Copy of talk given by

Captain B. E. Manseau, USN, before the

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(The opinions contained herein are those of the author, and are not to be construed as official, or reflecting the views of the Navy Department.)

It is very appropriate to discuss the salvage of the LAFAYETTE today. First of all, it is Navy Day, and second, the salvaged vessel was this date transferred from the cognizance of the Supervisor of Salvage to the Commandant, Third Naval District -- just seventeen months and twelve days after the Supervisor of Salvage was directed by the Secretary of the Navy to conduct salvage operations with a view to refloating the vessel-- and twenty months and seventeen days after the disaster.

It is impossible for me, in an hour or so, or for that matter with any amount of talking, to give you a complete description or a true impression of all the problems, worry, arguments, discussions and labor which those seventeen months or more represent. As is often the case in projects of this nature, the fundamental principles of the method employed to right and refloat the vessel were simple, but the detailed developments of the engineering features of the plan and, more important, the solution of the many organizational and practical problems involved in accomplishing the actual details of the work upon which the success of the entire operation depended is, of course, another matter. I will, therefore, cover only the high lights of the job.

Also, as is usually the case in a project of this magnitude, successful accomplishment is the result of coordinated effort on the part of the entire organization, which, in turn, is influenced by the key members of the organization. In this case, we will say that the key members were Mr. T. A. Scott, Chairman of the Board of Merritt-Chapman & Scott, who was very active in the LAFAYETTE project from its beginning, and who contributed materially to the decision to attempt salvage, -- Captain W. N. Davis, Vice President in Charge of the Salvage Division of Merritt-Chapman & Scott, whose character and spirit permeate the entire organization, -- Mr. A. C. W. Siecke, who conducted the naval architecture and engineering studies and calculations, -- and Mr. J. I. Tooker, known by his contemporaries as "Captain" Tooker, Salvage Officer in charge of the job. Although each member of the organization who had a hand in the salvage project contributed much in many ways, -- based on what I have observed during the past eleven months that I have been acting as Supervisor of Salvage and having seen the job carried to a successful conclusion, -- I am convinced that one of the most valuable contributions made by my predecessor, Commodore Sullivan,-- Mr. Scott -- and Captain Davis, was the appointment of Captain J. I. Tooker as the man to be on the job to make the plan of salvage work, because of years of experience as a diver, etc. I think after you have seen the movies that will follow this talk, and if I have given an accurate account, you will agree with me in this respect.

Again, though the job was accomplished by the entire organization, including an average of 700 workmen, each doing an important part, the job was essentially a diving job. The controlling work, upon which the preparation of the ship for pumping was dependent, had to be performed by divers under water by sense of touch and judgment alone, because visibility in the muddy water was zero. There were an average of 70 divers per day employed.

The entire project can be divided into four main phases --

(1) Preliminaries leading to the decision to attempt salvage and the development of the general plan.

(2) Preparation of the detailed plans and the long period of preparation for pumping.

(3) Pumping.

(4) Cleaning the vessel out, preparatory to delivery for rebuilding.

-- PRELIMINARIES --

Prior to the capsizing, the LAFAYETTE was moored at Pier 88, North River, undergoing conversion into a troop transport. The work was well under way -- the ship was shortly expected to depart on its assigned mission. At about 2:30 P.M. on 9 February 1942, a fire broke out in the Grand Lounge above the promenade deck where 1,100 bales of life preservers had been assembled prior to distribution throughout the vessel. The fire, fanned by a strong northwest breeze, swept throughout the entire superstructure, until shortly the three upper decks were enveloped in flames or in smoke. A combination of circumstances, resulting from initial attempts to extinguish the fire, caused the ship to capsize. It is estimated that the initial metacentric height was about 9/10 ft. and the metacentric radius (BM) about 28 ft., so that impairment of the moment of inertia of the intact water plane area due to the free surface of the water poured on the ship to extinguish the fire by 1/28th was all that was necessary to reduce the metacentric height to zero. In addition, water on the topsides contributed to this reduction by raising the center of gravity. The loss of initial stability caused the ship to take a list of port and when the list reached about 13° sea water flowed into open cargo ports and then into air ports, until about 2:30 A.M. on the following morning, 10 February, the ship capsized, coming to rest on the bottom at an inclination of about 79°.

