Sept. 29, 1959 J. F. BLACK 2,905,989

METHOD AND APPARATUS FOR CONTINUOUS CASTING OF METALS

Filed May 4, 1956 4 Sheets-Sheet 1

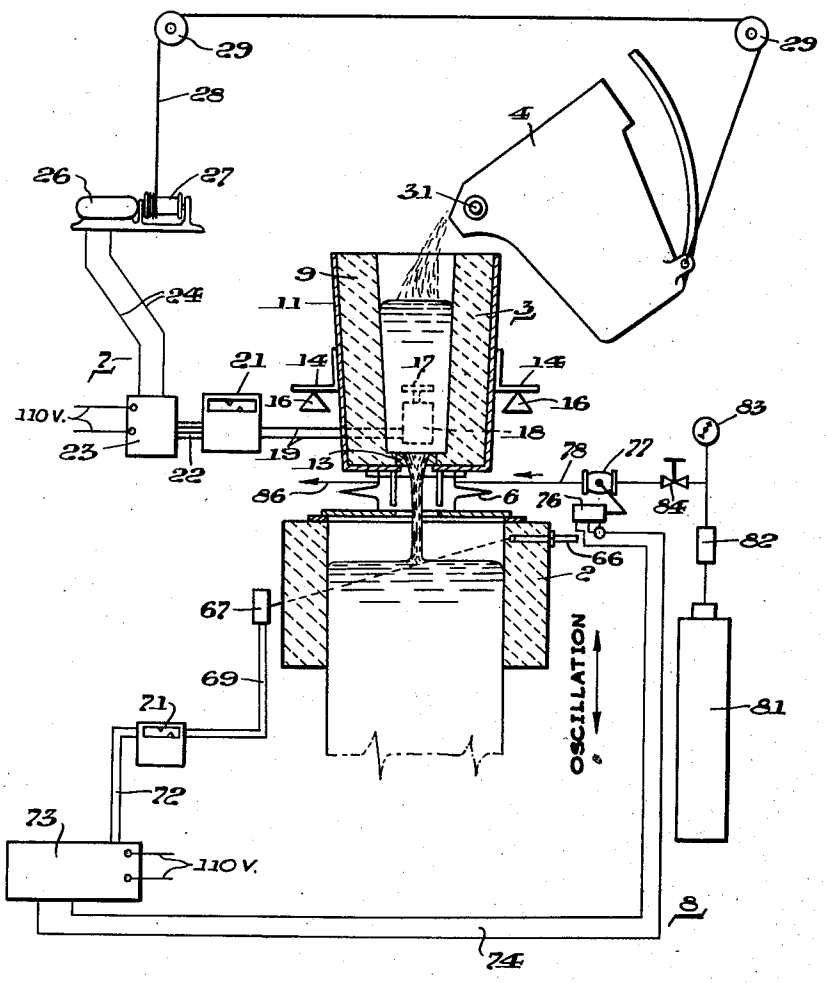


Fig. 1.

INVENTOR.
JOHN F. BLACK.

BY
Ralph B. Brick.
his ATTORNEY.

