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Yokota et al.

[11] **3,896,952**

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[54] **METHOD FOR UNLOADING AN IRON ORE BEING IN A STATE OF A CONSOLIDATED AND HARDENED BODY AND A GRAB-BUCKET FOR USE IN THE SAME**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** .... **214/152;** 37/187; 214/14; 214/15 C; 214/656

[51] **Int. Cl.** **B63b 27/24**

[58] **Field of Search** .... 214/14, 15 C, 152, 656, 214/657, 145; 294/115, 70; 37/183, 186–188

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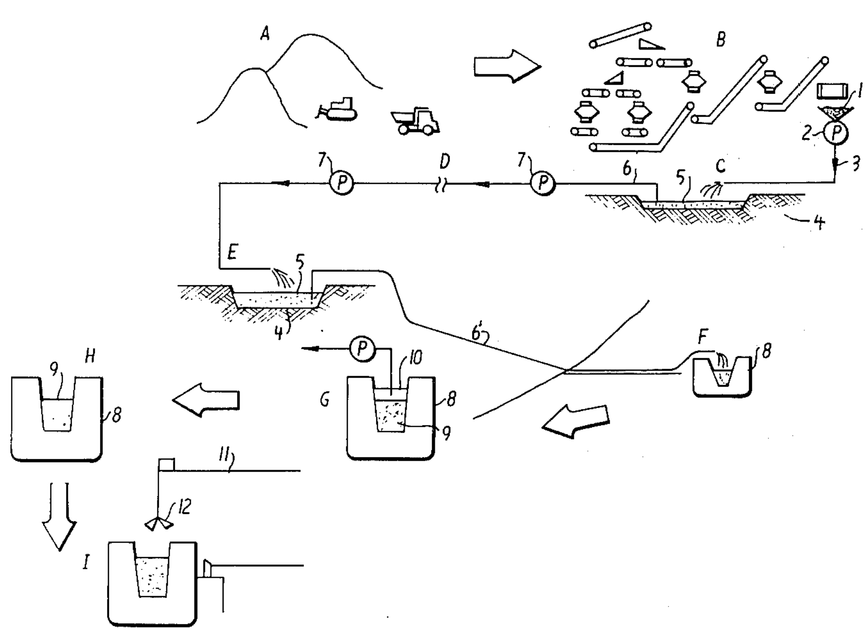
[57] **ABSTRACT**

There are disclosed herein a method for unloading an iron-ore being in the state of a consolidated and hardened body contained in a hold of an iron-ore carrier and a grab-bucket especially designed for use in the disclosed method. This method enables a novel combination of wet-loading and dry-unloading steps of an iron-ore in and from the hold of an iron-ore carrier, by using a grab-bucket having improved grabbing capability and adapted for such unloading operations of iron-ore in such a consolidated and hardened state. The grab-bucket includes a pair of bucket shells which have a plurality of pawls on and along the mating edges thereof, the pawls being so arranged that they mesh with each other when the bucket shells are in their closed position. Furthermore, the grab-bucket of the present invention is provided with vibrating means in the vicinity of the mating edges for accelerating the grabbing capability of the grab-bucket, the timing of the operation of the vibrating means being controlled by means of a tension detecting means which is located, for example, between part of the frame of the grab-bucket and the wire ropes which suspend the same.

