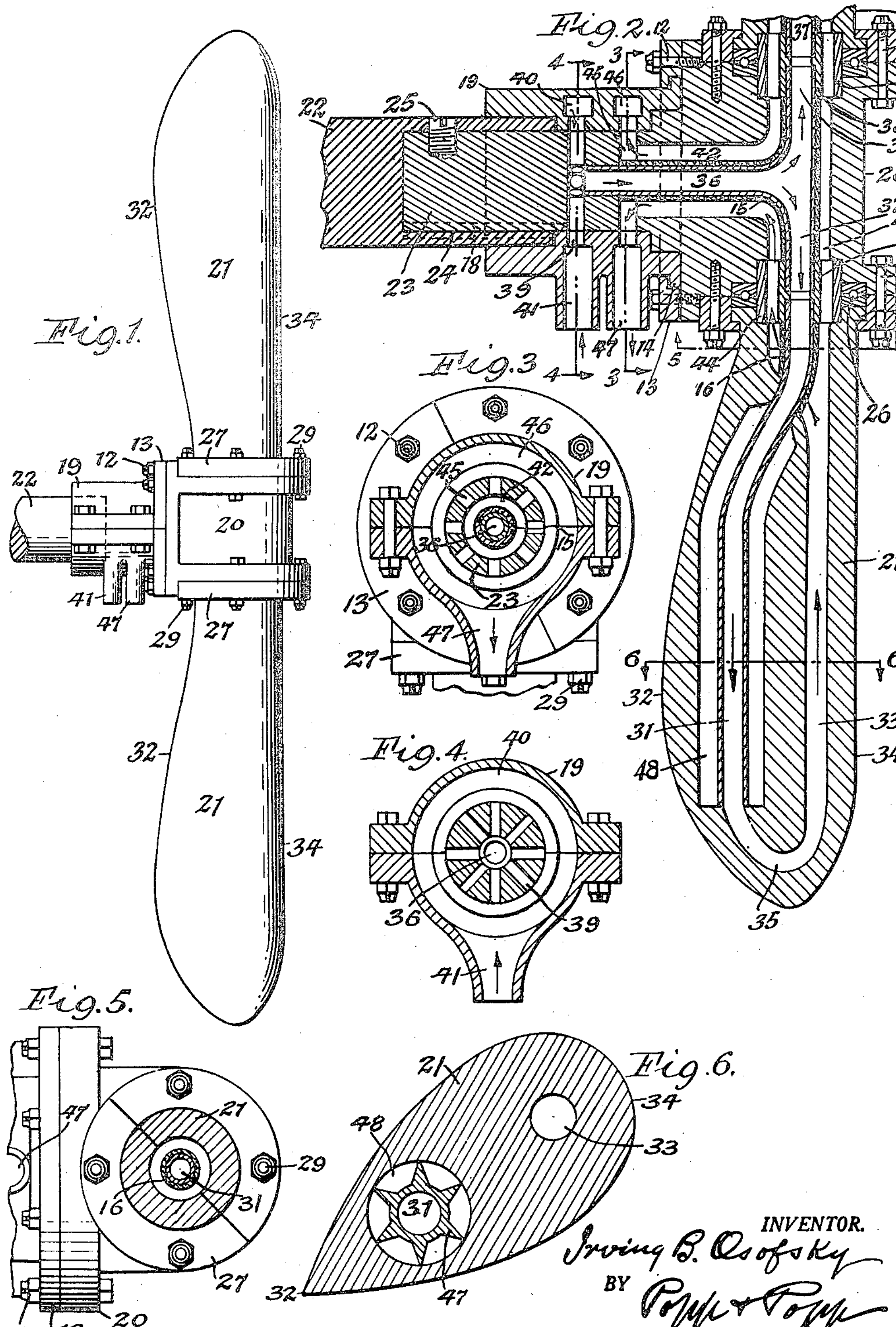
Nov. 30, 1948. I. B. OSOFSKY 2,455,313

HEAT EXCHANGING AIRPLANE PROPELLER

Filed Feb. 19, 1945 2 Sheets-Sheet 1



INVENTOR.
Irving B. Osofsky
BY Popp & Popp
ATTORNEYS

Nov. 30, 1948. I. B. OSOFSKY 2,455,313

HEAT EXCHANGING AIRPLANE PROPELLER

Filed Feb. 19, 1945 2 Sheets-Sheet 2

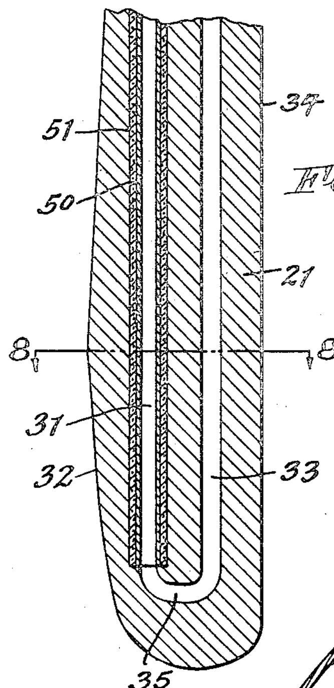
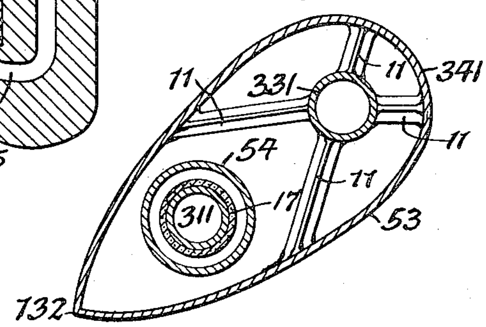


Fig. 7.

Fig. 10.



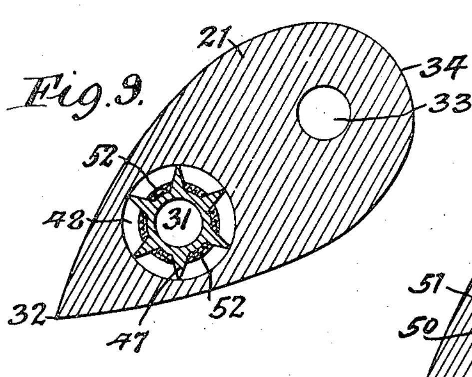
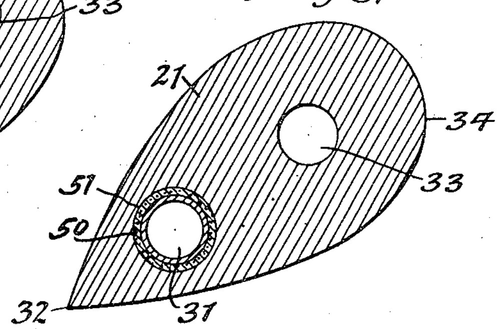


Fig. 9.

Fig. 8.



INVENTOR.
Irving B. Osofsky
BY Popp & Popp

ATTORNEYS

Patented Nov. 30, 1948 2,455,313

UNITED STATES PATENT OFFICE

2,455,313

HEAT EXCHANGING AIRPLANE PROPELLER

Irving B. Osofsky, Buffalo, N. Y.

Application February 19, 1945, Serial No. 578,641

5 Claims. (Cl. 257—259)

1

This invention relates to a heat exchanger for use in connection with the blades of an airplane propeller for the purpose of reducing the temperature of the oil or other coolant which has been heated during the operation of cooling the combustion engine which drives the respective airplane and incidentally warms the propeller blades so as to defrost the same and prevent the formation or accumulation of ice on said blades.

It is the object of this invention to provide a heat exchanger for this purpose which is very simple in construction, efficient in operation and which permits of transmitting the maximum amount of heat from the coolant to the propeller blades and thus maintains the engine in the coolest and best operative condition.

In the accompanying drawings:

Fig. 1 is a side view of an airplane propeller embodying this invention.

Fig. 2 is a fragmentary section, on an enlarged scale, taken lengthwise through the hub and one of the blades of the propeller.

Figs. 3 and 4 are cross sections of the propeller hub taken respectively on lines 3—3 and 4—4, Fig. 2.

Figs. 5 and 6 are cross sections of one of the propeller blades taken on lines 5—5 and 6—6, respectively, in Fig. 2.

