Nov. 29, 1938. D. ROEBLING 2,138,207

BOAT PROPULSION

Filed Aug. 13, 1937 3 Sheets-Sheet 1

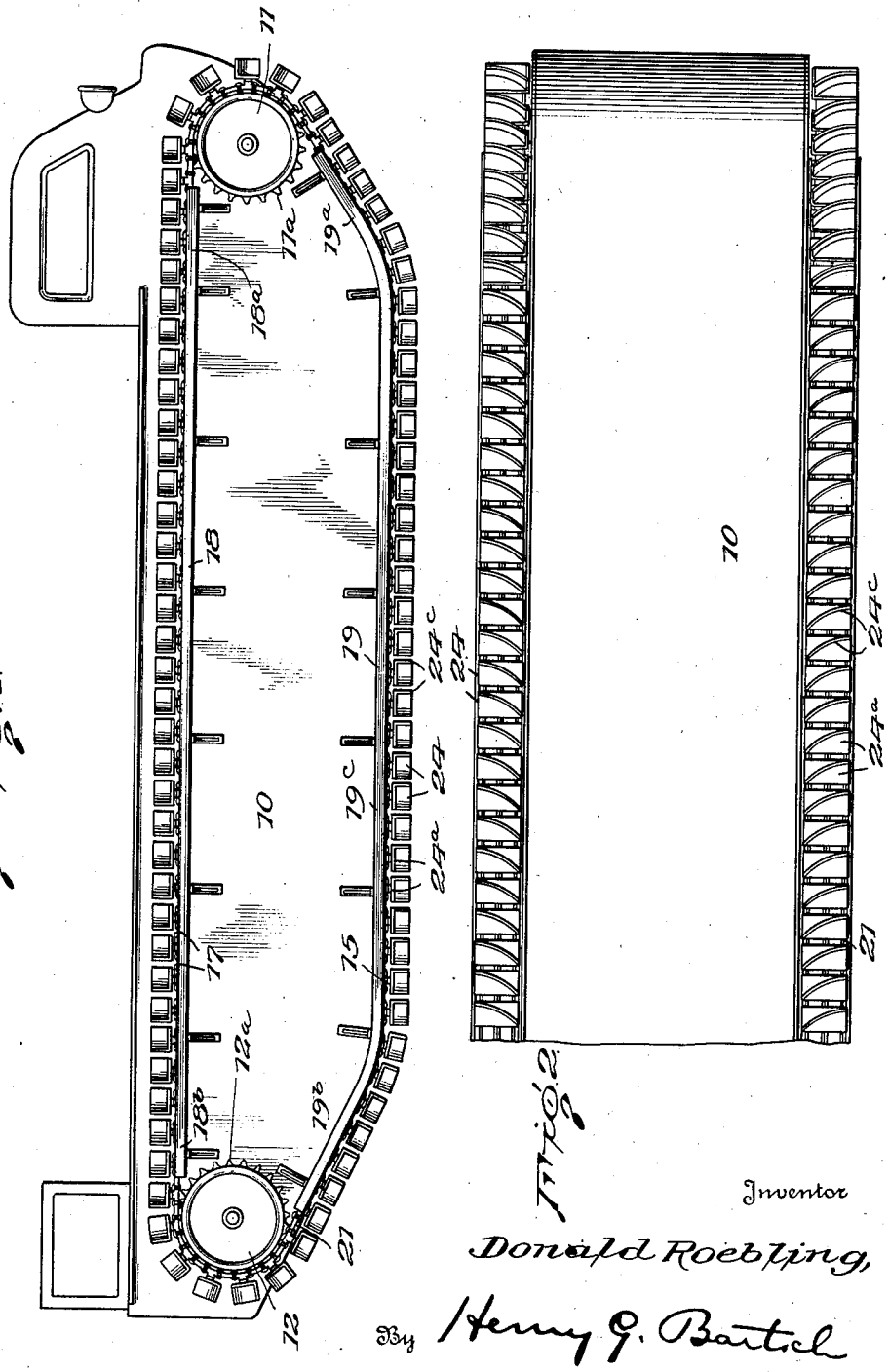


Fig. 1.

