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RELEASING GEAR FOR LAUNCHING AS USED ON THE U. S. S. WHITNEY

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THE shipbuilder having advanced his vessel on the ways to the point where he is ready to launch her is confronted with two problems. He must first provide a means for holding the ship on the ways while the launching gang removes the keel blocks, cribs and shores which have supported the ship during the building stage. During this stage he must be certain that his holding device will not prematurely release the vessel before the tide is up to the required level. In the second place he must be sure that at the moment when all is clear and the tide is right, he can effect a positive release and ensure the launching of the ship before the tide has fallen so low as to make launching unsafe. The increase in the size of ships has rendered the solution of the two problems more difficult and the methods previously in use are reaching their limit in offering a satisfactory answer to the two contradictory requirements.

The second problem may well be considered first. Ships built on land require to be placed in the water and the force required to effect the transfer has, from time immemorial, been provided by the ship herself through the medium of building on an incline. This inclination must provide a component of her weight down the ways sufficient to overcome frictional and other resistances to starting and to ensure that the ship, once started, will continue in motion. From experience with various kinds of lubricants on the ways it has been established that a slope of one-half to eleven-sixteenths of an inch to the foot is satisfactory and this slope is usual for vessels of any size. With a given slope, however, the pull down the ways is proportional to the launching weight of the ship and for the last battleships launched for the Navy, this pull has been so great as to render liable a premature launch. For the 40,000-ton ships laid down but not now to be completed, at some yards the initial pull was to be reduced by cambering the ways. This solution is effective for the result desired but it compromises the second requirement in launching. Starting friction is always more than sliding friction. If the slope of the ways is sufficient to ensure that the ship, once in motion, will continue in motion, a greater slope is required to ensure that she will start. Cambering the ways opposes this by reducing the initial slope and the probability of starting is consequently reduced. The possibility is brought in that the ship will not start at all under the component of her weight down the ways and that other means must be provided to get her under way. For a large vessel where every inch of tide is required for a successful launch, the anxiety of the builder who, struggling to make his ship start, sees the tide slipping away from him, can only be likened to the predicament of the unfortunate captain who strands his ship at the flood of a spring tide. No builder who has ever been present when a ship has failed to start will wish to risk the possibility for himself.

The first requirement has, up to the present time, been met in various ways—the favorite ones being the sawing off of wood sole pieces at the head of the ways, the dropping of dog shores set against the ways, the release of hydraulic triggers set into the sliding ways, or the method of not holding the vessel at all but simply splitting out keel blocks and shores until the vessel capsizes the remaining blocks and shores and slides away.

The sawing off of oak sole pieces bolted at their forward end to the grounding ways is much used for vessels of moderate size and is satisfactory where the pull is low. It is shortly found that for vessels where the launching weight is relatively large for the width of ways used, it is impossible to procure oak sticks of the length and thickness required and that even if other wood of a lesser strength is used the sawing through of the sole pieces would be relatively slow and laborious. Furthermore, there can be no certainty as to the uniformity of strength in the sole pieces. Concretely, it was found that for a launching weight of 5,000 tons, it was necessary, with a theoretical factor of safety of three, to use oak sole pieces consisting (on each way), of three sticks, each 10″ x 6″ x 30′. Not one bid for material of this size could be obtained in New England or the vicinity. It will also be obvious to anyone acquainted with the qualities of oak of this size that the factor of safety would have been entirely theoretical.

The release by dog shores consists of bolting a timber to the outboard side of the sliding ways, setting the dog shore against this and butting the after end of the dog shore against a wood trigger. The trigger rests at one end against a projection attached to the ground ways and is held at the other end by a lashing. The release is effected by cutting the lashing, thus permitting the trigger and dog shore to drop clear. This arrangement is much used as a preventer in all types of launching releases but as a final release in itself it has many objections. The amount of load which the dog shore and the trigger can carry is necessarily limited at the sliding ways by the strength which can be obtained in the attachment of the projection to the ways. It is limited at both ends of the spur shore and at the trigger by the load which these timbers can carry in compression. There is no certainty in getting a simultaneous release of the triggers on both sides and the possibility of the jamming of the shore or trigger is ever present and has occurred even when the device was being used only as a preliminary release. For vessels of any size this method is, by its uncertainty and lack of strength, entirely ruled out.

