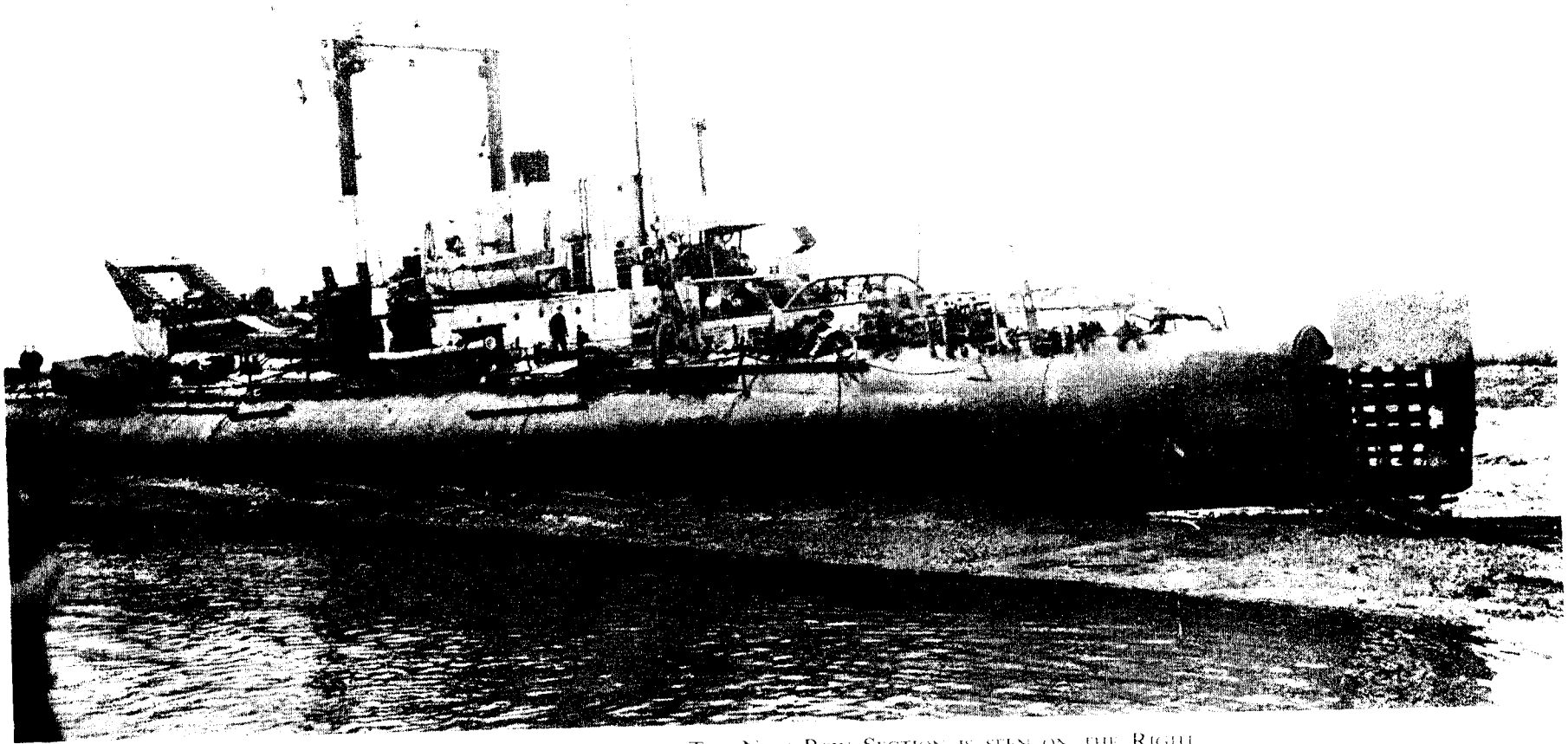


THE SECOND GROUNDING. THE NEW BOW SECTION IS SEEN ON THE RIGHT
(*Keystone Press Agency*)

CAISSON FAILURE AND H.M.S/M. 'TALENT'

BY

SENIOR COMMISSIONED ENGINEER P. A. KNOWLES, R.N.