The capsized ship rested in the slip between Piers 88 and 90, with the forefoot about 180 ft. north of the inboard edge of Pier 88, and the rudder at the stern protruding under Pier 88 about 5 ft. At mean low water, the keel forward was about 5 ft. below water and the ship trimmed slightly by the stern so that the after end of the keel was about 13 ft. below mean low water.

Explorations were started immediately to determine the nature of the ship's bearing on the bottom. It was found that the ship lay in a bed of soupy mud from about -26 ft. down to about -35 ft. or -40 ft. It was also found that a rock ledge at about -40 ft. extended from the Manhattan end of the slip toward the river, to a point at about one-third of the length of the ship from the bow. From this the rock ledge sloped

down steeply into the river bed so that at the stern, soil of varying densities extended to a depth of well below -100 ft. It, therefore, appeared that the ship was supported somewhat throughout by soft river silt, by a hard point at the edge of the rock ledge, and by more or less firm soil aft. It should be noted that amidships, the port side was close to 60 ft. below mean low water.

Because of the location of the wreck in New York City, the investment represented in labor and material, the publicity the ship had received both as a liner and because of its possible use in the War, and the doubtful circumstances surrounding the fire and capsizing, the disaster was constantly in the public eye and aroused considerable comment from the press and the general public. Consequently, it was necessary to exercise the greatest amount of caution and the best of judgment in determining what disposition was to be made of the wreck. In April, 1942, the Secretary of the Navy appointed a special committee to investigate the situation and make appropriate recommendations. Although the committee itself included experts in such matters, many other experts were questioned in an endeavor to explore all the possibilities and arrive at the most practical sound solution. In addition, thousands of suggestions were received from all sorts of sources. Many of the ideas submitted were good, but most of the writers did not know the particulars of the problems involved, nor did they appreciate the immense size of the vessel. A good many people were very insistent that their particular schemes be used, and practically guaranteed, or atleast assumed, that all physical laws conflicting with their particular schemes could be waved aside.

Expert opinion indicated that complete removal of the hulk both above and below the water would cost a prohibitive amount, and probabilities as to future use and development of the ship precluded leaving any appreciable portion of the wreck embedded in the mud. The idea of cutting it up where it lay was, therefore, abandoned, early in the deliberations. Likewise, methods of salvage involving construction of cofferdams around the ship or the application of external forces through mechanical devices were abandoned because conditions would not permit their use at a reasonable cost in time and money. Also, these methods, even if successful, offered only partial solutions, because the fact still remained that the vessel had to be cut up or floated out.

It was finally concluded that if the vessel could be salvaged at all, the fastest, most certain method of accomplishment was to seal all under-water openings and to right and refloat the vessel simultaneously by a single pumping operation. Preliminary estimates indicated that this could be done in some eighteen to twenty-four months, at a cost of five to six million dollars.

-- DEVELOPMENT OF THE PLAN AND PREPARATORY WORK --

It was planned to undertake the work of salvage, utilizing the services of Merritt-Chapman & Scott Corporation under the provisions of the Salvage Service Contract, NObs-36, whereby the entire Salvage Division of the Corporation was at the disposal of the Navy Department. However, it appeared that this job would be of such magnitude that a separate organization would have to be set up to handle it, using a minimum number of key members from the Salvage Division so as not to interfere with the extensive salvage operations then being conducted in coastal waters resulting from marine and war casualties. Using the very few key members assigned to the job, the first major problem confronting Captain Tooker and the Supervisor of Salvage was to build up an organization around these few men.

During the period from the time the vessel capsized until orders were received to proceed with salvage, work on the vessel was restricted to removing the superstructure, fire hazards within the ship, the installation of scaffolding throughout for access into the ship, and the explorations of certain unknown conditions which held the possibility of salvage in the balance.

