

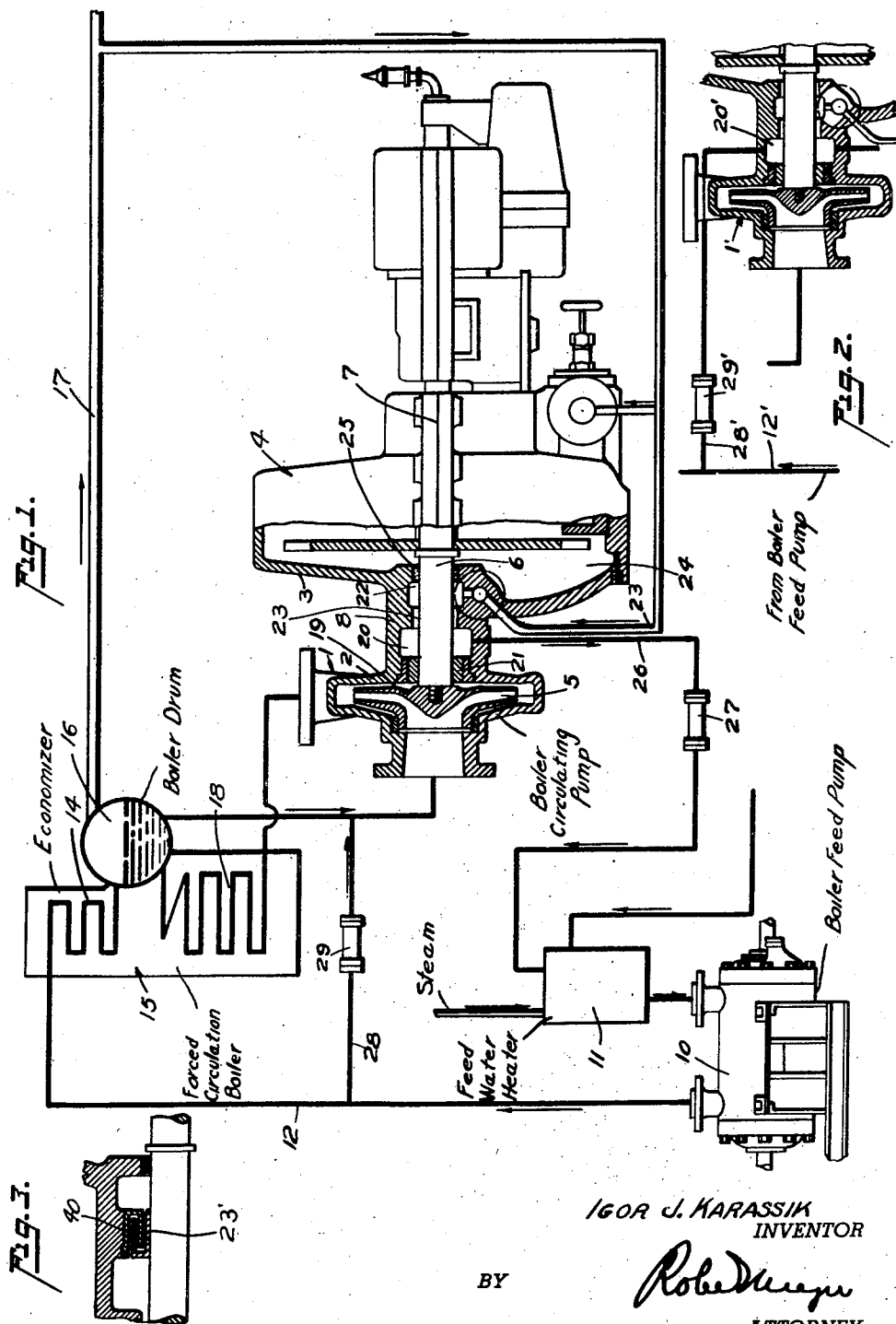
Jan. 24, 1950

I. J. KARASSIK

2,495,525

CIRCULATING PUMP FOR STEAM GENERATORS

Filed Nov. 3, 1943



IGOR J. KARASSIK
INVENTOR

BY

Robert M. Meyer
ATTORNEY

UNITED STATES PATENT OFFICE

2,495,525

CIRCULATING PUMP FOR STEAM GENERATORS

Igor J. Karassik, South Orange, N. J., assignor
to Worthington Pump and Machinery Corpora-
tion, Harrison, N. J., a corporation of Delaware

Application November 3, 1943, Serial No. 508,806

14 Claims. (Cl. 122-406)

1

This invention relates to centrifugal pumps, and more particularly to steam driven centrifugal pumps for circulating water through the boiler or steam generator of a forced feed circulation type of steam generator.

