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METHOD OF REMOVING SILT FROM TANKS

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This invention relates to a method for removing silt from metal tanks and particularly the ballast tanks of vessels or ships, and is most especially useful in connection with ore carriers of the type used, for example, on the Great Lakes, and to a method of preventing silt from caking in the bottom of tanks.

It is well known in the art pertaining to ships and vessels that the increased buoyancy which is imparted to an unloaded cargo vessel creates a considerable number of problems which must be solved if efficient operation is to be insured. In the absence of corrective measures, the propellers of unloaded vessels would be disposed too close to the water line to be properly operable. In addition, overly buoyant vessels lack those characteristics of maneuverability which are necessary to the safe operation of the vessel. In order to combat these and other problems, cargo vessels particularly are provided with large ballast tanks which may, when desired, be pumped full of water in order to decrease the buoyancy of the vessels, thereby maintaining propellers in the completely submerged condition and rendering the vessels more maneuverable and seaworthy.

The use of ballast tanks has presented a satisfactory solution to the problem of varying buoyancies of vessels, but at the same time has created another problem of a very serious and challenging nature. This newly created problem stems from the fact that the water pumped into the ballast tanks carries with it considerable quantities of mud or silt. A substantial portion of this material remains in the tanks when the same are emptied, and as might be expected, large accumulations of silt build up in the ballast tanks over extended periods of time. Experience has shown that over a period of time these accumulations may reach a weight of from 100 to 600 tons and, in fact, accumulations weighing as much as 1,500 tons have been discovered.

Obviously, accumulations of the magnitudes set forth hereinabove are extremely undesirable. A specialized knowledge of vessel design is not required in order to determine the fact that the cost of operating a given vessel is increased in proportion to the amount of silt which it must carry. It will also be realized that if overloading is to be avoided, the weight of useful cargo which may be carried by a vessel must necessarily be reduced as the weight of the silt in the ballast tanks is increased. It is, therefore, highly desirable that a commercially feasible method be developed by which accumulations of the type described may be effectively and easily removed, and further silting prevented.

Prior to this time, a number of solutions to the problem have been proposed but none have been particularly satisfactory. The method now employed throughout the shipping industry generally is, in fact, so far from being satisfactory that many ship owners prefer to allow the silt accumulations, together with the undesirable consequences which attend them, to remain rather than go to the inconvenience and expense of carrying out removal operations.

Under present practice, large holes are formed in the walls of the ballast tanks in order to allow workmen to enter them and clean out the silt by hand, by means of shovels, or by means of a pump which has a suction hose which is dragged throughout the length of the vessel. From the workmen's standpoint, this is a very dirty and unpleasant job, and from the ship owner's standpoint, a very expensive one.

For a time it was thought that a practical solution to the problem would involve the addition to the slit in the tanks of a deflocculating or dispensing agent to reduce the viscosity of the silt a sufficient amount to allow it to be pumped from the tanks.

A similar method had been used with some degree of success in connection with the removal of mud from wells. A considerable amount of experimentation directed along these lines, however, led to the conclusion that the amount of deflocculating or dispersing agent necessary to allow complete cleaning of a ship of average size was entirely too large to be commercially feasible in view of the relatively high cost of the agent. Normally, anywhere from 2,000 to 3,000 pounds of agent would be required.

By this invention, a method is provided which will allow silt accumulations to be pumped from the ballast tanks of ships without, at the same time, encountering the various difficulties inherent in previously employed methods. The instant invention contemplates the treatment of silt accumulations with a flocculating agent, preferably a polyelectrolyte so that the flocculating agent can suspend the individual particles and prevent classification, thereby reducing viscosity and increasing the flowability so that the silt accumulations may be easily removed as a suspension. The conventional ballast pumps on board a vessel may be used for such removal.

One would ordinarily be led to believe that the use of a flocculating agent for the purposes at hand would give results diametrically opposed to those desired. We have found, however, that this is not, in fact, the case. The formation of the mud particles into flocs under the influence of a flocculating agent imparts to the mud a fluffy characteristic. This fluffy characteristic gives to the silt a greatly increased freedom of flow such that it may, when mixed with water, be readily pumped from the tanks.

