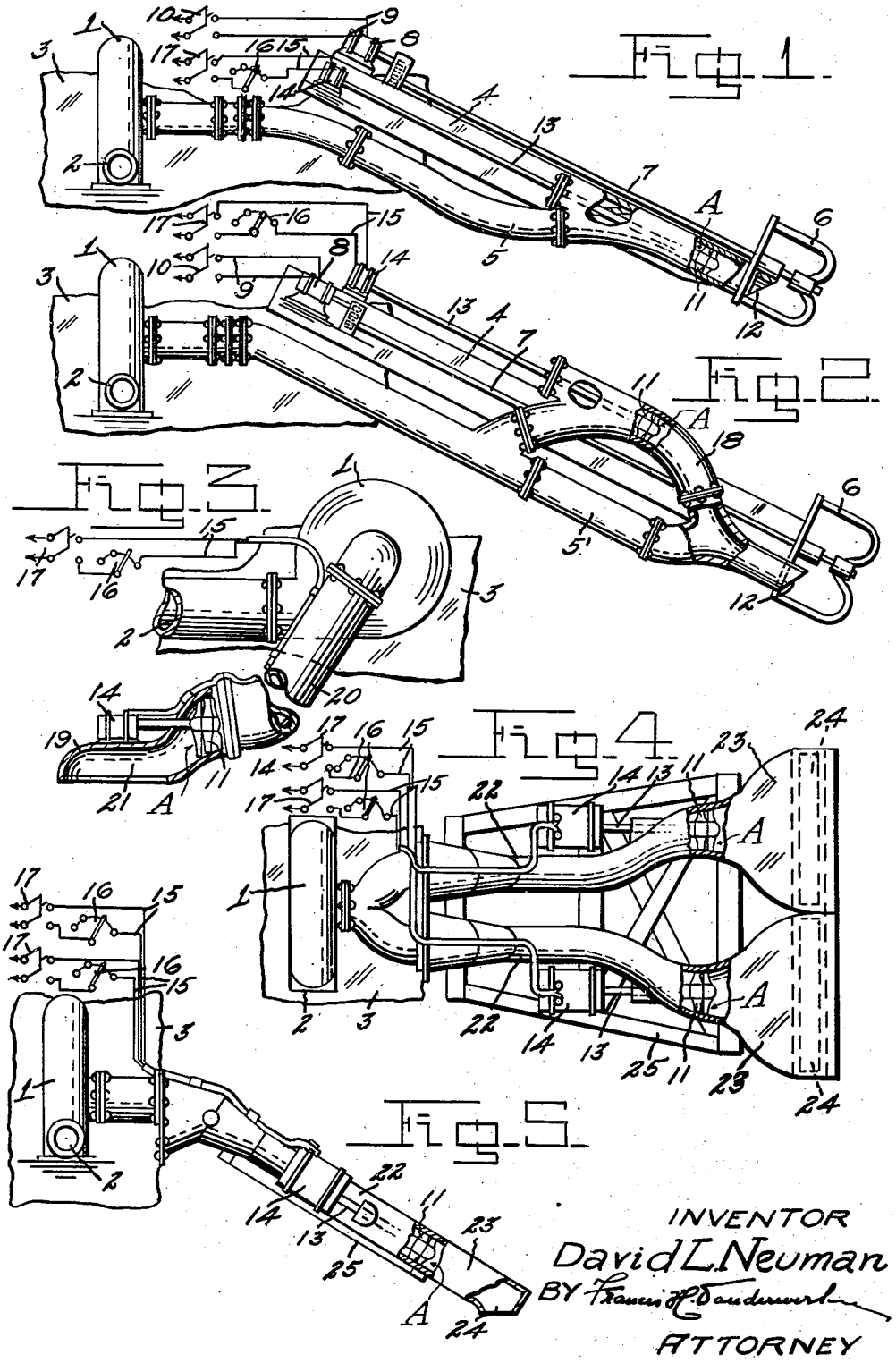
April 11, 1944. D. L. NEUMAN 2,346,180

MEANS FOR INCREASING DREDGE OUTPUT

Filed May 8, 1943 4 Sheets-Sheet 1



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MEANS FOR INCREASING DREDGE OUTPUT

Filed May 8, 1943 4 Sheets-Sheet 2

Fig. 6.

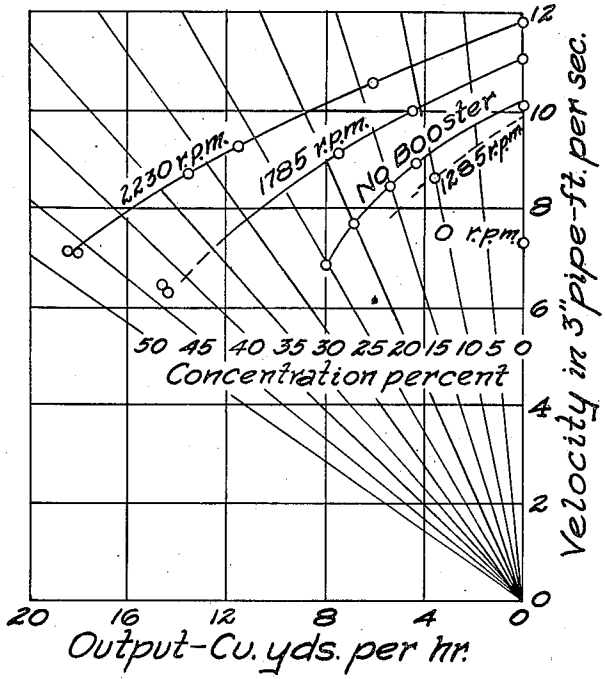



Fig. 5.