In forced circulation boiler feed systems, the water is circulated through the economizer or part of the tubes of the boiler, passing from this economizer in most instances to the boiler drum, from which the water is picked up by a circulating pump and forced under slightly increased pressure through the evaporator section or remaining tubes of the boiler. Thus the circulating pump must handle water or liquid at a high pressure and high temperature.

Such forced circulation system steam generators or boilers have many advantages over natural circulation types, especially in installations where maximum steam generation per unit of space and weight is required. These facts have been recognized in the field, but considerable difficulty has been experienced in providing an efficient, practical circulating pump for handling the water to the temperatures and pressures necessary to provide the proper operation of such a forced circulation of water through the boiler.

The primary object of the present invention is to provide a pump which will meet all of the requirements of such a boiler feed system, and which is particularly designed to overcome the packing and leakage difficulties which have been prevalent in circulating pumps heretofore employed in such systems.

In forced circulation boiler feed systems, the circulating pump withdraws water from the boiler drum and returns it to the boiler, adding sufficient pressure to the water to overcome friction losses in the boiler tubes. Due to the fact that the circulating pump receives water at the boiler pressure and saturation temperature, extreme difficulties are experienced in packing or sealing the pump against leakage.

While this problem of packing has been overcome at present by circulating pumps employing pressure reducing labyrinths, such, for instance, as shown in Patent No. 2,281,650, May 5, 1942, such structures are expensive and materially add to the cost of the pump, their use requires an increase on discharge capacity of a pump to deliver a predetermined desirable quantity of water and, consequently, increases the power consumption of the pump.

It is, therefore, an object of the present invention to provide a circulating pump for forced circulation boiler feed systems which will not

2

only overcome the sealing difficulties encountered in such a pump, but one which is comparatively simple in construction and eliminates the use of stuffing boxes for sealing; also one which will not require an extra capacity for the pump with its corresponding power consumption.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a circulating pump for steam generators of a preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a sectional view through a boiler circulating pump constructed in accordance with the present invention and showing it arranged diagrammatically in a forced circulation steam generating system.

Figure 2 is a fragmentary, longitudinal section through the pump illustrating a fragmentary modified system.

Figure 3 is a detail section showing a slight modification of the pump structure.

Referring more particularly to the drawings, the improved boiler circulating pumping unit comprises a boiler circulating pump 1, and a driving turbine 4. The casing 2 of the circulating pump 1, and the casing 3 of the turbine 4, are formed, cast together, or connected to each other to form a continuous or sectionalized casing free from spaces, between the pump and turbine, which freely communicate with the atmosphere. The casing 2 of the circulating pump is connected to the casing of the turbine by a connecting extension 8 clearly shown in the drawings.

The impeller 5 of the circulating pump is mounted upon and driven by the shaft 6 which is also the turbine driven shaft, thus the use of couplings or analogous structures are eliminated.

The boiler feed pump 10 receives water from the feed water heater 11 which may be of any approved type and delivers it through suitable piping 12 to the economizer or first section 14 of the tubes of the boiler 15. The steam and the water which is not vaporized in the section 14 of the boiler 15 passes into the boiler drum 16 from which the steam is taken for use through suitable piping 17. The water in the boiler drum 16 is passed to the suction of the boiler circulating pump 1 where its pressure is slightly increased to overcome the friction of the boiler

3

tubes and this water is discharged by the boiler circulating pump 1 to the second tube section 18 of the boiler 15. Thus the boiler circulating pump 1 receives water at its suction at the boiler pressure and saturation temperature, that is, at pressures such as five hundred to fifteen hundred pounds per square inch with the corresponding saturation temperature.