12 Claims, 9 Drawing Figures



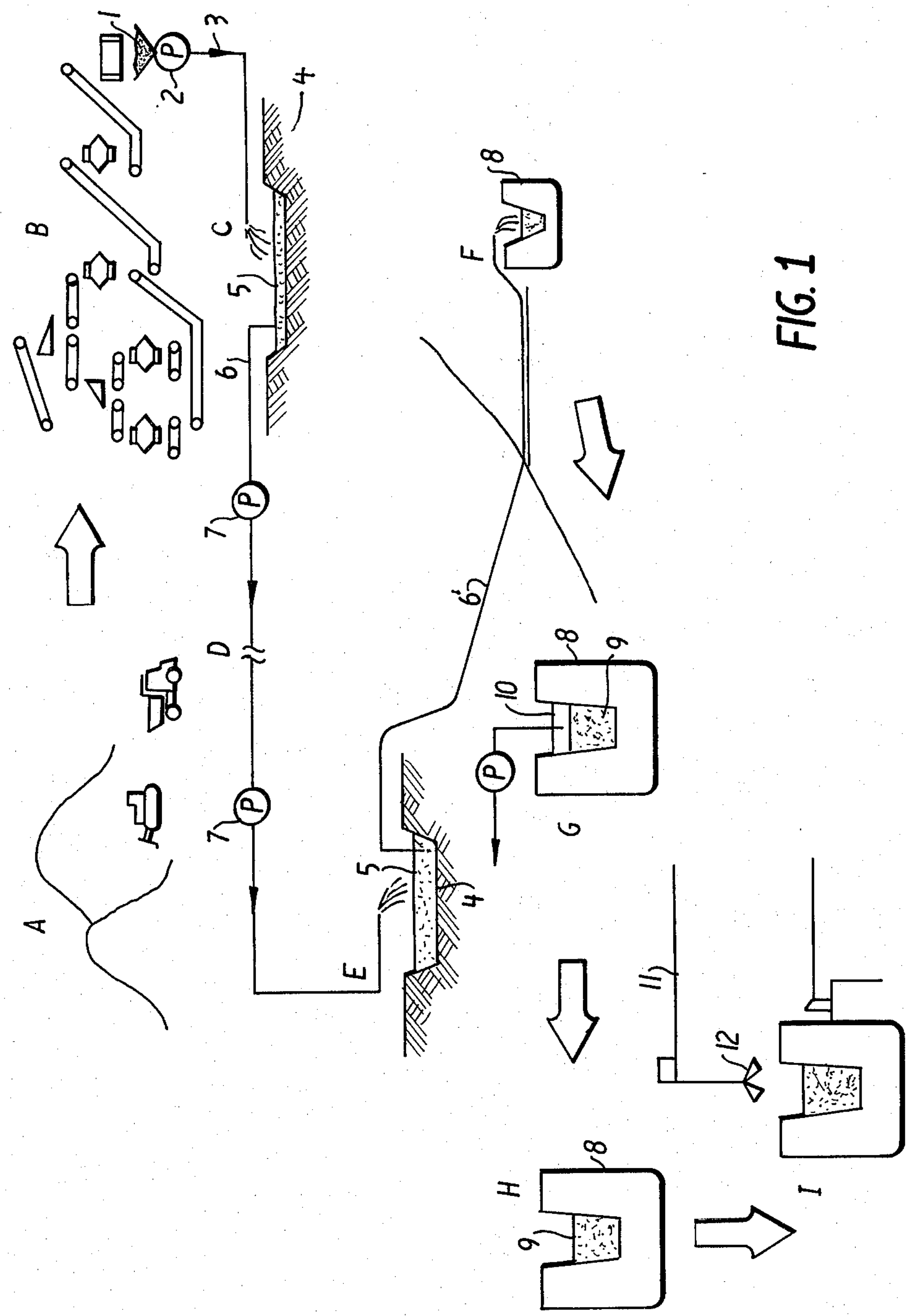


FIG. 1

FIG. 5

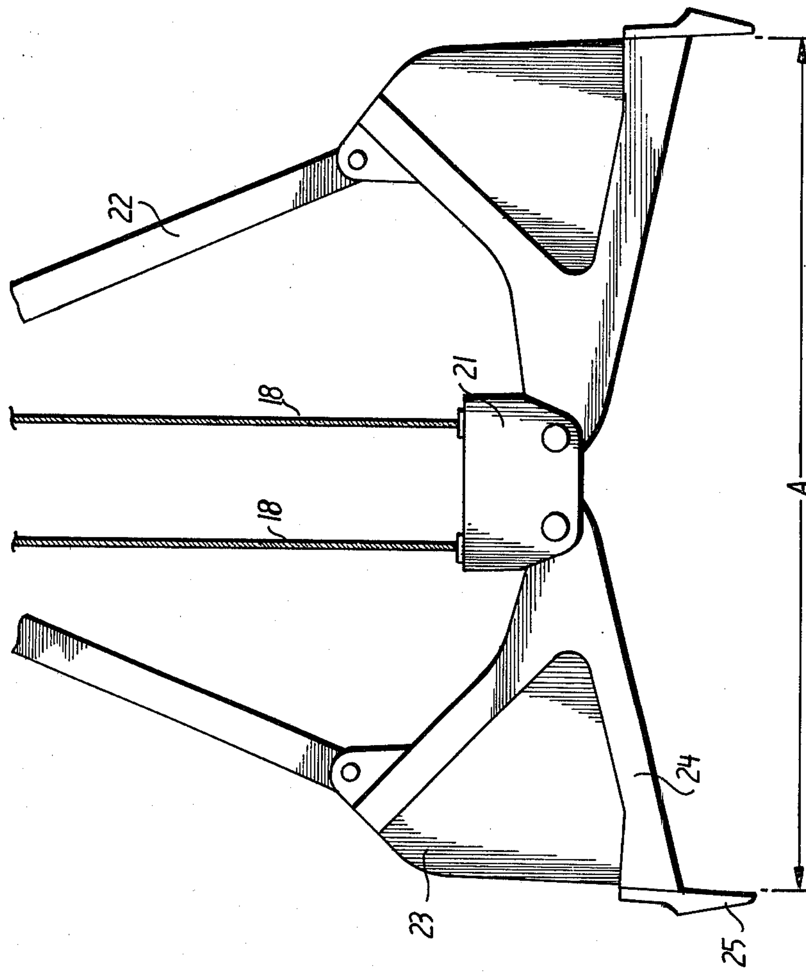


FIG. 2