An object of the invention is to provide a commercially feasible and convenient method for removing silt accumulations from the ballast tanks of vessels.

A further object of the invention is to provide a method for removing silt accumulations from the ballast tanks of vessels, which method contemplates the conditioning of the silt in order to allow the same to be removed by means of conventional pumps.

Still another object of the invention is to provide a method for conditioning silt accumulations in the ballast tanks of vessels in order to allow the same to be removed by pumps and which method includes the treatment of the silt with a flocculating agent, and/or the addition of a reagent which will bring about an adherence of small air bubbles to the mud which will tend to float the silt particles out. A preferred reagent is one of the type suitable for use in froth flotation of iron bearing minerals or silica or silicate minerals, including oleic acid, tall oil fatty acids, water-soluble petroleum sulfonates, oil-soluble petroleum sulfonates, cationic flotation collectors and the like.

Other and further objects of the invention will be apparent from the detailed description to follow.

Generally speaking, the mud or silt which has been found to accumulate in the ballast tanks of vessels is predominently composed of oxides of iron and silica, together with aluminum oxide and organic materials. The aluminum oxide and organic materials present together with other impurities appear to have a major influence in causing the particles of silica and the oxides of iron to unite together to form a caked mud or silt which solidifies and cannot be pumped conveniently.

Apparently the flocculating agent such as a polyelectrolyte affects the surface chemistry of the various components in such a way as to cause the formation of a dispersed floc, which prevents classification of the solids and causes them to remain in a fluidized suspension which may be easily handled by a pump.

In order better to understand the application of our method to the problem at hand, it is helpful to have some acquaintance with the broad technical aspects of flocculation. Flocculation may be defined in general terms as the aggregation of minute particles into a number of larger composites or flocs. Hence, flocculation is an action markedly contrasted to deflocculation in that a deflocculating action or dispersion is one which suspends particles, thereby dispersing them into a colloidal suspension.

In an unflocculated system, the denser particles or sands settle to the bottom while the less dense particles or fines remain in suspension for extended periods of time. Under the influence of a flocculating agent, however, the colloidal particles are aggregated or collected together randomly into flocs and both the dense and the less dense particles, i.e., the sands and the fines, settle together. Because of the fact that the flocs are relatively large in size as compared to the individual particles from which they are comprised, the flocs cannot pack or cake together as closely as can the unflocculated individual particles and, therefore, produce a fluffy sediment of large volume which is, by comparison to the unconditioned silt or sediment accumulation, much easier to pump. Experience has indicated that long chain high molecular weight polymers, in general, when added to a colloidal suspension of particles, have the ability to form the colloidally suspended particles into flocs. The mud or silt particles, when influenced by the polymer molecules, are induced to join themselves to the polymer chain, thereby forming a floc.

Among the flocculating agents useful for the fluidizing of silt deposits are the polyelectrolytes represented by polymers of compounds having the formula:

$$>C=C-R$$

wherein R is selected from the group consisting of nitrile, amide, and carboxyl radicals, COOM where M is a lower alkyl radical preferably of 1 to 4 carbon atoms, and the water soluble salts thereof. Elements such as halogens, particularly chlorine, or alkyl or aryl groups as well as hydrogen may be present on the backbond hydrocarbon chain of the polymer.

Particularly suitable polyelectrolytic polymers for use in the present invention are the polymers of acrylic or methacrylic acid derivatives, for example, acrylic acid, the alkali metal and ammonium salts of acrylic acid, methacrylic acid, the alkali metal and ammonium salts of methacrylic acid, acrylamide, methacrylamide, the N-alkyl substituted amides, the N-aminoalkylamides, and the corresponding N-alkylaminoalkyl substituted amides, the aminoalkyl acrylates, the aminoalkyl methacrylamides and the N-alkyl substituted aminoalkyl esters of either acrylic or methacrylic acids. These polymeric compositions may be homopolymers or they may be copolymers with other copolymerizing monomers, such as ethylene, propylene, isobutylene, styrene, a-methylstyrene, vinyl acetate, vinyl formate, alkyl ether, acrylonitrile, methacrylonitrile, vinyl chloride, vinylidene chloride, the alkyl acrylates, the alkyl methacrylates, the alkyl maleates, and the alkyl fumarites, and other olefinic monomers copolymerizable therewith. The copolymers of this type, having at least 50 mole percent of the acrylic or methacrylic acid derivatives, are preferred, and especially when the comonomer is hydrophobic or has no ionizable groups. Polymers of this type may be prepared directly by the polymerization of suitable monomers, or by the after chemical reaction of other polymers, for example by the hydrolysis of acrylonitrile or methacrylonitrile polymers.