The release by hydraulic triggers was introduced in this country when battleships above 20,000 tons (complete displacement) were laid down and is believed to have been first used on the *Texas*. In this method, a steel trigger pivoted in the ground ways bears at its upper end against a steel casting set into the sliding ways. The lower end of the trigger presses against a hydraulic ram. Release is effected by opening a valve and permitting the liquid in the cylinder to escape. For ships of ordinary size this releasing method is prohibited by its cost. For very large vessels the cost may be borne but here, with a considerable pull, the pressures developed in the cylinders and piping are extremely high and there is no positive assurance that the mechanism will hold its liquid and stand up under the strain for any period of time.

Releasing the vessel by providing no holding gear and splitting out blocks until the ship starts, involves considerable danger to the personnel under the ship and, furthermore, makes the time of release quite uncertain.

For the launching of the destroyer tender *Whitney* there was used a releasing method which it is believed obviates the defects of former methods by providing a secure fastening and permitting a certain release. Its use secured a successful launch under difficult circumstances.

The *Whitney* was constructed on a building slip too small for it. The ground ways were narrow, only thirty-one inches wide, and the sliding ways could not be widened beyond thirty inches. The declivity of the ways was, as usual, eleven-sixteenths of an inch to the foot. Owing to a previous uncertainty regarding ultimate completion the ship was held on the ways long after the normal time of launch with the result that her launching weight reached 5,800 tons. For the narrow ways to be used, this gave the high unit pressure of 3.12 tons per square foot, believed to be unprecedented in launching pressures. The pull down the ways, neglecting friction, was 330 tons, and using a coefficient for friction of .02 the starting pull was expected to be 214 tons. Starting seemed assured but the high pressure on the ways rendered the squeezing out of the grease probable and a quick release was essential.

The previous releasing method used at the yard could not be followed owing to the inability of securing oak of the proper size. Sole pieces 30″ x 6″ x 30′ would give a theoretical factor of safety of 2, but considering the uncertainty of the material, it was doubtful if the sole pieces could stand the simple strain. Triggers were ruled out of this case by the expense.

Steel plates presented themselves as a logical means of securing strength and their cutting away with acetylene torches offered a quick and certain release. A thirty-pound steel plate, 32″ x 28′ was bolted to the forward section of the sliding way on each side. The bolts were spaced to secure an even distribution of the stress in both steel and wooden members. Test coupons of the steel were put through a Riehle testing machine with the following average results:

Dimensions of test bars	1.56″ x .738″
Yield point	31,600 lbs. per sq. in.
Ultimate strength	60,700 lbs. per sq. in.
Elongation in 8″	29.2%

The steel, as a result of tests from several specimens, was determined to be uniform in texture and in strength.

The final release on the *Whitney* was to be effected by the burning through with acetylene torches of two steel plates which, up to the instant of launching, held the sliding ways to the ground ways.

To test the possibilities of burning, another steel plate of the approximate size of the plates to be used was cut through by two burners in about thirty seconds. It was found that the burners worked best by starting at the center of the plate and working toward the edges. Several experiments were made in having the burners keep together by marking off the plates in units but it soon appeared that the rates of burning were sufficiently uniform to permit them to burn individually at their best speed and avoid the loss of time in checking at the marks.

Finally, to determine the behavior of plates while being burned under stress, a plate ⅝″ x 31″ was placed in the chain testing machine and subjected to the unit stress expected on the ways. This required for the test plate a total pull of 140,000 pounds. Under this pull, the burners started to cut. When the area had been sufficiently reduced so as to bring the metal remaining to the yield point, the burning was stopped while the load was run up again to normal and burning recommenced till fracture took place. Nothing abnormal occurred at the instant of breaking to cause alarm or injury to the burners.

Having determined by test the feasibility of the method, its use was definitely adopted. A steel plate, large enough to furnish both sole pieces, was drawn from store and cut in two lengthwise. The portion to be used for the port side was selected for further calibration. In the excess length at each end, an eight-inch pin was placed, these pins being secured to the machine. Loads in increments of 50,000 pounds were added and readings taken with a Berry strain gauge. The curve obtained was plotted as curve "A." It was noted that this curve did not pass through zero. This variance was probably due to the fact that the extreme length of the plate, twenty-eight feet, necessitated intermediate supports which acted to throw the portion of the plate under measurement into a convex shape. This portion of the plate flattened as the load increased and a normal rate of extension was interfered with. By the time 100,000 pounds was reached flattening was completed and the extension then plotted in a straight line.