Fig. 2.

Inventor

Donald Roebling,

By Henry G. Bartch

Attorney

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BOAT PROPULSION

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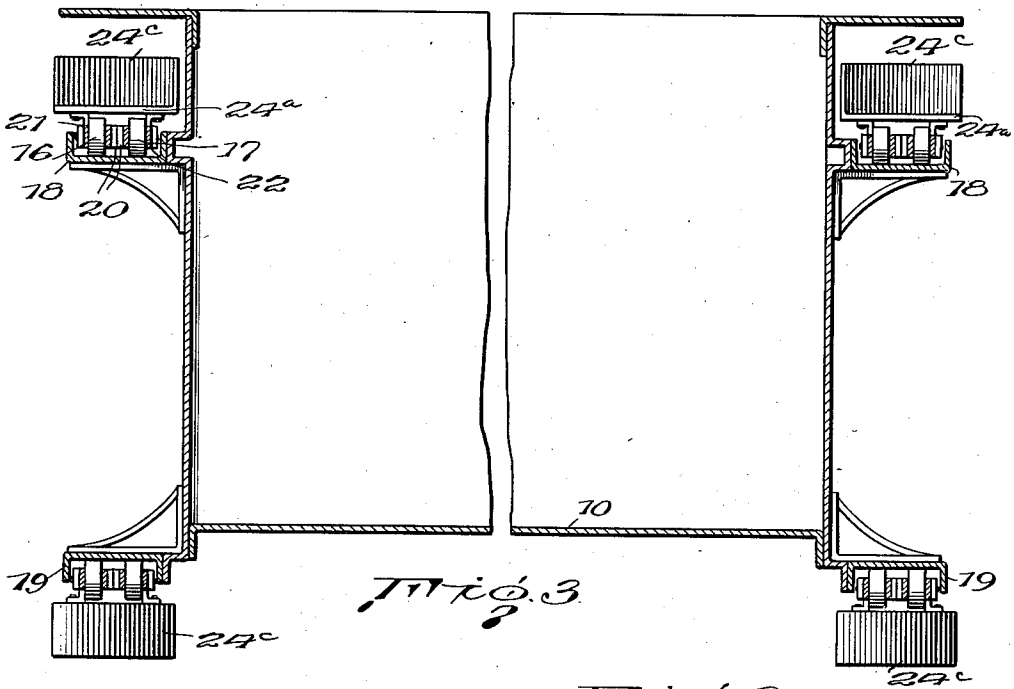


Fig. 3.

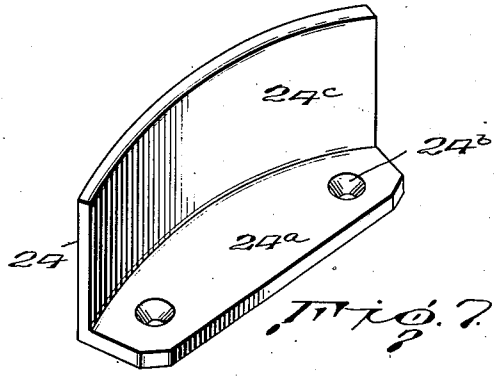


Fig. 7.

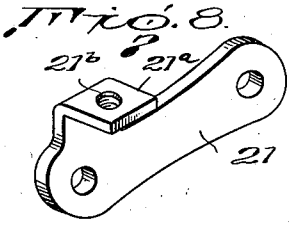


Fig. 8.

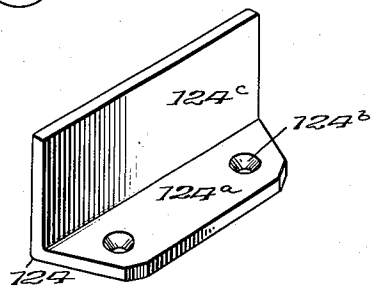


Fig. 9.

