INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1912-1913

President: SUMMERS HUNTER, Esq.

PAPER OF TRANSACTIONS No. CXC.

The Towing Machine

BY MR. THOS. W. WILSON (MEMBER).

READ

Monday, February 26, 1912.

CHAIRMAN: Mr. E. W. ROSS, MEMBER.

As towing machines are not very common on this side of the pond, I thought a description of them would be of interest to the Members. A brief digression as to their adoption may be here admissible.

The manila hawser has answered its purpose as a towing medium for a long time; its elasticity, or "give and take," adapt it for the "spring" to withstand sudden jerks and shocks to which a tow is often subject. But its comparatively short life, due to its rapid deterioration through strain and wet, renders it a costly item in towing, and after its first use, its reliability is very uncertain; while with increased size of tows where larger and stronger hawsers are necessary, it becomes clumsy and slow work to handle.

The wire rope gives a number of advantages over the manila hawser, both as to size, durability and reliance under ordinary conditions; but its want of flexibility causes steamer and tow

to receive the shock of any sudden strain, while the line itself, owing to its rigidity, is liable to part.

It is here that the towing machine comes in, providing an elastic spring or cushion to receive the shock, thus relieving both vessels and the hawser from all sudden jerks and strains and rendering the use of wire hawsers safe and reliable.

Some years ago an English firm of wire rope manufacturers suggested that a steam or air cushion acting on a piston, supported by buffer springs, should be used to take the shock of the tow and give the necessary " elasticity " to the line. They

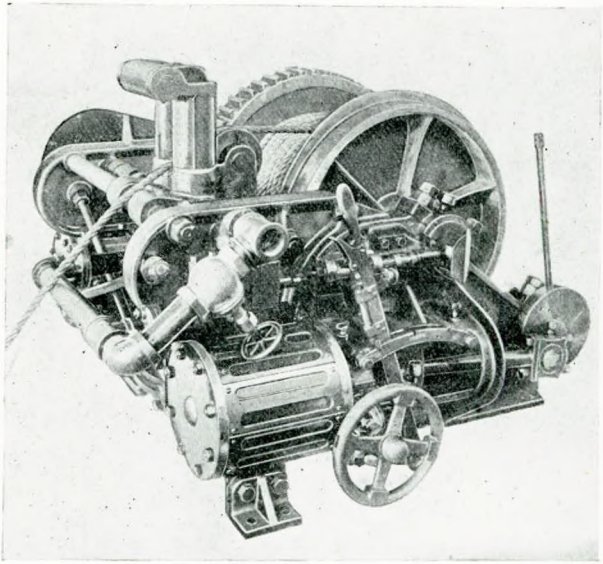


FIG. 1.

also suggested later that a steam winch of sufficient power to withstand the strain and pull of the tow should be used, the tow to be held by the steam pressure on the pistons, while the wire could be wound on the barrel (and there stowed when not in use) ; and in 1880 a patent (British) was taken out to that effect. In 1885 a patent was applied for, for an air-cushioning cylinder to take the bulk of the strain, and provided with an automatic device for regulating the pressure, the valve opening and increasing the pressure as the strain of the tow increases,

decreasing the pressure as the strain relaxes. These patents do not appear to have been put into effect in this country, probably as towing is not carried on to any great extent on this side. But in the States, where a great deal of towing is done, the problem came more to the front, and in 1888 a Mr. Shaw and a Mr. Speigell, connected with a shipbuilding firm and a tow boat company respectively, designed a machine which practically combined the steam winch of Scott & Gilmore's and the automatic control pressure valve of Hardy's. This machine was installed in a powerful tug, *Orion*, used for towing coal barges from Cape Breton coal mines to Boston. The result was so satisfactory, that more were soon installed; as the machine became known they were more widely adopted, and there are now some 200 in use.

The machine itself is really a large winch; the steel-wire towing line is wound on the drum, while the pull and strain of the tow is held entirely by the steam pressure on the pistons (aided of course by the friction of the machine and the gearing), which forms an elastic cushion to take any shocks. When towing, the desired length of cable is paid out, and the automatic gear put in; when an extra strain is put on the line—such as in a heavy sea-way, or the tow taking a sudden sheer—the machine is overhauled against the steam pressure, and the automatic gear is so arranged that when the machine runs out, the valve opens and increases the pressure in the cylinders. The more the machine runs out the more the pressure increases, thus checking the run out and providing extra power to wind back the line that has run out when the strain has relaxed. In the operation of winding back, the control valve gradually closes in until a balance is reached between the pull of the tow and the pressure in the cylinders.