By reference to the drawings, it will be noted that the boiler circulating pump 1 is of the overhanging impeller type, that is, the impeller 5 is mounted on the end of its driving shaft 6 and the suction to the impeller is direct into the impeller eye at one side of the impeller; thus the need of a stuffing box or sealing structure at the suction end of the pump is eliminated. The interior of the pump casing 2 behind the impeller 5, that is, the chamber indicated at 19, is open to discharge pressure of the pump and the shaft 6 extends through the back side of the casing to support and drive the impeller; therefore, means to prevent leakage of high pressure, high temperature water from the circulating pump about the shaft 6 is required.

To prevent leakage of high pressure, high temperature water about the shaft 6 and effectively seal the pump, a mixing chamber 20 is provided in the connecting extension 8. This mixing chamber 20 surrounds the shaft 6 and receives leakage from the chamber 19 of the pump casing through a pressure reducing bushing structure 21 surrounding the shaft 6.

A second chamber 22 is formed in the connecting extension 8 and it has communication with the mixing chamber 20 through a leakage passage 23. Live steam under a pressure in excess of the pressure of the water in the mixing chamber 20 is delivered to the chamber 22 from any suitable source of steam supply. As shown in Figure 1 of the drawings, the steam supply to the chamber 22 is from the steam supply to the turbine 4, through suitable branch piping 23, but it is to be understood that the present invention is not limited to the taking of the steam for the chamber 22 from the steam supply to the driving turbine 4. The chamber 22 is separated from the back pressure space or chamber 24 of the turbine 4 by packing 25 of any approved type such as is employed in back pressure turbines.

Leak-off piping 26 is connected to the chamber 20 at a suitable point so as to carry away the water and the condensate formed by the condensing of steam in the chamber 20. In the system shown in the drawings, the water which passes through the leak-off pipe 26 is returned to the feed water heater 11 and thence back to the boiler feed pump 10 for recirculation through the system. A pressure reducing orifice 27 of any approved type which may be purchased on the open market is interposed in the line of piping 26 between the chamber 20 and the feedwater heater 11. The dimensions of this pressure reducing orifice 27 are calculated in such a manner as to impose a back pressure of a predetermined quantity at the mixing chamber and to provide for a relatively small quantity of leak-off back to the heater. This back pressure is selected so as to be lower by fifty to one hundred and fifty pounds per square inch than the steam pressure at the inlet of the chamber 22. Thus it will be seen that the pressure drop across the pressure reducing bushing 21 is relatively low and the life of the pressure reducing bushing will be considerably longer than if the bushing were selected and designed to carry a pressure drop as high as

4

necessary to effect proper operation of the system or if it were to act as a pressure reducing labyrinth head of a conventional stuffing box, and, consequently, the life of the pressure reducing bushing 21 will be materially increased. Also, by proper choice or regulation of the back pressure in the mixing chamber 20, the pressure reducing bushing 21 may be employed to balance the axial thrust which would be developed by the single suction impeller. Since the suction pressure to the boiler circulating pump 1 will, in practically all instances, correspond to the saturation pressure, a reduction of the back pressure in the chamber 20 below this suction pressure would result in flashing into vapor of the water in the mixing chamber as well as in the pressure reducing bushing 21 which would be highly undesirable; therefore, means are provided to reduce the temperature of the said water in the mixing chamber below the vaporization temperature corresponding to the pressure by the admixture of water at a lower temperature.

Figure 1 of the drawings illustrates one method of reducing the temperature of the water, while Figure 2 of the drawings illustrates a modified method of reducing this temperature. In Figure 1 of the drawings, a by-pass 28 connects the discharge line 12 of the boiler feed pump 10 to the suction of the boiler circulating pump 1 so that a predetermined limited quantity of water will be discharged directly from the boiler feed pump to the suction of the boiler circulating pump and thus reduce the temperature of the water passing through the boiler circulating pump so as to prevent flashing of the water in the chamber 20. The quantity and pressure of the water passing through the by-pass 28 may be regulated by a pressure reducing quantity controlling orifice 29 of any approved type which may be purchased upon the open market.

