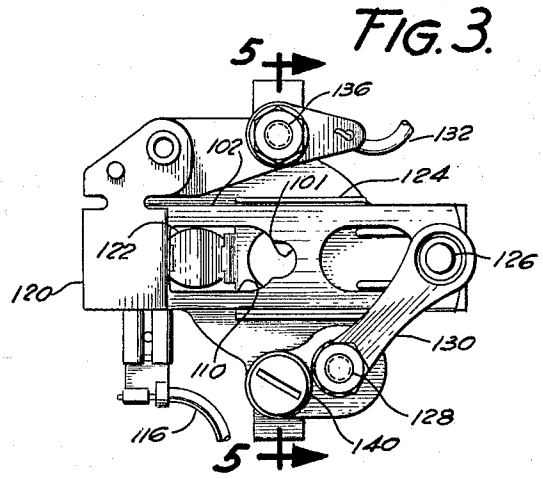


FIG. 3.

INVENTORS

Marshall Miles.
Joseph D. Northrup.
Edward T. Prell.

By Norton Lasser
Attorney

United States Patent Office 3,273,505 Patented Sept. 20, 1966

3,273,505

ELECTRICALLY OPERATED FUEL PUMP

Marshall Miles, Wilmette, Joseph D. Northrup, Mount Prospect, and Edward T. Prell, Chicago, Ill., assignors to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

Filed Nov. 10, 1964, Ser. No. 410,116
8 Claims. (Cl. 103—53)

The present invention relates to electrically operated fuel pumps and more particularly to an electric fuel pump utilizing an improved diaphragm, magnetic circuit, vibration damping and switch control.

Electrically operated fuel pumps for use with gasoline engines usually comprise a pump assembly having an inlet side connected to a fuel source and an outlet side connected through the carburetor to the engine. As the fuel consumption increases, the pressure on the outlet side of the pump falls and more fuel flows through the pump. A spring-biased diaphragm may be used to regulate the amount of fuel which passes through the pump, and this diaphragm generally responds to the change in pressure on the outlet side to regulate the passage of fuel through the pump.

The diaphragm is generally driven in a first direction by a spring to pump the fuel and concurrently a set of contacts close to complete a circuit to an electromagnet. The electromagnet then causes the diaphragm to move in the opposite direction and permits fuel to be drawn into the fuel chamber, after which the contacts open and the cycle is repeated with the rate of repetition being dependent on the fuel demand. The diaphragm thus moves through an intermediate position between two extreme positions, and under these circumstances it is desirable that the contacts remain either continuously open or closed to prolong their life until the diaphragm has moved to either limit or extreme position. This is preferably accomplished by using snap acting contacts which operate positively to either the open or closed position once the diaphragm has moved into a predetermined extreme position.

The coil which attracts an armature mechanically coupled to the diaphragm in order to flex the diaphragm must be coupled in an efficient and economic magnetic circuit to the armature and the coil must be securely positioned since it is often subject to continuous and severe vibration.

It is therefore an object of the present invention to provide an improved magnetic circuit for an armature connected to the diaphragm of a fuel pump.

It is still a further object of the present invention to provide an improved arrangement for securing a coil in an electric fuel pump.

It is still a further object of the present invention to provide a coil bobbin incorporating metallic elements which serve as a sleeve for controlling the reaction of the magnetic field created by the coil to prevent undesirable thumps or vibrations.

The above and other objects of the present invention will become apparent on examination of the following specification and claims together with the drawings wherein:

FIG. 1 is a sectional view of a fuel pump incorporating the principles of the present invention;

FIG. 2 is a side elevational view of a switch portion incorporated in the present invention;

FIG. 3 is a bottom elevational view of the switch portion shown in FIG. 2;

FIG. 4 is a perspective view of a switch actuator used in the present invention;

FIG. 5 is a sectional view taken through the line 5—5 in FIG. 3; and

FIG. 6 is a circuit demonstrating one arrangement in which a coil of the fuel pump is energized.

In FIG. 1 an electric fuel pump assembly is generally indicated by the reference character **10**. It comprises a tandemly stacked pump **12**, solenoid assembly **14**, and a switch assembly **16** adapted to be mounted on an appropriate support by means of apertured bracket ears **18**.