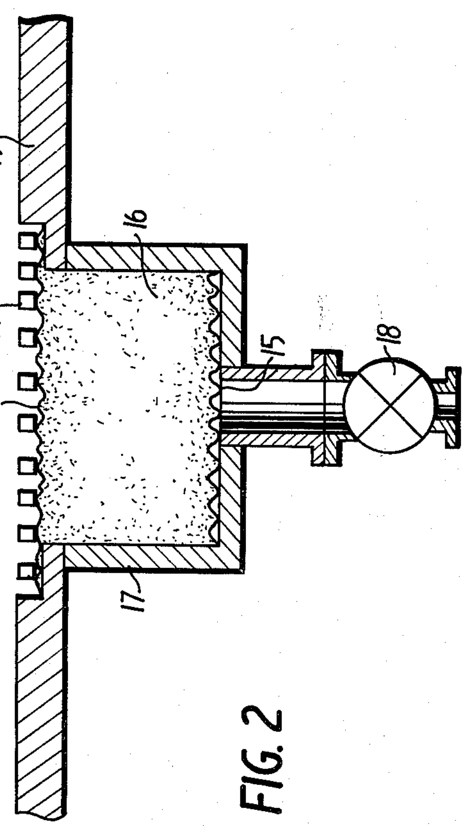


FIG. 4

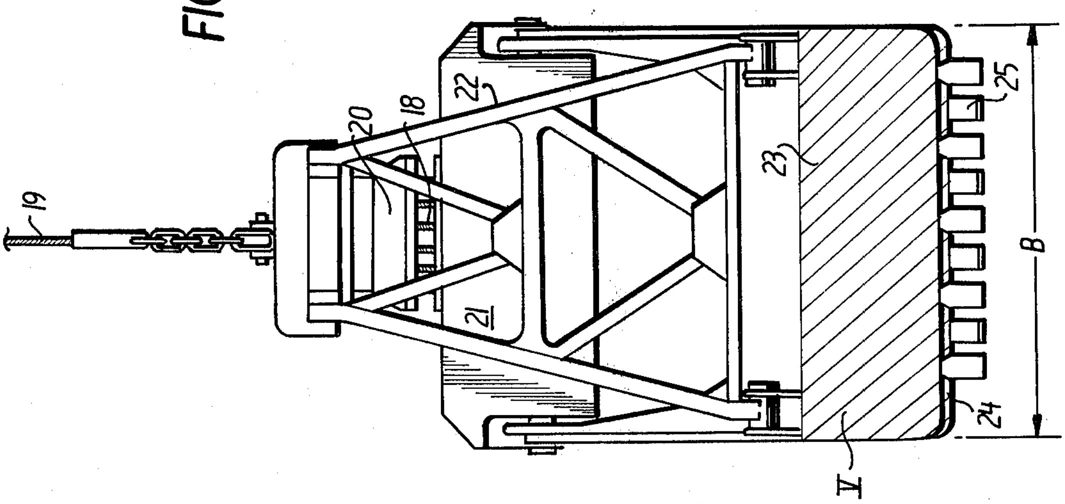
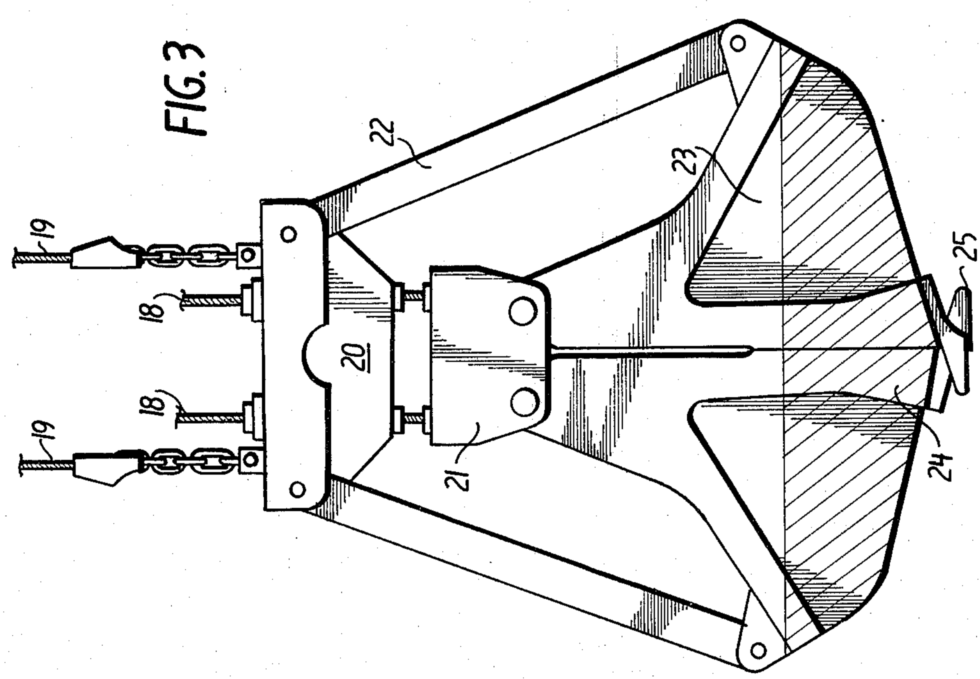