Sept. 29, 1959 J. F. BLACK 2,905,989

METHOD AND APPARATUS FOR CONTINUOUS CASTING OF METALS

Filed May 4, 1956 4 Sheets-Sheet 2

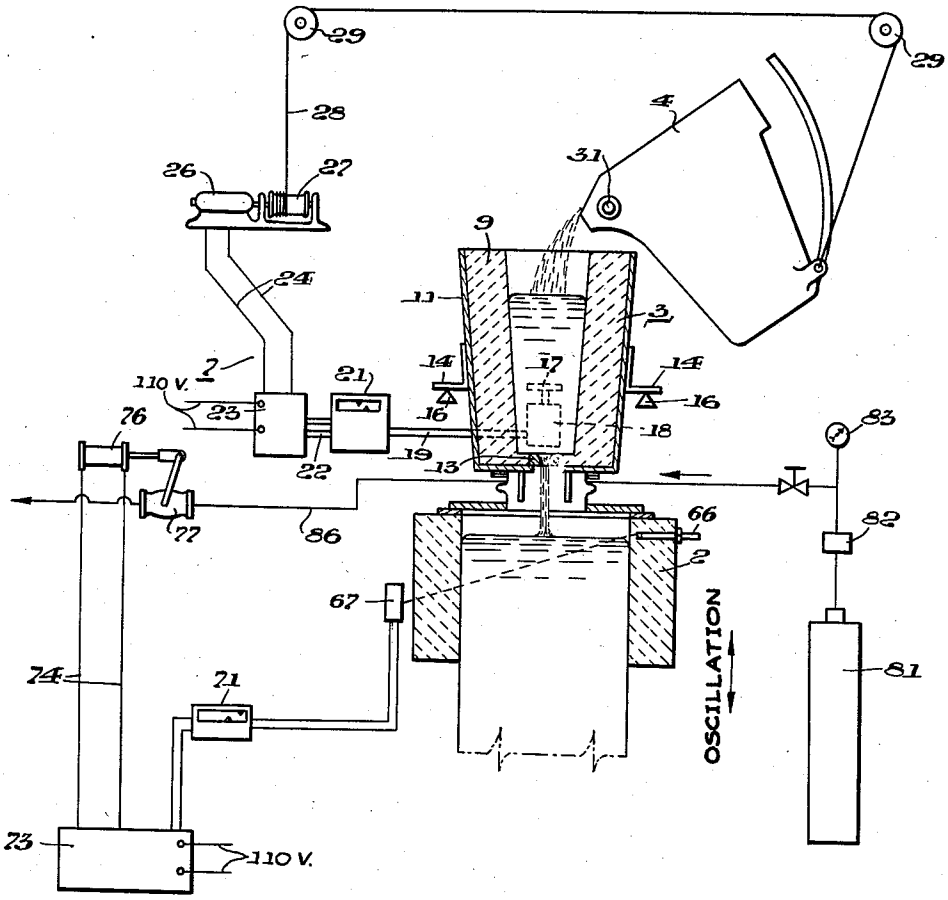


Fig. 2.

INVENTOR.
JOHN F. BLACK.
BY Ralph B. Brick.
his ATTORNEY

Sept. 29, 1959 J. F. BLACK 2,905,989

METHOD AND APPARATUS FOR CONTINUOUS CASTING OF METALS

Filed May 4, 1956 4 Sheets-Sheet 3

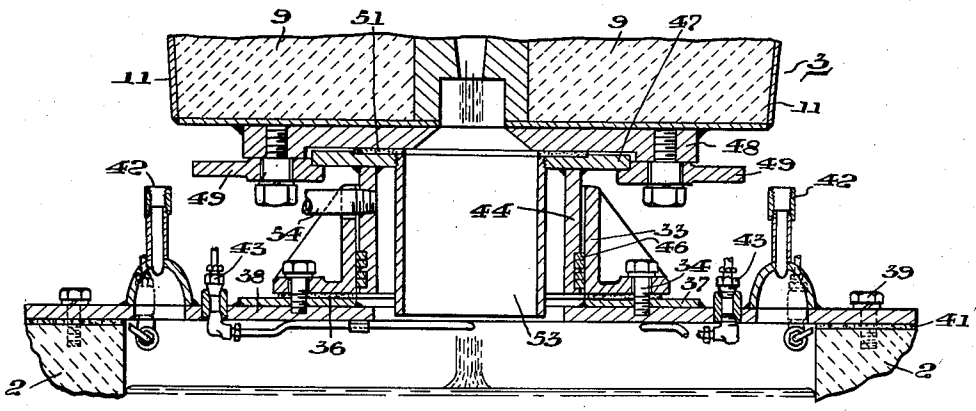


Fig. 3.