Fig. 7 is a fragmentary longitudinal section of an airplane propeller blade showing a variation in the form of this invention.

Fig. 8 is a cross section, on an enlarged scale, taken on line 8—8, Fig. 7.

Figs. 9 and 10 are sections similar to Figs. 6 and 8 but showing further modifications of this invention.

In the following description, similar reference characters indicate like parts in the several views of the drawings:

Although this invention may be used in airplane propellers of different constructions, that form which is shown in Figs. 1–6 of the drawings will serve as a satisfactory example and as there shown the same is constructed as follows:

In general the airplane propeller shown in the drawings comprises a central metal hub 20 and a plurality of metal blades 21 projecting radially from the hub. The number of blades may vary but two of them are shown in Figs. 1 and 2 and these are arranged on diametrically opposite sides of the hub. This propeller may be rotated by any suitable means, for example by a driving shaft 22 which is connected with the hub of the propeller by a shank 23 arranged axially on the rear end of the hub and seated in an axial socket

2

24 on the front end of the driving shaft and secured thereto by one or more fastening screws one of which is shown by full lines 25 in Fig. 2, or by one or more keys or splines one of which is shown by dotted lines 18 in the same figure.

The driving shaft and the propeller may be supported in any suitable manner so that the same rotate together about the same axis, this being accomplished in the present instance by means of a stationary supporting block 19 provided with a cylindrical bearing in the front part of which the propeller hub turns and in the rear part of which the driving shaft turns. The propeller is held against longitudinal movement relative to the bearing block 19 by an annular flange 14 which is formed on the front end of this block and engages its front side with the propeller hub, and a split retaining ring 13 engaging with the rear side of this flange and connected by screws 12 with said hub, as shown in Figs. 2, 3 and 5.

The blades of the propeller may be either rigidly mounted on the hub or the same may be capable of rotating thereon for changing the angle of the blades relative to the direction of rotation, and the means for adjusting the blades as to angularity may also be of the character which permits the same to be adjusted while at rest and remain in this position while in operation, or the blades may be adjusted into various positions by manually controlled operating means while the propeller is in operation. For the present purpose means are shown whereby the blades may be adjusted while the same are at rest which means, as shown in Fig. 2, are constructed as follows:

The numeral 26 represents a ball bearing which is interposed between the inner end of each blade and one side of the hub whereby the blade may be turned about its longitudinal axis into different angles relative to the plane of rotation of the propeller to suit requirements. After the blade has been adjusted into the desired position the same may be held rigidly in place on the hub by a split clamping ring 27 engaging with an outwardly facing shoulder 28 on the inner part of the blade, and fastening bolts or screws 29 connected with the hub and passing through the clamping ring. When the bolts or screws 29 are loose the blades may be turned as required and upon tightening these bolts and screws the blades will remain in their adjusted position. It is, of course, understood that the connection between the blades and the hub may be such that turning of the blades relative to the hub may be effected by means controlled by the pilot in the airplane cabin in a manner now commonly practiced in airplanes.

The preferred form of the heat exchanging means which are embodied in the propeller for reducing the temperature of a coolant which has been used for cooling the gas engine operating the propeller are constructed as follows:

In general this heat exchanger includes a main circulating conduit comprising two longitudinal main sections through which the fluid to be cooled is circulated and which are arranged lengthwise in each blade and communicate with each other at their outer ends adjacent to the tip end of this blade.

One of these sections forms an intake or outflow conduit section which is connected at its inner end with the outlet of the gas engine jacket supplying the heated fluid coolant and the other longitudinal section forms a return or inflow conduit section which is connected at its inner end with a discharge leading to the inlet of said gas engine jacket.

The intake or outflow conduit section **31** preferably has the form of a tube arranged within the propeller blade lengthwise adjacent to the trailing or rear edge **32** thereof and the return or inflow conduit section **33** is preferably formed directly in the metal body of the propeller lengthwise adjacent to the leading or front edge **34** of the same, and the outer ends of said inflow and outflow conduit sections are connected by a curved connecting passage conduit section **35** formed directly in the metal body of the blade, as shown in Fig. 2.