Thus, the towing line, steamer and tow are relieved from all the sudden jerks and extra strains that occur from any cause, the steam pressure receiving and cushioning the shocks. Thus the life of the hawser is prolonged, and the steamer is able to maintain a steadier speed and, it is claimed, make a quicker passage.

The towing machine, besides forming an elastic cushion, as it does, also forms an easy and convenient means of handling and stowing the line. The line can be lengthened or shortened with very little trouble in a short time, without slowing down, and the tow can be hauled right up close, going at full speed.

The control mechanism seems to be the principal point of difference in the different makes of machine. In the first Shaw-Speigell machine, the control was adjusted by a pressure-regulated valve, operated by a friction gear from the crank shaft, and arranged to increase the pressure as the line runs out; it was also fitted with a link reverse gear for hand controlling. As experience was gained with the working of the machines, so improvements came in; a slide valve working over a triangular port was substituted for the pressure control valve; this valve uncovering the port from the apex, admitted steam slowly at first, but as more cable runs out, the base of the triangle is

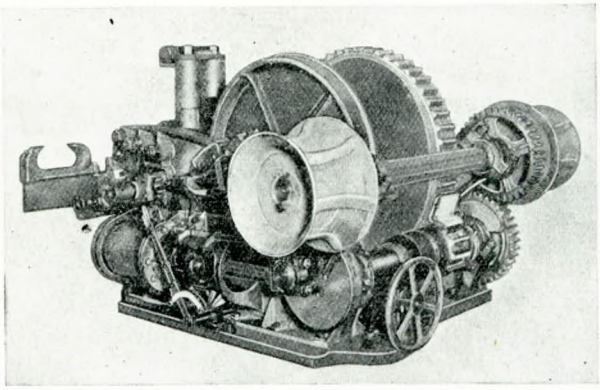


FIG. 2.

approached, the volume of steam is quickly increased, whilst in winding back, as the machine approaches the normal, the steam is throttled, thus preventing the machine from running away—as might happen in the event of the line parting—or the strain being suddenly released. The link reverse was discarded, and a windlass reverse was used instead. A separate steam connexion or bye-pass valve is provided for operating the machine by hand, independent of the control valve. Thus, when it is desired to pay out or shorten the tow line, the bye-pass valve is used, also the reverse valve when necessary; but under normal towing conditions the automatic valve controls the machine. These are the principal points about the Shaw-Speigell machine. It is claimed by some, however, that as the control valve is slow acting, an unnecessary length

of line is allowed to run out before being checked, entailing extra work on the machine, and using a quantity of steam in winding in the line again to recover what had run out.

In 1896 the Chase Machine Company brought out a machine with a different type of control valve. The control gear is designed to be quick acting; the ports are rectangular, and all the ports, passages and pipes are exceptionally large, to enable a good body of steam to be admitted, thus preventing a heavy run out of line, and allowing of its quick recovery. The steam admission valve and the reverse valve are both worked from the one lever; the automatic control gear is attached to this lever, and can be readily thrown out of gear when it is desired to work the machine by hand. Under normal working conditions only sufficient steam is admitted to hold the tow—the valve only being a small amount open—but when an extra strain comes, and the line runs out, the valve quickly opens and checks the run and recovers the line. Should the strain be suddenly released, the direction of winding in would soon close the steam admission valve, and at the same time close in the reverse valve—choking the exhaust—thus preventing the machine from over-running.

The sketches shown here were taken from a "Chase" Machine that I happened to be shipmate with. The towing steamer and tow are rather larger than the ordinary run of tows; the steamer has a carrying capacity of 9,000 tons of cargo, while the "Barge" can carry 10,000 tons; the steamer is very strongly built, and is fitted with twin screws driven by quadruple expansion engines of 5,000 indicated horse-power: and in fine weather an average of 10 knots is obtained between the United States and England. We are fairly well known across the track, and swell liners getting interrupted in their converse with each other by our wireless communications with our partner, dub us the "Horse and Cart," but should they chance to break down in our neighbourhood, they need have no fear, for we can safely take them in charge.