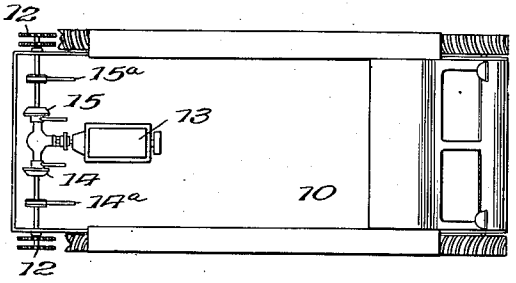


Fig. 4.

Inventor
Donald Roebling,

By Henry G. Bartel
Attorney

Nov. 29, 1938. D. ROEBLING 2,138,207

BOAT PROPULSION

Filed Aug. 13, 1937 3 Sheets-Sheet 3

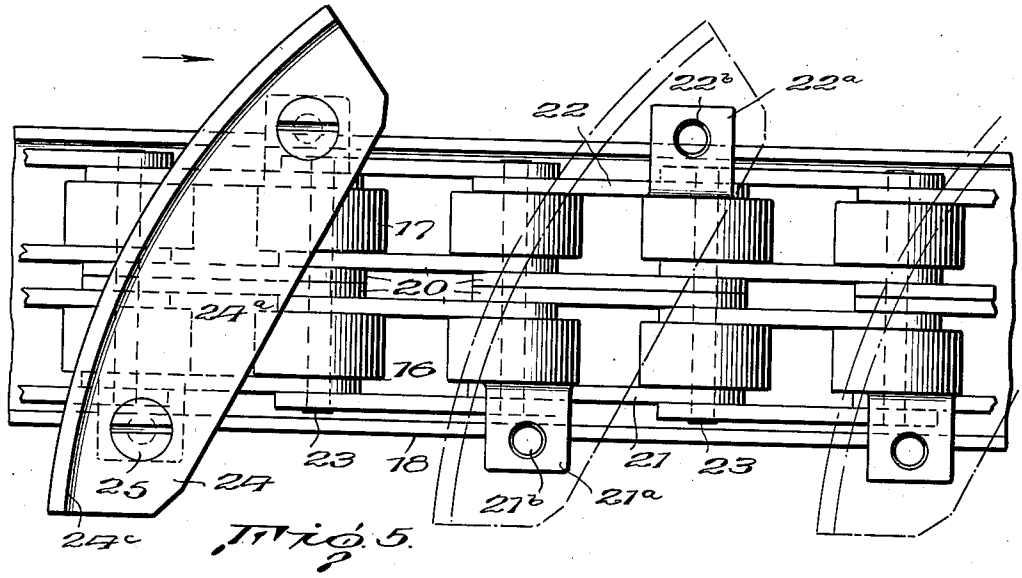


Fig. 5.