The liquid coolant is conducted from the engine jacket to the inner ends of the intake or outflow conduit sections by a distributing conduit which includes a central inlet section **36** arranged axially within the propeller hub and a plurality of branch conduits **37** projecting laterally from the front end of the central section **36** and the outer end of each branch conduit being connected with the inner end of one of the outflow conduits **31** by a coupling sleeve **38** whereby communication is established between the distributing conduit and the outflow conduits at all times, but each of the propeller blades can be turned for changing its angularity relative to the plane of rotation without disturbing the connection between its outflow conduit and the distributing conduit. At its rear end the axial conduit section **36** communicates with a plurality of radial inlet ports **39** which are in constant communication with the inner side of an annular inlet or feed chamber **40** formed in the bore of the supporting block **19**. This inlet chamber is provided on its outer side with an inlet nozzle **41** which is connected in any suitable manner with the outlet of the jacket of the gas engine which drives the propeller and receives therefrom the heated coolant which is to be cooled in the propeller.

The chamber **40** and the ports **39** form a rotary tubular coupling between the propeller hub and the coolant inlet chamber **40** which maintains communication between the intake conduits of the propeller and the feed chamber **40** regardless of the circumferential position of the propeller relative to the supporting block **19**.

Means are provided for collecting the liquid coolant from the inner ends of the several inflow or return conduit sections of the propeller blades and returning the same to the inlet of the gas engine jacket which collecting means include a main return conduit **42** arranged within the propeller hub co-axially around the tube or conduit **36** and provided at its front end with radially extending branch return conduits **43**, each of which coaxially surrounds one of the distributing branches **37** and communicates with the inner end of the inflow or return conduit section **33** in the respective propeller blade. The joint between the inner end of each propeller blade **21** and the propeller hub **20** is bridged by a coupling tube **44** which engages with the adjacent bore portions at the outer end of the branch return conduit **43** and the inner end of the respective return conduit **33** so as to avoid leakage through this joint to the exterior of the propeller and still permit the latter to be turned for changing its angularity relative to the plane of rotation of the propeller.

The rear end of the central return conduit **42** communicates with the inner ends of a plurality of return ports **45** which open into an annular return chamber **46** formed in the bore of the supporting block **19**. By these means the return coolant passages of the propeller remain in constant communication with the return chamber **46** regardless of the rotary position of the propeller relative to the supporting or bearing block **19**. At the side of the supporting block the return chamber is provided with a return nozzle **47** from which the coolant is carried back from the propeller, in which it has been cooled, to the gas engine jacket for reducing the temperature of the engine.

In the operation of the organization described thus far the coolant entering the supply or feed chamber **41** is conducted through the passages **36**, **37** to the inner ends of the intake passages **31** and flows radially outwardly therein along the trailing edges of the propeller blades, thence through the cross passages **35** at the tip of the propellers, thence radially inwardly through the return passages **33** along the leading edge of the propellers to the collecting passages in the hub of the propellers and thence through the return chamber **46** to the liquid jacket of the gas engine.

In the absence of any further provision the circulation of the coolant in this manner through the propeller would only effect a moderate cooling of this coolant and thus fail to secure the greatest efficiency from the gas engine which drives the propeller.

Heat radiating means are therefore provided in accordance with this invention whereby the radiation of the heat in the coolant to the atmosphere as it passes through the propeller blades is increased which means are constructed as follows:

In general these improved heat radiating means consist in heat insulating the intake or outflow conduit of each propeller blade from the metal body of the latter so that no appreciable amount of heat is transmitted from the coolant to the propeller blade and dissipated to the atmosphere, but the return conduits are not heat insulated from the metal propeller blades but permit the heated coolant to come fully in contact therewith and thus cause a greater heat transmission from the coolant to the propeller blades and diffusion to the ambient atmosphere.

Insulation of the intake conduits to prevent or minimize the transmission of heat in the coolant to the propeller blades and atmosphere may be accomplished in various ways, those shown in Figs. 1–2 and 6 consisting essentially in providing a closed air chamber **48** in the propeller blade around the intake conduit **31** and thereby confining a body of dead air around this inflow conduit which serves as a heat insulator and prevents or at least reduces the transmission of heat from the coolant flowing through this conduit to the adjacent metal parts of the respective blade. The radiation of heat of the coolant through this intake conduit is decreased by providing the periphery of the intake or outflow conduit 31 within the dead air chamber 48 with a plurality of radial supporting and spacing wings or fins 47 which extend lengthwise thereof and thus divide this air space into a plurality of longitudinal passages.