The machine installed in this steamer has two cylinders, each of 18 in. diameter × 20 in. stroke, cranks at right angles; the pinion on the crank shaft is 14 in. diameter of pitch circle, while the cog wheel on the drum shaft is 7 ft. diameter, giving a ratio of 6 : 1. Steam is supplied from the main auxiliary line through a reducing valve at a pressure of from 90 to 100 lb. (boiler pressure being 215 lb.). The steam

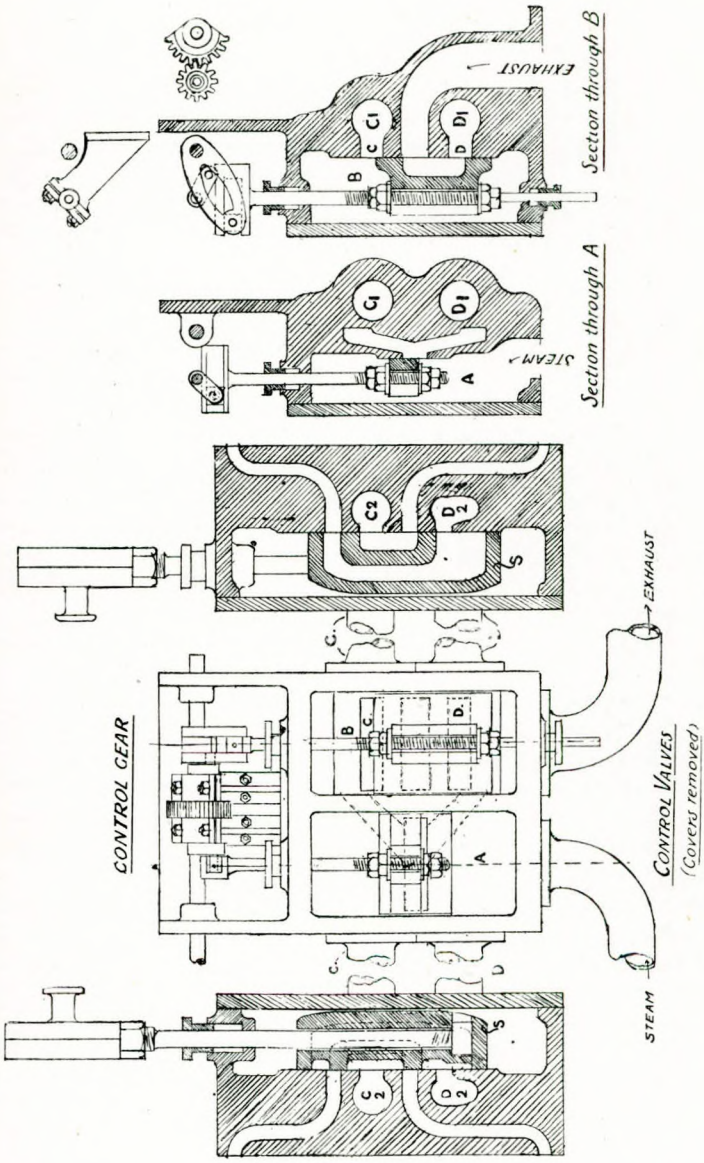


FIG. 3.

is carried practically the full length of the stroke, so that there is a good holding power at any position of the cranks. The

automatic control is worked from a small pinion attached to the end of the barrel shaft—(in this particular machine it has only two teeth)—gearing into a larger wheel G, to which is attached a connecting rod to the control lever H, which actuates the control valves. The gear wheel G is fixed eccentrically on the lever L, by which it can be thrown in and out of gear. When it is necessary to pay out or wind in cable, the automatic gear is thrown out, and the machine is worked by hand with the lever H ; when the desired length of line is obtained, the automatic control is put into gear again, and maintains it at that length.

Steam is first admitted into the chamber A, and passes by the port opening through the dividing wall between the two chambers. The amount of port opening is controlled by the automatic gear, which operates a crank attached directly to the valve spindle ; the reverse valve is in the chamber B, and is also operated by a crank on the same counter shaft as A, but working through a link, which, when the crank is on the bottom centre, gives a quick opening at first in either direction to the valve, leaving it well open, any further movement of the crank away from the centre altering the valve but little. The end ports in chamber B communicate with channels running through the casting, to which are attached pipes C^1 C^1 and D^1 D^1 connected to the slide valve chambers C_2 C_2 and D_2 D_2. The control valves are here shown in the normal working position, C forming the steam port admitting steam to the two slide valve chambers C_2 C_2, and exhausting through D. When it is desired to pay out cable, the automatic gear is thrown out, and the lever H is thrown over, altering the position of the reverse valve in B, when D becomes the steam port and C the exhaust port ; the steam admission valve in A is closed when the lever H is in mid position. A quadrant keyed on to the lever shaft, gears into a pinion on the crank shaft, which operates the control valves.

A $1\frac{1}{4}$-in. pipe E admits steam from the control valve chamber A to the back of the slide valves, keeping them held up tight against the face.

A brake band (not shown) is fitted around the rim of the barrel wheel F, and is worked by the hand wheel W through a bevel gearing and a screw, brake bands are also fitted around the crank discs.