Actually, the possibility of salvage by pumping, or probably by any method, depended first on the soil on which the aft portion of the ship rested - ultimately developing enough bearing value to resist settlement by the stern. Nature solved this problem when the vessel ceased to settle appreciably in about six months, during which time it had settled about 3-1/2 ft. Second, salvage depended on the possibility of removing the mud in way of open ports, sixty feet down, long enough to permit divers working from the inside to seal them without undermining the soil bearing to the extent of causing failure and consequent settlement of the ship. The fluidity and depth of the mud made it absolutely impossible to close the ports from the outside. After four months of constant effort to remove the mud in way of the most critical cargo port by use of air lifts, -- during the greater part of which time it appeared that mud entered the ports from the outside as fast as it was pumped from the inside, -- the soil became firm enough to permit the excavation of a cave around the port long enough to permit its being closed. This was the most critical and decisive point in the operation. Therefore, the possibility of salvage was largely hope -- afterwards it was a matter of time and hard work in performing the multitudinous details involved in sealing and subdividing the structure. Third, it was necessary to see that the relationship between the center of gravity and the center of buoyancy would permit righting and floating by pumping alone. It was calculated that with the superstructure removed, the lever arm from the axis of rotation through the low bilge to the center of buoyancy could always be kept greater than the lever arm to the center of gravity. The total displacement of the ship at mean low water was about 103,000 tons and at mean high water about 115,000 tons, which was, of course, ample to float the bare vessel containing about 50,000 tons of structure and installations. It was also

calculated that the center of bearing in the soil aft supported about 35,000 tons of the load and that the rock ledge forward supported about 5,000 tons of the load.

The details of the final plan of salvage were developed during the seventeen months, as the work progressed. However, the main feature of the plan crystallized early in the operation and was initially as follows: In order to control the inclination, trim, center of buoyancy, the center of gravity, as well as to insure both transverse and longitudinal stability during pumping, it was decided to subdivide the underwater portion of the ship into fourteen main watertight compartments, some extending from the keel to the promenade deck and some having an intermediate deck, such as "C" deck, as one of the boundaries. The location of the boundaries of the compartments was the result of compromises between desired engineering considerations and practical considerations involved in making these boundaries tight. Several times throughout the long period required to prepare the ship for pumping, changes in details of the subdivision had to be made to overcome otherwise unsurmountable practical difficulties. Once the degree of subdivision had been determined, it was necessary to make laborious calculations showing the effect on soil bearing, on center of gravity and center of buoyancy, on stability, etc., of various quantities of water in the different compartments at various angles of inclination. This required that various assumptions be made and the use of cut and try methods with attendant backing and filling throughout the studies. There were so many unknown factors, that a wide range of possibilities had to be computed and data assembled in such form so that the tentative pumping plan adopted at the start could be modified quickly to meet actual conditions encountered. Likewise, the choice of shoring and strengthening of the bulkheads and decks as required to withstand the expected hydrostatic pressures was governed by the probable pumping required.

Though the calculations involved in the development of the general plan were very laborious and important, the success of the entire plan, of course, depended on the ability of the outside force to carry it out, which, as indicated previously, involved a tremendous amount of underwater work which was necessarily not susceptible to inspection by the topside supervisors. It depended largely on the mutual confidence between the divers and the supervisors and the supervisors' judgment of, and the control they could maintain over the divers.

The main items of preparatory work on the ship consisted of:

(1) Removal of the superstructure above the promenade deck, both above and below the water line.

(2) Removal of all inflammables above the water line and the partitions, furniture, huge masses of debris and mud which had accumulated on the port side below the water line as the vessel capsized.

(3) Closing and sealing 16 cargo ports, 356 air ports on the port side, trimming the promenade deck and closing all openings therein below the water line.

(4) Making the boundaries of the 14 compartments water-tight, including the installation of the necessary timber and concrete bulkheads.

(5) Shoring and strengthening the decks and bulkheads which would be required to withstand pressure.

(6) Installing salvage pumps, together with the necessary suction, discharge and exhaust piping.

(7) Removing a portion of the Pier at the outboard and against which it appeared the ship would foul as it is rotated about its submerged bilge keel.

In connection with both the design work and the production work on the job, it is important to note that with approximately one-half of the vessel above the water line, a study of the portion of the ship above the water gave a good indication of the structure below. There were some few difficulties which arose--however--incident to the lack of symmetry in a few respects.