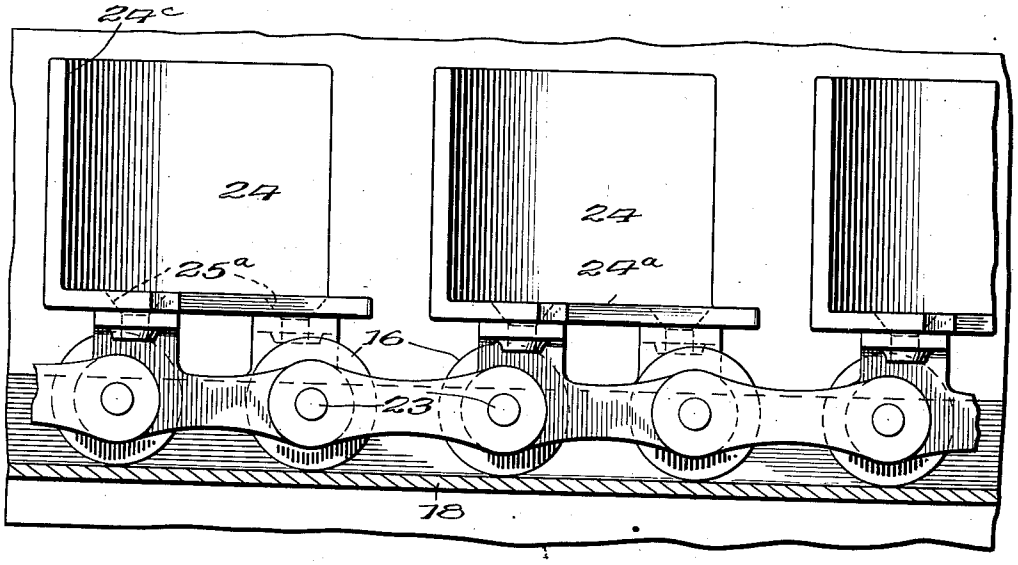


Fig. 6.

Inventor

Donald Roebling,

By Henry G. Bartel

Attorney

Patented Nov. 29, 1938

2,138,207

UNITED STATES PATENT OFFICE

2,138,207

BOAT PROPULSION

Donald Roebling, Clearwater, Fla.

Application August 13, 1937, Serial No. 158,987

8 Claims. (Cl. 115—1)

My invention relates to improvements in boat propulsion and has to do, more particularly, with the provision of belt-type propulsion means adapted to operate on land or in water without change-over or adjustment.

Propulsion mechanism consisting of an endless belt or belts provided with spaced transverse blades has been repeatedly proposed as a substitute for screw and paddle-wheel boat drives but, so far as I have been able to determine, no commercially successful belt-type propulsion arrangement has, prior to my invention, been devised. A number of problems are inherent to hitherto designed constructions of this general classification. One of the foremost of these is low-efficiency, caused primarily by cavitation and churning, even at moderate belt speeds. Other characteristics of this type of drive which contribute to low efficiency are excessive weight in the belt and friction losses in the belt and its supporting instrumentalities. Moreover, I have found that dual belt designs heretofore suggested for marine propulsion are incapable of effecting steering by differential driving of the belts, notwithstanding claims that by their use the conventional rudder may be eliminated.

With the foregoing and other problems of the prior art in mind, my invention has for its purpose several well-defined objects. It is a primary object of my invention to provide a boat-propulsion belt which is comparable in efficiency to conventional marine propulsion mechanisms.

It is also a salient object of my invention to provide a dual belt-type marine propulsion arrangement which may be readily steered solely by differential driving of the respective belts.

It is an object of my invention to provide an amphibian vehicle which will travel on land or in water and which will not stall or bog down in soft, swampy, rough or heavily overgrown terrain.

It is an object of my invention to provide an amphibian propulsion mechanism which, though relatively light in weight, may be driven over irregular, hard surfaced roads without material injury to the blade surfaces of the mechanism.

It is an object of my invention to provide an amphibian vehicle of low draft the propulsion mechanism of which is not subject to clogging or breakage by either submerged or surface objects such as limbs, logs, or dense thicket.

It is an object of my invention to provide an amphibian vehicle especially suitable for military defense and flood rescue work.

Further objects, and objects relative to details and economies of construction and use will more definitely appear from the detailed description to follow. My invention is clearly defined by the appended claims. Preferred embodiments of my invention are illustrated in the accompanying drawings forming a part of this specification, in which:

Figure 1 is a view, inside elevation, of an amphibian vehicle provided with belt-type propulsion means constituting what I regard to be a preferred embodiment of my invention;

Figure 2 is a bottom plan view of the front and central portions of the same vehicle illustrating the angular relationship of the impellers of the two propulsion belts;

Figure 3 is a vertical sectional view through the vehicle;

Figure 4 is a top plan view of the same vehicle drawn to a reduced scale and illustrating, diagrammatically, the driving mechanism for the propulsion belts;

Figure 5 is a plan view of several links of one of the propulsion belts of the craft, all but one of the impellers being shown detached therefrom to reveal details of the roller belt structure;

Figure 6 is a longitudinal sectional view through a portion of one of the belts and the channel-shaped guide which supports it;

Figure 7 is a perspective view of one of the impellers carried by the belts;

Figure 8 is a perspective view of one link element employed in the roller belt, which element is provided with an impeller-supporting flange; and

Figure 9 is a perspective view, on a reduced scale, of another form of impeller adapted for use in lieu of the form of impeller illustrated in Figure 7.

