Oct. 28, 1958 R. T. EFFINGER 2,857,922

APPARATUS FOR CLEANING TUBE BUNDLES

Filed Oct. 9, 1951 2 Sheets-Sheet 1

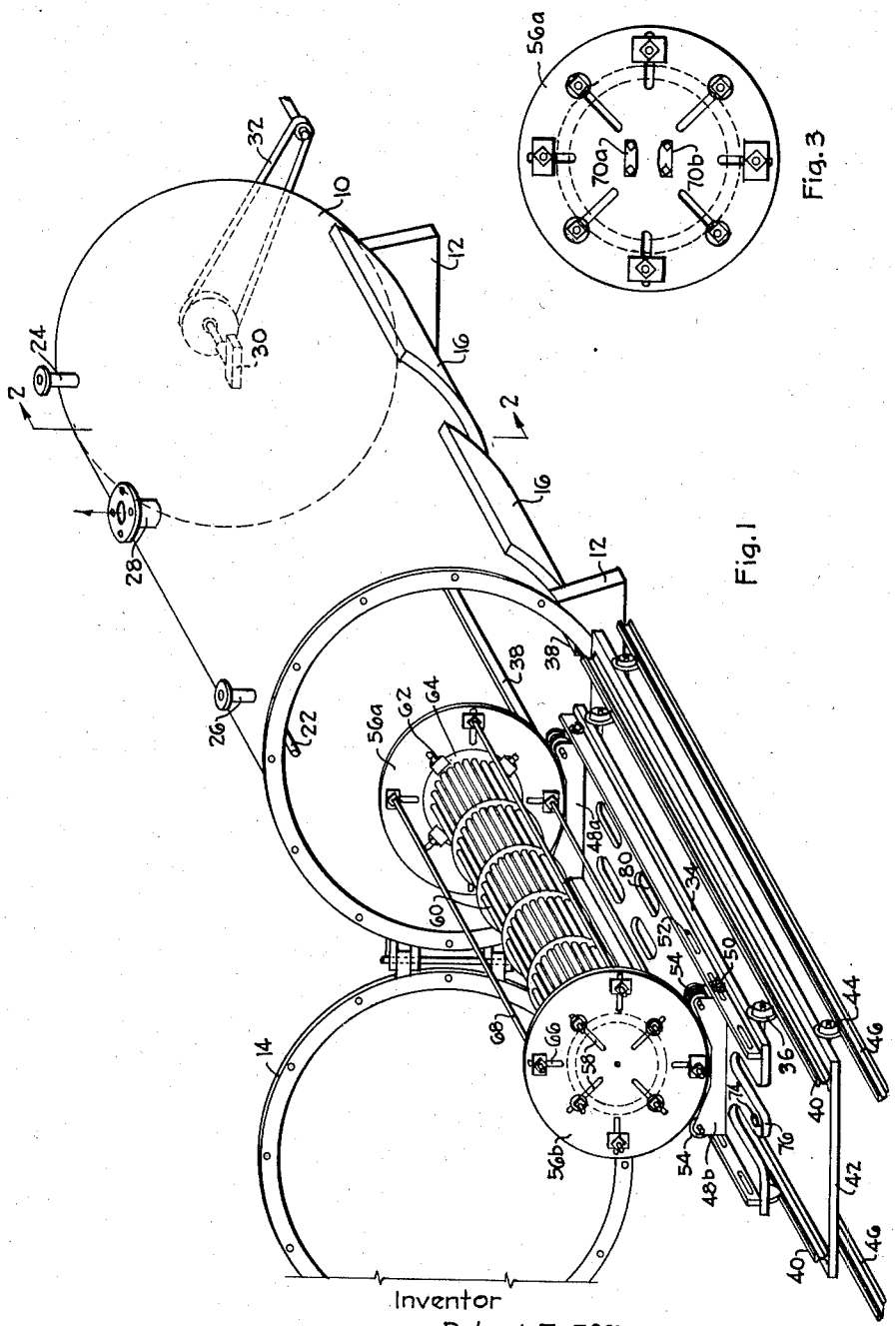


Fig. 3

Fig. 1

Inventor
Robert T. Effinger
By Oswald H. Milmore
his Attorney

Oct. 28, 1958 R. T. EFFINGER 2,857,922

APPARATUS FOR CLEANING TUBE BUNDLES

Filed Oct. 9, 1951 2 Sheets-Sheet 2

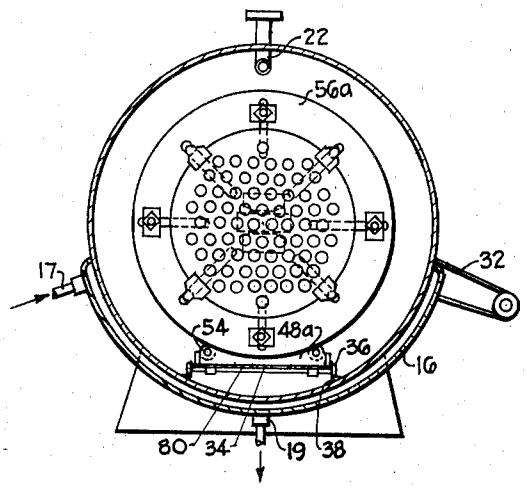


Fig. 2

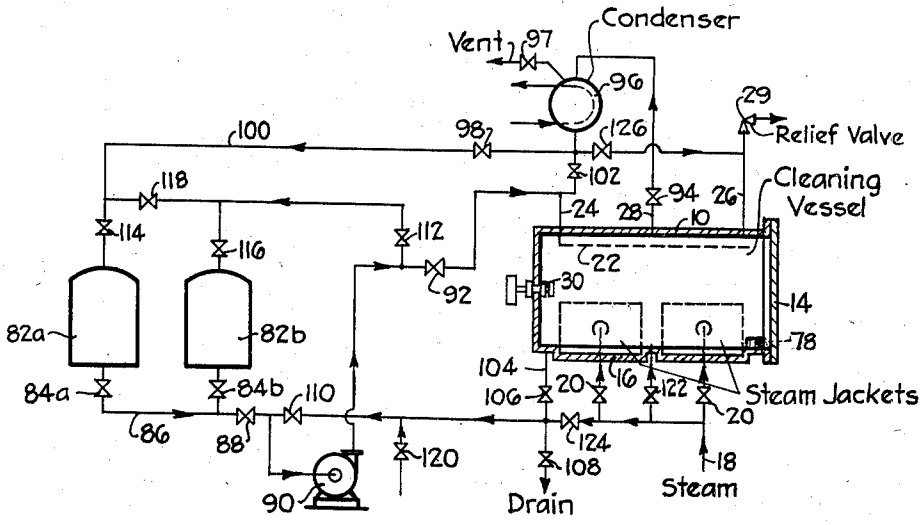


Fig. 4

Inventor
Robert T. Effinger
By Oswald R. Milmore
his Attorney

United States Patent Office 2,857,922
Patented Oct. 28, 1958

2,857,922

APPARATUS FOR CLEANING TUBE BUNDLES

Robert T. Effinger, Lafayette, Calif., assignor to Shell Development Company, Emeryville, Calif., a corporation of Delaware

Application October 9, 1951, Serial No. 250,480

2 Claims. (Cl. 134—133)

This invention relates to an apparatus for cleaning deposits from objects by means including the application of solvents to the deposits. It involves an apparatus for removing deposits consisting essentially of solids bound by resinous binder that are built up during prolonged exposure to petroleum liquids by subjecting such objects to the action of a cleaning liquid, specifically a solvent. Although certain features of the invention have other applications and the invention may be applied to cleaning other objects, it will be described as applied to cleaning the shell side of heat exchange tube bundles.

Due to the layout and pitch, it is often exceedingly difficult, if not impossible, to scrape the outside of tubes of such tube bundles by mechanical means; furthermore, satisfactory cleaning is not always obtained by mechanical means even where it is possible to use them.

Attempts have heretofore been made to avoid mechanical removal of deposits by recourse to solvents or detergents. However, deposits resulting from prolonged exposure of tubes and the like to petroliferous streams are difficult to remove by prior techniques employing solvents or detergents. Moreover, the handling of heavy and bulky objects such as tube bundles to introduce them into the cleaning vessel and the movement of such objects within the vessel during the cleaning operation have presented difficulties and required expensive equipment.