FIG. 3



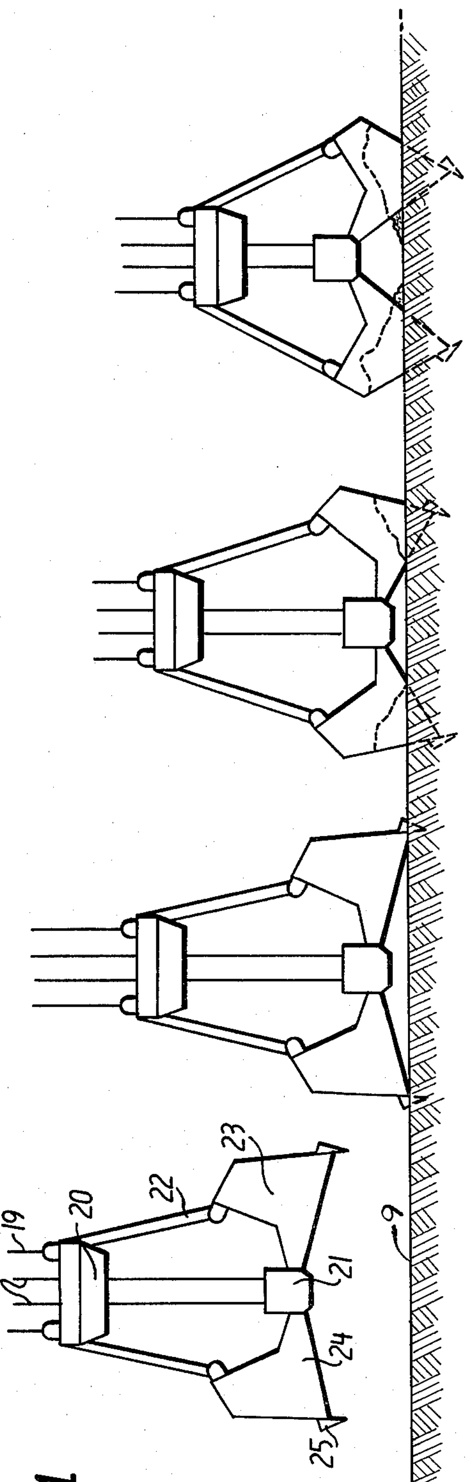


FIG.6-1

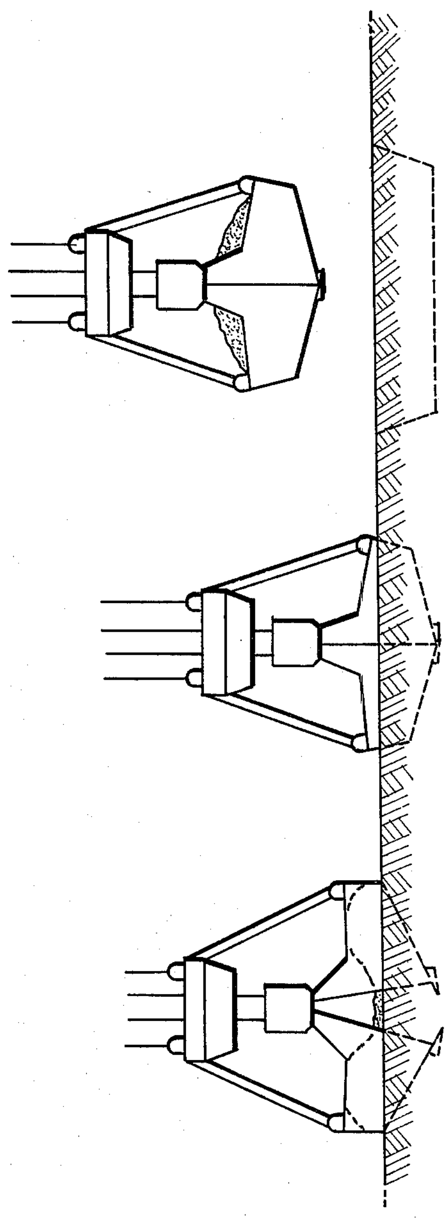


FIG.6-2

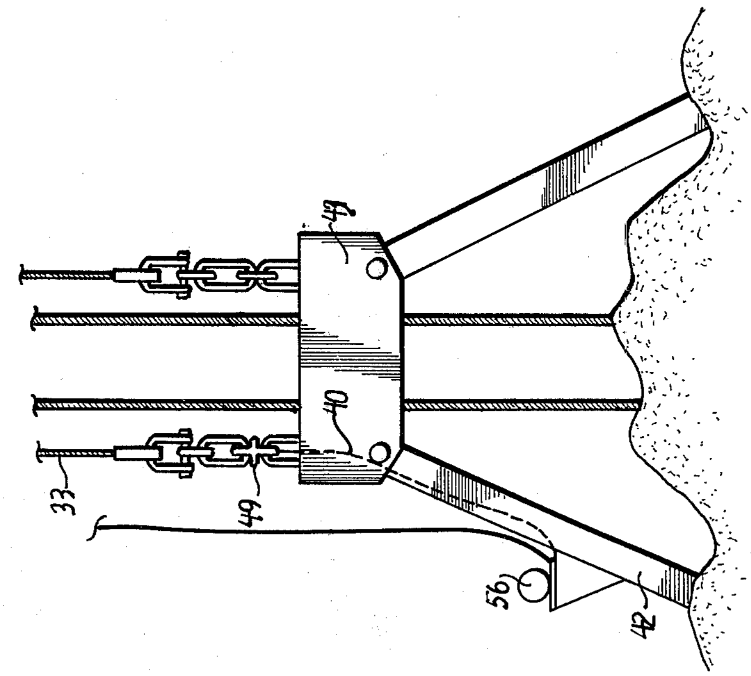

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FIG. 8

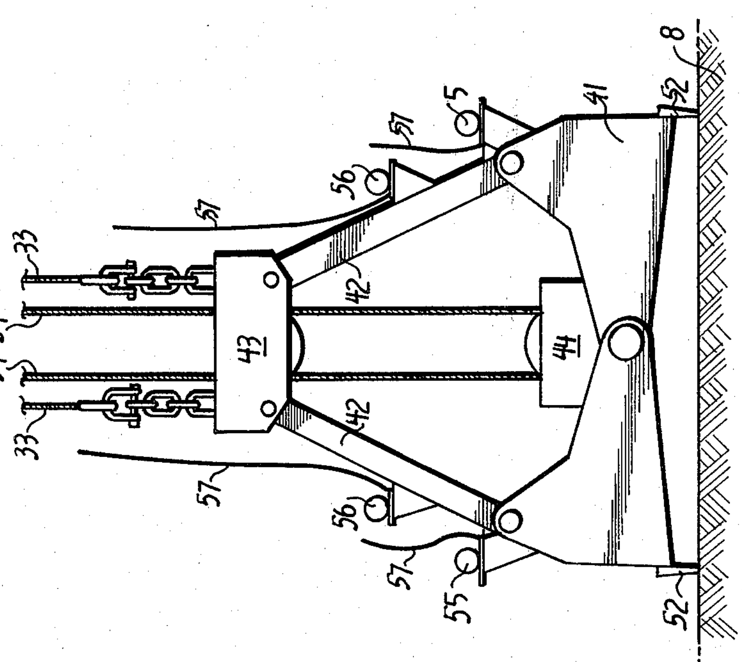
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FIG. 7

METHOD FOR UNLOADING AN IRON ORE BEING IN A STATE OF A CONSOLIDATED AND HARDENED BODY AND A GRAB-BUCKET FOR USE IN THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates generally to a method for unloading an iron-ore being in a state of a consolidated and hardened body contained in the hold of an iron-ore carrier and to a grab-bucket for use in performing the method, and more particularly to a grab-bucket having an improved grabbing capability and being particularly adapted for use in grabbing or unloading iron-ore in a consolidated and hardened state and having a flat top surface.

2. Description of the Prior Art:

Before proceeding with the description of the present invention, it may be of assistance for better understanding the features of the invention to give a detailed description of the background of the so-called "wet-loading and dry-unloading system" for use in transporting iron-ore of a slurry state from a mine via ocean to a refinery, including the use of an iron-ore transport ship or carrier.

Hitherto, there have been proposed two types of such transportation systems, that is, one being called a "dry-loading and dry-unloading system", and the other being referred to as a "wet-loading and wet-unloading system".

The iron-ore as used herein refers to a magnetite of a lower iron content, which is supplied as a fine powder after being crushed and dressed by known methods. The size of the aforesaid fine powder is -44μ, which usually occupies 80% of the total amount of the iron-ore. This kind of iron-ore, because of its very fine size and poor water permeability, incurs to the industry a number of troublesome and hence uneconomical problems in providing surface transportation thereof.

For simplicity of the description, the disadvantages or problems associated with the above two transportation systems will be enumerated below according to the type of system.

a. Dry loading and dry-unloading system

In this system which has long been practiced, iron-ore is transported by land transportation means, such as trucks or railroad, from a mine to a shipping harbor, where a huge ore transport ship or carrier, such as one having 160,000 ton load displacement, is loaded with such dry ore by means of belt conveyors. When the ore carrier arrives at an unloading harbor, the dry ore is unloaded by means of a crane after the carrier has approached to the quay.

The disadvantages of this system are as follows:

1. An extremely high transportation expense is involved because of the use of land transportation vehicles, such as trucks or railroad;

2. Large scale harbor facilities are required, because a huge ore carrier must approach thereto for loading. Accordingly, the natural conditions of the harbor are predominant factors to the solution of the problems. This results in the land transportation expense occupying a majority of the total transportation cost.

b. Wet-loading and wet-unloading system:

This system proposes to solve the problems of the high transportation expense required for transporting iron-ore from a mine to an ore carrier by mixing the iron-ore as a fine powder with water and laying a pipe line from the mine to a shipping harbor, which if required can be extended to the offing for loading the carrier with iron-ore in a slurry state. This provides very simple and economical facilities for the intended purpose, thereby reducing the cost of transportation a great extent. However, the disadvantages thereof offsets the above benefit, despite the convenience of the transportation facilities. Those disadvantages are as follows:

1. At the loading harbor, a large scale reservoir or pond near the shipping harbor is required for storing a great amount of iron-ore in a slurry state for subsequent loading, whereas the simple land-piling of the iron-ore of the former system is possible. This in turn requires a broad site for such reservoirs.

2. At the unloading harbor, the iron-ore is unloaded from a carrier in a slurry state so that a large scale reservoir or pond near the shipping harbor also is required for storing the iron-ore, just the same as at the loading harbor, and consequently a broad site for such reservoir or pond is again required.

3. At the unloading harbor, there is required a large scale dehydrating facility for the iron-ore in a slurry state, which consequently increases the construction costs remarkably.

4. In general, the mere supply of the iron-ore in a slurry state for use in an iron steel plant fails to meet its production demand in amounts, so that it is common practice to use the same in combination with an ordinary dry ore to remedy such shortage. carrier, in turn leads to the provision of two types of facilities in the plant, which leads to duplicate investment.

Accordingly, the present inventors hereby provide a newly developed wet-loading and dry-unloading system and the equipments incorporated, in which the iron-ore is loaded in a slurry state into a carrier and unloaded in a dry state therefrom.