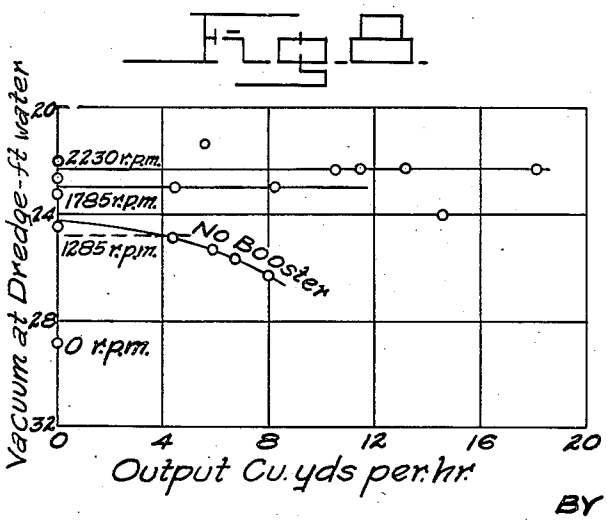
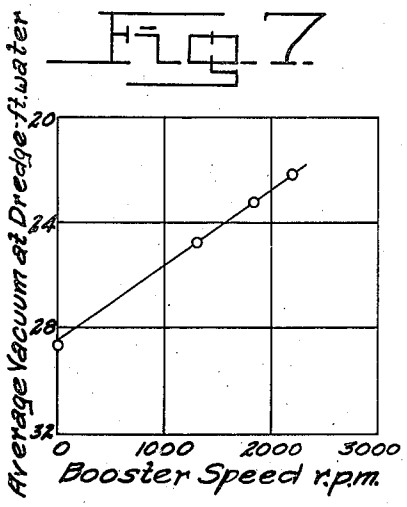



Fig. 7.




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MEANS FOR INCREASING DREDGE OUTPUT

Filed May 8, 1943 4 Sheets-Sheet 3

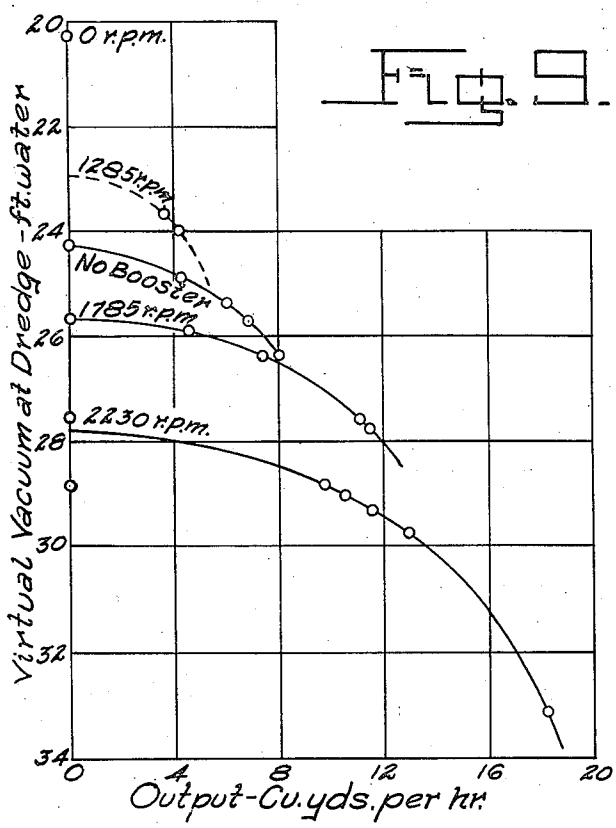



Fig. 9.

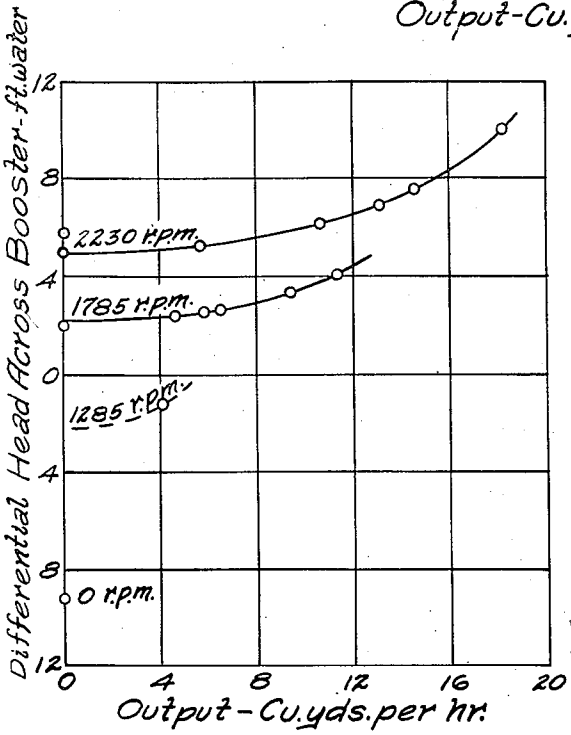



Fig. 10.

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MEANS FOR INCREASING DREDGE OUTPUT

Filed May 8, 1943 4 Sheets-Sheet 4

Fig.11.