In operation, when steam is admitted to the chamber 22 by way of the steam inlet 23, a certain portion of this steam leaks through the packing 25 into the back pressure space or chamber 24 of the turbine 4 and another portion of the steam passes through the passageway 23 into the mixing chamber 20. In the mixing chamber, the steam is condensed by the action of the incoming water through the pressure reducing bushing 21 and the mixture is bled off or evacuated through the pipe 26, through the pressure reducing orifice 27 to the feedwater heater 11 and thus any leakage of water out of the casing about the shaft 6 is prevented without recourse to the use of a stuffing box of conventional or any suitable design and without the use of relatively large, cumbersome, and expensive reducing labyrinths.

It might be desirable in some instances to use a relatively simple pressure reducing labyrinth in the passage 23 to prevent back flow of water into the chamber 22 upon reduction of the steam pressure therein, and such a modification is illustrated in Figure 3 of the drawings wherein a comparatively simple labyrinth 40 is shown in the communicating passageway 23'.

In Figure 2 of the drawings, a modification of the system is shown wherein the temperature of the water in the mixing chamber 22' is reduced by the delivery directly into the mixing chamber of water at a temperature lower than the vaporization temperature corresponding to the pressure through a by-pass 28'. The by-pass 28' is connected to the discharge line 12' of the boiler feed pump so that the water by-passed from the

5

discharge of the boiler feed pump instead of being delivered to the suction of the boiler circulating pump 1' is delivered directly to the chamber 22'. A pressure reducing quantity controlling orifice 23' of any approved type which may be purchased upon the open market is incorporated in the bypass 28' for controlling the by-passing of water to the mixing chamber 22'.

It is contemplated to provide means, if necessary, to vent the mixing chamber to atmosphere, or to provide drainage from the mixing chamber during shut-down periods. Such means may be a manually controlled valve and ordinary drain pipe.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a boiler circulating pumping unit, a centrifugal circulating pump, a steam turbine for driving said pump, a casing for said pump, a casing for said turbine, a single shaft for driving said pump and driven by said turbine, said casing having a mixing chamber therein surrounding said shaft between the pump and turbine, said chamber having communication with the interior of the pump casing to receive discharge pressure leakage from the pump, means for delivering steam from a source outside the turbine to said chamber at a pressure in excess of the water pressure in the chamber and in excess of the steam pressure in the turbine adjacent said shaft to prevent leakage of water from the chamber into the turbine, and means to reduce the temperature of water in said chamber below the flashing temperature for its pressure.

2. In a boiler circulating pumping unit, a centrifugal circulating pump, a steam turbine for driving said pump, a casing for said pump, a casing for said turbine, a single shaft for driving said pump and driven by said turbine, said casing having a mixing chamber therein surrounding said shaft between the pump and turbine, said chamber having communication with the interior of the pump casing to receive discharge pressure leakage from the pump, means for delivering steam from a source outside the turbine to said chamber at a pressure in excess of the water pressure in the chamber and in excess of the steam pressure in the turbine adjacent said shaft to prevent leakage of water from the chamber into the turbine, and means to reduce the temperature of water in said chamber below the flashing temperature for its pressure, an outlet for water and condensed steam opening into said chamber to lead water and condensate from said chamber away from said pump.

3. In a boiler circulating pumping unit, a centrifugal circulating pump, a steam turbine for driving said pump, a casing for said pump, a casing for said turbine, said pump including an impeller, a single shaft driven by said turbine and having said impeller mounted upon one end thereof, a connecting extension on said casing between the turbine casing and the pump casing and having a mixing chamber therein surrounding said shaft, said mixing chamber having communication with the interior of the pump casing to receive discharge pressure leakage from the pump, said connecting extension having a second chamber therein and having communication with said mixing chamber and the interior of the turbine casing, and means for delivering steam

6

into said second chamber at a pressure in excess of the water pressure in the mixing chamber whereby steam will flow from the second chamber into the mixing chamber and means for delivering water at a temperature lower than the temperature of the leakage into the leakage to reduce the temperature of the leakage below the vaporization temperature corresponding to its pressure.