During the sailing of an iron-ore carrier, gravity consolidation and hardening of the iron-ore in a slurry state loaded in a carrier occurs. This unfavorable phenomenon is an extremely troublesome problem experienced with the transportation of the slurry ore. More particularly, once the iron-ore is loaded in the hold of a carriere, the iron-ore particulates begin with sedimentation at a relatively higher rate, whle being accelerated due to the pressure or gravity of the upper layer of the slurry, with the result that the water content of the ore body is reduced from 30 to 40% at the time of loading to about 14%. As time goes on, the slurry in the hold of the carrier is further consolidated and hardened with the aid of vibration in the carrier. As a result, the water content in the ore body is reduced further to about 7% to 8%. This value is naturally dependent on the time period of the navigation, ranging from 8 to 10% for an average navigation period. The water content in the ore body exhibits gradual decrease from the top to the bottom of the ore body due to the gravity of the ore, thus leaving above the top layer of the ore body the water which has been wrung out from the ore body due to its gravity consolidation.

As understood from the foregoing, it is much too wasteful and inefficient in view of the installation and the process to adopt the aforementioned system (*b*) in which water is added to a consolidated and hardened iron-ore in the hold of a carrier so as to return it to a slurry state for unloading from the carrier and then it must be dehydrated to reduce it to the actual state for use in an iron and steel plant.

Accordingly, it has been desired to have novel steps of wet-loading and dry-unloading of the ore body thus consolidated and hardened in and from the hold of a carrier, thereby achieving an efficient and time and labor-saving unloading operation. However, this method further dictates the use of a grab-bucket having an improved grabbing or unloading capability. In other words, as stated earlier, after the navigation of a long period of time, the slurry body is not only consolidated and hardened but also presents a flat top surface of a considerable hardness like the interior of the ore body. Accordingly, to begin with grabbing by using a grab-bucket having flat mating edges, there arise difficulties, because of the extremely great resistance of the solidified ore body. It follows then that it is desired to have a grab-bucket having improved grabbing capability, that is, the means to solve the resistance problem of the consolidated ore body which is being grabbed.

Accordingly, it is a principal object of the present invention to provide a wet-loading and dry-unloading method for an iron-ore so consolidated and hardened in the hold of an iron-ore carrier.

It is a further object of the invention to provide a grab-bucket having an improved grabbing capability and useful in the disclosed method.

It is a still further object of the invention to provide a grab-bucket whose grabbing capability is accelerated by another type of energy provision.

It is a yet further object of the invention to provide a grab-bucket, in which the operation of another type of energy provision therefor is controlled to accomodate the phase of the grabbing operation.

SUMMARY OF THE INVENTION

Briefly stated, according to the present invention, a method is provided for unloading an iron-ore being in a state of a consolidated and hardened body contained in the hold of an iron-ore carrier, in which a grab-bucket having an improved grabbing capability is utilized, including the steps of dropping the grab-bucket having a pair of shells held in their opened position, utilizing its gravity, onto the consolidated and hardened ore body contained in the carrier hold to thereby demolish the body, closing the pair of shells to grab the ore body thus demolishehd, and thereafter lifting the grab-bucket to unload the demolished body being grabbed within the pair of shells in their closed position. According to another aspect of the invention, this method further utilizes vibration caused by vibrating means attached to the outer surfaces of the shells or the structure of the grab-bucket, but in the close vicinity of the mating edges of the shells.

According to a still further aspect of the invention, there is provided a grab-bucket which comprises an upper frame suspended by means of first wire ropes from an unloader, at least two pairs of suspension rods each connected at each one end thereof with the upper frame, a pair of bucket-shells pivotally connected at each of the edges thereof, on one side, with the other end of each of the suspension rods, and a sheave box, with which the other edges of the pair of bucket-shells are connected pivotally, the sheave box being suspended by means of second wire ropes from the unloader and adapted to be lowered to cause the bucket-shells to open. The bucket-shells each have mating edges adapted to mate with each other when the bucket-shells are brought into a closed position, the mating edges having a plurality of pawls thereon being adapted to mesh with each other in the closed position.

According to another aspect of the invention, vibrating means are located on the outer surface of the bucket-shell or a grab-bucket structure, but in the vicinity of said mating edges, respectively, for the purpose of accelerating the grabbing capability of the grab-bucket.

According to a further aspect of the invention, a tension detecting means is provided for detecting the tension exerted on the first or second wire ropes to thereby control the timing of the operation of the vibrating means, depending on the phase of the grabbing operation, that is, when the grab-bucket reaches the top surface of the ore body, the vibrating means starts vibrating, and when the grab-bucket is pulled upwardly, the operation of the vibrating means will be stopped.

According to a still further aspect of the invention, there is provided a means for protecting the electric wire cable, utilizing the members of the structure of the grab-bucket.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood from the following detailed description when considered in connection with the accompanying drawings, in which:

FIG. 1 is a flow chart showing the processing steps of ironore in a powder form from a mine to an unloading place;

FIG. 2 is a cross-sectional view of a dehydrating means for iron-ore in a slurry state contained in the hold of a carrier during its navigation;

FIGS. 3 to 5 are explanatory views of the operation of the grab-bucket of the present invention;

FIGS. 6-1 and 6-2 show the steps of unloading the gravity-consolidated and hardened ore body contained in the hold of an iron-ore carrier, by using the grab-bucket of the present invention;

FIG. 7 is an outline showing one operational phase of a grab-bucket embodying the present invention; and

FIG. 8 is a partially enlarged view showing the route of an electric wire cable or a signal transmitting cable leading to a vibrating means for the grab-bucket of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and more particularly to FIG. 1 which shows a flow chart of the processing of iron-ore in a powder form from a mine to an unloading station, the mining of the ore in a powder form at a working face of a mine is designated as Step A, while the crushing and screening of the ore in its powder form is designated as Step B. The ore 1 in a powder form, which has been processed to a desired grain size and grade, is mixed with water and transferred in a slurry state by means of a pump 2 through a pipe 3 to a reservoir or pond 4 as shown at C in an attempt to store the ore 5 in a slurry state. The ore in a slurry state thus stored is transported in the slurry state to a shipping harbor, as required, through a pipe line 6 by using a pump 7 as shown at D.

The ore 5 in a slurry state is then stored in a similar reservoir 4 as shown at E and a required amount thereof is then transferred in a slurry state through pipe line 6′ into the ore-transporting ship or carrier 8, as shown in the step F. In the subsequent step, that is step G, the ore 5 in a slurry state after loading in the carrier 8 is allowed to stand in a hold thereof, whereby it is separated into an ore layer 9 and supernatant water 10. The supernatant water 10 is then returned to land, prior to the departure of the carrier, through a pump and an appropriate conduit. The water content of the ore in the carrier hold at the time of the departure is in the range of 13 to 15%.