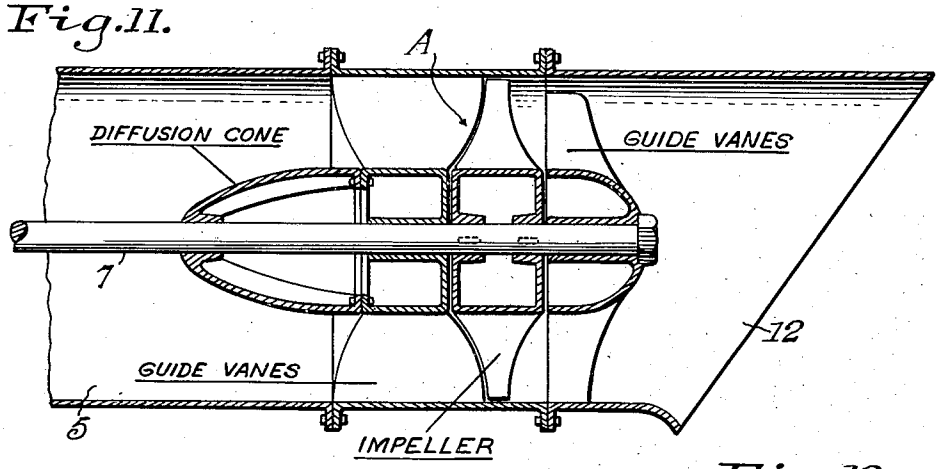
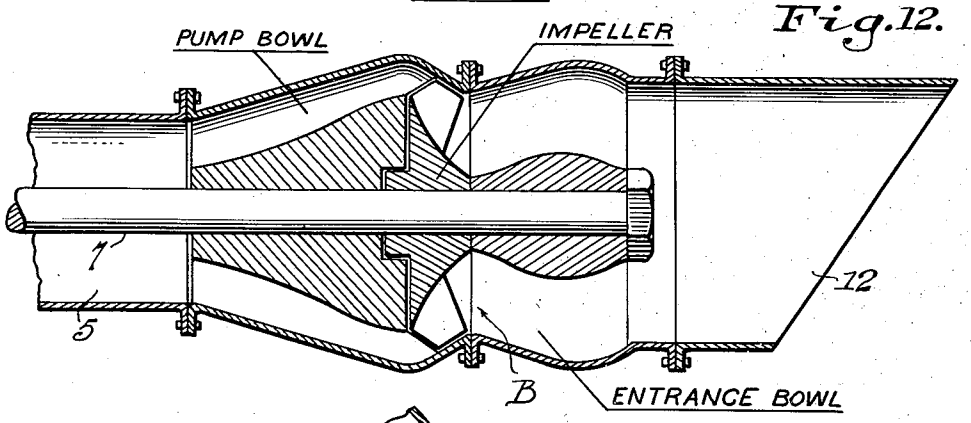



Fig.12.



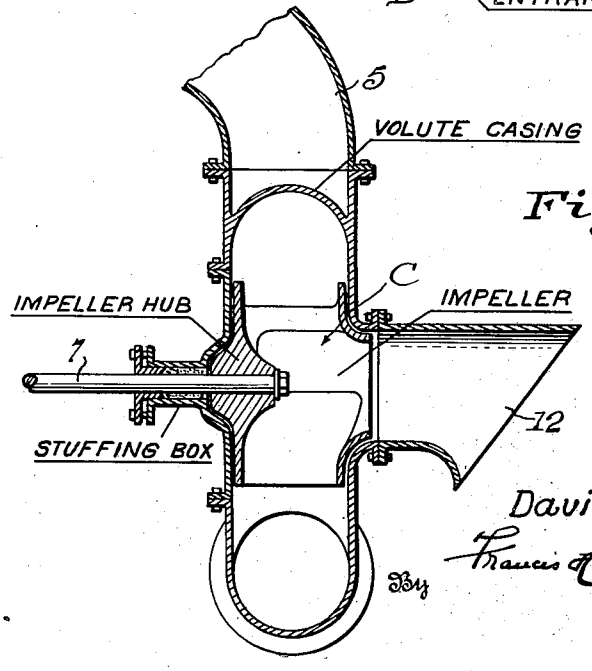




Fig.13.

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Patented Apr. 11, 1944

2,346,180

# UNITED STATES PATENT OFFICE

2,346,180

## MEANS FOR INCREASING DREDGE OUTPUT

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Columbus, Ohio

Application May 8, 1943, Serial No. 486,153

7 Claims. (Cl. 37—67)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without payment to me of any royalty thereon.

This invention relates to hydraulic dredges for excavating sand, gravel, mud, and the like from the bottom of lakes, rivers, and other bodies of water; more particularly it is directed to a method of and means for increasing the output of subaqueous material, from the large suction pumps used on hydraulic dredges of the type in which subaqueous material on the bottom of bodies of water is drawn into a suction pipe by a large suction pump and forced by the suction pump through discharge pipe lines for distributing the material.

One of the objects of the invention is to provide an improvement in the art of hydraulic dredging wherein a dredge pump of the suction type draws a mixture of water and solid material into the mouth of and through a suction pipe, and discharges said mixture into a discharge pipe and which consists in augmenting the energy normally available within the suction pipe to that of a virtual vacuum of at least atmospheric pressure.

Another object of the invention is to provide an improvement in the art of hydraulic dredging wherein a dredge pump of the suction type draws a mixture of water and solid material into the mouth of and through a suction pipe, and discharges said mixture into a discharge pipe and which consists in supplementing the energy normally available within the suction pipe from the dredge pump with an increase in head developed at the mouth of the suction pipe, said increase in head producing a virtual vacuum within the suction pipe of at least 34 feet of water, whereby to increase the concentration and output of dredged material for a given velocity of flow.

Another object of the invention is to provide an improvement in the art of hydraulic dredging wherein a dredge pump of the suction type draws a mixture of water and solid material into the mouth of and through a suction pipe and discharges said mixture into a discharge pipe and which consists in supplementing the energy normally available within the suction pipe from the dredge pump with an increase in head sufficient to develop a virtual vacuum within the suction pipe of at least 34 feet of water, whereby to increase the concentration and output of dredged material for a given velocity of flow.

Another object of the invention is to provide a method of increasing the output of subaqueous material from the main suction pump of hydraulic dredges of the type in which the subaqueous material is drawn up from the bottom of rivers through a suction pipe by the main suction pump and distributed through discharge pipes which consists of selectively creating an additional suction above a predetermined amount in said suction pipe other than that created by the main suction pump, thereby increasing the velocity of flow of the subaqueous material in the suction pipe to the main suction pump and the percentage of solids picked up with the subaqueous material.