The steel-wire rope used for towing is $2\frac{1}{4}$ in. diameter,

and about 500 fathoms long; the first layer on the drum is 3 ft. 4 in. in diameter, and the last layer is 6 ft. in diameter; there being about nine layers in all, and about twenty-two turns in each layer. There are generally about four or five layers on the drum, when towing in ordinary weather, but this varies considerably according to weather conditions, the line being lengthened in bad weather and shortened in fine.

There is a similar machine on the barge. At first both tow lines were shackled together, the other ends being wound on the barrels of either machine; this gave a considerably longer tow line with its consequent drag. Later the lines were tried in parallel, that is, the loose end of the line of either machine is placed on the hook of the other vessel, thus dividing the strains between the two lines, and should one hawser happen to break, the tow is still held by the other line; also a much shorter line is used. This connecting the hawsers in parallel has been found to answer much better than connecting by shackling the cables; in the latter system as much as 12 to 15 fathoms of cable would be paid out, in heavy weather, while when the cables are in parallel, the running out does not exceed about 15 ft. to 20 ft., or about one turn of the barrel. In smooth water, however, there is practically no movement in the machine, and consequently very little steam is used. Snifting valves are provided in the cylinder ends to allow the escape of any water that may gather. When the line runs out, the machine is overhauled against the steam pressure, which is really compressed back into the pipe again, raising the gauge pressure to a considerable extent, which of course assists in checking the run and in winding back. In addition to the automatic gear opening the valve, the steam is really only *used* in recovering the line, any other loss being that due to condensation or leakage. The brakes are only used when it is necessary to shut down the machine for any reason, while running, such as to effect a repair (sometimes a valve spindle breaks); although towing on a hard-set brake is sometimes resorted to with tugs in fine weather—with the idea of saving coal; but it is a very bad practice, and would sooner or later result in breaking the line or smashing the machine. In some of the more recent machines, however, a special spring-set brake is fitted, which can be set to retard the running out of the line, but leaves the machine free to wind in; but unless carefully set, it is liable to be abused.

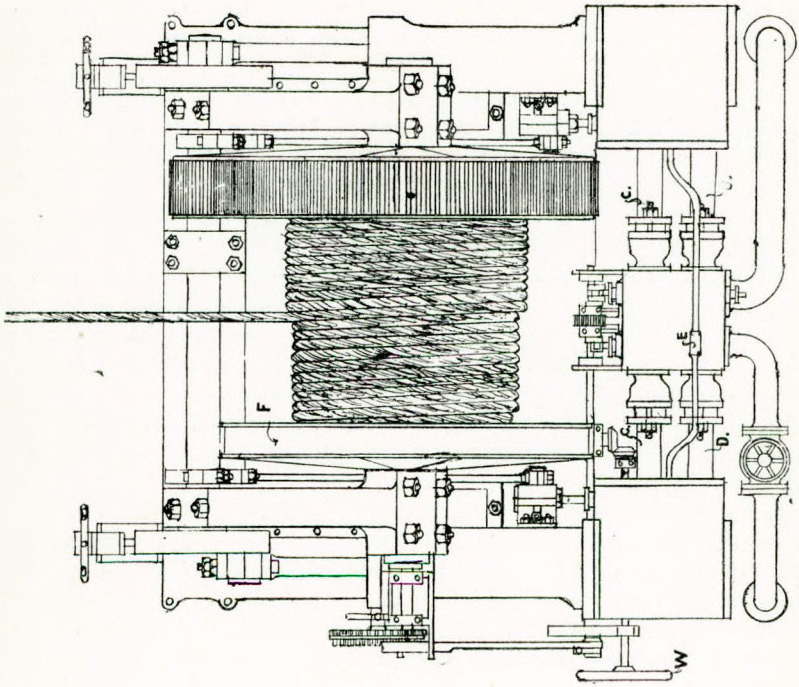
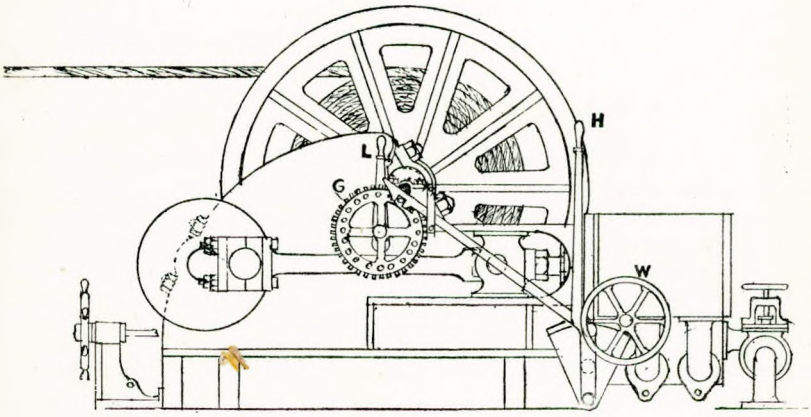


FIG. 4



In winding the cable on the drum, care should be taken to wind the turns on evenly. This is usually done with two pairs of rope-blocks attached to a pair of pulleys, between which

the cable runs. But in the later machines, an automatic winding gear is fitted, worked from the crank shaft, which guides the line on evenly and turns it at each end.