About 5,000 tons of superstructure were removed; a little less than half of this was above the water line, while the remainder was below and had to be removed by underwater burning and ripping. About 800 tons were embedded so deeply in the mud that it could not be removed. It is interesting to note, during the removal of the 5,000 tons of superstructure the ship righted itself a fraction of a degree, indicating that a natural tendency existed for the ship to rotate in the proper direction.

While the above work was in progress, the work of removing inflammables in the interior, cleaning out both above and below water, progressed. Roughly, 6,000 tons of debris and scrap were removed from the interior, including about 8,000 pounds of broken glass; also about 10,000 cubic yards of mud which had entered through the portholes were removed. As can be visualized, immediately after capsizing, the interior of the ship was a mass of wreckage -- all loose furniture and fittings fell to port); glass and other light paneling were broken; decks were vertical; longitudinal bulkheads were horizontal. It was a tremendous job to clear out the wreckage and remove the light structure, which presented either a fire hazard or a safety hazard to the workmen. Horizontal structures which often appeared solid would not support the weight of a man -- all this had to be removed, and walk-ways, ladders and scaffolding installed before any heavy traffic could pass. During the first year or more, a large part of the work was directed from and served by a plant in Pier 88 and on top the starboard side of the vessel. Cargo hatches and passageways, then vertical, were used as shafts through which to hoist out material removed. Hundreds of barge-loads of scrap and trash were carried away. Scrap steel was weighed and sold -- the weight of mud and unsaleable scrap and debris was estimated; reasonably accurate records were kept for use in calculating the final center of gravity.

Removal of structure and debris below the water line was carried out primarily for the purpose of permitting access by the divers to the numerous cargo and air ports which had to be closed from the inside and to permit the installation of timber and concrete bulkheads. In some cases

mud and trash had built up on the port side of the ship to a depth of 10 and 20 feet. Most of this had to be removed. After removal, divers working from the inside were able, in due course, to excavate the mud around the cargo ports long enough to pull the doors inboard and secure them with strongbacks so that no further mud entered. Subsequently dams and forms were built around the cargo ports, reinforcing members placed and the ports sealed by a backing of reinforced concrete poured either by hand from bags or by the Tremie process. In a similar manner, access had to be gained to each and every air port. One diver working continuously for almost a year sealed each and every port by slipping through a folding patch which was then opened and drawn in against a gasket, secured by a strongback from the inside, and sealed and strengthened by concrete poured from bags on to the inside of the port.

The location of the internal boundaries of the watertight compartments was chosen with due regard to the existing structure. Original watertight bulkheads and decks were used wherever appropriate. The bulkheads, however, in most cases extended only up to "E" deck. In view of this, it was necessary to extend such bulkheads up to the promenade deck which meant the construction of temporary timber and concrete bulkheads from the water line down to the port side between each pair of the various decks -- promenade, "A", "B", "C", "D" and "E". Having chosen the location of these bulkheads, it was necessary to completely strip everything in the way of all obstructions, which again included sheathing, wiring, ventducts, partitions and miscellaneous other material right down to the ship's side, in many cases about 60 feet below. This, again, involved a tremendous job for divers. Having cleared the way, vertical guide bars or bounding bars were secured to the original topside of the deck, on the one side, and to the original overhead, on the other. (In the case of the overhead, deck beams were in most cases used as bounding bars.) The bulkhead consisted of grooved 8" x 12" timbers. Starting at the top of the bulkhead, an 8" X 12" was installed between decks and bolted to the guide bars. The groove in the lower edge had a 2" X 4" spline fitted before installation. A second timber, similar to the first, was lowered and the timber pulled up so that the upper groove of the lower timber fitted over the spline in the lower groove of the upper timber. Similarly, each timber was placed in succession from the top working down and ends bolted up. In order to facilitate the work, the timbers were weighted to overcome buoyancy. As they were fitted in place by the divers, workmen on the topside pulled them into place by hauling on slings attached to a saddle placed under the timber. After the timber was in place, the weights were removed, and the saddle unhinged, preparatory to placing another timber. Eventually all the timbers of the bulkhead were in place with a tight fit between timbers but a non-watertight fit where the ends butted against the decks. Also, there remained, necessarily, a gap between the lowest timber and the ship's side at the bottom.