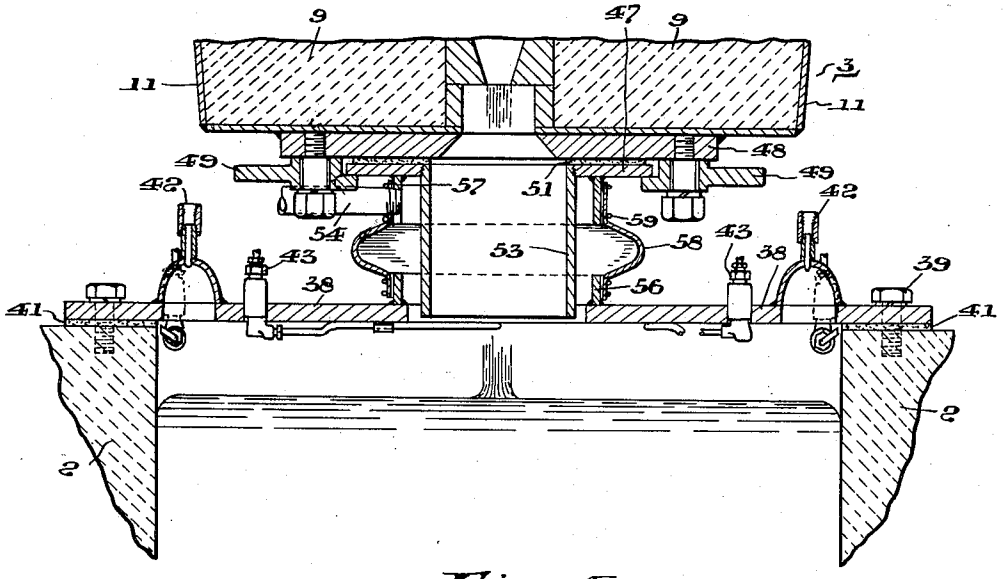


Fig. 4.

INVENTOR.
JOHN F. BLACK.
BY Ralph B. Brick.
his ATTORNEY

Sept. 29, 1959 J. F. BLACK 2,905,989

METHOD AND APPARATUS FOR CONTINUOUS CASTING OF METALS

Filed May 4, 1956 4 Sheets-Sheet 4

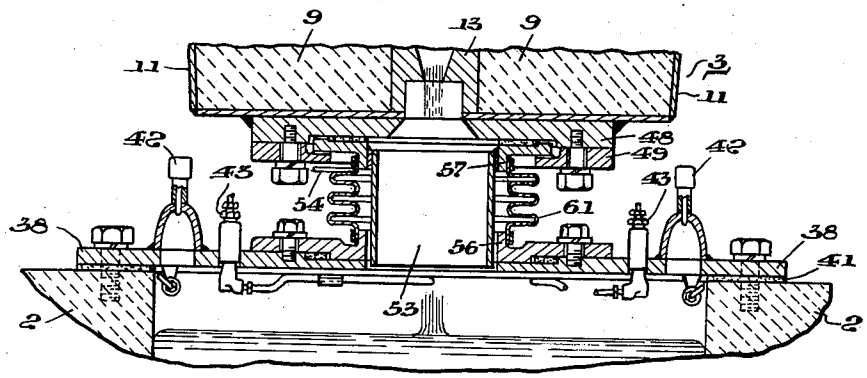


Fig. 5.

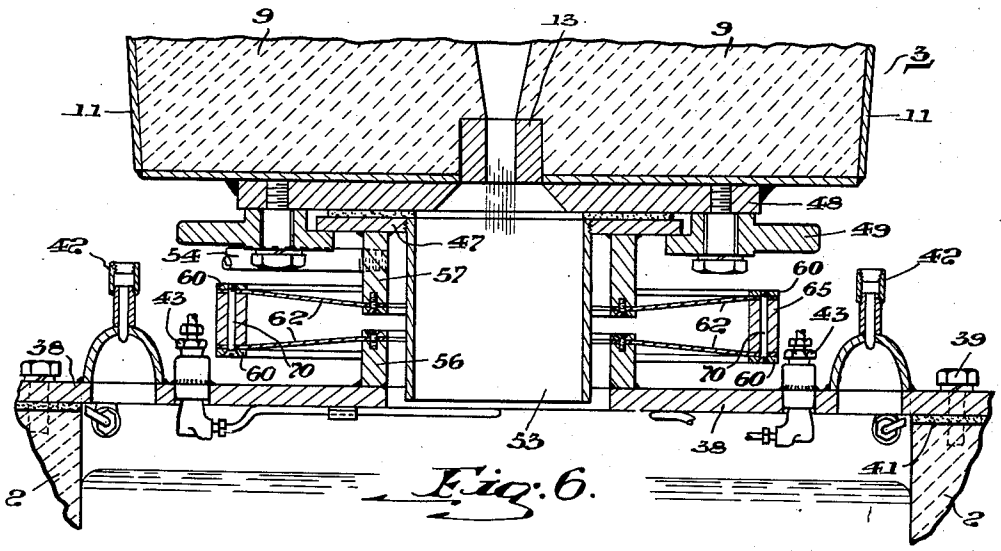


Fig. 6.

INVENTOR.
JOHN F. BLACK.