The pump **12** comprises a casting **20** having an inlet opening **22** for passing fuel from a supply through a spring-biased screen filter **23** to a port **24** formed in an insert **26** for the casting. A cover member **28** closes the top side of the pump casting to form a reservoir chamber **30** on the inlet side of the pump between the cover **28** and a rib **32** in the casting to prevent hammer during the fuel pumping operation. Port **24** is adapted to be closed by a valve **34** under influence of a bias spring **36**.

Fuel passing through port **24** is adapted to be transmitted through the diaphragm chamber **38**, whose lower end is closed by a diaphragm **40**, through a port **42** to an outlet opening **44** communicating with the engine carburetor. A valve **46**, biased by a spring **48**, is adapted to close port **42**.

The diaphragm **40** is peripherally secured between the pump casting **20** and a magnetic housing member **50** of the solenoid assembly **14**. A stainless steel shaft **52** is operatively connected to the diaphgram **40** adjacent the central axis by means of a washer **54** clamped to the pump side of the diaphragm and an armature **56** on the solenoid side of the diaphragm. The armature **56** is seated against a shoulder **58** of the shaft while the washer **54** is seated in a recess adjacent the end of the shaft and is held by a head **60** formed on the end of the shaft.

The housing member **50** has a central opening **62** defined by a short downwardly projecting annular wall **64** for receiving the shaft **52** and armature **56**, and for completing an effective magnetic circuit in response to the energization of a coil **66**. An external annular wall **68** spaced from wall **64** serves to house the solenoid assembly **14** and aids the completion of an effective magnetic circuit for coil **66**.

The coil **66** is wound on a bobbin **70** arranged coaxially with shaft **52** and seated on the end of wall **64**. The bobbin **70** is formed of a copper tube having steel end flanges **72** with the copper tube serving as a magnetic sleeve for preventing excessive build-up and release of the magnetic field. A wax encapsulating compound **74** deposited between walls **64** and **68** and around coil **66** serves to maintain the coil in a desired position despite severe vibrations, and the compound **74** also serves to facilitate heat dissipation.

An end magnetic plate **76** is secured to the end of wall **68** for enclosing the solenoid assembly **14** and it carries a core **78** extending coaxially through the bobbin **70** and terminating in a conical projection **80** at approximately 50% of the coil length and adapted to provide equidistant magnetic spacing with a similarly shaped recess **70** of the armature **56**. Thus this conical projection and recess arrangement are at an angle of 30° to the axis of the coil to provide maximum interception of magnetic flux between the core and armature while permitting a maximum movement axially of the coil for small incremental changes in the gap across which the work occurs. A recess **81** is provided in the periphery

of plate 76 and the edge of housing 68 is rolled over the plate edge and partially crimped into recess 81 to aid in preventing rotation of the plate 76 relative to the housing 68. Thereafter the wax 72 is poured through recess 81 to completely fill the chamber and adhere to the plate, housing and coil surfaces.

The shaft 52 extends through a bushing 84 in the core 78 and past the end plate 76 into the switch assembly 16. The bushing 84 serves as a guide during movement of the shaft with respect to the coil and core.

The switch assembly 16 comprises an insulator block 86 having a boss 88 projecting into a recess in core 80. A coil spring 90 is seated on the boss 88 and engages a washer 92 carried adjacent a shoulder 94 on the shaft 52 for biasing the shaft 52, armature 56 and diaphragm 40 upwardly. The shaft 52 extends through an opening in the block 86 whose wall serves to guide the shaft and cooperates with the bushing 84 to ensure that the shaft and associated components describe the same movement on each reciprocation of the shaft. The extending end of the shaft carries a plastic actuator 96.