Among the objects of this invention are the provision of an improved apparatus for removing deposits of petroleum origin from objects, such as the exterior surfaces of heat exchange tubes assembled as tube bundles, including a vessel with means for supporting the object rotatably therein and for rotating the object while it is subjected to the action of a solvent or other cleansing liquid; and the provision of an improved apparatus for facilitating the introduction and withdrawal of elongated objects into and removal of such objects from the vessel. Further objects will become apparent from the following description.

The improved method is founded upon the fact that deposits of the character described consist of two types of materials, viz., solids and binding material, and that the great majority of deposits formed on surfaces of heat exchange tubes and the like are of this character. The solids are primarily solid corrosion products derived from the tubes themselves or from other equipment with which the process stream has come into contact, or other solids such as carbon or carbonaceous material that is carried in suspension in the process stream. The binding material is resinous in nature and consists of hydrocarbons or polymerized resins derived from the petroleum liquid; it cements the solids together. No single detergent or solvent was found to be effective for removing both the binding material and the solids within a reasonable time period.

According to the invention such deposits are removed preferably by a two-step process, the first of which involves extracting the binding material with a suitable solvent under conditions insuring uniform contact of

the solvent with all parts of the surface of the object and insuring contact under conditions insuring the use of the solvent in a state of cleanliness and at a temperature promoting high solvent power. This step leaves a residual deposit that consists essentially of the solids. The second step involves the removal of the residual deposit by mechanical means, such as the application of a blast of air or jet of water, or by the use of a detergent solution; this may be performed within the vessel used in the first step.

The invention further resides in the improved apparatus for applying clean solvent to the deposit by exposing the object to a bath of vapors of the solvent while cooling the object by applying cooled liquid thereto, e. g., liquid solvent.

The apparatus according to the invention includes, in one aspect, a pressure vessel having means for providing vapors of the solvent and for cooling the object within the vessel by applying a coolant thereto, e. g., cooled solvent or another liquid such as water, to cause condensation of vapors as clean solvent on the surface of the object during the first step of the method. The invention further provides a vessel provided with a bearing support for a pair of circular supports that are fixed to the object to be cleaned whereby the object may be rotated while undergoing treatment, together with drive means within the vessel for causing such rotation. Moreover, the invention provides a cleaning system including a carriage, movable on a track exteriorly of the vessel and supporting a dolly that may be moved to the vessel on the carriage, the said bearings for supporting the circular supports being mounted on the dolly. In the preferred arrangement, the carriage and vessel are provided with tracks that may be brought into juxtaposition by movement of the carriage, and the dolly has wheels on which it may be rolled from the carriage onto the tracks in the vessel.

Having thus indicated the general nature of the invention, reference is made to the accompanying drawings forming a part of this specification and showing one illustrative embodiment of the invention, wherein:

Fig. 1 is an oblique projection of the apparatus showing the carriage and dolly in front of the pressure vessel;

Fig. 2 is a transverse sectional view taken on line 2—2 of Fig. 1 with a dolly and tube bundle within the vessel;

Fig. 3 is an elevation view of the inner bundle rotating plate secured to a tube bundle; and

Fig. 4 is a schematic diagram showing the pressure vessel and associated tanks and pipes.

The cleaning vessel **10** is constructed as a pressure vessel, supported on pedestals **12** and having a hinged door **14** that may be bolted to the end of the vessel. It has a plurality of steam jackets **16** to which steam may be admitted from a pipe **18** through valves **20** and inlet pipe **17** for heating solvent placed within the vessel. Condensate may be drained through outlet pipe **19**. A distributing pipe **22** having perforations along the length thereof extends the full length of the vessel near the top thereof and is connected at one end to a liquid supply pipe **24**. A safety blow-off conduit **26** connects a pressure relief valve **29** to the vessel. A large vapor draw-off pipe **28** communicates with the top of the vessel. A drive shaft **30** having a non-circular end is rotatably mounted slightly above the center of the rear wall of the vessel and extends through a stuffing box in the latter; the outer end of the shaft may be driven by any suitable means such as pulley and drive belt **32**. The end and side wall of the vessel **10** and the door **14** are advantageously thermally insulated, e. g., by covering with glass wool, not shown.