Tubular coverings 15, 16 of asbestos cork or the like are also placed around the central section 36 and the branches 37 of the coolant distributing conduit within the propeller hub and the inner ends of the intake or outflow conduits 31 for the purpose of heat insulating the same and practically preventing radiation of heat from the coolant while flowing through these conduits.

The effect of heat insulating the intake or outflow conduit 31 from the metal of the propeller blade may also be produced by interposing a tubular separator 50 of heat insulating material, such as cork, asbestos or the like between the periphery of the intake conduit 31 and the bore of the longitudinal opening 51 in the propeller blade which receives this conduit, as shown in Figs. 7 and 8.

If desired this purpose may be accomplished by applying heat insulating strips 52 of asbestos, cork or the like to the periphery of an intake conduit between longitudinal fins 49 therein, as shown in Fig. 9.

This improvement is also applicable to propeller blades having the form of a hollow metal shell 53, as shown in Fig. 10, in which case the return conduit is made in the form of a round tube 331 which is arranged lengthwise within the hollow body adjacent to the front or leading edge 341 of the blade while the intake conduit has the form of a metal tube 311 which is surrounded by a tubular cover 17 of heat insulating material, such as cork, asbestos or the like, and said tube and cover being arranged within a tubular housing 54 located within the hollow propeller adjacent to the rear or trailing edge 132 thereof. Radiation of heat in the coolant to the atmosphere is effected in the construction shown in Fig. 10 by means of metal radiating struts or webs 11 extending radially from different parts of the metal return pipe 331 to the adjacent parts of the metal shell 53 of the hollow blade shown in Fig. 10.

By heat insulating the intake conduit 31 but omitting heat insulation from the return conduit 33 the rate of dissipation of heat from the hot liquid to be cooled to the air is almost reduced to zero while flowing radially outward along the rear trailing edge of the propeller blade to the tip thereof, but during the radially inward flow of the hot liquid from the tip of the propeller blade along its front leading edge to the hub thereof the transfer of heat from the liquid to the air is at the maximum rate, this being accentuated by the front edge of the propeller blade being exposed to the strongest air pressure, thereby causing a more rapid transfer of heat from the coolant to the air and increasing the speed of the cooling effect on the engine which drives the propeller.

It will now be apparent that as the coolant flows radially outward in the intake conduit or tube 31 the same is practically unhindered in this movement and no appreciable amount of heat in the coolant is transmitted to the atmosphere but when this coolant flows radially inward through the return conduit or tube 33 the heat in the coolant is dissipated over the entire external area of the propeller blade to the atmosphere and thus reduces the temperature of the coolant very rapidly and increases the efficiency of the gas engine accordingly.

By heat insulating the intake conduit and omitting heat insulation of the return conduit the greatest temperature difference in the coolant is obtained while the same is flowing through the tip of the propeller blade where the same is exposed to the highest air speed, thereby cooling the coolant about twenty percent better than would be the case if the flow of coolant through these conduits were reversed.

The intake tube or conduit 31 may be of any shape in cross section but the return tube or conduit 33 should be circular in cross section inasmuch as this form of tube reduces turbulence in the coolant while passing through the return tube and therefore reduces the pumping losses of the means whereby the coolant is circulated through the cooling system of the gas engine and the heat exchange system of the propeller.

By thus cooling the coolant more rapidly the entire gas engine is lowered in temperature and its efficiency is increased.

Due to the insulation of the entire outgoing conduit, or substantially so, including the portion within and outside of the propeller the tendency of the hot outgoing fluid to heat the returning relatively cool fluid is reduced, thereby expediting the operation of cooling the liquid and permitting use of lighter and shorter blades and effecting a reduction in the weight of the same which is particularly desirable in the case of airplanes in which weight and bulk are important considerations.