The gap at the bottom was enclosed by wooden forms and sand bags. At the ends the timbers were enclosed by wooded forms placed at an angle of about 45° between the bulkhead to the nearest deck beam, giving the

appearance of a continuous bracket. There was then a continuous gap enclosed by forms extending down one end of the bulkhead along a deck, continuing along the ship's side below, and then up along the original underside of the other deck. This space was filled with Tremie concrete working from the bottom up, resulting in a tight bulkhead. All openings in the compartment boundaries made up of original ship's structure were ferreted out and closed by various types of patches and plugs. In connection with bulkheads - 15,000 lin. ft. of 8" x 12" timber were installed.

As the boundaries of any particular watertight compartment approached completion, a gang of divers proceeded with the installation of the necessary shoring. It was necessary to shore the promenade deck throughout and it was also necessary to shore the intermediate decks which formed compartment boundaries. In comparison, the shoring of the promenade deck was simple in that it was necessary to shore only between promenade deck beams and the deck opposite. However, this, again, entailed the removal of all obstructions in order that a good fit might be obtained. It was much more difficult in the case of the intermediate decks. Here it was found that the deck plating was so light that the panel between deck beams could not support the expected load. Therefore, it was necessary to strengthen the deck between frames. This was done by installing timber beams between the steel deck beams and running shoring between these timber beams, and placing similar beams or stringers on the opposite deck. A regular forest of shores was required in way of "C" deck. Roughly, in six weeks after all the temporary bulkheads had been installed, shoring was completed, and toward the end practically all divers on the ship were used on this particular job. About 1,000 shores were placed under water.

As the completion of shoring approached, the installation of platforms for the salvage pumps was undertaken. The pumps were installed on platforms which could be hinged so as to remain within 15° of the horizontal as the ship righted. Suctions were located with a view to their being able to drain from the lowest parts of the various pockets within the compartments. The discharges were led overboard horizontally through the promenade deck. In order to prevent the accumulation of exhaust gases in the ship, exhausts were piped overboard vertically through air ports on the starboard side of the ship. The pumps, all gasoline-driven, were installed in ample time to permit preliminary tightness tests of each compartment as it was completed. A total of 40 - 10" pumps, 28 - 6" pumps, and 25 - 3" pumps, having a total capacity of 40,000 tons per hour, were installed. It is well to note that work was scheduled so that the major items -- that is, installation of bulkheads, completion of shoring, and installation of pumps -- followed each other in rapid succession.

Just prior to the expected completion of the preliminary pumping tests, the north outboard corner of Pier 88, against which it appeared the vessel might foul as it righted, was removed and the original material in way of the Pier dredged out.

There were many other very important problems to contend with during the preparation of the ship for pumping. However, it would take too long to discuss them all, and many of these will be evident in the movie which will be shown later.

- PUMPING OPERATIONS -

Although the actual pumping of the ship comprised a definite, and the final stage, of the salvage effort, there was not a sharp division between the preparations for pumping and the commencement of final work of making the various compartments water-tight and the making of tightness tests of the various compartments merged into the final pumping operations.

As the construction work in each compartment was completed, the water was lowered inside the compartment to various levels up to ten or fifteen feet in order to determine the extent and location of leaks, and to correct them. In the LAFAYETTE an equivalent of fourteen separate ships had to be made tight. The volumes at 0.0 mean low water of the various fourteen compartments before pumping operations started were:

Compartment Number	Tons
1	3,100
2	3,700
3	4,900
4-14-5	17,500
6-15-7	17,600
8-16-9	15,000
14A	6,500
10	2,600
11	500
12	3,400
13	5,600
17	4,700
18	1.300
F.P. & 19	260

Despite the fact that plans were studied in minute detail, the emphasis placed on leakage prevention throughout the year or more of preparatory work, in almost every compartment the initial pump test resulted in long hours of search and plugging of leaks by divers. In some instances open ports, not shown on the ship's drawings, were found; in others, leakage through unblanked pipelines and ventilating ducts had to be found and made tight. Most of the troublesome leakage developed through numerous scupper and plumbing drains. When a compartment had been tightened until one 10" pump, working at half speed, could hold a ten-foot head, it was considered satisfactory, although work was continued until the last minute

to secure absolute tightness, if possible. Compartment-testing progressed as the construction work in more and more compartments was completed. The attention was given throughout the tests to the amount of buoyancy gained in compartments from the pumping. During this phase there was never enough water removed from the ship to result in any change in physical position. Likewise, compartment-testing and search for leaks were restricted to a certain extent by the allowable heads of water on the bulkheads of the compartment.