The machines are very strongly built (an unusual thing with American machinery), and designed to stand a heavy strain, well over the maximum that can be put on them by the power of the steamer. They are made in various sizes to suit the different requirements. There is an ample margin of power allowed to meet any emergency that may arise.

Taking the I. H. P. as 5,000, the pitch of propeller as 15 ft., revolutions per minute as 82, gives—$\frac{5{,}000 \times 33{,}000}{82 \times 15} =$ 134,146 lb. Indicated Thrust; allowing 10 per cent. slip (this is a small allowance for towing, as from 15 per cent. to 20 per cent. of slip is more usual even in fine weather, while in bad weather it may rise as high as 60 per cent. or 70 per cent.) will give an actual Indicated Thrust of 120,732 lb.

With the barge equal in size to the steamer, it is assumed that half this power is exerted in moving the steamer, and the other half in moving the barge; so that 60,366 lb. can be taken as the strain on the line. The breaking strain on a 7-in. (cir.) wire rope is given as 150 tons, or 336,000 lb. In this case a special wire is used which has a breaking strain of 180 tons, or 403,200 lb.

The diameter of the first turn is 3 ft. 4 in., and the last 6 ft.; assuming that about half the cable is out, the diameter of the drum will be somewhere about 4ft. 9 in., therefore the load on the machine will be $60{,}366 \times \frac{4{\cdot}75}{2} = 143{,}367$ ft. lb.

The resisting power of the machine will be—in the position of minimum torque, that is, with one crank on the dead centre, and the other at half stroke, area of piston deducting rod area—$(18^2 - 4^2)\ {\cdot}7854 = 242$ sq. in., taking steam at 125 lb., stroke 20 in., gear ratio, $6:1 = 242 \times 125 \times \frac{10}{12} \times 6 = 151{,}250$ ft. lb.; with the engine in the position of maximum torque, one crank at $\frac{1}{4}$ stroke and the other at $\frac{3}{4}$ stroke, this can be taken as 1·5 times more, that is, 226,875 ft. lb. So that there is a good margin all round, added to which the friction of the machine assists in holding.

Should the barge get aground and the whole pull of the tow were thrown on the machine, that is 286,734 ft. lb., with the

same amount of line on the barrel, the steam pressure could be increased to 160 lb., and the engine pull would then be 290,400 ft. lb., the line could also be lengthened till the last layer was on the barrel, and the leverage of the machine reduced to $\frac{3' 4''}{2}$.

In the earlier part of the paper I stated that steam was supplied through a reducing valve to the machine at a pressure of 90 to 100 lb. This is the pressure we work at, but it must be remembered that we are using the two hawsers in parallel, so that each should only have half of the strain. In my calculations I have taken the steam as 125 lb., but this is taken as the power of the machine towing with one line, and this was the pressure carried when towing with the hawsers shackled ; but as a matter of fact, we have towed with a single line, at full speed, with a steam pressure of from 90 to 100 lb., and always single up on coming into close waters.

So far as I can make out, the towing machine is not used very much in Europe ; but in the United States and Canada, on both the Atlantic and the Pacific sides, they are used extensively by a variety of firms, and a good many firms have a number of machines. They are used, too, for towing rafts of logs on the Pacific coast. The dry dock *Dewey* was towed from the Chesapeake to Manila with three tugs using towing machines.

In all cases, they appear to have given general satisfaction, and many consider that they pay for themselves in a short time in the saving of manila hawsers alone, as well as enabling the vessels to make better time on the passages.

There is a difference of opinion as to whether the towing machine should be placed on the steamer or on the barge. One point in favour of placing it on the steamer, is that there will be a better supply of steam available, and it is more likely to receive skilled attention. However, they are used in both ways, and some firms place them on both tug and barge.