For moving the object to be cleaned into the vessel and for supporting the object rotatably within the vessel, I

provide a dolly 34 having flanged wheels 36 movable on a pair of tracks 38 which are fixed within the vessel and on a pair of tracks 40 in alignment therewith and outside of the vessel. The latter tracks are preferably carriage-borne, i. e., they are mounted on a carriage 42 having flanged wheels 44 that move on tracks 46, these tracks being laid on the ground exterior to the vessel and extending longitudinally away from the front end thereof. By this arrangement, the carriage 42 may be rolled to place the tracks 40 into abutment with the tracks 38, permitting the dolly 44 to be rolled into the vessel. The carriage 42 may be then rolled away permitting the door 14 to be closed.

The dolly 34 has a pair of supports 48*a*, 48*b*, the latter being longitudinally adjustable, as by means of bolts 50 extending through slots 52. These supports comprise double-flanged rollers 54 having stellited shafts extending longitudinally with respect to the dolly to form roller nests adapted to receive circular rotating supports 56*a* and 56*b*. These plates, constituting bundle rotating plates, have radial slots 58 for securing the object to be cleaned, such as a heat-exchange tube bundle 60, by means of clamps 62. Thus, the body portions of these clamps may engage the margins of the tube sheets 64 at the end of the tube bundle and the clamp bolts may extend through these slots. Additional radial slots 66 receive tie rods 68. As is shown in Fig. 3, the inner plate 56*a* has a pair of lugs 70*a*, 70*b*, bolted thereto at the center; these lugs are spaced apart for receiving between them the end of the drive shaft 30 when the dolly and the support assembly are moved into the vessel. A hole 74 in a forwardly projecting arm 76 of the dolly is located to be over a threaded nut 78 when the dolly is in position within the vessel; the nut 78 is fixed to the bottom of the vessel. When the dolly has a floor, as shown, the latter is provided with openings 80 to permit liquid to drain.

It is evident that the dolly, when positioned within the vessel and secured thereto by a bolt extending through the hole 74 into the nut 78 forms a support for rotatably supporting the object to be cleaned. By virtue of the fixed position of the inner support 48*a* and sizes of the circular plates 56*a* and 56*b* which bring their centers to the axis of the vessel, driving engagement of the drive shaft 30 with the drive lugs 70*a* and 70*b* is assured. Tube bundles of various lengths may be accommodated by adjustment of the support 48*b* while the radial slots 58 permit tube bundles of different diameters to be supported.

Considering next the piping, any desired number of closed tanks 82*a*, 82*b* for separate storage of different cleaning liquids may be provided. They are connected by valves 84*a*, 84*b* to a common discharge manifold 86 which is connected by a valve 88 to a circulating pump 90. The discharge of the latter is connected through a valve 92 and the pipe 24 to the distributing pipe 22. The vapor draw-off line 28 is connected through a valve 94 to a water cooled condenser 96 which may have a vent valve 97; condensate from the latter may be returned to tank 82*a* via a valve 98, pipe 100 and valve 114 or to the cleaning vessel through a valve 102 and the pipes 24 and 22. A further return flow path to the vessel via a valve 126 and pipe 26 may be provided if desired. Liquid from the bottom of the vessel may be withdrawn through a pipe 104 and valve 106 and discharged from the system through a drain valve 108 or fed to the suction side of the pump 90 through a valve 110; from the latter it may be returned through the valve 112 to any tank by manipulation of the valves 114, 116 and 118. When valve 118 is closed, it is possible to return condensate to the tank 82*a* while returning liquid from pipe 104 to the tank 82*b*. Fresh make-up solvent may be admitted to the system through valve 120, and steam may, if desired, be admitted into the vessel through a valve 122 and to the solvent piping through a valve 124.

In operation, the bundle of heat exchange tubes 60 is secured to the circular bundle rotating plates 56*a* and 56*b* by the clamps 62 and tie rods 68, and the outer support 48*b* is adjusted longitudinally by means of the bolts 50 extending through the slotted holes 52 to space the supports 48*a* and 48*b* apart the required distance to permit the circular plates to be supported on the edges of the flanged rollers 54. These preparations being made in a service area provided with suitable hoisting equipment, and the carriage 42 with the dolly 34 thereon being at that area, the assembly of the tube bundle and circular rotating plates are placed on the supports. The door 14 being open, the carriage and dolly are moved on tracks 46 up to the vessel 10 and the dolly is rolled from the carriage-borne tracks 40 onto the interior tracks 38 within the vessel, the drive shaft 30 being turned slightly if necessary to enter the space between the lugs 70*a*, 70*b* on the support plate 56*a*. A bolt is then passed through the hole 74 at the outer end of the dolly and into the fixed nut 78 to hold the dolly in place. The door 14 is then shut and bolted fast.