I claim as my invention:

1. A heat exchanger for a blade of an airplane propeller, comprising a conduit having two longitudinal sections arranged lengthwise in said blade and communicating with each other at their outer ends and one of said sections being connected at its inner end with a heated fluid supply and forming an outflow section through which heated fluid is carried from the inner end of the blade to the outer end of the same and the other of said longitudinal sections being connected at its inner end with a discharge and adapted to carry the heated fluid from the outer end of the blade to the inner end of the same, and said outflow conduit section and its inlet connections being heat insulated from said blade to avoid transmission of heat from the liquid flowing through said outflow conduit section to said blade and the inflow conduit section being non-heat insulated from said blade to promote the transmission of heat from the liquid flowing through the inflow conduit section to said blade.

2. A heat exchanger for a blade of an airplane propeller, comprising a conduit having two longitudinal sections arranged lengthwise in said blade and communicating with each other at their outer ends and one of said sections being connected at its inner end with a heated fluid supply and forming an outflow section through which heated fluid is carried from the inner end of the blade to the outer end of the same and the other of said longitudinal sections being connected at its inner end with a discharge and adapted to carry the heated fluid from the outer end of the blade to the inner

end of the same, and said outflow conduct section and its inlet connections being heat insulated from said blade to avoid transmission of heat from the liquid flowing through said outflow conduit section to said blade and the inflow conduit section being non-heat insulated from said blade to promote the transmission of heat from the liquid flowing through the inflow conduit section to said blade, the heat insulation between said outflow conduit section and said blade including said spaces between said outflow conduit and said blade.

3. A heat exchanger for a blade of an airplane propeller, comprising a conduit having two longitudinal sections arranged lengthwise in said blade and communicating with each other at their outer ends and one of said sections being connected at its inner end with a heated fluid supply and forming an outflow section through which heated fluid is carried from the inner end of the blade to the outer end of the same and the other of said longitudinal sections being connected at its inner end with a discharge and adapted to carry the heated fluid from the outer end of the blade to the inner end of the same, and said outflow conduit section and its inlet connections being heat insulated from said blade to avoid transmission of heat from the liquid flowing through said outflow conduit section to said blade and the inflow conduit section being non-heat insulated from said blade to promote the transmission of heat from the liquid flowing through the inflow conduit section to said blade, the insulation between said outflow conduit section and said blade including longitudinal fins arranged on the periphery of said outflow conduit section and forming longitudinal air spaces between said outflow conduit section and said blade.

4. A heat exchanger for a blade of an airplane propeller, comprising a conduit having two longitudinal sections arranged lengthwise in said blade and communicating with each other at their outer ends and one of said sections being connected at its inner end with a heated fluid supply and forming an outflow section through which heated fluid is carried from the inner end of the blade to the outer end of the same and the other of said longitudinal sections being connected at its inner end with a discharge and adapted to carry the heated fluid from the outer end of the blade to the inner end of the same, and said outflow conduit section and its inlet connections being heat insulated from said blade to avoid transmission of heat from the liquid flowing through said outflow conduit section to said blade and the inflow conduit section being non-heat insulated from said blade to promote the transmission of heat from the liquid flowing through the inflow conduit section to said blade, the heat insulation between said outflow conduit section and said blade including a heat insulating material applied to the outer side of said outflow conduit section.

5. A heat exchanger for rotary airplane propellers having blades arranged radially relative to the axis of rotation, comprising a conduit for a coolant arranged in each blade and including an intake section extending outwardly from the inner end of the blade to the outer end of the same and arranged along the rear trailing edge of the blade, a return section extending from the outer end of the blade to the inner end of the same and arranged along the front advancing edge of the blade, and a transverse section connecting the outer ends of the intake and return sections adjacent to the tip of the blade, said intake section and its inlet connections being heat-insulated from the blade but the return and transverse sections having the capacity of transmitting heat to said blade.

IRVING B. OSOFSKY.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,623,746	Murray	Apr. 5, 1927
2,364,279	Dodge	Dec. 5, 1944

FOREIGN PATENTS

Number	Country	Date
386,165	Great Britain	Jan. 12, 1933
556,983	Great Britain	Oct. 29, 1943
729,523	France	Apr. 26, 1932