THE ACCIDENT

The view of a caisson from the dock bottom makes one realize the faith exercised in the course of one's duties. Behind that barrier lurks destructive power; yet the engineer officer will go about his business inspecting the underwater fittings with perhaps only a passing thought for the great forces surrounding him. One does not normally have suspicions about the reliability of dry dock caissons; great care is taken to ensure their structural soundness by adequate maintenance. Besides, ships have been docked for centuries without grave mishaps. The flooding of a dock is quite a simple evolution and provides a fascinating sight, with great volumes of water gushing in, clouds of spray and, if the sun is shining, a miniature rainbow. But that is when all is under control. What would happen if the caisson suddenly failed ? For the answer to this, one would normally need a special nightmare. However, the question was very effectively answered during the afternoon of December 15th, 1954, at Number 3 Dock in Chatham Dockyard.

The following is an extract from the statement made by the First Lord of the Admiralty in the House of Commons on 26th January, 1955 (*Hansard* No. 310, Vol. 536, No. 19) :—

'The type of caisson which closes the dock in which H.M. Submarine *Talent* was refitting is kept in position during a rising tide by counteracting the increased buoyancy created by the water outside. This is normally done by leaving open the flooding holes, which allow water to flow into the tidal chamber of the caisson, thus adding to the sinking ballast already contained in it. On this occasion, repairs were being done to the deck of the caisson and shipwrights were working inside it. This made it necessary to plug the flooding holes and put water into the bottom of the caisson. This operation has been done only once before (on a similar caisson in the yard) within living memory. The caisson in No. 3 dock was of roughly the same dimensions, and water was put in the bottom to the same level as on that occasion. Calculations, made since the accident, have established that this quantity was seriously insufficient (and that the quantity used on the other occasion was also miscalculated though, on that occasion, fortunately, no untoward incident occurred).

' The result was that, as the tide rose on 15th December, the caisson became buoyant, rose out of the groove at the bottom of the entrance of the dock which normally positions it, and water rushed into the dock, sweeping the *Talent* out. The caisson party also failed to realize that the tide was running nearly three feet higher than had been predicted, and this greatly increased the buoyancy of the caisson.

' I should like to emphasize that there was no structural failure in the caisson ; the accident was due entirely to excessive buoyancy created by a miscalculation, the effect of which was intensified by an abnormal tide.'

THE FOLLOWING DAY. THE MUD OF THE FAR BANK CAN BE SEEN IN THE DISTANCE
(*International News*)

Talent was approximately half way through a modernization refit, but had been docked only a week before the accident. Work had only just started on underwater fittings because a ' flood warning state ' (high winds and tides) had been in force during the week, and, fortunately, only one fitting had actually been removed. However, this good fortune was completely offset because all six torpedo tubes were open and the asdic outfit had been removed for the machining of the housing. In addition to this, two portions of hull plating above the water line had been removed but had not been secured ; all hatches had been removed and all main ballast tanks were opened up. Theoretically, the submarine had no buoyancy, except perhaps for a little afforded by the temporarily blanked free flood holes in the main ballast tanks.

I had visited the submarine about 1400 on the fatal day to have my usual look round, and to witness a test on the port stern tube. I was passing that way again, on other business, at about 1545, and beheld a scene which I trust will remain unique, at least for me. The *Talent* had disappeared. In its place was a battered caisson and heaving water. After getting over the first shock and gathering my wits, I looked round for *Talent*, and, with very mixed feelings, spotted her through the gathering fog, apparently afloat near the opposite bank of the Medway.

It has been impossible to decide what really happened, as very few facts have been ascertained. No two witnesses agree. This is not surprising when one considers that the whole incident took place in a few seconds only. However, taking into account the evidence of the damage done, the following seems to be the sequence of events. As soon as the caisson loosened and broke free from its slot, a great mass of water swept it into the dock, as far as the submarine's stern. Here, the free flooding portion, known as the ' duck's tail ' acted as a buffer, concertina-ing under the impact At the same time the rudder,