Curve "B" was drawn through zero, parallel to "A" and was assumed as being the proper curve when the errors due to the zero reading were eliminated.

Curve "C" was the theoretical curve for the material, based on a value of Young's Modulus of 30,000,000. It was noted that curve "B" had a greater slope than the theoretical curve and it was to determine this slope that the calibration was made.

The steel sole pieces, after calibration, were bolted through the ways as shown. A factor of safety of four was desired and the spacing and number of bolts was such as to secure this strength in the plates, the bolts and the connections to the yellow pine sliding ways and ground ways. The photograph, figure I, shows a side view of the port sole piece in place. The piping in the picture is for the hydraulic jack always provided for use in case the ship fails to start.

On the morning of the launch, the Berry strain gauge was re-installed on the port plate. Readings were taken at important steps. The launching was set for noon, with an expected tide at that time of twelve feet over the way ends and the current running about .3 knot flood. The launching gang worked with considerable speed and by 11:45 A. M., had all the shores and blocks out from under, leaving the ship on the grease. The tide was higher than expected, having reached twelve feet three inches at that moment. As all conditions were better than anticipated, the dog shores used as preventers were dropped and the ship left secured only by the steel plates. At 11:51 A. M., the signal was given to burn off and the acetylene torches commenced. The four burners cut steadily at their best speed. In about thirty seconds, with a few inches of steel still left on each side, the plates were seen to yield, then snap, and the ship moved quickly down the ways, developing a maximum speed of 15 knots.

The readings of the strain gauge were as follows:

Start of third rally	.0000
End of third rally	.0010
After keel blocks out	.0023
Sand blocks out	.0039
All blocks and shores out	.0043
Spur shores dropped	.0125
Maximum reading just before burning off	.0130