The compartment-testing continued throughout the latter half of July, 1943, and by 2 August, all preparations having been made, an overall pump test was made. The water in the high or promenade deck compartments (Nos. 1, 12, 13, 14A, 16, 17 and 18) was lowered one foot, and in the lower or keel side of the compartments two feet, so as to place a head on the pressure side of each patch. This test was maintained for about forty-eight hours during which time divers applied sawdust to all patches, seams, etc., where minor leakage might exist. Sawdusting, along with the tightness gained as a result of setting up of the patches, resulted in the ship overall being close to bottletight. It was estimated that two 6" pumps could control all leakage during the rise of tide. The importance of securing as much preliminary tightness as possible cannot be overestimated, because of the great probability of leakage increasing during pumping due to increasing heads, working of the structures, and local failures to the point where they could not be controlled by the pumps.

At 0430 on 4 August, the water was lowered to seven feet in the high compartments and eight feet in the low with reference to mean low water. At high tide, a small vertical movement of the bench mark on the bow was perceptible but this movement was attributed to change in trim or strain rather than rotation. It is well to note here that the entire pumping plan was designed to lighten the bow as much as possible to relieve the pressure that was believed to exist at the rock ledge in way of Compartment 16.

Because there was no particular reason for speed and because it was extremely important to build up no forces or develop leakage which could not be controlled, pumping continued cautiously and each rising tide was utilized to supply the additional buoyancy necessary to move the ship. At 1730, just prior to the rising tide on 4 August, the water in the high and low compartments was lowered to -9 ft. and -9-1/2 feet so that the five-foot rise in tide would give a 14 ft. and 14-1/2 ft. negative head inside. Air and water jets installed in various patches in the port side and along the port edge of the promenade deck, were started and maintained continuously in order to relieve any mud suction which might exist. The midships movement-measuring devices indicated a horizontal movement of the promenade deck of a little less than one inch. It was felt that this movement in the right direction was a definite sign that the tendency for righting existed and all was well.

During the morning of 5 August, water in the compartments was maintained at fourteen feet as the tide fell. At low tide, the high compartments were pumped to -15 ft. Between 0440 and 2250, 5 August, compartments were pumped and flooded to hold the above negative heads. As tide fell and rose no appreciable movement was noted. During the day fifteen wire rope cable stays were rigged from the uncut portion of the superstructure buried in the mud to the above water-side of the promenade deck, to strengthen the superstructure which in righting would have to plow through many feet of thick mud.

It was evident that additional buoyancy would be required before the vessel would commence righting and consequently greater heads would of necessity be imposed on the promenade deck. An inspection was made of the deck and shoring. As there was absolutely no evidence of undue loads on the exposed shores, or of leakage through seams and rivets, as might be expected from overloaded deck plating, it was decided to pump down, at 0800 on 6 August, to about sixteen feet negative head and allow this head and buoyancy to increase with the rise in tide. It had been calculated that the moments of buoyancy and of gravity about the bilge keel would be approximately equal at that point. By 0915 at about one-half tide, the vessel started to roll slowly and steadily.

At 1200, rotation (totaling about $1\text{-}1/2^{\circ}$) was stopped by flooding all compartments two feet following the parting of some of the superstructure stays. Pumping was halted, while all hands turned to installing additional one-inch cable stays with turnbuckles. Such action was necessary lest the inadequately supported cantilever load overstrain the connection of the superstructure in the promenade deck with the result that serious ruptures might occur had this happened.

The tying of the vessel's superstructure to the promenade deck was completed about 2200 of the evening of 6 August. The pumps were again started and the ship once more responded quickly. After fifteen minutes of steady movement, amounting to about 4°, the compartments were again partially flooded to stop the ship's rotation in order to inspect the superstructure stays and relieve the strain on the superstructure incident to the rapid motion. At this point, one fact was definitely ascertained. There was no appreciable mud suction resisting the movement of the ship. This, of course, became apparent when it was observed that each time the water in the ship was lowered relative to the outside water level, the ship started to rotate and the instant pumping stopped the ship's movement stopped. It was felt that absolute control was had over the vessel's every movement.