4. In a boiler circulating pumping unit, a centrifugal circulating pump, a steam turbine for driving said pump, a casing for said pump, a casing for said turbine, said pump including an impeller, a single shaft driven by said turbine and having said impeller mounted upon one end thereof, a connecting extension on said casing between the turbine casing and the pump casing and having a mixing chamber therein surrounding said shaft, said mixing chamber having communication with the interior of the pump casing to receive discharge pressure leakage from the pump, said connecting extension having a second chamber therein and having communication with said mixing chamber and the interior of the turbine casing, means for delivering steam into said second chamber at a pressure in excess of the water pressure in the mixing chamber whereby steam will flow from the second chamber into the mixing chamber, and means for retarding leakage of steam from said second chamber into the turbine casing and means for delivering water at a temperature lower than the temperature of the leakage into said mixing chamber to reduce the temperature of the leakage below the vaporization temperature corresponding to its temperature.

5. In a boiler circulating pumping unit, a centrifugal circulating pump, a steam turbine for driving said pump, a casing for said pump, a casing for said turbine, said pump including an impeller, a single shaft driven by said turbine and having said impeller mounted upon one end thereof, a connecting extension on said casing between the turbine casing and the pump casing and having a mixing chamber therein surrounding said shaft, said mixing chamber having communication with the interior of the pump casing to receive discharge pressure leakage from the pump, said connecting extension having a second chamber therein and having communication with said mixing chamber and the interior of the turbine casing, means for delivering steam into said second chamber at a pressure in excess of the water pressure in the mixing chamber whereby steam will flow from the second chamber into the mixing chamber, and pressure reducing means in the communication between said mixing chamber and the pump casing means for delivering water into said mixing chamber to reduce the temperature of the leakage below the vaporization temperature corresponding to its temperature, and means for regulating the pressure of the water introduced into the mixing chamber to substantially the pressure of the leakage.

6. In a boiler circulating pumping unit, a centrifugal circulating pump, a steam turbine for driving said pump, a casing for said pump, a casing for said turbine, said pump including an impeller, a single shaft driven by said turbine and having said impeller mounted upon one end thereof, a connecting extension on said casing between the turbine casing and the pump casing and having a mixing chamber therein surrounding said shaft, said mixing chamber having communication with the interior of the pump casing

to receive discharge pressure leakage from the pump, said connecting extension having a second chamber therein and having communication with said mixing chamber and the interior of the turbine casing, means for delivering steam into said second chamber at a pressure in excess of the water pressure in the mixing chamber whereby steam will flow from the second chamber into the mixing chamber, and means to reduce the temperature of water in said mixing chamber below the flashing temperature for its pressure.

7. In a boiler circulating pumping unit, a centrifugal circulating pump, a steam turbine for driving said pump, a casing for said pump, a casing for said turbine, said pump including an impeller, a single shaft driven by said turbine and having said impeller mounted upon one end thereof, a connecting extension on said casing between the turbine casing and the pump casing and having a mixing chamber therein surrounding said shaft, said mixing chamber having communication with the interior of the pump casing to receive discharge pressure leakage from the pump, said connecting extension having a second chamber therein and having communication with said mixing chamber and the interior of the turbine casing, means for delivering steam into said second chamber at a pressure in excess of the water pressure in the mixing chamber whereby steam will flow from the second chamber into the mixing chamber, means to reduce the temperature of water in said mixing chamber below the flashing temperature for its pressure, and an outlet for water and condensed steam opening into said mixing chamber to lead water and condensate from said mixing chamber away from the pump.

8. In a boiler circulating pumping system, the combination with a boiler, a boiler feed pump for delivering water to the boiler, a boiler circulating pump for receiving water from and returning it to the boiler, said boiler circulating pump including a casing and an impeller, a driving shaft for said impeller, said casing having a chamber therein surrounding said shaft and having communication with the interior of the circulating pump to receive discharge pressure leakage from the circulating pump, of means for delivering steam to said chamber at a pressure in excess of pressure of water in the chamber, means for by-passing a part of the discharge from the boiler feed pump to said circulating pump to reduce the temperature of water in said chamber below the flashing temperature for its pressure, and means for controlling the pressure and quantity of water by-passed from the discharge of the boiler feed pump to the circulating pump.