In connection with the various types of polyelectrolytic polymers suitable for the practice of this invention, the hydrophilic polymer may be prepared directly by the polymerization or copolymerization of one or more of the various available organic monomers with aliphatic unsaturation, if the said compounds contain a hydrophilic group, for example, carboxyl groups. Generally, more

types of polyelectrolyte polymers can be prepared by subsequent reactions of polymers and copolymers. For example, polymers containing nitrile groups may be hydrolyzed to form water-soluble amide and carboxy containing polymers or hydrogenated to form amine containing polymers. Similarly copolymers of maleic anhydride and vinyl acetate may be hydrolyzed to form polymers containing hydrophilic lactone rings. Other hydrophilic polymers may be prepared by the hydrolysis of copolymers of vinyl acetate wherein the acetyl groups are removed leaving hydroxy groups which promote the solubilization effect of polyelectrolytic groups present. By other reactions non-hydrophilic polymers may be converted into lactam or amide containing polymers which are more hydrophilic. Polyvinyl alcohol, not in itself a polyelectrolyte, may be converted into polyelectrolytes by esterification with dibasic acids, one of said carboxylic acid groups reacting with the alcohol radical and the other providing the hydrophilic characteristics by a carboxy group on the side chain. Still other types of polymers may be prepared by reacting halogen containing polymers, for example, the polymers or copolymers of vinyl chloroacetate or vinyl chloroethyl ether, with amines to form amine salt radicals and quaternary ammonium radicals whereby hydrophilic characteristics are introduced into what otherwise would be an insoluble polymer. Other soluble polymers may be prepared by the ammonolysis of ketone containing polymers, for example, polyvinyl methyl ketone. Similarly active halogen atoms may be reacted with bisulfite to substitute sulfonic acid group for the reactive halogens.

Thus, the various polyelectrolytes of the types described above are ethylenic polymers having numerous side chains distributed along a substantially linear continuous carbon atom molecule. The side chains may be hydrocarbon groups, carboxylic acid groups or derivatives thereof, sulfonic acid groups, or derivatives thereof, phosphoric acid or derivatives thereof, heterocyclic nitrogen groups, aminoalkyl groups, alkoxy radicals and other organic groups, the number of which groups and the relative proportions of hydrophilic and hydrophobic groups being such as to provide a water-soluble polymeric compound having a substantially large number of ionizable radicals. The length of the said continuous carbon chain must be such as to provide compounds having a weight average molecular weight of at least 10,000.

Among the various polymers as described above and water-soluble salts thereof useful in the practice of the present invention, there may be mentioned hydrolyzed polyacrylonitrile and polyacrylamide, sulfonated polystyrene, acrylamide-acrylic acid copolymers, polyacrylic acid, ½ calcium salt of hydrolyzed 1:1 copolymer of vinyl acetate-maleic anhydride, hydrolyzed styrene-maleic anhydride copolymer, ammonium polyacrylate, sodium polyacrylate, ammonium polymethacrylate, sodium polymethacrylate, diethanolammonium polyacrylate, guanidinium polyacrylate, dimethylaminoethyl polymethacrylate, acrylamide-acrylonitrile copolymer, methacrylic acid-dimethylaminoethyl methacrylate copolymer, methacrylic acid-dimethylaminoethyl methacrylate copolymer, sodium polyacrylate-vinyl alcohol copolymer, hydrolyzed methacrylic acid-acrylonitrile copolymer, vinyl acetate-maleic anhydride copolymer, vinyl formate-maleic anhydride copolymer, vinyl methyl ether-maleic anhydride copolymer, isobutylene-maleic anhydride copolymer, styrenemaleic anhydride copolymer, ethyl acrylate-maleic anhydride copolymer, vinyl chloride-maleic anhydride copolymer, hydrolyzed acrylonitrile vinyl acetate copolymer, hydrolyzed acrylonitrile-methacrylonitrile copolymer, hydrolyzed acrylonitrile-methacrylonitrile-vinyl acetate terpolymer, hydrolyzed acrylonitrile-methacrylic acid copolymer, vinyl pyridine-acrylonitrile copolymer, etc. Polymers containing cationactive groups are also useful. Suitable compounds are, for example, ethyl acrylate and acrylamidopropyl-