During both tides on 7 August, pumping continued slowly and the ship rotated to about 67°. On the morning of 8 August, it was decided to move the ship from its 67° inclination directly to 45° by removing more than 11,000 tons of water chiefly from Compartments 14, 15 and 16.

By the time the ship reached 49° inclination, pumping was stopped in order to shift a considerable number of pumps so that more favorable suction heads could be had. Early in the morning of 9 August, pumps in Compartment 16 were unable to lower the water beyond the existing level, and, by 0800, the head in that compartment was reduced to an alarming degree, in spite of the operation of all pumps at full capacity. Shortly thereafter, as many as nine pumps could not maintain anything more than a 2 ft. head in Compartment 16. A leak of an extremely serious nature had developed in way of the rock ledge.

While efforts were being made to locate the leak it was decided to attempt to dewater the compartment by sheer pumping volume. During the night and early the next morning, activities were centered around shifting reserve pumps from other compartments into Compartment 16, where by this time the inside water line was at the same level as the water outside the ship. It was considered unwise to further lower the water in other compartments appreciably because of the resultant great differential in head between adjacent compartments and Compartment 16. However, such pumping as could be done, brought the ship over to about 42° by 10 August.

It was still impossible to gain more than a foot or two head in the leaking compartment, with 9-10" pumps operating full capacity. From the out of phase movement of the bow and stern, it was evident that the stern was afloat and the ship was pivoting about the rock ledge with the rise and fall of the tide. At this angle of inclination, most of the uncut portion of the superstructure, including boat davits, had emerged from the water, and, while divers searched for ruptures inside and outside of Compartment 16, some 500 tons of the superstructure were removed. Early in the morning of 11 August, the first of a series of ruptures in the double bottom and wing tanks forward of the first row of boilers in No. 2 Fire Room was found. Divers were unable to get down through the mud and rock to locate the rupture from the outside at this time. By the morning of 14 August, it was felt that all of the ruptures in the tanks in Compartment 16 had been located and it was decided to attempt to fill most of the wing tanks, Nos. 3 and 4, double bottom tank No. 13, and the corner between the wing tanks and double bottoms, with some 100 cu. yds. of concrete. The concrete pour was to be made by the Tremie method and bounded forward by No. 4 watertight bulkhead and aft by a dyke which divers built of bags of cement. During this period the ship righted about 6° as a result of adding ballast in two starboard tanks and removing the remaining superstructure.

By the morning of 17 August, the laying of the concrete had been completed. Twenty-four hours were allowed for the concrete to harden and pumping was once again resumed on the morning of 18 August. At first, Compartment 16 held tight but, suddenly, with a negative head of 10 ft., the water in Compartment 16 commenced to rise rapidly with

all pumps going, and within about half an hour the head was reduced to 5 ft. Subsequent inspection by the divers indicated that a rupture in the tanks had opened abaft the concrete dam which had been previously laid. These new ruptures were found to be in way of the boilers; and, because the clearance between the boilers and the sides of the wing tanks was so small, divers could not actually reach them.

Following the failure on the morning of 18 August, to dewater Compartment 16, it was felt that if the vessel were righted to 20-25°, it would be safe to attempt flotation by pumping compartments adjacent to No. 16, as at that angle allowable heads would be acceptable. Consequently, on the afternoon of 18 August, the first of 2,800 tons had been placed in the wing tanks; by the morning of 21 August the full amount of 2,800 tons was in. This resulted in the righting of the ship to about 25°. Additional water was then removed from Compartments 14 and 3 and divers were busy scouring and using an air lift in the general vicinity of the hull damage. It was hoped that the new rotation would perhaps make the rupture in the hull accessible. Failing to get close enough to the rock pinnacle to actually locate the bottom damage, divers were instructed to place rags and sawdust bags near the outside ruptures with poles, or any other means possible, in hopes that some of them would be sucked into the rupture and partially choke off the leakage. Simultaneous explorations of the rock ledge finally revealed that the bearing was very jagged, so that further righting by counterflooding was abandoned.