9. In a boiler circulating pumping system, the combination with a boiler, a boiler feed pump for delivering water to the boiler, a boiler circulating pump for receiving water from and returning it to the boiler, said boiler circulating pump including a casing and an impeller, a driving shaft for said impeller, said casing having a chamber therein surrounding said shaft and having communication with the interior of the circulating pump to receive discharge pressure leakage from the circulating pump, of means for delivering steam to said chamber at a pressure in excess of pressure of water in the chamber, and an outlet connection from said chamber to said boiler feed pump to deliver water and condensed steam from the chamber to the boiler feed pump, and pressure reducing means in the

communication between said chamber and the circulating pump casing.

10. In a boiler circulating pumping system, the combination with a boiler, a boiler feed pump for delivering water to the boiler, a boiler circulating pump for receiving water from and returning it to the boiler, said boiler circulating pump including a casing and an impeller, a driving shaft for said impeller, said casing having a chamber therein surrounding said shaft and having communication with the interior of the circulating pump to receive discharge pressure leakage from the circulating pump, of means for delivering steam to said chamber at a pressure in excess of pressure of water in the chamber, and an outlet connection from said chamber to said boiler feed pump to deliver water and condensed steam from the chamber to the boiler feed pump, and means for delivering a part of the discharge water from the boiler feed pump to said circulating pump to reduce the temperature of water in said chamber below the flashing temperature for its pressure.

11. In a boiler circulating pumping unit, a centrifugal circulating pump including a casing, a steam turbine for driving said pump and including a casing, a shaft driven by said turbine and driving said pump, a sealed casing extension enclosing said shaft, said casing extension having a chamber therein surrounding said shaft and having communication with the pump to receive leakage therefrom, means for delivering steam to said chamber, and means to reduce temperature of the leakage below the vaporization temperature corresponding to its pressure.

12. In a boiler circulating pumping unit, a centrifugal circulating pump including a casing, a steam turbine for driving said pump and including a casing, a shaft driven by said turbine and driving said pump, a sealed casing extension enclosing said shaft, said casing extension having a chamber therein surrounding said shaft and having communication with the pump to receive leakage therefrom, means for delivering steam to said chamber, and means for delivering water at a temperature lower than the temperature of the leakage into the leakage below the vaporization temperature corresponding to its pressure.

13. In a boiler circulating pumping unit, a centrifugal circulating pump including a casing, a steam turbine for driving said pump and including a casing, a shaft driven by said turbine and driving said pump, a sealed casing extension enclosing said shaft, said casing extension having a chamber therein surrounding said shaft and having communication with the pump to receive leakage therefrom, means for delivering steam to said chamber, and means for delivering water at a temperature lower than the temperature of the leakage into said chamber to reduce the temperature of the leakage below the vaporization temperature corresponding to its pressure.

14. In a boiler circulating pumping unit a centrifugal circulating pump including a casing, a steam turbine for driving said pump and including a casing, a shaft driven by said turbine and driving said pump, a sealed casing extension enclosing said shaft, said casing extension having a chamber therein surrounding said shaft and having communication with the pump to receive leakage therefrom, means for delivering steam to said chamber, means for delivering water at a temperature lower than the temperature of the leakage into said chamber to reduce the temperature of the leakage below the vaporization tem-

perature corresponding to its pressure, and means for regulating the pressure of the low temperature water to substantially a pressure corresponding to the pressure of the leakage.

IGOR J. KARASSIK. 3

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
853,059	Bunge	May 7, 1907
1,004,822	Scheurmann	Oct. 3, 1911

Number
1,020,704
1,070,809
1,352,743
1,734,458
1,815,439
1,867,236
2,169,935
2,281,650
2,393,691

10

Name	Date
Kieser	Mar. 19, 1912
Hodgkinson	Aug. 19, 1913
Hall	Sept. 14, 1920
Allen	Nov. 5, 1929
LaMont	July 21, 1931
Rijswijk	July 12, 1932
Vorkauf	Aug. 15, 1939
Wislicenus	May 5, 1942
Karassik	June 29, 1945

FOREIGN PATENTS

Country	Date
Great Britain	Sept. 29, 1932

Number
380,886