Another object of the invention is to provide a method of increasing the efficiency of the main suction pump of hydraulic dredges of the type in which subaqueous material is drawn up from the bottom of rivers, through a suction pipe and distributed through discharge pipes which consists of causing the subaqueous material to flow in the suction pipe at a higher velocity than that produced by the main suction pump, whereby a higher concentration of solids is produced in the suction pipe and the amount of material picked up by the main suction pump is increased without increasing the vacuum at the suction side of the main suction pump, thus eliminating the possibility of the breaking of the vacuum at the suction side of the main suction pump, which permits the operator of the dredge to cut more boldly into the subaqueous material without fear of costly stoppage of the main suction pump and eliminates the loss of hydraulic efficiency and of output of the subaqueous material from the main suction pump due to cavitation.

Another object of the invention is to provide an auxiliary suction booster on hydraulic dredges of the type in which subaqueous material on the bottom of bodies of water is drawn into a suction pipe including a suction mouth and forced through pipe lines by a large centrifugal pump for distributing the material through discharge pipes, whereby the suction available for picking up the subaqueous material is increased or boosted and the additional suction made available by the suction booster will draw in the material when the suction mouth of the suction pipe becomes blanketed by the subaqueous material, thus avoiding breaking of the vacuum at the intake of the main centrifugal pump.

Another object of the invention is to provide a booster pump on a hydraulic dredge of the suction type as an auxiliary to the main suction

pump thereof, whereby the main suction pump is adapted to pump a larger percentage of solids by permitting some of the power of the main suction pump to be used to maintain the velocity of the solids in the discharge line of the dredge high enough to prevent the solids from settling to the bottom of the discharge line and thus clogging the line.

Another object of the invention is to provide a booster pump on hydraulic dredges of the suction type as an auxiliary to the main suction pump including a suction pipe and adapted to be operated for increasing the available energy in the suction pipe without increasing the vacuum at the intake of the main suction pump and which may be attached to suction dredges at present in use, without alteration of the main pump or its driving mechanism. For any quantity of flow the combination of the main pump and the booster in the suction line uses no more power than would the main pump itself but that portion of the power used on the booster being hydraulically more efficient produces a greater flow of material carrying fluid.

In hydraulic dredges of the suction type for excavating subaqueous material at present in use, the suction developed by the main suction pump, which is strictly limited in amount by natural laws, is used up in overcoming frictional resistance to the flow of the subaqueous material in the suction pipe from its entrance to the pump, in overcoming the so-called entrance losses, in creating velocity head, in creating any necessary lift from the bottom of the body of water to the pump and in picking up material at the mouth of the suction pipe. It is well known that a centrifugal pump, such as a section dredge pump, becomes progressively less efficient as the suction at its intake is increased, and therefore a decrease of suction at the intake thereof results in increased efficiency. Furthermore, a dredge operator must constantly be on guard against operation of the dredge pump at too high a vacuum, otherwise the suction will be broken and the pumping action will cease. In the usual type of dredges when the vacuum on the dredge pump breaks, dredging operation must be stopped and the pump primed in starting it up; in the combination herein described the need for pump priming is eliminated.

When dredging with the usual type of dredge in mud, sewerage, sludge or other material containing gases, the output is greatly reduced. This is due to the reduction of vacuum in the suction pipe of the dredge caused by the expanding and breaking gas bubbles reducing or destroying the vacuum available for picking up the material. In practice the reduction of output of material containing gases from dredges is as large as 35 percent of the output possible in nongaseous similar material.

It is therefore the aim and purpose of this invention to provide a suction booster for use on suction dredges as an auxiliary to the main suction pump thereof, the said suction booster being placed near the suction mouth of the suction pipe and adapted to produce a higher velocity and higher concentration of dredged material in the suction pipe by overcoming the increase in frictional resistance to the flow of the dredged material in the suction pipe, overcoming entrance losses, velocity head and lift, occasioned by such high velocity and concentration. The device may be utilized to dredge at greater depths by overcoming and increasing lift thus occasioned, whereby the output and the range of usefulness of the dredge are thereby extended without increasing the vacuum at the intake of the main pump. Operation is permitted with lower vacuum at the intake of the main pump with consequent increase in efficiency of the main pump and loss of output due to cavitation and the danger of breaking the suction at the intake of the main pump are reduced or eliminated. By reducing or eliminating the possibility of the breaking of the suction at the intake of the main pump and the cessation of pump action the operator of the dredge is permitted to cut more boldly into the material being excavated without fear of costly stoppage of the dredge operation.

The suction booster being located near the suction mouth of the suction pipe the output of the dredge is greatly increased when working in mud, sewerage, sludge or other material containing gas. This is because a lower vacuum or a positive pressure on the discharge side of the suction booster can be maintained, thereby preventing the degree of expansion or breaking of gas bubbles which reduce or destroy the vacuum in the suction pipe. With the combination both the main pump and suction booster are started together and no priming of either pump is necessary, and the usual lost time for this operation is eliminated.