The actuator 96 is provided with spaced apart peripheral flanges or shoulders 98 and 100, each adapted to engage the sides of an aperture in a cantilever spring blade 102 on movement of the shaft 52 in a respective direction. In order to ensure that the actuator 96 engages blade 96 at the proper position in the travel of the shaft 52, it is threadingly received on the respective end of shaft 52 until the shoulder 100 operates the blade 102, and then it is threaded an additional three-quarters to full turn. A U-shaped spring clip 104, having one leg adapted to be inserted through an appropriate slot 106 in the actuator and an aligned opening in the threaded end of shaft 52, serves to lock the actuator in position on the shaft while its other leg is indended at 108 to seatingly engage the end of the shaft within the confines of the slot 106.

To pass the flange 98 of the actuator 96, the blade 102 is provided with a widened aperture 110 which intercepts the aperture 101 at a position enabling passage of the actuator into alignment with the axis of aperture 101, after the flange 98 is inserted through aperture 110. The blade 102 is provided with a contact 112 at its free end for engagement with a stationary contact 114 riveted onto block 86 above contact 114 and connected to coil 66 over a lead 116 passing through an aperture 118 in plate 76. A stop 120 fastened on the block 86 serves to limit travel of blade 102 in a direction opposite contact 114.

The blade 102 is provided with snap action operation in response to engagement with either flange 98 or 100 by a bowed spring 122 depending through aperture 110 and having one end hinged on spring 102 and its other end hinged on a support element 124.

Both the support element 124 and the blade 102 are secured at one end to block 86 by a common rivet 126. A source of potential is adapted to be connected through blade 102 and contacts 112 and 114 to coil 66 by means of a stud 128 extending through block 86 and connecting to a terminal 130 fastened to rivet 126. A return path to ground for coil 66 is furnished by a lead 132 passing through an aperture 134 in the plate 76 and connected to a stud 136 extending from block 86. The leads 116 and 132 are protected from excessive vibration by the wax which partially fills the aperture 118 and 134 and thereby permits visual detection of the wax level in the solenoid assembly. The stud 136 depends from the plate 76 and extends, together with stud 128, through a cup-shaped housing 138. This permits the necessary electrical connections to be made, and together with a screw 140 secures the assembly of block 86 and housing 138 to the plate 76.

Referring now to FIGS. 1 and 6, it will be noted that on closure of the ignition switch I, associated with the engine to which the fuel pump 10 is connected, that the coil 66 is energized from battery B through contacts 112 and 114 since the diaphragm 40, shaft 52 and blade 102 are then biased in an upward direction by spring 90. With the coil 66 energized, it attracts armature 56 downward thereby pulling diaphragm 40 downwards to create a vacuum in the diaphragm chamber 38. This enables valve 34 to open and fuel from the fuel supply enters chamber 38 through the inlet 22.

As the actuator 96 reaches the bottom of its stroke, flange 98 engages blade 102 and its contact 112 is disengaged from contact 114 to de-energize coil 66. Diaphragm 40 is again moved upwardly under the influence of spring 90 until flange 100 again engages blade 102 at which time contacts 112 and 114 are again engaged to reenergize coil 66 and the cycle is repeated. During the upward movement of diaphragm 40, pressure is exerted on the fuel in chamber 38 and valve 46 opens while valve 34 is held closed. Fuel is thus pumped through port 42 and outlet 44 to the engine carburetor.

If the outlet pressure should fall due to increased fuel consumption, the average pressure in chamber 38 will tend to drop with the result that the return force of spring 90 will meet less resistance and thereby return the diaphragm 40 and blade 102 more quickly so that cycling is more rapid and additional fuel is pumped. On the other hand, if the outlet pressure becomes high due to a lesser demand of fuel, the return force of spring 90 will meet increased resistance so that the pumping cycle is in effect slowed and lesser amounts of fuel are delivered.

The foregoing constitutes a description of an improved fuel pump whose inventive concepts are believed set forth in the accompanying claims.