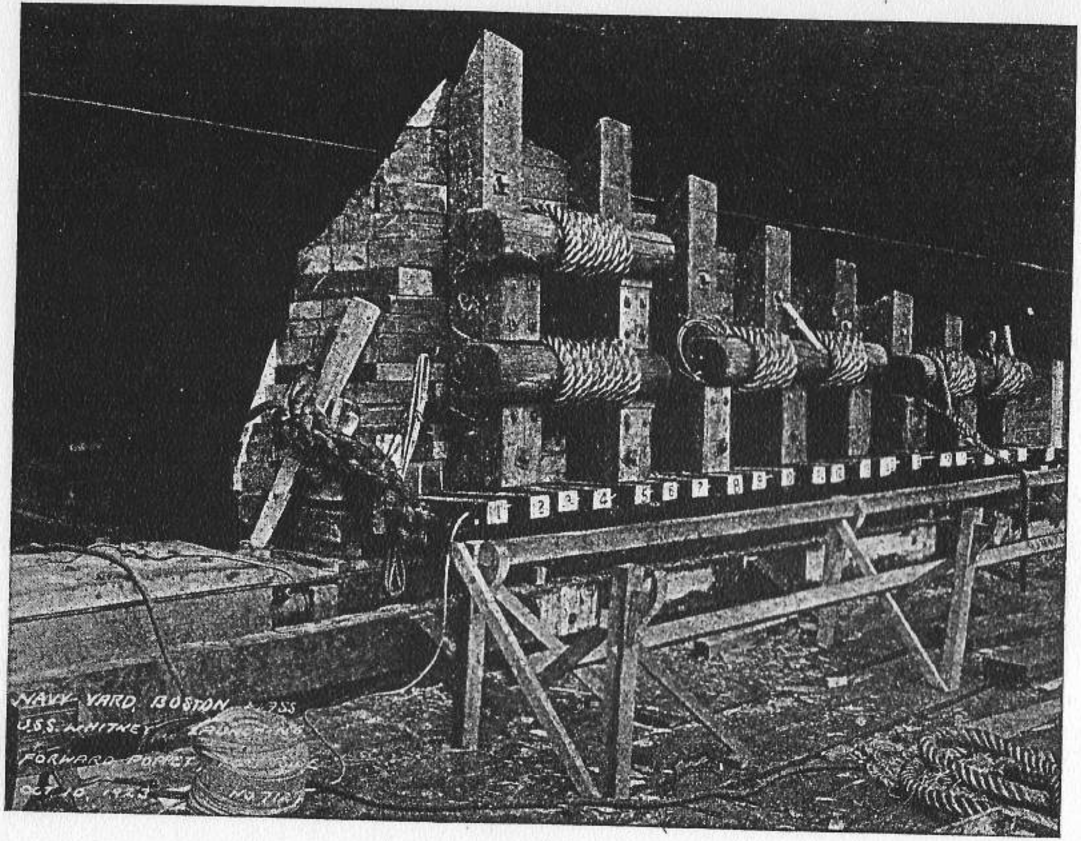

FIG. I

The stresses on the plates at the various stages were:

	One Plate	*Both Plates*
Start of third rally	0 lbs.	0 lbs.
End of third rally	24,000 lbs.	48,000 lbs.
After keel blocks out	50,000 lbs.	100,000 lbs.
Sand blocks out	85,000 lbs.	170,000 lbs.
All blocks and shores out	95,000 lbs.	190,000 lbs.
Spur shores dropped	265,000 lbs.	530,000 lbs.
Maximum reading	275,000 lbs.	550,000 lbs.

The gauge was removed from the plate just before the burning off commenced.

The fracture of the sole pieces furnishes an independent means for computing the maximum load. These areas, shown in the photograph, were: starboard, 2.41 square inches; port, 6.66 square inches; total, 9.07 square inches. Using 60,000 pounds per square inch as the value for the ultimate strength, it appears that a load of 540,000 pounds was exerted on the sole pieces. This checked with the maximum value on curve "B."

The photographs, figures II and III, show the ends of the sole pieces left at the head of the ways when release occurred. Only the sections of the plates adjacent to the break are shown, the remainder of the sole pieces having been removed after launching for convenience in handling. In both photographs the views are looking down on the plates as they were on the ways, the legends being placed toward the stern. In the edge views the tops of the plates are toward the legends as can be noted from the flow of the slag. It will be observed that the fracture is similar to that usually obtained in testing machines. The width of the plate at the break was reduced from 32″ to 31⅛″ on the starboard plate, and to 30⅞″ on the port plate. This reduction is shown in the photographs. As the burners on the starboard plate developed somewhat greater speed than those on the other side, the area remaining on the starboard plate was about one-third that on the port plate at the instant when fracture of both plates occurred.

The method having been entirely successful in its initial launching, it may be well to consider it as launching means for the largest vessels to be launched or likely to be launched for fourteen years in this country. For the purpose, the ex-battle cruiser *Lexington,* now being completed as an aircraft