All valves being initially closed, a suitable solvent for the resinous binding material that holds together the solids of the deposit on the external surfaces of the tubes is admitted from one of the storage tanks. Thus, to admit a volatile solvent from the tank 82*a*, the valves 84*a*, 88 and 92 are opened and the pump 90 is operated to force liquid to the perforated pipe 22, from which it flows onto the heat exchange tubes, from which it drains to the bottom of the vessel. Steam is admitted to the jacket 16 from the pipe 18 through valves 20 and inlet pipes 17, water condensate being discharged through pipes 19. The drive shaft 30 is rotated slowly, thereby rotating the tube bundle on the rollers 54. When the steam vaporizes the solvent, the resulting vapors form a vapor bath that envelops the rotating tube bundle. The tubes are cooled by the solvent admitted continuously all along the length of the pipe 22, causing vapors to condense over extended areas of the tubes as clean, warm solvent, having a high solvent power for the resinous material. This forms an extract solution of resinous material in the condensed solvent that drains down to the bottom of the vessel.

Cooling water is supplied to the condenser 96 and valves 94, 98 and 114 are opened, thereby withdrawing solvent vapors which are condensed and the condensed liquid is returned to the storage tank 82*a*. The rate of vapor draw-off is regulated by the valve 94 to maintain the desired pressure in the vessel, e. g., from 20 to 70 lbs. per sq. in. abs., which exceeds the vapor pressure of the vaporized solvent for the temperature of the cooled tubes; even higher pressure are at times desirable to permit operation at higher temperatures and cause condensation of the solvent at temperatures at which it has a greater solvent action. The rate of admission of liquid solvent through the pipe 22 may be regulated by operation of the pump 90 or throttling the valve 92 to maintain a desired quantity of solvent within the vessel; thus, it was found convenient to supply about 50 to 150 gallons of liquid solvent for every 100 cu. ft. of capacity of the vessel at the start and thereafter to maintain the total quantity of solvent within the vessel constant by maintaining the liquid level within the tank 82*a* constant, e. g., by an automatic device, not shown, responsive to the level in the tank. As a variant, condensate may be returned by gravity flow from the condenser through the valve 102 and pipe 24, the valves 98, 114, 84*a*, 88 and 92 being closed and the pump being stopped. By rotating the tube bundle different parts thereof are successively cooled for the condensation of solvent vapors, whilst, moreover, the direction of drainage relatively to the tubes is altered. Extracted resinous material accumulates in the bottom of the vessel.

The above treatment is continued for a time dictated by the nature of the deposit, the type of solvent, and the

temperature of operation, e. g., from 4 hours to 4 days. At the end of this cleaning period, the valve **84***a* is shut off and the pump **90** is stopped, and the solvent in the vessel is distilled overhead, condensed and returned to the tank **82***a* by continued heating. The vessel is steamed out by admitting steam through valve **122** and opening drain valves **106** and **108** prior to being opened.

The vessel may then be opened and the bundle pulled out with the dolly onto the carriage and immediately washed with hot water. The inside of the vessel is then also washed down to remove resinous material and other impurities removed from the tubes. By removal of as much solid material as possible at this stage, the effectiveness and useful life of the secondary stage cleansing liquids, when used, are greatly increased.

The residual deposit remaining on the tubes after the first stage treatment is porous and consists mainly of solids. These may be removed by mechanical means, such as by applying a blast of air or a jet of liquid against them, or by applying a liquid detergent that separates the solid particles from the tube surface. Treatment with liquid is advantageously carried out in the same vessel by again moving the tube bundle into the vessel and shutting the vessel and admitting a suitable cleansing liquid, such as a detergent solution, from the tank **82***b* through valves **84***b*, **88** and **92** and the pump **90** until the vessel is filled to a level at which the tube bundle is at least partially immersed, preferably to or slightly above the mid-level. Steam may be admitted to steam jackets **16** if desired, and rotation of the shaft **30** is started. The condenser **96** in this case is used as a knockback unit and all condensate is returned directly to the vessel through the valve **126** and pipe **26**, the valves **98** and **102** being shut. As soon as the desired temperature, such as 100 to 200° F., is reached, steam flow is reduced to maintain the temperature. The residual deposit is effectively removed from the tubes by continuing this treatment for a period of about one to ten hours by the movement of the liquid over the surfaces of the tubes. Steam flow is then shut off and the liquid is discharged through the pipe **104** and valve **106**, being either discharged through the drain valve **108** or passed through valve **110**, pump **90** and valves **112** and **116** to the tank **82***b*.