In the drawings, similar numerals of reference refer to similar parts throughout the several views.

In a broad sense, my invention finds embodiment in a water vehicle provided with one or more endless belts of flexible construction carried upon suitable guide means to present a substantially plane active string provided with suitably spaced cleat-like impellers, the blade surfaces of all of which impellers are substantially parallel and are arranged at an angle within the limits of 61 degrees and 69 degrees with respect to the longitudinal axis of the hull. More specifically, but not essentially, the impeller blades are of a form definable as sections of a cylinder having, in the

case of a blade of 8 inch width and 4 inch depth, a radius of curvature of 12¾ inches measured to the external surface of the blade. In the case of a propulsion belt provided with impellers of the size set forth, the optimum blade spacing, from the standpoint of efficiency in power required and speed afforded, is approximately six inches. As is apparent from Figure 2 of the accompanying drawings, the impeller blades of the two belts incline horizontally inwardly and rearwardly with respect to the longitudinal axis of the craft. This feature is of great importance in that only through this design is it possible to effect steering of the craft by differential driving of the respective belts. In addition, I have found that angular disposition of the impeller blades with respect to the craft axis is essential to high efficiency, the optimum angular relationship being in the neighborhood of 65 degrees.

Another feature of my invention consists in the fabrication of the impeller elements from aluminum or aluminum alloy and in securing the elements to the belts by means of rivets or bolts. Such a design affords great reduction in weight and attendant wear of the belts. In addition, such detachable aluminum impellers have been found to resist distortion and wear on land to a far greater degree than similar impellers of ferrous materials. Actual tests have established that extreme driving strains imposed upon the impellers will effect shearing of the ½'' securing bolts before injury can be inflicted upon the impeller blades. Continued driving over hard road surfaces has been found to cause only negligible wear upon the blade edges of such aluminum impellers.