benzyldimethylammonium chloride, copolymers of methylolacrylamide and acrylamidopropylbenzyldimethylammonium chloride, copolymers of butadiene and 2-vinyl pyridine, and certain quaternary compounds such as polydimethylaminostyrene quaternized with benzyl chloride, allyl chloride, etc. and quaternized copolymers of vinyl alcohol and morpholinylethylvinylether and the like.

The molecular weight of these polymers is fairly ambiguous. Molecular weights as low as 100,000 are useful as are molecular weights which range over 5 to 15 million. As long as the polymers are sufficiently low in molecular weight so as to be water soluble they have the characteristics required. Polymers of molecular weights of well over 2 million have such solubility. The difficulty of measuring molecular weights in the range of 2 to 20 million causes the numerical values to be somewhat ambiguous. Viscosity measurements particularly intrinsic viscosity determinations are particularly effective in attempting to determine the molecular weights in this range.

The polyacrylamides are particularly useful in the present invention. Polyacrylamide having a molecular weight of approximately 4 to 5 million gives good results.

Polyelectrolytes have centers of electronic activity along the chain. Polyacrylamides for instance usually have at least a few polyacrylic acid links along the chain and whereas for a molecular weight of a million or two, the percentage of such acid links is very small, still there are enough acid links or other centers of electronic activity to bridge between two or more particles and in effect cause various centers of electronic activity on the same long molecule to interact with more than one particle. Without being limited to the above or the following theories as to the operations involved in the present invention; the results which occur are consistent with these theories.

It is important to note that flocculation in a given colloidal system cannot be increased indefinitely beyond a particular optimum polymer concentration. The various physical laws which explain this phenomenon are rather involved, and the most technical aspects of them are beyond the scope of this application. It may be said, however, that up to the optimum concentration nearly all of the polymer added to the colloidal system is absorbed on the surfaces of the silt particles and very little is left in the solution itself. The point beyond which complete adsorption fails to take place corresponds generally to the optimum polymer/silt ratio. If the flocs formed in the presence of excess polymer are agitated they degrade faster than those formed in the presence of the optimum polymer to silt ratio. If the flocs are broken apart, fresh surfaces are exposed upon which the polymer is rapidly adsorbed. The flocs then cannot reform as well as before because the new polymer molecules have insulated the portions of the surface which had previously served as so called "bridgeheads."

The existence of the optimum ratio indicates the presence of two competing processes when polymer is added to a suspension. These processes are (1) the formation of polymer bonds to a single particle, and (2) the formation of polymer bridges between particles. Both mechanisms must always occur because 2 is simply a second step, which can occur only after reaction 1. The extent to which 2 occurs depends upon the frequency with which the particles approach closely enough to form the second bond which is turn depends upon the pulp density, the surface charge of the particles, the temperature and the polymer concentration. Large numbers of collisions, and hence a dominating bridging will occur when the pulp density is high, when the number of silt particles per unit weight of silt aggregate is high and when the repulsive surface charges are low. These effects with the polyelectrolytes, particularly polyacrylamides, are effective over the range of pH normally found in shipping operations. Up to a point, increasing the polymer usage is beneficial because more bridges are formed. However, excessively high polymer concentration is detrimental because the excess material tends to cover or insulate the exposed surfaces before interparticle collisions needed for bridging can occur.

Higher rather than lower molecular weight polymers are generally but not always more effective flocculating agents because of the fact that a larger portion of the high molecular weight polymer present in a system in excess of the optimum ratio previously mentioned can be utilized in floc formation, while a smaller portion of the lower weight polymers in excess of the optimum ratio is adsorbable because of the detrimental phenomenon of insulation previously discussed. Therefore, the degree of flocculation is lessened by the addition of excess lower weight polymers.