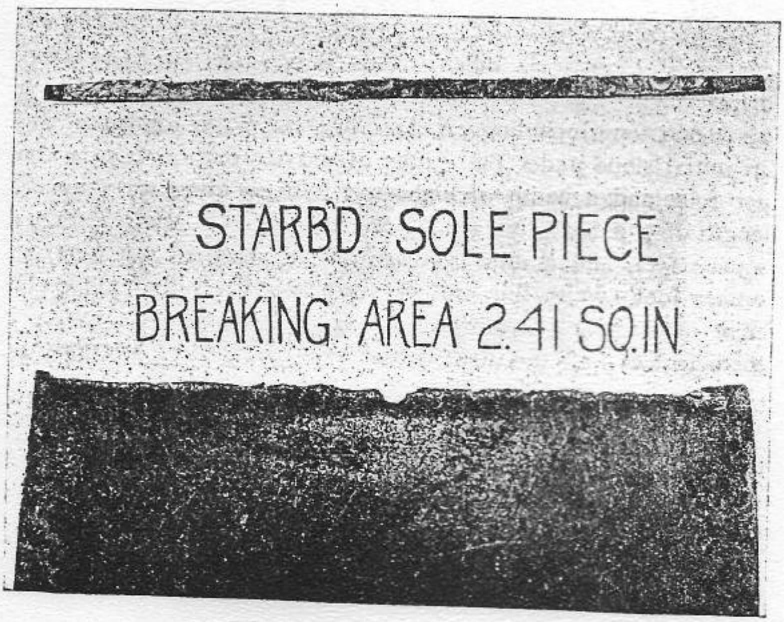

Fig. II

Fig. III

carrier at Quincy, is taken. This is a vessel of 35,000 tons displacement completed, with an estimated launching weight of 26,000 tons including cradle. The ways are cambered with an initial slope under the center of gravity of about .55 inches per foot, and a width of eight feet. The sliding ways have a length of 710 feet, giving a bearing area on both ways of 11,360 square feet, and a unit pressure on the ways of 2.3 tons per square foot. With this unit pressure it is likely that the coefficient of starting friction will be .04 or more, but for safety a coefficient of half this will be assumed. Neglecting friction, the pull down the ways is $26{,}000 \times \frac{.55}{12} = 1{,}196$ tons. The frictional resistance is $26{,}000 \times .02 = 520$ tons. The net pull to be withstood by the releasing gear is $1{,}196 - 520 = 676$ tons. Taking account of the frictional assumptions already made, a minimum factor of safety of 3 is desired for the releasing gear itself, and a factor of 4 for the connection to the ways themselves.

The vessel may be held at either one of two points—amidships or at the bow. The latter method, as used on the *Whitney*, requires that the first three or four joints in the sliding ways be so connected as to be able to transmit part of the pull up the ways. A release design for this location would be similar to that used on the *Whitney*. Using a one inch medium steel plate, the width required is $\frac{3 \times 676}{26.8 \times 2} = 38''$. A plate the full width of the ways should be used to distribute the pull over the sliding and ground ways but at the point of release it may be reduced in width to 38″ to expedite burning. Using one inch steel bolts, the bearing value of each bolt in the ways is $12 \times 1.7 = 20.4$ tons, requiring

$$\frac{4 \times 676}{2 \times 20.4} = 65 \text{ bolts.}$$

The first joint in the sliding ways below the poppets should be equally strong. This joint can be made with a three-quarter inch plate, the full width of the ways, bolted through each end of the adjoining sections by sixty-five through bolts. The next joint in the ways has a strain (both sides) of 676 tons, less the friction of packing timbers in sliding over each other if the joint opens. The general condition here is similar to that in a disk brake. Assuming ten feet as a reasonable overlap longitudinally of the packing timbers, the friction to be overcome in opening the joint is the product of the pressure per square foot, 2.3 tons; the area, 10×8 square feet; the frictional coefficient, .3; and the number of surfaces in contact, assumed as 5. This amounts to 276 tons or 552 tons for both sides. On the other hand, the joint might open by the packing slipping over the section of the ways forward. Assuming that the two forward sections of each way have a combined length of fifty feet, the friction here is $2.3 \times 50 \times 8 \times .3 = 276$ tons, or 552 tons for both sides. Consequently, it appears that the frictional resistance to opening the second joint is practically equal to the expected pull. If this joint is, in addition, strapped to stand three quarters the strain of the first joint, the strength will be adequate.

Instead of holding the vessel at the head of the ways, it may be held amidships. In this case, a vertical strap is secured to the outside of each sliding way, the strap being held to the ground ways at its after end. The connections to the ground and sliding ways are such as to develop practically the full strength of the ways. For the steel plates to be burned, the factor of safety is 3.2. This factor can easily be increased to four by making the strap wider, placing the added width along the top edge of the plates. The connections to the ground ways have a safety factor of 4.5; to the sliding ways of 5.8. The stresses are well distributed through all members.

Holding the vessel amidships has the advantage that no attention need be paid to the strength of the connection in the joints of the sliding ways other than as necessary for pulling the ways out after the launch. The release from amidships is also slightly quicker as the width of metal to be burned is only one foot. Here two burners only, one on each way, are required for the actual burning. This method of releasing vessels is recommended for future launchings of large vessels. Variations in details to suit conditions will naturally suggest themselves to suit individual launching slips. It will be noted that in any case without increased complication it is possible to make the holding gear any strength desired up to the full strength of the ways themselves, thus permitting an initial slope sufficient in every case to insure a start.