BY
Ralph B. Brick.
his ATTORNEY

United States Patent Office 2,905,989
Patented Sept. 29, 1959

2,905,989

METHOD AND APPARATUS FOR CONTINUOUS CASTING OF METALS

John F. Black, Pittsburgh, Pa., assignor to Koppers Company, Inc., a corporation of Delaware

Application May 4, 1956, Serial No. 582,843

1 Claim. (Cl. 22—57.3)

This invention relates to a method and apparatus for casting molten metals and more particularly to a method and apparatus for controlling metal flow in the continuous casting of molten metals.

In continuously casting metals such as copper, brass, aluminum, steel, and the like, it has been found desirable to control the flow of such metals from the supply zone to the mold zone in as accurate a manner or possible to obtain a selected, uniform quality cast. In the past, much of the control operation has been effected manually, one or human operators being required to pay constant attention to the metal level in the mold, to the metal level in the supply tundish, and to the apparatus associated therewith. When undesirable variations in flow rate have been observed by any of the operators, necessary adjustments have then been effected for the most part through manually actuated valve means. Obviously, in the aforedescribed practices, there has been an inevitable and undesirable lapse of time between an operator's observations and the effected corrections by him. Although attempts have been made to control a valve member cooperable with the outlet in the supply tundish in accordance with a selected height of the metal level in the mold, such attempts have not proved entirely successful, the valve member in the tundish outlet being exposed directly to the intensely heated metal, creating problems of wear, replacement, clogging, and flow distortion.

The present invention avoids many of the above-mentioned difficulties of the past, permitting a single operator to supervise the simultaneous casting of several strands of molten metal from a single tundish to several molds cooperating with such tundish, each of which molds in the past would have required the attention of one or more operators. The present invention further provides an automatic system for controlling the rate of flow of molten metal in continuous casting operations, which system, in addition to greatly reducing required manpower, brings about decided improvements in the quality of metal cast.

More particularly, the present invention provides a method and apparatus for continuously casting molten metal from a supply zone to a mold zone wherein the molten metal is passed through a variable fluid pressure zone on its way to the mold zone, with the variations of the metal level in the mold zone being measured, and the pressure in the fluid pressure zone varied in accordance with such metal level measurements to control the flow of metal into the mold zone.

It will be obvious that various changes can be made by one skilled in the art in the arrangement, form, and construction of the structure disclosed and in the several steps of the method disclosed without departing from the scope or spirit of the present invention.

Referring to the drawings:

Figure 1 is a schematic elevational view of one advantageous embodiment of the present invention, the control for the fluid pressure chamber being maintained on the fluid inlet side of such chamber;

Figure 2 is a schematic elevational view of another advantageous embodiment of the present invention, the control for the fluid pressure chamber being maintained on the fluid outlet side of such chamber;

Figures 3–6 are enlarged cross-sectional views of several arrangements of contractible chambers, any one of which can be included in the structures disclosed in Figures 1 and 2.

Referring to Figure 1 of the drawings, there is broadly disclosed one embodiment of the apparatus of the present invention, this apparatus including an oscillatable mold 2 having spaced thereabove a molten metal supply means which includes a tundish 3. Positioned above the tundish in cooperative relation with the inlet side thereof is a ladle 4. A fluid pressure means is arranged to cooperate directly with the outlet side of the tundish, the fluid pressure means including a contractible chamber 6 having one end communicably connected to the inlet side of mold 2 and the other end communicably connected to the outlet side of tundish 3.

Connected between ladle 4 and tundish 3 is a weight cell sensing means broadly designated by the reference numeral 7, this weight cell sensing means cooperating between the ladle and the tundish to maintain a substantially constant head of metal in the tundish, as will be described hereinafter.

Connected between mold 2 and contractible chamber 6 is a control system broadly designated by the reference numeral 8, this control system serving to regulate fluid pressure in contractible chamber 6 in response to variations of the level of molten metal in mold 2, as will also be described hereinafter.