With the above and other objects and advantages in view, the invention consists of certain features of construction and operation of parts which will hereinafter appear and in which—

Fig. 1 is a side elevation partly in section of a cutterhead type of suction dredge apparatus having the invention applied thereto and illustrated as being mounted on a fragmentary portion of a dredge;

Fig. 2 is a side elevation partly in section of a modified form of cutterhead type of dredge apparatus embodying the invention;

Fig. 3 is a fragmentary side elevation partly in section of a hopper type sea-going dredge having the invention applied thereto;

Fig. 4 is a top plan view partly in section of a dual dustpan type dredge, each dustpan portion of the dredge having the invention applied thereon;

Fig. 5 is a side elevation partly in section of the dual dustpan type dredge illustrated in Fig. 4;

Fig. 6 is a chart illustrating the output and percent of concentration of material from a dredge embodying the invention with the suction booster standing still, rotating at different speeds, and without the suction booster;

Fig. 7 is a chart illustrating the average vacuum at the dredge pump with the suction booster rotating at different speeds;

Fig. 8 is a chart illustrating that, for any given output of material from a dredge, the suction booster, when rotated at an increased speed, decreases the vacuum at the dredge pump;

Fig. 9 is a chart illustrating the virtual vacuum of the dredge pump being plotted as a function of the output thereof;

Fig. 10 is a chart illustrating the energy supplied by the suction booster in terms of head, in feet of water being plotted as a function of the output of the dredge;

Fig. 11 is an enlarged longitudinal sectional view of the inlet end portion of a suction pipe having an axial-flow propeller type pump mounted therein, which may be used as a suction booster in carrying out the invention;

Fig. 12 is an enlarged longitudinal sectional

view of a centrifugal mixed-flow type pump mounted in the inlet end of the suction pipe and may also be used as a suction booster; and

Fig. 13 is an enlarged sectional view of a centrifugal radial-flow type of pump mounted in the inlet end portion of the suction pipe and also may be used in carrying out the invention.

In the illustrated embodiment characterizing this invention, there is shown in Fig. 1 a suction booster as being applied to a cutterhead type of suction dredge including a centrifugal pump 1 having a discharge outlet 2 which is adapted to be connected to long pipe lines (not shown) for transporting the material to be excavated to a distant discharge point when operating in a river or along a shore, the said pump being mounted on the fragmentary portion 3 of a float known as a dredge. The other parts of the dredging apparatus include the usual ladder 4, a suction pipe 5, which is connected at one end of the pump 1 and through which the material to be excavated is drawn and forced by the pump through the discharge pipe lines, a revolving cutterhead 6 which loosens the material and mixes it with water so that it will be readily sucked up, the said cutterhead 6 being connected to one end of shaft 7 which is driven by an electric motor 8 connected to a suitable source of electrical supply (not shown) by conductors 9 through a switch 10. A suction booster 11, preferably of the centrifugal type, is provided which is placed inside the suction pipe 5 at or near its mouth 12 and directly driven at any desired speed through a shaft 13 by an electric motor 14 connected to any suitable source of electrical supply, not shown, by wires 15 through a rheostat 16 and switch 17.

The suction booster 11 may be an axial-flow propeller pump A as shown enlarged in Fig. 11 and including an impeller, a diffusion cone, and inlet and outlet guide vanes. The outlet guide vanes may be omitted if desired in carrying out the invention. The suction booster 11 may also consist of a centrifugal mixed flow type of pump B including an impeller, and entrance and pump bowls, as illustrated in Fig. 12, or the suction booster may consist of a centrifugal radial-flow type of pump C, including a volute casing, an impeller mounted within the casing, an impeller hub, and stuffing box, as illustrated in Fig. 13.

The modified form of cutterhead type of suction booster, as illustrated in Fig. 2 consists in providing an auxiliary suction pipe section 18 which is shunted around a portion of the main suction pipe 5'. The booster pump 11 is placed within the auxiliary pipe section 18 substantially at its middle portion, whereby the main suction pipe 5' is left clear. The dredging apparatus can be operated in this modified form of cutterhead type of suction dredge without operating the suction booster 11 and, when large solid pieces pass through the suction line, they will tend to stay in the lower main suction pipe 5' and thereby reduce the possibility of clogging the suction booster.

In the sea-going hopper type of suction dredge apparatus having the invention applied thereto, as illustrated in Fig. 3, the electric motor 14 of the suction booster is adapted to operate under water and is connected to a suitable source of electrical supply (not shown) through the rheostat 16 by electric wires 15 and is mounted on the top surface of the mouth portion 19 of the suction pipe 20, with the booster pump 11 operating within the mouth portion 19 adjacent to suction mouth 21. The main pump 1 in the sea-going hopper type of dredge may be eliminated entirely and the booster pump 11 used by itself as the necessary conditions are present in this type of dredge. The main advantage of so doing is by the elimination of the main pump on the dredge more of the load carrying capacity of the dredge can be used for bin space for dredged material.

In Figs. 4 and 5 are illustrated dual suction pipes 22 having inlet ends 23 of the dustpan type which are severed by a single main suction pump 1. Each of the inlet ends 23 of the suction pipes 22 is provided with a booster pump 11, which is directly driven by a waterproof electric motor 14 and arranged to operate within each suction pipe 22 of the dredge near the inlet suction mouth 24 thereof. It will be readily understood that only one suction pipe 22 having an inlet end 23 of the dustpan type may be used instead of the dual suction pipes. In other words, it is equally applicable to dustpan type of dredges with a single suction. A suitable ladder 25 is provided for the dustpan suction pipes.

The electric motors used on the sea-going hopper and dustpan type of dredges, as illustrated in Figs. 3, 4 and 5, are now available for normal operation under water and due to the cooling effect of the submersion of the motors in water they may be made appreciably lighter and smaller than the nonsubmersible electric motors used on the cutterhead type of suction dredges, as illustrated in Figs. 1 and 2, and adequate protection of equipment and personnel from the effects of possible short circuits can be provided. Although electric motors are shown and described to be the driving elements for the booster pump or pumps 11, it will be understood that any other suitable forms of driving elements may be employed.