In this manner, the ore carrier sails for its destination, that is, the unloading harbor. However, navigation of a long period of time leads to sedimentation and consolidation of the ore 9 in the lower portion of the hold as shown at H, due to the vibration, and pitching and rolling movements of the carrier, thus increasing the amount of the supernatant water 10 on top of the slurry layers. The supernatant water thus produced is discharged from the hold during the sailing. Alternatively, the ore in a slurry state is dehydrated by means of a vacuum pump or the like from the bottom or the side of the hatch, as required.

Thus, when the carrier arrives at the unloading harbor, the water content of the slurry ore contained in the hold is in the range of 7 to 9%, and such a water content enables dry-processing of the ore.

Although dehydrating processing, using a vacuum pump, has been referred to earlier, the need to use dehydrating processing is dependent upon the grain size of the ore in a powder form. In other words, in the case of ore grains or particulates being less than 44μ and occupying over 60% of the total amount of the ore, the ore grains will be consolidated and hardened during the sailing of the carrier, and hence dehydrating processing is not required, because a resultant water content of 7 to 9% is obtained without the use of dehydrating processing in this case.

In contrast thereto, in the case of the ore grains of over 2 mm in size, occupying over 20% of the total amount of the ore, there would not result the aforesaid consolidation, such that dehydrating processing is essential. Most preferable of the means for accomplishing the dehydrating processing is the one using a vacuum pump, while dehydrating holes may be provided in the bottom or the side of the hold, coupled with the use of filtrating means.

The greater the size of the dehydrating holes, the greater the dehydrating efficiency. However, there arises some limitation from the viewpoint of the strength of the hull of the carrier. The desired ratio of the filtrating area to the whole area of the bottom of the hold has proven to preferably be about 6%.

FIG. 2 shows one embodiment of the dehydrating means used herein. Provided at the bottom or the side wall 13 of the hold is a dehydrating device, which is filled with filtrating materials 16. Thus, the water contained in the ore slurry in the hold is filtrated through the filtrating materials 16 under the suction of a vacuum pump, not shown, and then discharged through a pipe and valve 18.

In this connection, two sheets of filter cloth 15 are each laminated on both the upper and lower surfaces of the filtrating materials for the sake of protection of the latter. In addition, an iron lattice 14 should preferably be provided on top of the filtrating device, that is, at the bottom of the hold for protection of the upper filter cloth 15.

In the absence of the filtrating device, or in the case of a carrier being used for transporting crude oil, the iron lattice may be replaced with an iron plate, thus imposing no limitation on the application of the ship. The water content of the iron-ore may be reduced to 7 to 9% to that of the powder substantially dried through dehydration during the sailing.

If required, the water content can be reduced to be less than 7%.

The ore body contained in the hold of a carrier, after approaching to the unloading quay, is unloaded by means of a crane 11 and grab-bucket 12, as shown at I in FIG. 1. However, the ore in the hold is considerably solidified due to the vibration or pitching and rolling movements of the carrier. This in turn causes difficulties with the unloading operations, even when having resort to the conventional grab-bucket, which has a poor grabbing capability for such a consolidated and hardened ore body, thus resulting in poor unloading efficiency. To solve the aforesaid problem, the present invention presents an improved type of grab-bucket adaptable to grabbing such a considerably solidified or hardened ore body, as shown in FIGS. 3 to 5. Shown at 18 therein are wire ropes for use in opening and closing the grab-bucket shells 23, wire ropes 19 being provided for supporting or suspending the grab-bucket, an upper frame 20 and lower frame 21 which is a sheave box, and suspension rods 22 connecting the upper frame 20 and the bucketshells 23. The mating edges of the bucket shells 23 are designated by the numerals 24, and pawls 25 are secured to the ends thereof.

The improved grab-bucket of the present invention is greater in weight and smaller in dimensions as compared with the conventional grab-bucket heretofore used in unloading materials of powder or grain form, and further features sharp mating edges 24 and pawls 25 of great strength, which are so designed as to mesh with each other, when in their closed position. With such an arrangement, the aforesaid consolidated and hardened ore body can be readily demolished and grabbed, thus enhancing the unloading efficiency.

the steps of unloading such a body 9 from the hold by using the grab-bucket of the present invention will briefly be described with reference to the drawings. As shown at (1) of FIG. 6-1, a grab-bucket with opened bucket-shells 23 is suspended from an unloader and slowly lowered onto the surface of the ore 9. When the opened mating edges of the bucket-shells 23 reach the surface of the ore 9, the pawls 25 thereof will be pierced into the slurry body by virtue of the gravity or weight of the grab-bucket assembly itself, as shown at (2) of FIG. 6-1.

Then, as shown at (3) of FIG. 6-1, when the wire ropes 18 are wound to close the bucket-shells 23, the pawls 25 and the mating edges 24 of the bucket-shells will be pierced into the ore body to a desired depth. Further winding of the wire ropes 18 will cause the pawls 25 and mating edges 24 to be pierced to a horizontal direction, thus grabbing the ore within the bucket-shells 23, as shown at (4) and (5) of the same figure. Upon completion of the grabbing operation, that is, after the pawls 25 on the mating edges 24 of the bucket-shells have been meshed with each other completely, or when the bucket-shells 23 have been closed completely, as shown at (6), then the supporting wire ropes **19** are wound to carry the grab-bucket out of the hold, as shown at (7).

In general, the factors affecting the grabbing capability of the grab-bucket are the weight of the grab-bucket, the size and configuratiion thereof, the presence of the pawls and their shapes, and the number of turns of the wire ropes. In terms of grab-buckets having equal weights, the grabbing capability of the grab-bucket having bucket-shells of greater size will be greater. Conversely, if the bucket-shells are too large in size, then the construction thereof will be less strong, and poor grabbing capability with result. Meanwhile, in the case of lesser winding turns of the wire ropes, when the bucket-shells are being closed, there will develop an upward tension on the wire ropes, thereby impairing the grabbing capability. This should also be put into consideration in designing grab-buckets of this type.

Alternatively, to improve the grabbing capability of the grab-bucket, there may be proposed attempts, such as sharpening the configurations of the pawls or providing a construction in which the weight of the grab-bucket will effectively act on the mating edges of the grab-bucket shells, or otherwise dropping the grab-bucket assembly from a substantial height.

However, among those factors associated for improvements with the grabbing capability of the grab-bucket, there are incorporated four important factors therein, which will be described hereinafter by referring to the drawings, particularly FIGS. **3** to **5** thereof.

1. Weight to volume ratio W/V, or

the ratio of the weight W of the grab-bucket assembly to the inner volume V of the bucket-shells, that is, the inner volume of the bucket-shells in their closed position.