In conclusion, I trust that I have made clear the working of the towing machine. Upon the merit of conveying freight by tows instead of each vessel under its own power, I have not touched, or upon the adaptability of our coasts for towing ; but so far as the reliability of the machine is concerned, the one I have endeavoured to describe speaks for itself ; conveying

19,000 tons of cargo at a time, across the Atlantic in all kinds of weather, for the last three or four years; and after this time the steamer is on its third hawser and the barge is on its fifth. The machine is as good as when new, in fact, better, as it has been improved and strengthened.

The steamer by itself can do about 12 knots, and with the barge in fine weather about 10 knots, though of course in bad weather this is much reduced; while the consumption during towing is only a few tons more per day than when running alone.

DISCUSSION

CHAIRMAN: The towing machine is not altogether in our particular line, but it is interesting to know what economies are being effected in this direction. As Mr. Wilson remarks, I do not think this machine is so much in use on this side of the Atlantic as it is in America and on the Great Lakes. A few weeks ago we had a paper from a Member in the United States, who gave us some idea of the enormous sizes of vessels on these Lakes; but he did not make any reference to ships being towed, yet a great deal of this is done there. Mr. Wilson has given us the stresses and all other data here very elaborately, and has shown how reliable the machine is after some considerable number of years' service. In the olden days we only used to think of towing when we were unfortunate enough to have a breakdown in a sea-way; with such a machine as this there would not be the trouble with broken hawsers we hear so much of when a ship is being towed into port.

Mr. G. W. NEWALL: Perhaps Mr. Wilson would tell us how the machine is secured to the deck, as there appear to be very few bolts. I can only make out about eight $1\frac{1}{2}$ in. bolts on the whole of the machine, and I should imagine a good tug would move some of these.

Mr. WILSON: The bedplate itself is very securely bolted to the deck and the machine is bolted to the bed plate. There

are extra strong beams and the bolts pass right through to the bedplate.

Mr. NEWALL: But there are only about eight bolts. I should have thought that this number would be too small.

Mr. WILSON: There are a good many more in the machine I am acquainted with. There is very little strain on the machine itself; the whole of the strain is taken by the steam, and in the least bit of a sea-way it adjusts itself right away. There have not been any signs of shifting in this steamer. There was a little trouble with a barge; the steam was rather low and on putting on the brakes some of the bolts got loose. But with sufficient steam on there is not the slightest movement.

Mr. F. M. TIMPSON: Is this large lever on the side connected to the control gear? Mr. WILSON: Yes.

Mr. G. W. NEWALL: I must say I have had no experience with this class of machine, and it seems to me it is another of those engines which will not adapt itself to the use of oil when we get rid of steam on board ship. It seems to me to be opposed to the use of oil, unless it can be driven by air pressure from an oil engine to create the pressure.

Mr. WILSON: It should work well on air pressure if provided with a good sized reservoir.

Mr. NEWALL: Some years ago I had to get out drawings for a law suit in connection with a large ship that had towed another—a very heavy boat—some distance home. I had to show the line of the ropes running on either side of the ship and the amount of disturbance. The deck had suffered due to shock, the winches were shaken up, shafts broken, and a lot of damage done, so much so that the towing ship had put in a heavy claim. At the time I remember thinking of the excessive strain there must have been, and it appealed to me as demanding a machine that would get over it. In this country it is more or less an unknown machine.

Mr. WILSON: The Americans have found they can save a great deal by towing. It is a well-known fact that a vessel can tow another vessel at much less cost than by putting separate engines in each vessel. There are very many firms in

America using the machine, and there are also one or two in Europe.

Mr. TIMPSON : We have to thank Mr. Wilson for bringing this subject before the notice of the Institute. It is a novel machine, and it is of interest to us as a machine used in marine engineering. Although it is not very well known, perhaps it is for that reason that it is not more widely used. It is wonderful how quickly it is taken up when once it is used. Certainly it is a scientific method of towing heavy vessels and in many deep-sea tugs I should think it would be an economical investment for the towing boat owner. On this side we do not hear much of it, but, as Mr. Wilson says, it is used regularly in trading on the American coast. It is used in big tows of gypsum on the Bay of Fundy, also in the lumber runs. I have seen tow boats in the centre of a huge island of logs and wondered how they got out of it. A number of years ago a huge raft drifted into the Altantic and was a danger to shipping ; then there is the danger of the tow rope breaking, all pointing to the necessity of machines for easing the strain on the rope. The idea seems to be an extension of the steering gear control valve, except that there is a great travel of the rope. The explanations by Mr. Wilson give a fair idea of how the machine works.