More specifically, tundish 3 can be of a conventional type with an inner refractory lining 9 surrounded by a steel jacket member 11, the tundish having on its outlet side a stable zirconium or magnesium oxide nozzle 13, as is known in the art. Connected to the outer wall of the jacket member of the tundish are spaced bracket members 14, these bracket members being adapted to ride on supporting trunnions 16. Also connected to the outer wall of the jacket member of the tundish between the bracket members is a flange 17, this flange being so positioned as to be in cooperative relation with a weight load cell 18. Load cell 18 can be of a Baldwin-Lima-Hamilton type and is electrically connected through electrical conductors 19 to recording controller 21. Recording controller 21, in turn, is electrically connected through conductors 22 to motor control panel 23, and motor control panel 23 is electrically connected through conductors 24 to a variable motor 26. A winch 27 is positioned at one end of the drive shaft of motor 26, the winch having one end of a cable 28 attached thereto. Cable 28 passes over a series of spaced apart sheaves 29 and the other end of the cable is connected to the lower end of ladle 4, the ladle being adapted to pivot about trunnions 31 when the cable is wound in on the winch.

With this arrangement, it will be obvious that the ladle 4 is automatically tilted in accordance with the weight imposed upon the weight cell 18, and that by a proper setting of the controls, a selected and substantially constant head of metal can be maintained in tundish 3. It is to be understood that other type mechanisms besides this weight cell sensing type can be used to maintain a substantially constant head of metal in the tundish. For example, it is possible to use a system wherein a variable vacuum is maintained in an enclosed area between a stationary ladle outlet and the tundish inlet to effect the metal level head control.

Since it has long been desirable in conventional type continuous casting practice to oscillate the mold in

which the metal is formed, structures like that disclosed in the recently expired Junghans Patent No. 2,135,184 being used to effect this oscillation, the fluid pressure chamber 6 of the present invention has been constructed in such a manner that it contracts so as to yield with the oscillations of such a mold.

Referring to Figures 3–6 of the drawings, four advantageous embodiments of contractible chambers are shown. More specifically, in Figure 3, the contractible chamber includes an outer cylindrical sleeve member 33, which is fastened by bolts 34 through gasket 36 and support plate 37 to mold cover plate 38. The mold cover plate is, in turn, fastened to the top of mold 2 by bolts 39, bolts 39 passing through gasket 41 positioned on the top face of the mold. Spaced gas inlets 42 are provided on opposite ends of the mold cover plate for the introduction of the gases into the fluid chamber. Also provided in the mold cover plate are lubrication port and duct assemblies 43, these port and duct assemblies providing for the introduction of lubricant which flows along the inner walls of the mold as it oscillates.

Slidably disposed within the cylindrical sleeve member 33 is piston 44, sealing rings 46 being provided between the inner wall of sleeve 33 and the outer wall of this piston to seal the contractible chamber formed by the piston and sleeve. Piston 44, which has one end free to permit sliding movement within the cylinder, has its other end fastened to a plate 47, the plate 47 being held in place by means of a latch and pin assembly 49 against a face plate 48 that is welded to the outlet side of the tundish 3. A gasket 51 is provided to seal the chamber between the plates 47 and 48, and suspended from the plate 47 by a threaded connection is a splash sleeve 53 which serves to prevent molten metal from splashing on the inner walls of the chamber.

From the aforegoing description, it will be obvious that as mold 2 is oscillated, sleeve 33 is caused to move along with the mold and slide relative piston 44, thus acting as a contractible chamber, this chamber being provided not only with aforementioned gas inlets 42, but also with gas outlet 54 to permit the gases to pass from such chamber.

Referring to Figure 4, a second advantageous embodiment of a contractible chamber is disclosed. This chamber includes a first sleeve member 56 connected to the inlet side of mold 2 through an opening in cover plate 38 and a second sleeve member 57 spaced from this first sleeve member and connected to the outlet side of the tundish 3 through cover plate 47. Surrounding and connecting spaced apart sleeve members 56 and 57 is a flexible metallic cloth member 58, this cloth member being made of a non-porous aluminum material which serves to seal the chamber and yet permit contractibility. One of the advantages of such a contractible arrangement is that cloth member 58, which is held to the sleeves by retaining bands 59, can be readily replaced in an economical manner in the event of damage.

Referring to Figures 5 and 6 of the drawings, two other advantageous contractible chamber members are disclosed in the form of flexible metallic bellows, the bellows in Figure 5 comprising a flexible corrugated metallic sleeve 61 having its opposite ends welded to spaced sleeves 56 and 57, and the bellows in Figure 6 comprising facing, flexible metallic sleeve members 62 which are spaced apart by an annulus 65 fastened to the sleeves by clamping rings 60 and bolts 70.