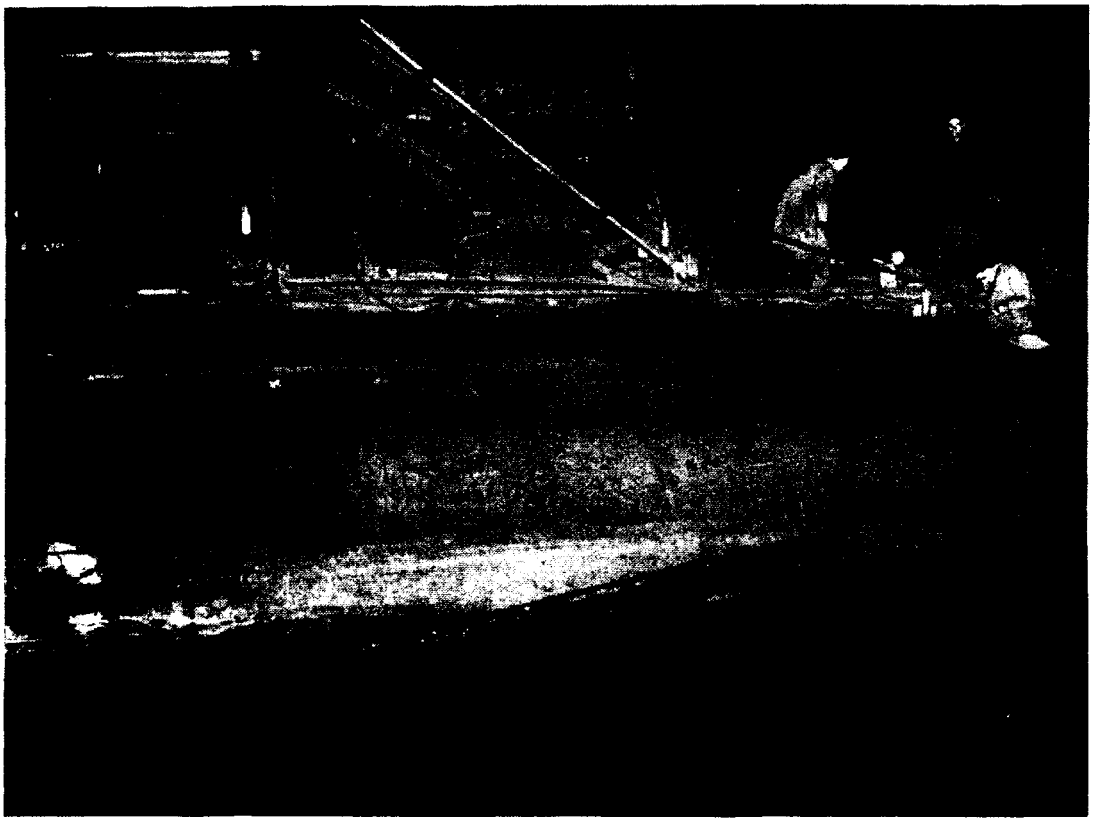
which is directly underneath, was forced over to starboard. This momentary block enabled the men working on the dock bottom to get moving before the main mass of water caught them up. The caisson, working round to the port side, forced the rudder very hard to port and then crashed on, taking staging and shores with it. The combined action of water and caisson lifted the submarine from the chocks, thrust her forward and to starboard, her bows striking the end of the dock and her starboard ballast tanks hitting the step. The water, rushing forward, spilled liberally over the edge carrying with it one workman, who had not escaped it, and depositing him safely on the dockside, shaken but unharmed. The backward surge carried the submarine, at an estimated speed of 10 or 12 knots, out of the dock, scraping the entrance heavily on the way out. Somehow she remained afloat, swung round, stern to port, and came to a muddy halt on the river bank some 300 yards away.

SALVAGE

Being broadside on to the river bank, the nature of which had not, by then been examined on the charts, it was thought that the submarine might topple over and, after a search for possible casualties and a preliminary inspection by dockyard authorities, she was temporarily abandoned. The chart, however, showed that the bank was not steep, and that the mud was very soft, a fact which caused much regret the following morning.

It became evident, by taking advantage of low tide to shut off all hull openings while the vessel was high and dry, that she could be refloated on the next high tide. It was also evident that all salvage gear must be brought to the scene before the falling tide prevented boats getting alongside. Most of this equipment, including blanks, oxy-acetylene cutting apparatus and portable lighting plants, was readily available. Portable light-weight pumps were not. On urgent request six, supplied by the local fire brigade, were ferried across the river and were manned throughout the operation by the Kent Fire Brigade with precision, efficiency and enthusiasm.