What is claimed is:

1. In a fuel pump assembly of the type having an inlet port normally adapted to be closed by an inlet valve and communicating with an outlet valve through a diaphragm chamber whose volume is adapted to be varied by a movement of a diaphragm for either drawing fuel into said chamber or pumping fluid from said chamber, the improvement comprising a coil having a movable armature carried on a shaft fixedly connected to said diaphragm and biased to move said diaphragm in one direction for pumping fuel from said chamber, a copper bobbin for said coil, an integrally formed magnetic housing for said coil having one wall portion surrounding said coil and an inner wall portion encircling said armature and engaged against one end of said copper bobbin, an end plate engaged against the end of said one wall and spaced from the other end of said bobbin with a small recess in the periphery of said plate into which said one wall is partially crimped to prevent relative rotation of said plate, a wax encapsulation adapted to be poured through said recess after said crimping and surrounding said coil to prevent displacement of said coil with the level of said wax being visually ascertainable, a stationary core for said coil having an aperture through which said shaft extends, a snap acting switch having a blade movable in either of two directions for respectively establishing or opening a circuit to said coil, an actuator adapted to be threaded on the extending end of said shaft and having a pair of spaced apart flanges located on opposite sides of said blade, and movable with said diaphragm for operating said blade in either of said two directions dependent on which flange engages said blade, and a spring clip having one leg passing through a slot in said actuator and an aperture in said shaft and another leg formed to grasp the end of said shaft for holding said actuator in its adjusted position.

2. In a fuel pump assembly of the type having an inlet port normally adapted to be closed by an inlet valve and communicating with an outlet valve through a diaphragm chamber whose volume is adapted to be varied by a movement of a diaphragm for either drawing fuel into said chamber or pumping fluid from said chamber, the improvement comprising a coil having a movable armature fixedly connected to said diaphragm and biased

to move said diaphragm in one direction for pumping fuel from said chamber, a copper bobbin for said coil, an integrally formed magnetic housing for said coil having one wall portion surrounding said coil and an inner wall portion encircling said armature and engaged against one end of said copper bobbin, an end plate engaged against the end of said one wall and spaced from the other end of said bobbin with a small recess in the periphery of said plate into which said one wall is partially crimped to prevent relative rotation of said plate, a wax encapsulation adapted to be poured through said recess after said crimping and surrounding said coil to prevent displacement of said coil, a snap acting switch having a blade movable in either of two directions for respectively establishing or opening a circuit to said coil, an actuator operatively connected to and movable with said diaphragm for operating said blade in either of said two directions dependent on the direction of movement of said diaphragm, means for adjustably relating the position of said actuator relative to said blade, and a spring clip for holding said actuator in its adjusted position.

3. In a fuel pump assembly of the type having an inlet port normally adapted to be closed by an inlet valve and communicating with an outlet valve through a diaphragm chamber whose volume is adapted to be varied by a movement of a diaphragm for either drawing fuel into said chamber or pumping fluid from said chamber, and wherein a coil having a movable armature carried on a shaft fixedly connected to said diaphragm and biased to move said diaphragm in one direction for pumping fuel from said chamber is provided for moving said diaphragm in the opposite direction, the improvement comprising a copper bobbin for said coil, an integrally formed magnetic housing for said coil having one wall portion surrounding said coil and an inner parallel wall portion encircling said armature and engaged against one end of said copper bobbin with one end of said inner wall being joined to one end of said one wall by a planar wall engaged against the periphery of said diaphragm, an end plate engaged against the other end of said one wall to form an enclosure for said coil, and an encapsulating compound adapted to be poured through an opening in said end plate into said enclosure for preventing displacement of said coil and aiding in heat dissipation.

4. In a fuel pump assembly of the type having an inlet port normally adapted to be closed by an inlet valve and communicating with an outlet valve through a diaphragm chamber whose volume is adapted to be varied by a movement of a diaphragm for either drawing fuel into said chamber or pumping fluid from said chamber, the improvement comprising a coil having a movable armature fixedly connected to said diaphragm and biased to move said diaphragm in one direction for pumping fuel from said chamber, a copper bobbin for said coil, an integrally formed magnetic housing for said coil having one wall portion surrounding said coil and an inner wall portion encircling said armature and engaged against one end of said copper bobbin, a core for said coil with said core terminating approximately midway between the ends of said coil and having a conical projection adapted to cooperate magnetically with a similarly shaped recess on said armature, an end plate engaged against the end of said one wall and spaced from the other end of said bobbin and having a small recess in the periphery of said plate and into which said the one wall is crimped to prevent relative rotation of said plate, and an encapsulation adapted to be poured through said recess and around said coil prior to said crimping for retaining said coil in position.