2. Ratio of length to width of the opened grab-bucket shells, A/B, or

the ratio of the length or distance A of one mating edge of a bucket-shell to another mating edge of the other bucket-shell, when in their open positions, to the width B of the bucket-shells.

3. Ratio of the weight of a grab-bucket to the effective widths of the mating edges, W/2B, or

the ratio of the weight W of a grab-bucket to the effective width **2B** of the mating edges thereof.

4. Grabbing force per unit width of mating edges, H/2B, or

the ratio of the grabbing force H of the bucket shells, when they are being closed, to the effective widths 2B of the mating edges of the bucket-shells.

In general, for better results, the harder the ore of a slurry state, the more preferable it is to use a grab-bucket of smaller size and of greater weight. On the other hand, in the case of a grab-bucket having a greater weight, the grabbing capacity of the bucket-shells will be reduced accordingly, since the suspension capacity of the crane in use is limited, thus resulting in lowered unloaded efficiency.

Accordingly, to attain improved efficiency of the unloading operation, it is necessary to select and determine the values of the aforesaid factors, depending on the conditions of the iron-ore of a slurry state, particularly on the hardness thereof.

Although it may be difficult to primarily determine the hardness of the compacted slurry body, it may be proper to use "N" value of the piercing test, which is widely accepted for use in the civil engineering field.

The value N as used herein is defined according to JIS (Japanese Industrial Standard) A1219 as the dropping cycles of a weight or a block of 63.5 kg which is dropped from the height of 75 cm upon the top end of a pipe of 51 mm in diameter to drive the same into the ground to a depth of 30 cm, that is, how many times the weight has been dropped on the pipe to reach the specified depth.

The hardness of the iron ore of such a consolidated and hardened body covers the values from 15 to 25 in terms of the aforesaid definition. It is considered that a wide distribution of the N values results from varying transportation periods, that is, the navigation period, as well as the varying degrees of vibration and movement of a carrier under the varying weather conditions, plus the resultant varying degrees of gravity consolidation and hardening and dehydration of the slurry body contained in the hold of a carrier.

Table I gives the values of the aforesaid factors which give the maximum unloading or grabbing efficiency for the ore body, by using the grab-bucket.

TABLE I

	I	II
Hardness of an ore body (N Value)	15 – 20	20 – 25
Weight to volume ratio (W/V) (ton/m^3	3.0 – 4.5	4.5 – 6.0
A/B ratio	2.6 – 3.0	2.6 – 3.5
W/2B ratio (kg/cm)	40 – 50	50 – 60
H/2B ratio (kg/cm)	40 – 60	60 – 150

In the light of the fact that the W/V ratio of the grab-bucket used for unloading dry ore grains having a true specific gravity of about 5.0 ton/m^3 is in the neighborhood of 2.5 ton/m^3, the grab-bucket of the present invention is smaller in size and greater in weight, such that the volume of the iron-ore grabbed in the grab-bucket shells is smaller comparatively.

However, the volumetric specific gravity of the dry iron-ore is in the range from 2.5 to 2.7 ton/m^3, whereas the volumetric specific gravity of the iron-ore which has been of a slurry state and which is consolidated and hardened to an N value of about 15 is in the neighborhood of 3.6 ton/m^3, and, in addition, the volumetric specific gravity of the iron-ore which has been so consolidated and hardened to an N value of 25 is found to be 4.0 ton/m^3.

It can be seen from this that the harder the iron-ore of a consolidated body, the heavier and smaller in size the grab-bucket should be, such that the volume of the iron-ore to be grabbed by the grab-bucket will be reduced. However, the harder the iron-ore of a consolidated body, the greater the volumetric specific gravity of the iron-ore, such that the weight of the iron-ore to be grabbed with the bucket-shells will not be reduced, that is, lowered unloading efficiency will not result. It follows then that the use of grab-buckets having values as given in Table I will present grabbing or unloading efficiency comparable to that of the dry iron-ore, even in the case of an extremely consolidated and hardened ore body.

Meanwhile, the water contained in iron-ore of a slurry state is exuded out under gravity as a supernatant fluid on top of the slurry body, with the aid of vibration and movements of the carrier, and then the supernatant fluid is usually removed from the carrier. Accordingly, the water content in the slurry body can be estimated and thereby has direct bearing on the hardness of the iron-ore as a consolidated and hardened body. Table II gives the relationship between the hardness N of the ore body and the water contents which have been actually measured, the N values shown therein corresponding to the N values as given in Table I.

TABLE II

	I	II
Hardness of the consolidated body of iron-ore (N value)	15 – 20	20 – 25
Water content in ore body (%)	9 – 7	7 – 5

As is clear from Table II, the water content is the function of the hardness of the consolidated and hardened iron-ore, such that the hardness of the ore body should preferably be adjusted by using the aforesaid dehydrating means during the navigation of the iron-ore carrier to obtain the hardness of the ore body within the predetermined range which is commensurate with the characteristics of the grab-bucket used at the destination, thus providing maximum unloading efficiency. As is apparent from the foregoing description, the grab-bucket of the present invention enables so-called wet-loading of an iron-ore in a slurry state and dry-unloading of the iron-ore of a consolidated and hardened body in and from the iron-ore carrier containing the ore in its hold, with improved unloading efficiency.

The description will now be given to further embodiments of the present invention, in which the grabbing or unloading capability of the grab-bucket of the invention is further improved.

Turning now to FIG. **7**, the grab-bucket is suspended by means of supporting wire ropes **33** from an unloader. As shown, the grab-bucket consists of an upper frame **43** suspended by means of the first wire ropes **33**, at least two pairs of suspension rods **42**, **42** each connected at one end thereof with the upper frame **43**, a pair of bucket-shells **41** pivotally connected at each of the edges thereof, on one side, with the other end of each of the suspension rods **42**, a sheave box **44**, with which the other edges of each of the pair of bucket-shells are pivotally connected, the sheave box being suspended by means of second wire ropes **54** from the unloader, not shown, and adapted to be lowered so as to cause the bucket-shells to open, the bucket-shells each having mating edges adapted to mate with each other when the bucket-shells are brought into a closed position, the mating edges having a plurality of pawls **52** on and along each of the mating edges, and the pawls **52** being adapted to mesh with each other in the closed position of the bucket-shells.

With this arrangement, the grab-bucket is lowered onto the top surface of the slurry body in a hold, and the wire ropes **54** are then wound up such that the pawls **52** may be pierced into the surface of the slurry body in a vertical direction at the initial state of the operation, followed by the horizontal operation of the bucket-shells **41** to thereby grab a certain volume of iron-ore of a consolidated and hardened body therein.