At high water, some two hours after the accident, a team of dockyard officials, ship's personnel and the fire brigade had returned on board with the salvage equipment. The submarine was sitting almost upright with a slight bow-down angle, the pressure hull almost submerged. On the falling tide she very conveniently began to empty herself through the torpedo tubes and work started on plugging the numerous small holes in the hull and bulkheads. The main difficulty was the large opening in the keel for the asdic equipment. To replace the cover, it was necessary to pump the torpedo compartment dry and cut through the 4-inch steel boring bar being used by the dockyard to refit the housing. The pump on this compartment failed to start, in spite of the persistent efforts of the fire brigade. Time marched on ; war experience in salvage warned against over-optimism ; priorities ; but a pump, brought from elsewhere, worked. Cutting through the boring bar seemed to take an age, and was bad for the nerves—in fact, it took only 20 minutes. The six torpedo tube rear doors were easily shut, and the two remaining hull openings below the water line, a hull valve and the port stern tube, were re-blanked, an acrobatic operation performed on slippery decks amid a mixture of wires, planks, loose equipment and scattered dockyard tool boxes. Meanwhile, the main ballast tanks were emptied, kingston valves shut and manhole covers replaced. Finally the pumps were put on internal tanks and bilges. The whole operation was completed, apart from minor pumping out, well before the next high tide. There remained only the exercise of patience, the passing of time by reflection on the night's happenings, exchanging opinions on the future of *Talent* and looking forward to a hot bath and tasty breakfast.



INSPECTING THE BALLAST TANKS DURING SALVAGE (*John Topham Ltd.*)

Unfortunately, the fog thickened before sunset, bringing down visibility to thirty yards, and making it extremely difficult for the salvage vessel and tugs to find us. Communications were maintained by sound-powered megaphone and portable W/T on board and loud-hailing equipment and portable W/T on Thunderbolt Pier, across the water. After the utmost difficulty in most adverse weather, the salvage vessel and tugs eventually secured alongside. As the tide rose, the bows lifted and it was obvious that the submarine would float without any difficulty. The idea was to try to navigate *Swin*, the salvage vessel, across the river with *Talent*, using loud-hailing equipment, and secure her alongside *Slinger* at Thunderbolt Pier. At the last moment a tidal swirl, assisted by *Talent's* jambed rudder, proved too much for the single-screwed *Swin*, and after a hard and protracted struggle we drifted away into the fog and grounded again. Our hopes of getting ashore before breakfast were diminishing, and, even with daylight, the chances did not improve, for the fog completely enveloped us. However, a local boat found us and offered a most acceptable lift to the dockside. But alas!—our troubles were not over and we were soon lost in the fog again, and stuck fast in the mud. Our only chance of a breakfast lay in wading ashore to the submarine to await another boat. On my way home that morning, sullied and bespattered with mud, I meditated on the uncharitableness of my fellow men. A Medway mud impregnated naval officer is, I fear, bound to carry some stigma.

At the following high tide in the afternoon, the fog cleared, and the tugs pulled *Talent* off the mud again and towed her to the locks and safety. During this manœuvre the new bow portion of the casing, which had only been tack welded in position, caught in a projection on the salvage vessel, broke away and fell into the river. Much publicity was given to this incident in the newspapers, and one would have thought that this was indeed the death blow of the unfortunate *Talent*. But far from it, for the following day it was salvaged !

DAMAGE AND REPAIR

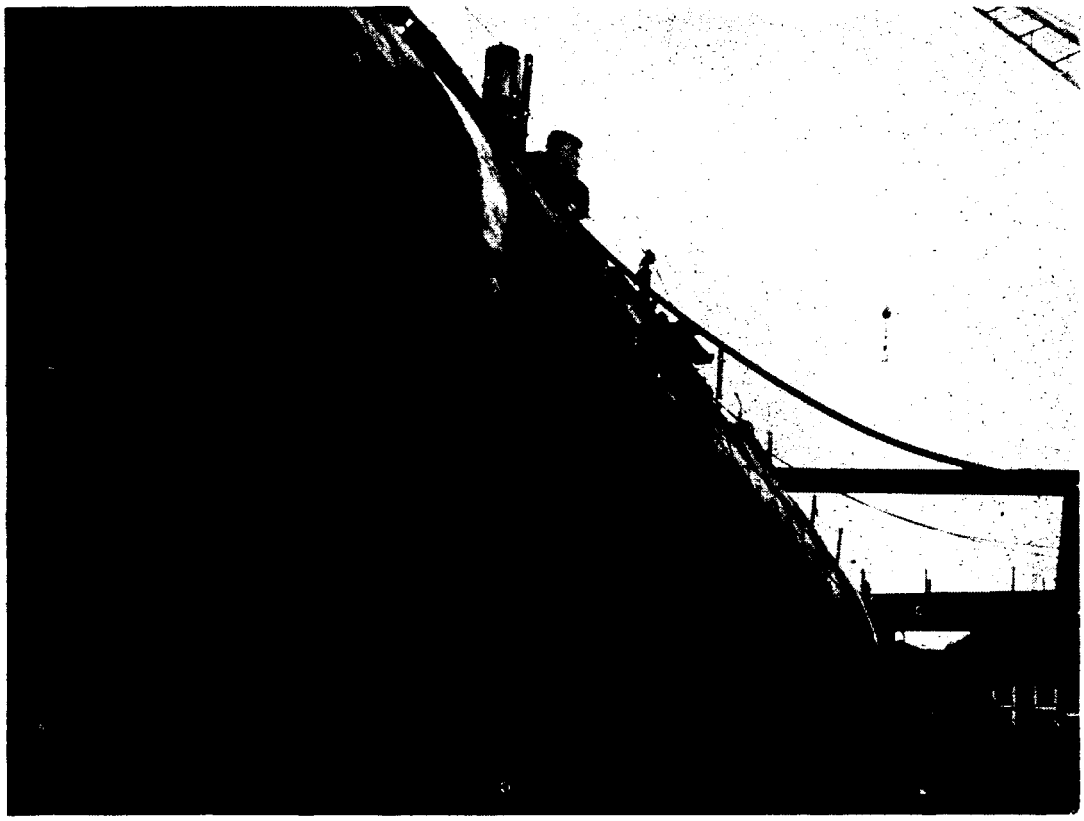
During a submarine's refit, nearly all the machinery is removed to the shops, and kept there until actually required for fitting on board, in accordance with a carefully prepared programme. At the time of the accident, only a few items of machinery and equipment had been replaced. However, a considerable amount of new electric cable had been run throughout the submarine, and most of the junction boxes were either non-watertight or were open. Main motors, main engine frames, crankshafts, clutches and shaft bearings had not been removed. All these had been completely submerged.