More specifically, and with reference to Figures 1 to 4 of the accompanying drawings, my invention is embodied in a hull **10**, preferably of flat bottom construction curved upwardly at each end, and propulsion mechanism for said hull consisting of a pair of impeller-belt-carrying sprockets **11**, **12** fore and aft of said hull and disposed at each side thereof. One or both of the sprockets **11**, **12** at each side of said hull are adapted to be driven by a prime mover, such as a gasoline engine **13** mounted within the hull. Preferably, the sprockets are driven through independently operable clutches **14**, **15**, and each driven sprocket is further provided with an independently operable brake **14***a*, **15***a* to permit differential driving of the belts at each side of the hull. The pair of sprockets **11**, **12** of each side are arranged in alinement and are adapted to carry and drive a belt **15** of articulated chain construction. Preferably, and as shown, the chain **15** is of the roller type including a multiplicity of freely moving rollers **16**, **17** which are engaged by the teeth **11***a*, **12***a* of the respective sprockets to impart the drive to the chain. These rollers also serve to support the two stretches or "strings" of the chain upon the surfaces of a pair of guide members **18**, **19** of channel cross section, which guide members extend along each side of the hull **10** in alinement with the sprockets **11**, **12** and terminate in portions **18***a*, **18***b*, **19***a*, and **19***b* lying in planes substantially tangent to the chain driving surfaces of the sprockets at each side of the hull. More specifically, the lower guide member **19** of each side is, for a major portion **19***c* of its length, disposed in a plane substantially parallel to the plane of the hull bottom and is, preferably, disposed slightly therebelow to afford road clearance for the craft when traveling on land. In a sense, the link belt or chain **15** at each side of the hull is of double form consisting of two series of alined rollers **16**, **17** held in uniform spacing by connecting links **20**, **21**, **22** on transverse, roller-carrying, pintles **23** which are riveted at their ends to maintain the rollers and links in assembly. As will be noted from an inspection of Figures 5 and 6 of the drawings, the links **21** and **22** are provided with elevated flanges **21***a*, **22***a* disposed in a common plane, which flanges constitute a platform for the reception of the impeller members **24**. Each of the flanges **21***a* and **22***a* is slightly embossed inwardly by the punching of the holes **21***b*, **22***b*, thus providing a bolt-receptive bore of greater depth than the thickness of the flange proper. These bores **21***b*, **22***b* are slightly tapered at their outer ends and are threaded to receive impeller-securing bolts **25** having conical heads **25***a* which engage within the countersunk apertures **24***b* of the impellers **24**. Each impeller element consists of a base **24***a* and a blade **24***c* extending perpendicularly outwardly from the normal surface of the base **24***a*. Preferably, and as shown to scale, the several impeller blades **24***c* are identical and have the form of cylindrical sections struck on a radius of curvature of 12¾ inches measured to the outside surface thereof. Such a curvature has been found to yield an increase in efficiency of 20% over that obtainable with a straight blade. In the case of a blade having a width of approximately 8 or 9 inches and a height of 4 inches measured from the impeller base, a spacing of 6 inches between the blades has been found to be practical. In addition to the curvature of the impeller blades above described, it has been found necessary to dispose said blades obliquely with respect to the longitudinal axis of the craft. This oblique disposition of the impeller blades with respect to the craft axis is effected by the formation of the flanges **21***a*, **22***a* of the links **21**, **22** at the forward and rear portions thereof, respectively, and the appropriate location of the threaded holes **21***b*, **22***b*. Accurate tests have established that the most efficient angularity of the arcs of the propeller blades with respect to the longitudinal axis of the craft is in the neighborhood of 65 degrees, although the efficiency curve is quite flat between 61 and 69 degrees. My research also establishes that, with blades of either straight or curved form disposed at an angle of 90 degrees with respect to the craft axis, cavitation and churning occurs and is so excessive as to render the drive incomparable with conventional paddle wheel and screw propulsion mechanisms. Another interesting feature of this general type of drive is that the blades of the two belts must be angularly disposed in forwardly-open herring-bone relation if steering of the craft by differential driving of the belts is to be obtained. Accordingly, it will be noted from an inspection of Figure 2 of the drawings that the pattern defined by the several blades of the two belts is herring-bone in nature, the herring-bone pattern being divergent toward the front of the craft. Reversal of the pattern defined by the blades does not materially affect the efficiency of the craft in straight motion but does, however, render the craft incapable of steering by differential movement of the impeller belts or chains.

Preferably, the chains proper are fabricated from steel links, **20**, **21**, **22**, pintles **23** and hardened steel rollers **16**, **17**, but the impellers **24** are formed of aluminum or aluminum alloy. The formation of the impellers **24** of aluminum not

only renders possible a material reduction in the weight of the driving mechanism, but also has been found to afford high resistance to blade wear when the craft is driven over hard land surfaces such as concrete roads. Moreover, such aluminum or aluminum alloy impellers are highly resistant to bending and distortion, even though subjected to localized strains such as are experienced in traveling over large stones, stumps and the like. Experience has demonstrated that in most instances of excessive strain upon individual impellers, a shearing of the securing bolts **25** will take place before injury to the blade surfaces occurs. In the event of such injury, the efficiency of the drive is not excessively impaired and repair of the propelling mechanism may be readily accomplished by replacement of the sheared attaching bolts.

In the case of an amphibian craft it is especially desirable that the cylindrical blade portions of the impellers be disposed perpendicular to the supporting links of the driving chain for the reason that the strains thereon due to weight support in land travel are, for the most part, compressive in nature and tendency toward clogging of the blades, as well as buckling thereof, is materially reduced.