Polymer adsorbed on mineral surfaces may be held by at least three distinctive types of bonding. Any one, or a combination of the three, may be operative in a given system. The principal mode of attachment of polyacrylamide type flocculant is by hydrogen bonding. This is a common type of bonding exhibited by organic acids, amides, alcohols, amines and others which contain a hydrogen atom attached to a strongly electronegative atom. In these compounds the hydrogen atom has lost much of its electronic atmosphere, and is ready to accept electrons donated by the surface atoms of the silt particles or solids. The hydrogen is then shared between the surface atoms (usually oxygen) and the oxygen or nitrogen in the polymer.

Specific electrostatic site-bonding is another type of bonding which occurs when the polymer forms a salt-like attachment to specific groups or sites on the particle or solid surface. Examples of this type of bonding are found in the adsorption of polyacrylic acid on clay, limestone and the like in which the surface calcium atoms essentially precipitate a calcium acrylate on the particles. Similar bonding occurs between such reagents as mercaptans and heavy-metal ore surfaces. In general, bonding of this type is limited to solids having metal ions in their lattices. In practice the number of functional groups forming such bonds is limited to carboxylates, phosphates, sulfonates and mercaptan derivatives.

The last of the three types of bonding is known as nonspecific, double-layer interaction. This is an electrostatic interaction which occurs between a charged mineral surface and the ions in solution. The charge on the ion rather than its chemical nature primarily determines its attraction to the surface. Since most solids are negatively charged when suspended in water, positively charged polymers will be attracted to the surface, and will enter the ionic double layer. For this reason variations in the degree of flocculation in a given system may be obtained by making the flocculating agent either cationic or anionic.

The effectiveness, then, of a given flocculating agent in a given colloidal system is dependent on a number of factors. Among these factors may be included the pH of the system, the type and molecular weight of polymer added to the system, the presence or absence of electrolytes, the chemical and physical state of surfaces of the silt particles, and the charge of the flocculating agent. It should be remembered, however, that in any event the degree of flocculation which may be obtained is primarily a function of the polymer chain length and weight.

In practicing the invention for the removal of silt from the ballast tanks of vessels, the flocculating agent is put into solution in a tank located in the engine room of the vessel, and then by means of a small auxiliary pump, gravity or any other suitable method, the solution of flocculating agent is added to the ballast water on the intake side of the ballast pump, i.e., on the suction side of the pump, discharging into the ballast tanks, and in this manner the agent is introduced into the ballast tanks.

Subsequently, sufficient water is added to cover the sediment, and we have found that a depth above the surface of the mud of from about 2 to about 36 inches of water produces acceptable results, with a depth of about 6 inches being preferred. Where the silt deposits are not of an aggravated nature, the normal motions of the vessel have been found sufficient to provide thorough distribution of the flocculating agent and thereby to insure a satisfactory degree of flocculation. Once a satisfactory degree of flocculation has been obtained, pumps are used to remove the sediment from the ballast tanks.

In cases where the sediment deposits in the tanks have reached large magnitudes, more than one treatment may be required to achieve thorough cleaning, and by continuing this treatment a number of times, a gradual disintegration of the silt deposits takes place. The number of applications will vary depending upon the quantity of mud and silt to be removed. As few as three applications and as many as one hundred applications may be involved. Often the ballast pump itself will efficiently remove the flocculated mud since this pump generally is valued so as to pump water into or out of the ballast tanks. Ratios of polymer to sediment ranging from about 0.01 pound polymer per ton of silt (dry basis) to about 5.0 pounds per ton have been found to produce effective results with the ratio of about 0.2 pound polymer per ton of silt being preferred. It will be realized, of course, that where heavy deposits of silt are involved as say on the order of 100 to 1500 tons so as to require a plurality of treatments or application, the amount of flocculating agent employed during the course of each treatment need not be as great as in the case where only a single treatment is required. In such instance, the amount of flocculating agent employed per treatment may range from about 5 pounds to about 15 pounds. The total amount of agent employed in connection with these plural applications will, of course, fall within the range specified hereinabove of from about 0.01 of polymer per ton of silt to about 5.0 pounds of polymer per ton of silt.