Since the booster pump 11 must operate in a moving mixture of water and solids, there will be no pumping or booster action unless the speed of rotation of the booster pump exceeds a certain critical speed, the value of which depends on the design of the booster, the velocity of the moving mixture, and the concentration of solids in the moving mixture. If the booster pump operates at a speed of rotation below its critical speed, then it acts as an obstruction in the suction pipe. The driving element must therefore be adapted to drive the booster pump at a speed or speeds of rotation greater than the critical speed. The dredge operator may adjust the speed of rotation of the booster pump and maintain it at any desired value above the critical speed by means of the rheostat 16 or other suitable device.

The critical speed of the booster is not an arbitrary one but for each installation depends on the type and characteristics of the individual suction booster selected, and the term "critical speed" has meaning in reference to the output of the dredge. In operating the suction booster below its critical speed, the output from the dredge will be less than if no booster were used. If the suction booster is operated at its critical speed, the output from the dredge will be the same whether or not the booster is used and, if the booster is operated above its critical speed, the output from the dredge will be more than if the booster were not used.

By using the suction booster 11 as an auxiliary to the main suction pump 1 and placing the

suction booster pump near the suction mouth of the suction pipe or pipes of the various forms of dredging apparatus disclosed, the full suction which can be developed by the suction booster pump is available for picking up subaqueous material and for overcoming blanketing of the suction mouth of the suction pipe by the subaqueous material, thus avoiding breaking of the vacuum at the intake of the main pump. After loading the suction pipe with the subaqueous material the suction booster creates an increase in pressure forcing the subaqueous material to the main pump, thereby enabling it to pump a larger percentage of solids by permitting more of the power of the main pump to be used to maintain a velocity of the solids in the discharge line of the dredge high enough to prevent the solids from settling to the bottom of the discharge line and thus clogging the line. Increased energy in the suction pipe, furnished by the booster pump, permits an increase in depths of dredging which cannot be accomplished otherwise except by increasing the vacuum at the intake of the main pump. With the cutterhead type dredge working in material permitting loading of the suction pipe with dredge material and generally for the sea-going hopper type and the dustpan type of dredge, the main pumps are operated at the highest vacuum feasable and therefore the booster pump by increasing the virtual vacuum at the main pump, furnishes a practical method of increasing the output of the dredges and of extending the range of usefulness thereof. The increase in pressure in the suction pipe caused by the booster pump permits operation of the main suction pump with a lower vacuum at its intake with consequent increase in its efficiency, reduces or eliminates losses in output due to cavitation and reduces or eliminates the danger of breaking the suction at the intake of the main pump, thus permitting the operator to cut more boldly into material being excavated without fear of costly stoppage.

The term "virtual vacuum" is given as a name for the algebraic sum of the vacuum at the dredge pump and the differential head across the suction booster. For a dredge booster combination, the virtual vacuum is a measure of the energy in the suction line in exactly the same sense that the vacuum is a measure of the energy in the suction line for a dredge without the booster; in other words, for a dredge without the booster, the virtual vacuum is the same as the vacuum.

The booster pump 11 as described and illustrated, may be attached to existing suction dredges without alteration of the present main suction pumps or other driving motors or engines.

If a dredge is working near its maximum peak power and the booster is placed in the suction line, sufficient increased flow of the subaqueous material is obtained with a small increase of power input (low cost installation) which overcomes the handicap (as far as maintaining output is concerned) of working the main pump at or near its maximum peak power. If the usual practice is followed in placing a booster pump on the discharge side, this booster pump must be practically the same size as the main pump, although its prime-mover can be smaller. In effect, by combining a booster pump in the suction line of the main dredge pump, the main pump is lowered to the bottom or surface of the material to be dredged. In practice this cannot be actually done with the main pump due to the weight and size of the main pump and mechanical difficulties encountered thereby. It is feasible under certain conditions such as when using a sea-going hopper type dredge to eliminate the main pump entirely and use only a centrifugal booster pump located in the suction mouth opening of the suction pipe whereby more of the load carrying capacity of the dredge can be used for bin space for dredge material than when using a main pump.

In using the dredge for dredging mud, sewerage, sludge and other material containing air or gases, the suction booster functions to prevent expansion of the air or gases, thus affording a decided increase in dredge output and a reduction in the cost of the dredging operation. The air or gases in the material cannot be regulated as they are the result of a natural process and therefore no absolute control thereof can be had, but their volume may be substantially controlled, however, by operating the suction booster at a speed above its critical speed, so as to produce a positive pressure on the discharge side of the suction booster.

The graphs illustrated in Figs. 6 to 10, inclusive, were derived from a series of tests made to determine the actual effect obtained by the use of suction boosters in combination with a main dredge pump. These tests were made with a three inch centrifugal pump representing the dredge pump and a mixed flow impeller installed near the mouth of the suction pipe representing the booster pump. As a result of the tests, the following general conclusions regarding the action of suction boosters were established:

I. For any given set of conditions there is a critical booster speed below which the booster acts as an obstruction dissipating energy supplied by the dredge pump and above which the booster is a source of energy supplementing that supplied by the dredge pump.

II. For any given concentration a booster increases the velocity and the amount of material pumped by the dredge pump.

III. For any given output, a booster decreases the vacuum at the dredge pump.

IV. For any given output of the dredge pump the available energy in the suction pipe is greatly increased by a booster. Therefore the dredge pump can operate under conditions which without a booster would lead to a vacuum higher than that which the dredge pump can develop.

V. A booster increases the maximum output of material, increases the maximum concentration of material and decreases the vacuum at the dredge pump under these maximum conditions.