In Figure 10 of the drawings I have disclosed an alternate form of impeller construction which also embodies the generic concept of my invention. This form of impeller is characterized by the fact that the blade portion **12***4c* thereof is planar instead of arcuate. Such a blade construction has been found to be less efficient than the arcuate form illustrated as a preferred embodiment of my invention, but has the advantage of being capable of fabrication at slightly lower cost, from conventional angle stock. Tests have demonstrated that impellers of this modified type require the same angular disposition as the arcuate type. Considering only "active" blades of each belt, i. e. those blades which lie for the moment along the lower guide member, the optimum angular disposition of the blades with respect to the longitudinal axis of the craft is in the neighborhood of 65 degrees, and the angularity between the active blades of the two sets is 130 degrees, the several planes of the active blades of both chains mutually converging inwardly and rearwardly with respect to the craft. In defining the angle of the arcuate type of blades, reference is made to the chord of the arc of such blades.

The mode of operation of the craft should be apparent from the description of its construction. Through the clutches **14**, **15** and brakes, **14***a*, **15***a*, the prime mover may be caused to drive either one or both of the impeller-carrying chains at any desired relative speed. Forward or backward motion of the craft is obtained by appropriate turning of the respective belts. Steering of the craft to port or starboard is readily effected by driving the starboard or port belt at a greater speed than its companion. Sharp turning of the craft may be effected by locking one belt against movement and turning the other belt. The steering of my craft on land corresponds to the conventional steering of caterpillar tractors and tanks, and the steering of the craft in water operation is closely analogous thereto.

I am aware that numerous changes in construction and design will readily appear to those skilled in the art upon familiarization with the disclosure of this application. Obviously, although aluminum has been found to be a superior material for the fabrication of the impellers disclosed, other materials may be employed. Likewise, and particularly in the case of craft intended to be used solely for travel in water, the formation of the hull with a flat bottom disposed above the lower strings of the belts at each side of the hull is not an essential feature of my invention. Similarly, the mounting of the propeller belts as outboard units is not required for it is obvious that the belts might be disposed in wells formed within the hull proper. The specific guide means and roll chain structure disclosed as the support for the impellers is but one of many forms of construction which might be employed. In fact, the term "belt" is employed in its broad sense, and contemplates any form of flexible annulus which might be employed for the purpose, for example a non-articulated band of flexible material. Either one or both of the fore or aft sprockets of each side may be driven by the prime mover. Where only one sprocket is driven, the other serves the simple function of an idler. If desired, reversing mechanism may be installed intermediate of prime mover and each driving sprocket, whereby very rapid and sharp turning of the craft may be obtained by rotation of the belts in opposite directions. The foregoing and numerous other changes in construction and arrangement of the parts are contemplated, and I, accordingly, claim my invention broadly, as indicated by the appended claims.

What I claim is:

1. In a water craft, a hull, a prime mover, and means for propelling said hull, said means comprising a pair of endless belts, each mounted for annular movement along a side of said hull and driven by said prime mover, each of said belts being provided upon its periphery with a multiplicity of spaced, outstanding impeller blades similarly curved on radii parallel to their adjacent belt surfaces and arranged with the chords of their curvatures defining an acute angle with the adjacent sides of said hull.

2. In water craft, a hull, a prime mover, and means for propelling said hull, said means comprising a pair of endless belts, each mounted for annular movement along a side of said hull and driven by said prime mover, each of said belts being provided upon its periphery with a multiplicity of spaced, outstanding impeller blades similarly curved on radii parallel to their adjacent belt surfaces and arranged with the chords of their curvatures defining, with the adjacent side of said hull, an acute angle of approximately sixty-five degrees.

3. In water craft, a hull, a prime mover, and means for propelling said hull, said means comprising a pair of endless belts, each mounted for annular movement along a side of said hull and driven by said prime mover, each of said belts being provided upon its periphery with a multiplicity of spaced, outstanding, impeller blades similarly curved as sections of a cylinder on radii parallel to their adjacent belt surfaces, said blades of one belt defining, with the respectively corresponding blades of the other belt, a chord angle of approximately one hundred and thirty degrees.