Again referring to Figure 1 of the drawings, the control system 8 as disclosed in this figure includes a radioactive impulse and sensing means which can be in the form of a gamma ray emitter 66 positioned on one side of mold 2 and a gamma ray detector 67 positioned on the other side of mold 2 opposite said emitter and at a lower level thereto. In the event of variations in the level of molten metal in the mold, the distance of metal through which the radioactive rays from the emitter 66 passes varies and thus the detector 67 measures varying impulses in accordance with the variation of metal level in the mold. These impulses are transferred electrically through conductors 69 to amplifier 71 and thence electrically through conductors 72 to hydraulic variable power unit 73. As disclosed in Figure 1 of the drawings, hydraulic power unit 73 is connected through conductor 74 to a cylinder and piston arrangement 76 which, in turn, controls gate valve 77. In Figure 1, gate valve 77 is shown as positioned in inlet line 78 of a gas pressure system connected to contractible chamber 6. This gas pressure system includes a supply tank 81, a pressure regulating valve 82, a pressure gauge 83 and a shut-off valve 84. The system further includes a gas outlet line 86 connected to the outlet side of the contractible chamber 6. It will be obvious from the aforegoing description that any variations of metal level in the mold will be picked-up by the radioactive sensing means and translated through the hydraulic power unit 73 so as to effect an opening or closing of the gate valve 77 in the gas pressure inlet line 78 in accordance with the variations of the metal level to regulate the pressure in chamber 6. In this connection, it is to be noted that inert gases such as argon or propane can be used in the system, these gases not entering into chemical reaction with the molten metal passing through chamber 6.

Referring to Figure 2 of the drawings, a modified embodiment of the invention is shown wherein the hydraulic power unit 73 and the actuating cylinder and piston arrangement 76 are arranged to control the valve 77 which, in this instance, is positioned in the outlet side 86 of the gas supply system.

With the apparatus as above-described, it is now possible to continuously cast molten metal in an automatic, efficient and economical manner to effect a uniform rate of metal flow, resulting in a uniform quality of metal. In carrying out the casting operation automatically, the weight cell sensing means 7 controls the tilting of ladle 4 in accordance with the weight of tundish 3 to thus assure that a substantially constant head of metal is maintained in the tundish. At the same time the control system 8, through the radioactive sensing device 66 and 67 cause valve 77 to be regulated in accordance with variations in the metal level in mold 2. This, in turn, regulates the gas pressure in chamber 6, which contracts with the upward stroke of mold 2, the fluid pressure in the chamber directly controlling the amount of metal which passes from the tundish 3 to mold 2.

The invention claimed is:

Apparatus for continuously casting molten metal comprising an oscillatable mold, molten metal supply means spaced from said mold, said metal supply means having an outlet from which said molten metal passes to said mold, a contractible chamber having one end communicating with said mold and the other end communicating with the outlet side of said supply means, said contractible chamber comprising a cylindrical sleeve and piston slidably disposed therein, and sealing ring means interposed between the inner wall of said sleeve and the outer wall of said piston to seal the contractible chamber formed by said piston and sleeve, fluid pressure means communicating with said chamber, valve means connected to said fluid pressure means to regulate the pressure of the fluid introduced into said chamber and thus regulate the metal flow through said chamber, and means responsive to the variations of the level of molten metal in the mold to regulate said valve means in accordance with such variations.

References Cited in the file of this patent

UNITED STATES PATENTS

1,139,888	Mellen	May 18, 1915
1,988,425	Summey	Jan. 15, 1935

(Other references on following page)

5

UNITED STATES PATENTS

2,135,183	Junghans	Nov. 1, 1938
2,232,886	Robertson et al.	Feb. 25, 1941
2,246,907	Webster	June 24, 1941
2,357,013	Spooner	Aug. 15, 1944
2,379,401	Poulter	June 26, 1945
2,586,713	Ratcliffe et al.	Feb. 19, 1952
2,609,575	Morin	Sept. 9, 1952
2,647,826	Jordan	Aug. 4, 1953

6

2,743,492	Easton	May 1, 1956
2,753,605	Carleton	July 10, 1956
2,768,413	Alexanderson	Oct. 30, 1956
2,792,602	Rossi	May 21, 1957
2,825,104	Jones	Mar. 4, 1958

FOREIGN PATENTS

891,444	Germany	Sept. 28, 1953