Mr. WILSON : So far it has been adopted by very few firms on this side ; but a few firms on the Continent are using it ; some in Antwerp and some in St. Petersburg. The British Admiralty have ordered two small machines ; but I do not think it has been adopted at all in this country otherwise. It is used very extensively for towing large rafts of logs ; that is one of the special points the makers claim for it—the greater safety in towing these rafts. This is very necessary, because if the rafts get adrift they are a menace to shipping. There is no shock whatever to the towing vessel. The machine is right over the chief engineer's head and is rather noisy ; but it is absolutely safe. The only trouble we have had was with the valve spindles breaking at times ; but I believe we are getting over that difficulty now.

Mr. A. R. NEWMAN : Is the rope made fast to the bitts, or made fast permanently to the drum ?

Mr. WILSON : It is always made fast on the drum and a number of layers of wire are held on the drum. For ordinary towing four or five layers are on the drum ; roughly speaking, half the line is out in normal or moderate weather. The free end is made fast to a hook on the other vessel, and it is so arranged that a blow from a hammer disconnects it. There is one towing machine on the barge and one on the steamer, and the free end of each rope is on the other vessel in this case ; but, ordinarily, there is just a single line.

Mr. NEWALL : Does the barge carry a boiler specially for the towing ?

Mr. WILSON : Yes, an oil-fired boiler for the electric light, steering gear and towing machine.

Mr. TIMPSON : Could it be used both as a towing machine and winch combined ?

Mr. WILSON : It is used solely for the purpose of towing. We always wind it up on the barrels out of the way when it is out of use.

Mr. TIMPSON : I should think it would be better if it could be used for some other purpose when not used for towing ; such as for use as a winch.

Mr. WILSON : It is too large. There is 3,000 ft. of towing line wound on the barrel, so you could not get rid of that very well. But in some of the more recent machines another independent drum is provided which can be put into gear instead of the main drum.

Mr. E. SHACKLETON : I think some kind of flexible cable very necessary if a big barge is being towed, and apparently some of the oil barges are very cumbersome. For these machines I should think compressed air would do almost equally as well as steam. There is this to remember ; that all the time you are towing on this system there will be from 50 to 60 tons of fuel missing from the boiler. I do not think it would be possible with this machine to get much below 40 to 50 lb. because the pipe losses are only about 22 lb. per horse power developed. That, of course, is an item which I do not think could be well reduced either with steam or air. I think, on the whole, it is a very good machine for the purpose.

Mr. WILSON : The steam consumption is practically nothing in fine weather, excepting condenser losses or leakage. The only time when the steam is used is when winning back the line run out, and we carry 90 to 100 lb. If compressed air is used, I should imagine it would need a pretty large reservoir to maintain a good pressure in all weathers.

Mr. NEWALL : With regard to the reference in the paper to the long cylinder for compressed air or steam which is stated to be the subject of a patent, may I ask if this was Patent No. 2156 of 1885. I saw there a reference to a long cylinder, perhaps 18 ft. to 20 ft. long, fitted on a ship.

Mr. WILSON : I have not seen this particular one ; I only happened to read about it. That was the first idea ; to act as a kind of steam buffer to give spring to the hawser. This was also an air cushion to take any strain on the tow.

Mr. A. COOKE : We are very much indebted to the author for this interesting paper. He has shown us very clearly the working of it, and the uses to which it is put, in the United States and Canada more especially, where there is so much more towing than in this country. But there are instances where it would prove very useful over here ; for instance, in towing out floating docks. On several occasions they have gone amissing. I do not know whether these machines are used for this purpose. Several of these docks, all built on the Tyne, have been towed out by a Dutch company, who seem to get them out successfully as a rule. I should think they would be of decided value in the States, where there is an enormous amount of towage as compared with this country. I have very much pleasure in proposing a vote of thanks to Mr. Wilson for his interesting paper.