In this connection, it should be recognized that vibrating means **55** and **56** are provided on the outer surface of the grab-bucket, that is, on the outer sides of the suspensions rods **42** and bucket-shells **41**, as shown, in the close vicinity of the mating edges thereof.

The vibrating means **55** or **56** house therein an eccentric weight which is adapted to be rotated to thereby create the vibration.

The reason why the vibrating means **55** and **56** are provided on the outer surfaces of the suspension rods **42** or of the grab-bucket shells **41** is that, if such vibrating means are located on the inner surfaces of the bucket-shells **41** or of the rods **42**, there arises a possibility of damage being given to the vibrating means. It is however not recommendable to encompass the vibrating means with another protecting casing, from the viewpoint of cooling the vibrating means. It follows that the vibrating means should be provided on the outer surfaces of the bucket-shells and rods, as shown at **55** and **56** in FIG. **7**.

The vibrating means is driven electrically with an electric current being fed through an electric wire cable **57** led through the unloader from an electric power source. In this respect, the electric wire cable is retractable or extensible with the upward or downward movements of the grab-bucket, respectively, by the provision of a cable winding means, not shown, which is mounted on the body of the unloader.

The vibration which is to be caused by the vibrating means is required only when the bucket-shells are in contact with the consolidated body of iron-ore, since the vibratin during the winding and unwinding operation of the wire ropes is not desirable for the grabbing operation. It is accordingly desirable to provide an interlocking switch which is adapted to actuate the vibrating means only when the bucket-shells contact the consolidated ore body.

FIG. **8** shows one embodiment of such an interlocking switch. In this instance, there is provided a pressure sensitive means **49** between the grab-bucket body, that is, the upper frame **43** and the supporting wire ropes **33**, such that the vibrating means will be free from actuation when a tension is present in the supporting wire ropes, and actuated on the other hand, when no tension is present. The signal transmitting cables **40**, which are adapted to transmit a signal from the pressure sensitive means **49** to the vibrating means **56**, run through the upper frame **43** and rods **42** to protect themselves from damage.

Thus, when the bucket-shells reach the ore body, and thereby the supporting wire ropes are brought into a loosened condition, the vibrating means will start operation, while, when the grabbing operation of the grab-bucket has been completed and then the bucket-shells begin closing themselves by means of the wire ropes **54**, then there will be created tension on the supporting wire ropes, whereupon the vibrating means will stop operation.

Alternatively, such an interlocking switch, that is, a tension detecting means, may be provided between the wire ropes **54** and the structure of the grab-bucket.

As is apparent from the foregoing description, the difficulties experienced with the grabbing or unloading operation for such a consolidated and hardened iron-ore body contained in the hold of an iron-ore carrier can be overcome by the improved grab-bucket of the present invention with the aid of sophisticated means, such as vibrating means and tension detecting means, thus presenting the most efficient and fresh approach to this sort of problem.

It will be understood that the above description is merely illustrative of preferred embodiments of the invention. Additional modifications and improvements utilizing the discoveries of the present invention will be obvious to those skilled in the art from the present disclosure. It is to be understood therefore that within the scope of the appended claims the invention may be practiced otherwise than as specifically disclosed herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method for unloading iron ore from the hold of a shipping vessel, comprising the steps of:
- loading said iron ore into said hold of said shipping vessel while in a slurry state;
- permitting said iron ore to consolidate and become a dry and hardened body;
- dropping a grab-bucket having a pair of shells held in their opened position, utilizing its gravity, onto said consolidated and dried hardened body contained in the hold of said vessel so as to thereby demolish said body;
- closing said pair of shells to grab a portion of said body thus demolished, and thereafter lifting said grab-bucket so as to unload the dried demolished body thus grabbed within said pair of shells in their closed position; and
- transferring said unloaded demolished body to a suitable transport medium whereby said demolished body may be further processed.

2. A method as defined in claim 1, wherein said method further comprises vibrating the structure off said grab-bucket in the close vicinity of the mating edges of said shells.

3. A method as defined in claim 2, wherein the hardness of said consolidated and hardened body of iron-ore ranges from 15 to 25 in N value, while the water content in said ore body ranges from 5 to 9 percent, accordingly.

4. A method as defined in claim 3, wherein the grab-bucket used has a weight to volume ratio (W/V) ranging from 3.0 to 6.0 ton/m, ratio of length to width of opened grab-bucket to effective widths of mating edges (W/2B) of 40 to 60 kg/cm and grabbing force per unit width of mating edges (H/2B) of 40 to 150 kg/cm.

5. A method as defined in claim 3, wherein said grab-bucket is vibrated only while the pawls are contacting the surface of the consolidated and hardened body.

6. The method as defined in claim 1, wherein said grab-bucket is supported by ropes and said method further comprises sensing the tension within said ropes and vibrating the structure of said grab-bucket only when said ropes are free of tension.

7. For use in a wet-loading and dry-unloading method of an iron-ore carrier initially with iron-ore of a slurry state in its hold, a grab-bucket for use in unloading said iron-ore comprising:
- an upper frame suspended by means of first wire ropes from an unloader;
- at least two pairs of suspension rods each connected at one end thereof with said upper frame;
- a pair of bucket-shells pivotally connected at each of the edges thereof, on one side, with the other end of each of said suspension rods;
- a sheave box, with which the other edges of said pair of bucket-shells are connected pivotally, said sheave box being suspended by means of second wire ropes from said unloader and adapted to be lowered to cause said bucket-shells to open;
- said bucket-shells each having mating edges adapted to mate with each other when said bucket-shells are brought into a closed position, said mating edges having a plurality of pawls on and along each of said mating edges, and said pawls being adapted to mesh with each other in said closed position;
- vibrating means disposed upon the outer surfaces of said bucket-shells in the vicinity of said mating edges, respectively; and
- tension detecting means electrically connected by means of signal transmission cables with said vibrating means.

8. A grab-bucket as defined in claim 7, wherein said tension detecting means is connected between said upper frame and said first wire ropes.

9. A grab-bucket as defined in claim 8, wherein said tension detecting means feeds a signal to said vibrating means for actuating the same when said first wire ropes are free of tension, and for rendering said vibrating means inoperative when said wire ropes are under tension.

10. A grab-bucket as defined in claim 7, wherein said tension detecting means is connected between said second wire ropes and the structure of said grab-bucket assembly.

11. A grab-bucket as defined in claim 10, wherein said tension detecting means feeds a signal to said vibrating means for actuating the same when said second wire ropes are free of tension, and for rendering said vibrating means inoperative when said wire ropes are under tension.

12. A grab-bucket as defined in claim 7, wherein said signal transmission cables run inside and through said upper frame and said suspension rods.

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