Following considerable study and search, between 22 and 30 August, it was decided to again attempt to stop the leaks by filling all of the double bottoms and wing tanks in way of any of the ruptures with concrete. This involved considerable preparation including burning and clearing out in the No. 2 Fire Room so that Tremie pipes could be fitted in place. Some 800 tons of concrete were poured into the tanks. This operation continued until the morning of 10 September, after which forty-eight hours were allowed for setting. Not much faith was placed in the probability of reducing the leakage by the use of concrete along; however, it was necessary to provide an obstruction of some sort, in the bottom, to prevent bags, mats, etc., which would ultimately be necessary to stop the leak, from being sucked clear through the openings.

However, since it was necessary to float the ship clear of the rock in order to "feed" bags to the leaks, dependence had to be placed on something other than the ability to pump out Compartment 16. Inasmuch as only about 5,000 tons had to be removed from adjacent compartments to float at high tide, the boundaries of Compartment 16 were inspected and reinforced by shoring to permit entirely pumping out Compartments 10 and 17, just forward of Compartment 16, and gaining at least five feet more differential in head between Compartments 16, 15, 14, etc.

Compartment 16 was given a trial test by pumping down and holding three feet. This test seemed fairly successful, so at 2300 on the evening of 12 August, pumping was once again attempted. By the morning of 13 August it was realized that the latest attempt at choking the leak by pouring concrete was only partially successful, and 13-10" pumps, delivering approximately 9,000 tons per hour, were required to hold a 5-7 ft. head in Compartment 16. Pumping several thousand tons of water out of Compartments 10, 15, and 16, at this time, however, had definitely brought the vessel afloat at high water on 13 September. At the same time, a heavy strain was maintained on the bow mooring lines so that the ship was moved laterally about 16 ft. It was hoped that a considerable number of the rags and sawdust bags, which had been planted as close to the turn of the bilge as possible, would be sucked into the ruptures as a result of this movement. This operation was partially successful and resulted in the gaining of control of the leakage in Compartment 16, so that about a 12 ft.head could be maintained. The ship floated clear both at high and low tides by the morning of 15 September.

Thereafter, pumping in all compartments was prosecuted as rapidly as possible. However, it was extremely slow as access for shifting pumps as they lost suction became very difficult, it being necessary to cut access openings through doors, bulkheads, etc., to move the pumps and run suction to the numerous low pockets. Insofar as Compartment 16 was concerned, since the bottom was well clear of the rock ledge, it was just a matter of time and labor for divers to choke off the leakage until it could be controlled and pumped all the way down with 1-10" pump in each of the two Fire Rooms comprising that compartment. Some 2,000 to 3,000 bags of rags were ultimately fed into the ruptured hull to fill the voids between the plating and the concrete before the leakage was finally reduced to a negligible amount.

Because of the large off-center weights and the flooded condition of the ship, it floated in equilibrium at about 26°. From 16 September work has been directed toward removing the tremendous amount of timber and concrete construction from the port side of the ship, cleaning out cork and oil, ballasting the starboard wing and bottom tanks, removing the remaining water and large quantities of mud and debris from the ship, preparatory to turning it over to the Commandant of the Third Naval District for rebuilding.

On the whole the entire salvage operation, from the initial development of the plan, through the preparations, and to the final floating and cleaning of the ship, was considered extremely successful. Except for the failure and consequent leakage in Compartment 16, where at the start there was no indication of leakage and where bearing on the rock precluded inspection, absolutely no leaks developed, nor were there any signs of failure in any of the construction work, practically all of which was done under water and not susceptible of

thorough inspection. Examination after dewatering revealed workmanship of as high a quality as is usually encountered in work done in the dry. As a result there was little anxiety on the part of those in charge during the long period required to "conquer" Compartment 16, because the leakage into the remainder of the ship was so small as to require very little attention, and it was a simple matter to hold any gains made. Credit is primarily due to Captain Tooker, the supervisors, the divers, and other workmen who were responsible for devising means for, and the actual accomplishment of, the many details of the construction and other preparatory work, on which the success of the plan depended.