Volatile solvents suitable for use in the first step include hydrocarbon liquids, particularly a fraction rich in aromatics, such as benzene and toluene, and having a boiling point range at atmospheric pressure within the limits of about 150° and 300° F. Other solvents are halogenated hydrocarbons, such as chloroform, carbon tetrachloride, etc. Usual operating temperatures are from 120° to 300° F., e. g., 220° F., when working with a hydrocarbon fraction of the type indicated.

Suitable cleansing liquids suitable for use in the second step include caustic soda, sodium salt of alkyl phenols, and the like.

The invention is not limited to any of the solvents and cleansing liquids indicated by way of specific examples. As a variant, water may be used as a coolant during the first step and supplied to the pipe **22** instead of solvent; rich water, upon being vaporized in the cleaning vessel and condensed in condenser **96** flows to the tank **82***a* wherein it settles from the hydrocarbon solvent.

I claim as my invention:

1. In apparatus for cleaning bundles of heat exchange tubes, the combination of a horizontally elongated pressure vessel having a removable closure at one end thereof to provide an access opening when the closure is removed; exterior track means exterior to said vessel having a part thereof situated adjacent to said opening; a wheeled carriage adapted to move on said exterior track means; carriage-borne track means on said wheeled carriage disposed to be opposite the said opening and to extend longitudinally away from the vessel when the carriage is in front of the opening; a dolly adapted to support said bundle of heat exchange tubes and to enter the vessel through said opening and having wheels adapted to move on said carriage-borne track means; and interior track means within said vessel adapted to support wheels on the dolly and extending longitudinally inwardly from said opening, whereby the dolly may be rolled into the vessel from the truck on said carriage-borne and interior track means.

2. In apparatus for cleaning bundles of heat exchange tubes, the combination of a horizontally elongated pressure vessel having a removable closure at one end thereof to provide an access opening when the closure is removed; exterior track means exterior to said vessel having a part thereof situated adjacent to said opening; a wheeled carriage adpated to move on said exterior track means; carriage-borne track means on said wheeled carriage disposed to be opposite the said opening and to extend longitudinally away from the vessel when the carriage is in front of the opening; a dolly adapted to enter the vessel through said opening and having wheels adapted to move on said carriage-borne track means; interior track means within said vessel adapted to support wheels on the dolly and extending longitudinally inwardly from said opening, whereby the dolly may be rolled into the vessel from the truck on said carriage-borne and interior track means; means on said dolly for supporting said bundle of heat exchange tubes in horizontal position for rotation about a horizontal axis; and drive means within said vessel for rotating said bundle of tube about said horizontal axis when the dolly and bundle are within the vessel.

References Cited in the file of this patent

UNITED STATES PATENTS

318,205	Rau	May 19, 1885
512,683	Cochrane	Jan. 16, 1894
958,812	Judge	May 24, 1910
1,414,928	Backus	May 2, 1922
1,559,346	Moore	Oct. 27, 1925
1,753,243	Liddle	Apr. 8, 1930
1,834,872	Rosenberg	Dec. 1, 1931
1,934,677	Ash	Nov. 14, 1933
2,202,344	Hamilton	May 28, 1940
2,231,087	Protin	Feb. 11, 1941
2,273,039	Hudson	Feb. 17, 1942
2,295,912	Pagenkopf	Sept. 15, 1942
2,349,000	Phillips	May 16, 1944
2,366,949	Woppman	Jan. 9, 1945
2,371,644	Petering	Mar. 20, 1945
2,371,645	Aitchison	Mar. 20, 1945
2,371,647	Petering	Mar. 20, 1945
2,409,402	Thompson	Oct. 15, 1946
2,538,457	Hudson	Jan. 16, 1951
2,685,293	Dauphinee	Aug. 3, 1954