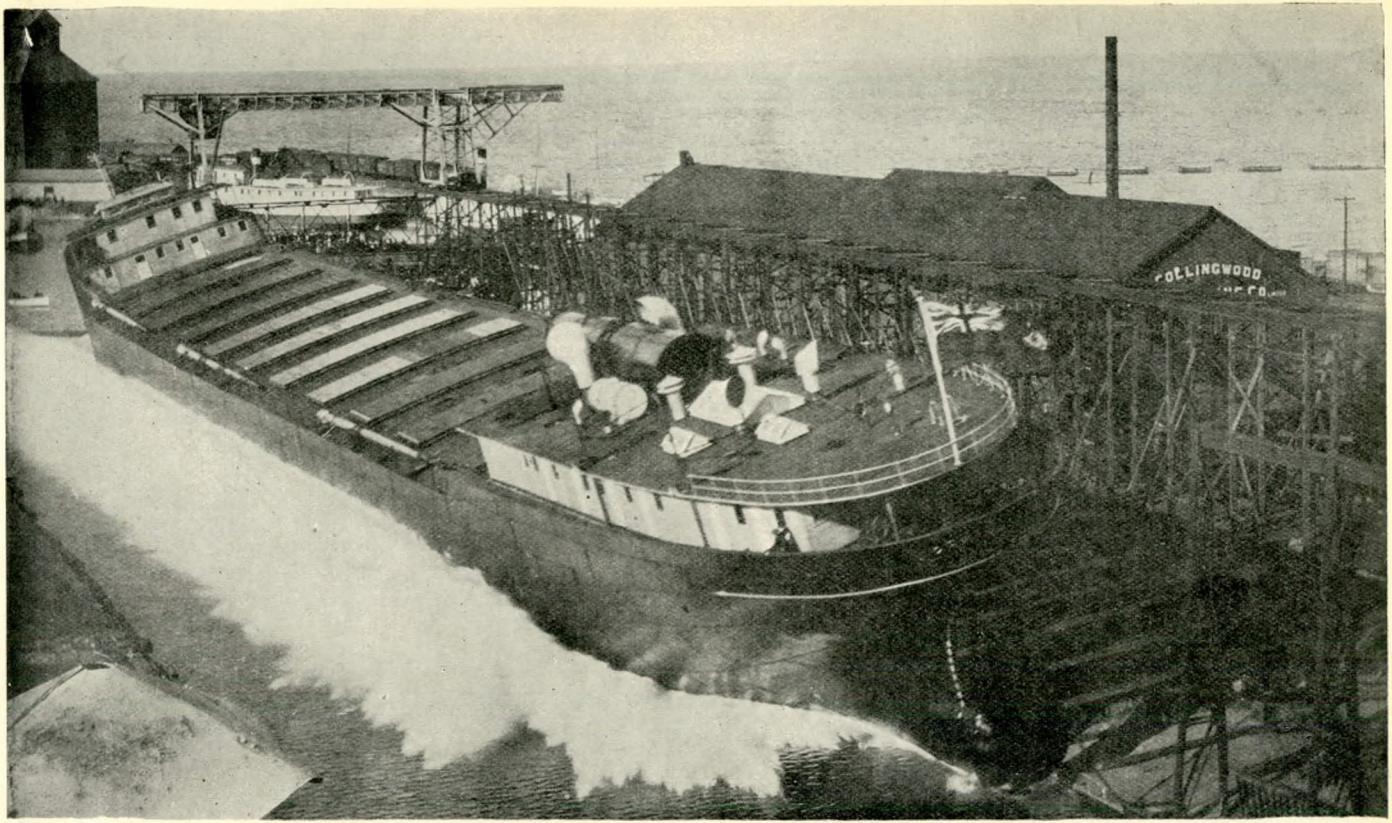
Mr. A. H. LEDGER : I should like to second that vote of thanks. I have listened to the paper with great interest and certainly it was very novel to me. I have seen these huge boats being towed, and often wondered how it was done. I think there is certainly a field for the machine on this side.

Mr. WILSON : I must thank you very much for the way in which you have received my paper. I am not used to writing papers ; but the machine being so novel and the information not being general, I thought it might be of

interest to the members. I had not an opportunity of being at sea with them until about a year ago, and after seeing them at work, I think they are absolutely necessary for safe towing. The American owners state that they are a very great saving. It is said they pay for themselves in hawsers alone in a few months. With regard to towing docks, I do not know if this machine was used, but I think it probable. A number of machines have been supplied to European owners. Some time ago one of these docks was towed by a steamer to the Cape. She managed to get it as far as the Cape coast and there lost it. She was not provided with a towing machine. On the American coast it is a common sight to see a small river tug with three barges in tow far bigger than itself. If it were better known in this country I think tug boat owners would adopt it to a greater extent.

Another way in which it could be usefully employed would be in case of a vessel getting aground. A steamer equipped with a towing machine could anchor in safe water some little distance off, get the tow line connected up and start winding in with the machine. By this means she could exert a very much greater power than churning the water with her propeller. As I remarked at the beginning of the paper, the towing machine is really a large powerful winch, with an automatic control gear added, which can be thrown out of action at will, and the machine worked by hand as in an ordinary winch.

The meeting closed with a vote of thanks to the Chairman on the proposal of Mr. T. A. Crompton, seconded by Mr. Timpson.



By courtesy of] [*"Canada"*

Launching a Lake Bulk Freighter at Collingwood, Ont.

SHIPBUILDING ON THE GREAT LAKES.