This invention has reference to deep well turbine pumps, either of the extensible line shaft or submerged motor driven types, the principal objects of the invention being directed to improvements whereby the operating efficiencies of such pumps may be materially increased over the efficiencies heretofore obtainable, and whereby the useful life of such pumps may be substantially prolonged.

One of the factors tending to lessen the operating efficiency of turbine well pumps, is fluid friction loss in the submerged pump proper, that is within the series of bowls in which impellers are carried on the pump shaft. Where the interior surfaces of the bowls and the impeller surfaces are left rough, a substantial amount of the power input to the pump is taken up in overcoming friction losses between the pump parts and the well liquid being discharged upwardly through the pump to the ground surface. It is customary to reduce such friction losses by special operations on the pump bowl castings, as by sandblasting or otherwise smoothing their interior surfaces. The impeller surfaces are made smooth by machining operations, and by forming the impellers, in some instances, of bronze, which presents a smooth surface, but which, incidentally, is comparatively expensive.

It is a universal practice and necessity in making the pump parts as castings, to subject them to special operations for smoothing their liquid contacting surfaces to lower frictional losses within permissible limits; and prior to the present invention, it has not been practical to use comparatively rough surface castings without the necessity for finishing operations.

I may also mention that experience has indicated that after a pump has been in operation in the well over a considerable period of time, the parts become subject to deterioration as a result of galvanic action of the well liquid, particularly in water wells carrying minerals tending to promote such action. Also the pump parts are continuously subjected to great wear as a result of erosion by abrasive particles, usually sand, carried in the well liquid and discharged through the pump at high velocities.

In accordance with the invention, frictional losses are reduced to a low minimum and deterioration of the pump parts as a result of the agencies above noted, are prevented, by a vitreous enamel or porcelain coating applied to the pump parts by fusing the coating into the metal. So smooth is the surface of the enamel, as compared to that of the uncoated metal, that very material reductions in friction losses may be attributed to the application of the vitreous coating, the latter having a coefficient of friction approximately the same as that of pump glass. To illustrate the increase in the over-all operating efficiency of the pump, as the result of vitreous coating being applied to the impellers and bowl interiors, it may be mentioned that in one test, a pump normally operating with an efficiency of 74% was increased in efficiency to 79%.

Deterioration as a result of galvanic action is completely overcome, since the exposed surfaces of the pump parts are coated with a vitreous enamel not subject to attack by galvanic action. Wearing of the parts as a result of the abrasive action of sand particles carried in the well liquid, is also relieved from serious consequence inasmuch as the enamel presents a hard surface extremely resistant to abrasive wear.

The invention will perhaps be more fully understood from the following detailed description, throughout which reference is made to the accompanying drawing.

In the drawing there is shown a fragmentary sectional view of a typical deep well turbine pump. While for purposes of illustration I have shown a particular type of pump construction, it will be understood that such showing is illustrative only, and that the invention is applicable to all types of deep well turbine pumps, irrespective of particularities as to structure.

The pump body includes a series of pump bowls which are joined together by screws 11, there being attached to the lower bowl by screws 12, the usual suction nozzle 13, the details of which will not be necessary to describe. Each of the bowls comprises an outer shell 10a and an inner concentric tubular core 10b cast integrally with the outer shell by way of circularly spaced radial ribs 14. Suction nozzle 13 is similarly formed with a central tubular core 13b within which the shaft journaling bushing 15 is inserted. A similar bushing 15a journals the shaft 17 within the bore of core 10b of the pump bowl. The pumping elements comprise impellers 18, keyed to shaft 17, and contained within impeller chambers of the bowls 10, the impellers being of the usual type having upwardly extending radial passages between the ribs 14. The structural characteristics of this type of pump are so commonly known that no further description of details will be required for present purposes.

In the operation of the pump, shaft 17 and the impellers 18 are rotatively driven by a motor, not shown, connected to the shaft, well liquid being
taken upwardly through passages 22 in the suction nozzle and discharged upwardly by the series of impellers through passages 23 in the pump bowls, and finally into the usual eduction pipe leading to the ground surface.

The surfaces of the impellers 18, including the surfaces of ribs 21, are shown to be coated with vitreous enamel 24. Similar vitreous coatings 24 are applied to the interior of the bowls, including ribs 14, and also to the exterior surfaces thereof, if desired. It will be understood that in the broad aspect of the invention, the impellers alone, or the bowls alone, may be given the vitreous coating, since such coating applied to either of the elements will effectively increase the operating efficiency of the pump. However, it will generally be best to apply the vitreous coating to all the parts, to the end that the highest working efficiency possible will be obtained, and all surfaces will be protected from galvanic action or wearing away by abrasives. Thus, as shown in the drawing, the enamel coatings may preferably cover all or substantially all the interior surfaces, including its internal fluid passages; and all or substantially all the impeller surfaces, both internal and external. This may include the surfaces, for instance, at A and B where the bowl and impeller closely interfit to prevent leakage, as well as the vitreous enamel, when omitted. Thus the drawing indicates omission of the enamel at such points on one or the other of the bowl and runner. It is desirable that the whole of the runner be enameled, except perhaps at the points of close approach to the bowl, as indicated.

The surfaces of the pump parts, the latter may be enameled from less expensive and comparatively coarse grained metals which, in the absence of the vitreous coating, would require machining operations and hand-work to reduce their surfaces to the necessary smoothness. It has been found that the vitreous enamel, when in a fused state, fills in the surface irregularities of the metal and hardens to present surfaces of glass-like smoothness. This is due to the fact that although applied to rough or irregular surfaces, the fused vitreous enamel has a sufficient tension which causes the exposed surfaces of the enamel to harden to an extremely smooth finish.