For more aggravated conditions or more accelerated removal of mud and silt, the procedure is recommended whereby after the addition of the polymer to the sediment, the resulting composition is mixed as by walking through the same, stirring the same by means of hoes, poles, or the like, or by any other suitable agitating means. The sediments which have been settled previously may be easily re-suspended by hydraulic means. A high pressure stream of water, or a mixture of water and air, can be directed against the sediment which will agitate and re-suspend the sediment. Pressures as low as 10 to 20 pounds per square inch give a certain amount of suspension, but pressures in the range of several hundred pounds per square inch will produce a more rapid suspending of the sediment. The suspending action is in part similar to the use of hydraulic giants in mining operation, although smaller streams are useful because the scale of operation is smaller. A high pressure stream of water may be used to get into crevices and corners and will wash out suspended sediment. If the high pressure stream of water is a stream containing the polymer, the silt which is broken up by the stream of water is suspended in such a fashion that the silt may be pumped out. It is convenient to pump the water out as rapidly as it is fed into the compartment of the vessel so that a fairly rapid cycle is obtained and the amount of residual sediment can be determined by inspection. It is also convenient to use submerged water jets which will suspend the sediment and when it has been ascertained either by feel or by estimation that a proper degree of suspension has been achieved, the entire tank may be pumped at one time, with subsequent treatment being used for any portions which have been missed. The important thing is that the flocculating agent such as polyacrylamide is effective in causing the suspension of all particles so that when the tanks are pumped dry, the sediment is removed along with the water.

In some cases we have found that the introduction of air into the flocculated sediment increases the flowability of the flocs with water, and consequently the facility with which the same may be removed by means of pumping apparatus is easier.

In practice, under this latter procedure, a workman may enter the ballast tank with a pipe provided with a number of small perforations through which air under pressure may be forced. By moving the pipe through the silt or sediment piles the workman is enabled to intermix air therewith. This serves two purposes. First, it agitates the mud so that the same will be fully mixed with flocculating agent, and second, it facilitates the floating of the silt for pumping purposes because of the adherence of small air bubbles to the flocs.

It is often helpful to introduce in addition to the flocculating agent a second reagent, or reagents which have a tendency to cause adherence of the small air bubbles to the flocs. A preferred reagent is one of the type suitable for use in froth flotation of iron-bearing minerals or silica or silicate minerals, including oleic acid, tall oil fatty acids, water-soluble petroleum sulfonates, oil-soluble petroleum sulfonates, cationic flotation collectors and the like.

Once the ballast tanks of a vessel have been well cleaned, the accumulation of further silt deposits may be prevented by adding flocculating agent to the ballast water as it is pumped into the tanks. Consequently, any new silt which enters the tanks will be affected by the agent, so that at the conclusion of a given ballasting operation the flocculated silt will be carried away by the ballast water as it is removed. Obviously, the amount of agent which is employed in connection with this phase of the invention will vary somewhat depending upon the capacity of the particular tanks involved. For most normal applications, however, I have found the addition in the range of from 1 pound to 20 pounds per ballasting to be effective, with the preferred addition being about 10 pounds per ballasting.

Within the contemplated applications of the invention is the removal of silt deposits from the surfaces of the cooling jackets of large blast furnaces and the doors of open hearth furnaces and the like.

In this application the solution of flocculating agent is introduced to the cooling water before it reaches the jacket of the blast furnace or the doors of the open hearth furnace in order that the agent may treat the mud adhering to the surfaces of such doors and jackets. This process would provide for a continuous treatment of the water introduced and would after a length of time act to remove mud and silt accumulations and accumulations of other foreign material from the jackets or doors and prevent further deposits from occurring.

In this manner the heat transfer properties of the furnaces are much improved and the life of the jackets and doors are greatly increased. Particularly satisfactory results may be obtained by adding approximately one part per million of flocculating agent to the cooling water, although dosages from 0.01 to 100 p.p.m. are effective.

For purposes of description, certain specific examples have been employed, but these specific examples are meant to be illustrative only. Obviously, a number of variations may be made with respect to the particular polymer or other flocculating agent employed, the particular amounts of polymer or other flocculating agent utilized and the like, without departing from the spirit of the invention. It is our desire, therefore, to be limited only by the scope of the appended claims.