The material output from the dredge pump and booster combination is illustrated in Fig. 6, and also the percent of concentration of material by weight. The curve marked "No booster" in this figure shows results obtained when the dredge pump alone was operating. The point marked 0 R. P. M. shows results obtained when the booster was installed but prevented from rotating. It was not possible to pump material under these conditions, on account of the great resistance offered by the stationary booster. When the booster was rotated at 1285 R. P. M. it was possible to pump material but the output as shown by the curve marked 1285 R. P. M. was considerably less than without the booster. When the speed of the booster was increased to 1785 R. P. M. and to 2230 R. P. M. the material

output was increased accordingly, as shown by the curves marked 1785 R. P. M. and 2230 R. P. M. The curves indicate that for some speed between 1285 R. P. M. and 1785 R. P. M., there is a critical speed (not shown on the drawings) which may be inferred to be in the neighborhood of 1500 R. P. M. when the booster would furnish only sufficient energy to overcome its own resistance, and the dredge pump-booster combination would operate as if the booster were not present.

The first general conclusion that for any given set of conditions there is a critical booster speed below which the booster acts as an obstruction dissipating energy supplied by the dredge pump and above which the booster is a source of energy supplementing that supplied by the dredge pump follows directly from the result plotted in Fig. 6. The critical speed would probably vary slightly with varying material concentration and velocities.

With reference to the second general conclusion that for any given concentration a booster increases the velocity and the amount of material pumped follows directly from the result plotted in Fig. 6. The slopes of the lines of equal concentration in this figure show that the higher the concentration the higher will be the relative increase in material output, and the lower will be the relative increase in velocity. This conclusion may be stated in the alternative form; for any given velocity of flow in the suction line, a booster increases the material concentration and the material output. Attention is called to the very great increase under maximum discharge conditions. From the curves illustrated in Fig. 6, at a velocity of the material at 7 feet per second, the output of the material was 7.8 cubic yards per hour without the booster, 12.9 cubic yards per hour with the booster rotating at 1785 R. P. M., and 18.6 cubic yards per hour with the booster rotating at 2230 R. P. M.

The third conclusion, that for any given output the booster decreases the vacuum at the dredge pump as stated above, follows from Fig. 8 in which the curves marked 2230 R. P. M. and 1785 R. P. M. are compared to the curves marked "No booster." In this Fig. 8, the observed vacuum at the dredge pump is plotted as a function of the output and it will be seen that, under the test conditions, the vacuum at the dredge pump was constant for all outputs for any given dredge booster combination. Also the higher the booster speed the lower was the vacuum at the dredge pump. This is shown particularly in Fig. 7. When no booster was used, the vacuum at the dredge pump increased with increasing output. The difference in results obtained with and without the booster is due to the fact that without the booster the vacuum is a measure of the total energy in the suction line, but this is not so when a booster is added. To obtain the true measure of the total energy in this case, it is necessary to add the energy furnished by the booster.

An explanation of the fourth general conclusion that for any given output the available energy in the suction line is greatly increased by a booster; therefore, permitting the dredge to operate under conditions which, without a booster, would lead to a vacuum higher than that which the dredge pump can develop follows. In Fig. 10, the energy supplied by the booster, in terms of head, in feet of water, is plotted as a function of the output. The gain at the higher speeds, above the critical speeds, is appreciable and increases as the output increases. In Fig. 9, the virtual vacuum at the dredge is plotted as a function of the output. The virtual vacuum is defined as a measure of the effective energy in the suction pipe and is computed by taking the algebraic sum of the vacuum at the dredge pump, Fig. 8, and the gain or loss in head across the booster (Fig. 10) plus a correction of 0.5 feet to take into account a slight shortening of the suction pipe when the booster was installed. When no booster is used, the virtual vacuum becomes simply the vacuum at the dredge pump. If now in Fig. 9 the curves marked 2230 R. P. M. and 1785 R. P. M. are compared with the curve marked "No booster," it is readily seen that the virtual vacuum, and hence the energy available in the suction line, is greatly increased by the booster. In any dredge the theoretical limit of the vacuum is equal to the atmospheric pressure, that is, about 34 feet of water. Practically no pump can be built to reach this limit, and working conditions further require that a dredge should be operated considerably below its maximum possible vacuum, usually in the neighborhood of 20 feet of water. Hence, it is seen that a booster by increasing the virtual vacuum in effect removes the limitations attendant on operating on a high vacuum. Taking the extreme end of the curve marked 2230 in Fig. 9, we have a dredge pump-booster combination operating at a virtual vacuum of 33.8 feet of water or substantially 34 feet of water, which is exactly equivalent to the vacuum at zero pressure. A further increase of speed would permit operation at a virtual vacuum in excess of 34 feet of water; in fact, any desired virtual vacuum may be obtained. For instance, if the booster were operated at 2700 R. P. M. the vacuum at the main pump would be 20.5 feet of water, the differential head across the booster with an output of 24 cubic yards per hour would be 16 feet of water and the virtual vacuum would be 36½ feet of water. A dredge pump by itself could not possibly operate at so high a vacuum.

With reference to the fifth conclusion that a booster increases the maximum output of material, increases the maximum concentration of material and decreases the vacuum at the dredge pump under maximum conditions, follows directly from the data in Figs. 6 to 8, inclusive, wherein the curves terminate at the maximum outputs which could be obtained with the experimental set up.

In the experimental set up a three-inch suction pipe having a mixed flow impeller installed near the mouth thereof representing the booster pump, which mixed flow impeller was operated at a predetermined speed within the range 1285 R. P. M. and 2230 R. P. M. as represented in the charts, together with a two and one-half inch discharge pipe and a three-inch centrifugal pump representing a practical size dredge pump. It will be readily understood that, in using a suction booster in practical size dredges, the speed of operation of the suction booster would have to be operated at a different predetermined speed within a different speed range than when using the mixed flow impeller operating within a three-inch suction pipe and with a two and one-half inch discharge pipe used in the tests.

While the tests were made with apparatus of comparatively small dimensions, the general conclusions may be confidently applied to dredges of large dimensions on the basis of established laws of hydraulics relating to flow in pipes and pumps. Further, if the hydraulic characteristics of a large dredge pump, its suction line and a proposed

booster pump are known separately, an approximate estimate of the performance of the combined units may be made.