From the drawing it can be seen that the bowl and impeller are formed, in the main, each from a single casting in contrast to the "built-up" types of pumps. When the bowl and impeller are each cast in a single piece, the water passages are relatively inaccessible, because of their small size and their tortuosity, so that it becomes very difficult to produce smooth surfaces on the walls of these passages.

The only manner in which irregularities on the inner surface of the pump bowl castings may be removed, is by sand blasting operation. However, sand blasting is effective only to remove loose irregularities adhering to the inner surfaces of the bowls, and is ineffective to render such surfaces smooth where irregularities other than comparatively loose particles, occur in the castings. Thus, heretofore, because of the inaccessibility of the interior parts of the bowl castings, it has been necessary to allow such surface irregularities to remain.

The advantages and utility of the present invention become apparent upon considering the fact that by applying the vitreous enamel to the interior surfaces of the castings, these surfaces can be given a smoothness heretofore unobtainable by any other means, notwithstanding the inaccessibility of the surfaces, since the coatings may be dipped in the enamel solution and the coating hardened by baking.

The same may be said to be true of the interior passages within the impellers. The only practical manner in which it has heretofore been possible to smooth the interior walls of the impellers, is by costly hand-work, requiring considerable time. By the provisions of the invention, the interior surfaces within the impellers can be given glass-like smoothness by the vitreous coating, to the exclusion of hand-work heretofore required.

Sandblasting provides a clean surface to receive the enamel, and though other methods of cleaning may be used, sandblasting is most effective as it reaches all parts of the inaccessible surfaces. Such cleaning of adhering matter is necessary to the proper formation and adhesion of the enamel to form a regular, smooth and lasting surface.

By virtue of the smoothness of the enameled surface, the frictional resistance to the flow of well liquid through the pump is reduced to such an extent by the high viscosity of the liquid that this liquid would be possible in the case of metallic surface parts, even though they be specially machined or sand blasted to smooth their surfaces to the greatest extent.

I claim:
1. In a deep-well turbine pump structure suitable for pumping water containing abrasive material from a well, the combination of: a casting forming a bowl element positioned in an inaccessible position in said well beneath the surface of said water and providing passages for conducting said water upward, portions of said passages being inaccessible for smoothing, said bowl element providing an impeller chamber, said impeller chamber and said passages being coated with porcelain fused directly to clean irregular surfaces of the casting to form a hard abrasive-resistant smooth surface through which said water moves at high velocity, the outer edges of said porcelain and the exterior surface of said upper and lower shrouds being also coated by said porcelain adhering to clean irregular surfaces of said casting.

2. In a deep-well turbine pump structure suitable for pumping water containing abrasive material from a well, the combination of: a casting means positioned in an inaccessible position in said well beneath the surface of said water and providing passages for conducting said water upward, portions of said passages being inaccessible for smoothing, said bowl means providing an impeller chamber, said impeller chamber and said passages being coated with porcelain fused directly to clean irregular surfaces of the casting to form a hard abrasive-resistant smooth surface through which said water moves at high velocity, the outer edges of said porcelain and the exterior surface of said upper and lower shrouds being also coated by said porcelain adhering to clean irregular surfaces of said casting.
guiding a high-velocity stream of said water; a shaft extending into said impeller chamber; and an impeller means comprising a casting forming an impeller in said impeller chamber and providing an upper shroud and a lower shroud and vanes extending therebetween to provide impeller passages relatively inaccessible for smoothing, the walls of said impeller passages being coated with porcelain contacting and fused directly to a clean irregular surface of the casting forming said impeller to form a hard abrasive-resistant smooth surface through which said water moves at high velocity, the exterior surfaces of said upper and lower shrouds being also coated by said porcelain adhering to clean irregular surfaces of said casting, said impeller means providing a skirt portion with an external surface extending in close proximity to a corresponding portion of said bowl means, the porcelain coating on at least one of said means terminating short of said portion which is in proximity to the other adjacent portion whereby at least one of these adjacent portions provides no coating of porcelain thereon.

3. In a deep-well turbine pump structure suitable for pumping water containing abrasive material and minerals from a well, the combination of: a cast bowl means positioned in an inaccessible position in said well beneath the surface of said water and providing high-velocity internal passages of relatively restricted cross-sectional areas for conducting said water upward, portions of said passages being inaccessible for smoothing, said cast bowl means providing an impeller chamber; a shaft extending into said impeller chamber; an impeller casting providing a central opening through which said shaft extends and forming an impeller fitting rotatably within said cast bowl means in said impeller chamber and having certain limited surfaces at which it closely approaches complementary interior surfaces of said bowl means to restrict leakage of fluid past said impeller, said impeller casting providing high-velocity internal passages of relatively restricted cross-sectional areas discharging into said internal passages of said bowl means; a coating of porcelain fused directly to the clean rough surfaces of said impeller casting and covering the exterior surface thereof in those parts which do not closely approach said bowl means but terminating exterior of said central shaft-receiving opening whereby the walls of said central opening are uncoated by said porcelain, said coating also covering the whole of the wall surfaces of said internal fluid passages of said impeller casting; and a coating of porcelain similarly applied directly to the clean rough surfaces of said bowl means bounding said impeller chamber and said high-velocity internal passages of said bowl means, said coatings of porcelain covering and submerging all minor irregularities of said clean rough surfaces of said castings and entering the irregularities thereof to increase the bond between said coatings and said castings to withstand contact with the high-velocity pumped liquid and to withstand high centrifugal forces developed by rotation of said impeller casting, said coatings being formed of material more resistant to abrasion by said water than said castings and presenting smooth surfaces for guiding said water with greatly decreased skin-friction loss and for protecting said castings from abrasion and corrosion.

DE MONT G. MILLER.