We claim:

1. A method of removing accumulations of silt and mud from tanks which comprises adding to the tanks an effective proportion of a water soluble polyelectrolytic organic polymer and water; mixing said water and organic polymer with the silt and mud to form a flocculent mixture, and then removing the mixture.

2. The method of claim 1 further characterized in that the polyelectrolytic organic polymer has a molecular weight ranging from about 100,000 to 15,000,000.

3. The method of claim 2 further characterized in that an effective proportion of the polyelectrolytic organic polymer ranges from about 0.01 to 5.0 pounds of polymer per ton of silt and mud accumulations.

4. The method of claim 3 further characterized in that the polyelectrolytic organic polymer is prepared from a compound characterized by the formula C=C—R wherein R is selected from the group consisting of nitrile, amide, and carboxyl radicals.

5. The method of claim 1 further characterized in that the flocculent mixture is removed by means of a pump.

6. A method of removing accumulations of silt and mud from ballast tanks of ships and drydocks which comprises adding to the ballast tanks an effective proportion of a water soluble polyelectrolytic organic polymer and water; mixing said water and organic polymer with the silt and mud by utilizing the rolling action of the ships and drydocks to form a flocculent mixture and then removing the mixture.

7. The method of claim 6 further characterized in that the polyelectrolytic organic polymer has a molecular weight ranging from about 100,000 to 15,000,000 and the mixture of water, organic polymer, and mud is agitated further by air and water pressure.

8. The method of claim 7 further characterized in that an effective proportion of the polyelectrolytic organic polymer ranges from about 0.01 to 5.0 pounds of polymer per ton of silt and mud accumulations.

9. The method of claim 8 further characterized in that that polyelectrolytic organic polymer is prepared from a compound characterized by the formula C=C—R wherein R is selected from the group consisting of nitrile, amide, and carboxyl radicals.

10. The method of claim 9 further characterized in that R is a carboxyl radical characterized by COOM wherein M is a lower aliphatic radical having 1 to 4 carbon atoms per molecule.

11. A method of removing accumulations of silt and mud from ballast tanks of ships and drydocks which comprises adding to the tanks an effective amount of ballast water and about 0.01 to 5.0 pounds of a water soluble polyelectrolytic organic polymer per ton of slit and mud; said polymer having a molecular weight ranging from about 100,000 to 15,000,000 and prepared from a compound characterized by the formula C=C—R wherein R is selected from the group consisting of nitrile, amide, and carboxyl radicals; mixing said water and polymer with the silt and mud to obtain a flocculent mixture and then removing the mixture.

12. The method of claim 11 further characterized in that an effective amount of a compound selected from the group consisting of maleic acid, tall oil fatty acids, and petroleum sulfonates, is added to the tank with the polyelectrolytic organic polymer.

13. The method of claim 11 further characterized in that the mixture of mud and silt, organic polymer, and water, is agitated with air and water pressure.

14. The method of claim 11 further characterized in that the mixture of mud and silt, organic polymer, and water is agitated by the normal rolling action of the ship.

15. The method of claim 11 further characterized in that the amount of water added to the tanks is sufficient to cover the accumulation of silt to a height ranging from about 2 to 36 inches.

16. The method of claim 15 further characterized in that the polymer is polyacrylamide having a molecular weight ranging from about 4,000,000 to 6,000,000.

17. A method of removing and preventing the accumulation of silt and mud in ballast tanks of ships and drydocks which comprises mixing with the water entering the ballast tanks about 1 to 20 pounds of a water soluble polyelectrolytic organic polymer per ballast to flocculate the mud and silt and subsequently removing the mixture; said polymer having a molecular weight ranging from about 100,000 to 15,000,000 and being prepared from a compound characterized by the formula C=C—R wherein R is selected from the group consisting of nitrile, amide, and carboxyl radicals.

18. A method of claim 17 further characterized in that the polymer is polyacrylamide having a molecular weight ranging from about 4,000,000 to 6,000,000.

References Cited in the file of this patent

UNITED STATES PATENTS

2,089,691	Cross	Aug. 10, 1937
2,396,938	Bersworth	Mar. 19, 1946

FOREIGN PATENTS

761,021	Great Britain	Nov. 7, 1956