4. In water craft, a hull, a prime mover, and means for propelling said hull, said means comprising a pair of endless belts, each mounted for annular movement along a side of said hull and driven by said prime mover, each of said belts being provided upon its periphery with a multiplicity of spaced, outstanding impeller blades sim-

ilarly curved as sections of a cylinder on radii parallel to their adjacent belt surfaces, the chords of the arcuate blades of the active portion of one belt having, with the chords of the respectively corresponding arcuate blades of the active portion of the other belt, a forwardly-open herringbone relationship characterized by a defined angular spread of approximately one hundred and thirty degrees bisected by the longitudinal axis of said hull.

5. An amphibian craft, comprising: a hull of substantially flat bottom construction, a prime mover, and means for propelling said hull on land or in water, said last mentioned means comprising upper and lower guide members of channel form extending along each side of said hull, each of said lower guide members having a major portion thereof lying in a plane adjacent and substantially parallel to the flat bottom of said hull, supporting and driving sprockets fore and aft of said guide members, in alinement therewith and adapted to be driven by said prime mover, and an endless articulated roller belt drivingly carried by each pair of sprockets and supported intermediate thereof by said guide members, each of said belts being provided with a multiplicity of spaced impeller blades arranged obliquely with respect to the adjacent hull side, each of said blades having the form of a section of a cylinder the cylindrical axis of which is substantially perpendicular to the adjacent belt plane and the height of which are such as to effect support of said hull bottom well above the common traction surface of the active strings of said impeller belts.

6. An amphibian craft, comprising: a hull of substantially flat bottom construction, a prime mover, and means for propelling said hull on land or in water, said last mentioned means comprising upper and lower guide members of channel form extending along each side of said hull, each of said lower guide members having a major portion thereof lying in a plane adjacent and substantially parallel to the flat bottom of said hull, supporting and driving sprockets fore and aft of said guide members, in alinement therewith and adapted to be driven by said prime mover, and an endless articulated roller belt drivingly carried by each pair of sprockets and supported intermediate thereof by said guide members, each of said belts being provided with a multiplicity of outstanding impeller blades angularly arranged with respect to the blades of the other belt to define a herringbone pattern converging rearwardly with respect to the normal line of the craft, said blades being formed of aluminum and having a height such as to reach well below the bottom of the craft hull to effect land support thereof by the active strings of said impeller belts.

7. A dirigible amphibian craft, comprising a buoyant hull of substantially flat bottom construction and means for propelling and steering said hull on land or in water consisting of upper and lower guide members extending along each side of said hull, each of said lower guide members having a major portion thereof lying in a plane adjacent and substantially parallel to the flat bottom of said hull, supporting and driving pulleys fore and aft of said guide members and in alinement therewith, an endless belt carried upon said pulleys and guide members at each side of said hull, each of which belts is peripherally provided with a multiplicity of spaced, obliquely-set impeller blades the active strings of which extend below the hull and jointly define a forwardly-open herringbone pattern characterized by an angular spread of approximately one hundred and thirty degrees bisected by the longitudinal axis of the craft, and means for selectively imparting either conjoint or differential driving motion to said driving sprockets and belts.

8. In dirigible water craft, a buoyant hull and means for propelling and positively steering said hull, said means consisting of a pair of similar endless belts, one mounted for annular movement along the port side of said hull and the other mounted for independent annular movement along the starboard side of said hull, a multiplicity of uniformly spaced impeller blades obliquely mounted upon the periphery of each of said belts in inverse arrangement jointly defining, in their active immersed zones, a forwardly-divergent herringbone pattern characterized by an angular spread of approximately one hundred and thirty degrees bisected by the longitudinal axis of the hull, driving means for imparting annular movement to the port belt, independent driving means for imparting annular movement to the starboard belt, and means for controlling the relative rates of movement of said two independent driving means to selectively operate said port and starboard belts in unison or at desired differential speeds and effective, through the defined forwardly-divergent arrangement of the belt-carried blades, to steer said craft by direct propulsive efforts without resort to a rudder or like steering mechanism.

DONALD ROEBLING.