It has been found that the suction boosters to increase the output of dredge material in practical size dredges must be operated at a predetermined speed within the range 375 R. P. M. to 900 R. P. M.

The suction boosters to be used in various working size dredges, size being designated by the diameter of the discharge pipe line in inches, must operate at a predetermined speed within the following ranges to increase dredge output:

| | R. P. M. |
|---|---|
| 12 inch dredge | 600 to 900 |
| 15 inch dredge | 500 to 850 |
| 18 inch dredge | 450 to 700 |
| 20 inch dredge | 400 to 650 |
| 30 inch dredge | 375 to 600 |

It will thus be seen that by combining a centrifugal booster pump 11 positioned in the suction pipe or pipes at or near the outer end thereof with the usual form of hydraulic dredging apparatus consisting of a main pump, discharge line and suction pipe, with or without a material cutting tool, the following is accomplished: the output of the dredge is increased, the vacuum at the dredge pump at its suction side is reduced and even eliminated, and the available vacuum at the suction mouth of the suction pipe is increased. The output of the dredge may be increased independently of reducing or eliminating the vacuum at the dredge pump at its suction side or by increasing the available vacuum at the suction mouth of the suction pipe or in conjunction with reducing or eliminating the vacuum at the main pump at its suction side, or in conjunction with increasing the available vacuum at the suction mouth of the suction pipe, or in conjunction or independently of both of these.

The various advantages derived by the above conjunctions of effect are as follows: The output of the dredge is increased by increasing the velocity of flow of the material and percentage of solids picked up and when used in conjunction with reducing or eliminating the vacuum at the dredge pump at its suction side and in conjunction with increasing the available vacuum at the suction mouth of the suction pipe the efficiency of the main pump is increased and increased flow of material is accomplished in the suction pipe with the same power input which is extremely valuable at peak power loads, also the chances of breaking the vacuum on the main dredge pump is reduced or eliminated thereby permitting bolder attack of dredge cut face, thus producing a large increase in output of dredged material. The available vacuum at the suction mouth of the suction pipe and the velocity of flow of the material and percentage of solids picked up to increase the output of the material from the main pump is present after the cave-in of material on the suction mouth of the suction pipe of the cutterhead or dustpan type of dredges, and is always present in the sea-going hopper type of dredge using the usual drags.

The effect of the velocity of flow of the material and percentage of solids picked up together with reduced vacuum at the dredge pump at its suction side and the increase available vacuum at the suction mouth of the suction pipe is always present on the main dredge pump when the main dredge pump is used. The available vacuum at the suction mouth of the suction pipe may be used independently if, in a sea-going hopper type of dredge, the main dredge pump is entirely eliminated and the vacuum created therein is dependent entirely on the centrifugal pump located just above the drag.

It will thus be seen that there is herein described a novel method of and means for increasing the output of dredges which is well adapted for all the purposes intended. Even though there has been herein described certain features of construction and operation of parts, it is nevertheless to be understood that various changes may be made therein if the changes do not depart from the claims.

This application is a continuation-in-part of my application Serial No. 392,089, filed May 6, 1941.

Having thus described my invention, what I claim as new and wish to secure by Letters Patent is:

1. In combination with a hydraulic dredge including a suction pipe, a pipe section in communication with and shunted around said suction pipe, a main suction pump connected in communication with said suction pipe and section and adapted to create a suction therein and a propeller type pump operatively positioned within and adapted to create an additional suction in said pipe section, other than that created by said main suction pump.

2. In combination with a hydraulic dredge of the cutterhead type, a suction pipe having a suction mouth at one end, a pipe section connected in communication with and shunted around said suction pipe, a main suction pump connected to the other end of the suction pipe, and adapted to create a suction in said suction pipe and section, a propeller type pump operatively positioned within said pipe section and adapted to create an additional suction therein other than that created by said main suction pump and a prime mover located without the pipe section for driving said propeller type pump. said prime mover being connected to a source of energy.

3. In combination with a hydraulic dredge, a cutterhead, means for operating said cutterhead, a main suction pipe, a pipe section in communication with and shunted around said main suction pipe, a main suction pump connected to produce a suction in said main suction pipe and section, a propeller type pump operatively positioned within and adapted to create an additional suction in said pipe section other than that created by said main suction pump and means for operating said propeller type pump independently of said first mentioned means for operating said cutterhead.

4. The combination with a dredge of the type including a suction pipe having a suction mouth at one end and a dredge pump at the other, of a booster pump operatively positioned within the suction pipe adjacent to its mouth and operable at a predetermined speed within the range 375 R. P. M. to 900 R. P. M. for increasing the concentration and output of dredged material.

5. The combination with a hydraulic dredge including a suction pipe having a suction mouth at one end and a dredge pump at the other, of a centrifugal-type booster pump operatively positioned within the suction pipe adjacent to its mouth and operable at a predetermined speed within the range 375 R. P. M. to 900 R. P. M. for increasing the concentration and output of dredged material.

6. The combination with a dredge of the dual-type including a plurality of suction pipes having a suction mouth at one end of each of said pipes and a single dredge pump connected with each of the other ends thereof, of booster pumps operatively positioned within the suction pipes adjacent to the suction mouths and operable at a predetermined speed within the range 375 R. P. M. to 900 R. P. M. for increasing the concentration and output of dredged material.

7. The combination with a hydraulic dredge of the type including a plurality of suction pipes having a suction mouth at one end of each of said pipes and a single dredge pump connected with each of the other ends of said pipes, of centrifugal-type booster pumps operatively positioned within the suction pipes adjacent to the suction mouths and operable at a predetermined speed within the range 375 R. P. M. to 900 R. P. M. for increasing the concentration and output of dredged material.

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