5. In a fuel pump assembly of the type having an inlet port normally adapted to be closed by an inlet valve and communicating with an outlet valve through a diaphragm chamber whose volume is adapted to be varied by a movement of a diaphragm for either drawing fuel into said chamber or pumping fluid from said chamber, the improvement comprising a coil having a movable

armature fixedly connected to said diaphragm, means for biasing said armature to move said diaphragm in one direction for pumping fuel from said chamber, an integrally formed magnetic housing for said coil having one wall portion surrounding said coil and an annular wall portion extending from adjacent one end of said coil and spaced inwardly from said one wall portion for immediate encircling relationship with said armature and joined to said one wall portion by an end wall spaced from said coil for abutting engagement with said diaphragm between said wall portions and integrally formed with said one and annular wall portions, an end plate engaged against the end of said one wall portion and spaced from said coil, a core for said coil having a conical projection adapted to cooperate magnetically with a similarly shaped recess in said armature, a shaft rigidly connected to said armature and diaphragm and extending through said core, and means restraining said shaft from nonaxial movement at spaced apart positions along said shaft to prevent misalignment of said armature and diaphragm.

6. In a fuel pump assembly of the type having an inlet port normally adapted to be closed by an inlet valve and communicating with an outlet valve through a diaphragm chamber whose volume is adapted to be varied by a movement of a diaphragm for either drawing fuel into said chamber or pumping fluid from said chamber, the improvement comprising a coil having a movable armature carried on a shaft fixedly connected to said diaphragm and biased to move said diaphragm in one direction for pumping fuel from said chamber, a magnetic housing for said coil having an annular portion surrounding said coil and an inner annular portion encircling said armature and shaft, an end plate closing off said annular portion surrounding said coil with said shaft adapted to pass through said end plate, a snap acting switch having a blade movable in either of two directions for respectively establishing or opening a circuit to said coil, and actuator connected to said shaft and movable with said diaphragm for operating said blade in either of said two directions dependent on the direction of movement of said diaphragm, means for adjustably relating the position of said actuator relative to said blade, and a spring clip for holding said actuator in the adjusted position.

7. The arrangement claimed in claim 6 in which said actuator comprises a pair of spaced flanges each adapted to operate said blade in response to said diaphragm passing a respective predetermined position, said actuator having a slot, and said spring clip having a pair of legs one of which legs is adapted to pass through said slot into said shaft and the other of which is adapted to engage on the end of said leg.

8. In a fuel pump assembly of the type having an inlet port normally adapted to be closed by an inlet valve and communicating with an outlet valve through a diaphragm chamber whose volume is adapted to be varied by a movement of a diaphragm for either drawing fuel into said chamber or pumping fluid from said chamber and wherein a coil having a movable armature carried on a shaft fixedly connected to said diaphragm and biased to move said diaphragm in one direction for pumping fuel from said chamber is provided for moving said diaphragm and shaft in another direction to draw fuel into said chamber, the improvement comprising an integrally formed magnetic housing for said coil having one wall portion surrounding said coil and an annular projecting wall portion extending from adjacent one end of said coil and spaced inwardly from said one wall portion for immediate encircling relationship with said armature and joined to said one wall portion by an end wall spaced from said coil for abutting engagement with said diaphragm between said wall portions and integrally formed with said one and annular wall portions, an end plate engaged against the end of said one wall portion and spaced from said coil, a snap acting switch having a blade movable in either of two directions for respectively establish-

ing or opening a circuit to said coil, an insulating block carrying said blade and having a boss extending thruogh said plate with said shaft extending through said boss, and an actuator adjustably positioned on the extending end of said shaft for movement with said diaphragm and adapted to operate said blade in either of said two directions dependent on the direction of movement of said diaphragm and the position of said diaphragm.

References Cited by the Examiner

UNITED STATES PATENTS

1,695,535	12/1928	Carter.	
1,779,420	10/1930	Carter	103—53 X
3,015,835	1/1962	Dyer et al.	103—53 X

ROBERT M. WALKER, *Primary Examiner.*