The first task was to try to save the main motors, as their replacement entails a lot of work, including the removal of a large section of the pressure hull above the motor room. The quicker the salt water could be removed, the greater the chance of obtaining satisfactory insulation ; so the electrical fitters set to work pumping out, flushing with fresh water, reflushing with distilled water and finally steaming out. The source of steam supply was a donkey boiler, probably the first time one of these old enemies had been subdued for use in submarines. After about a fortnight's flushing, steaming and drying out, the insulation rose, reaching figures up to 2 megohms. However, an Admiralty directive was given to change the motors, in spite of the good insulations produced, as it could not be guaranteed that all salt had been removed, and consequently left a risk of a subsequent breakdown.

Radiators were placed throughout the submarine for general drying out, and with the hope that the insulation on the runs of electric cable would rise to a satisfactory level. Practically all megger tests gave good readings, and much satisfaction was expressed with these spectacular results. But it was too good to be true. Although the cable ends showed every sign of having dried thoroughly, on cutting back some of the larger cables, water literally poured out. This speaks well for the quality of Admiralty Pattern cables but insulation has the habit of deteriorating and failing at the wrong moment and it became clear that no reliance could be placed on any of the wiring, except the main armoured cables, sealed at both ends. Insulation resistance readings, which show the state of insulation at the time, do not always indicate the presence of foreign matter such as water, which may, with time, cause the insulation to deteriorate. So the whole submarine would need rewiring.

Work on main engines and shafts (as far as the thrust blocks) was comparatively simple. All bearings were lifted, cleaned, oiled and replaced. The rapidity of rust formation was frightening and no chances were taken with any of the machinery. Ball bearings seem particularly susceptible to rusting, seizures occurring within 24 hours of being submerged. All removable machinery, electrical equipment and torpedo tube gear was sent back to the shops. H.P. air and telemotor (main hydraulic) systems were blown through and some H.P. air bottles were again removed for cleaning. The fresh water system was completely renewed.

On re-docking, the structural damage revealed was rather more than expected, although the pressure hull itself sustained only one slight dent. There were quite a number of dents along the port main ballast tanks caused by the caisson, and long indentations on the starboard main ballast tanks caused by the fall on to the dock steps. The damaged portions were cut away and renewed by the much used method of oxy-acetylene cutting and arc-weld patching. The lower edge of the new bow had taken on quite an impressive fold when the submarine hit the end of the dock, but no misalignment of torpedo tube orifices occurred which, under such severe testing, indicates a high standard of design. The concertina-ed ' duck's tail ' was removed and revealed that the after bulkhead of ' Z ' tank was slightly caved in. Both hydroplane guards were



THE DAMAGED EXTERNAL BALLAST TANKS WITH TEMPORARY BLANK ON THE FREE FLOOD HOLES (*M.C.D., Chatham*)

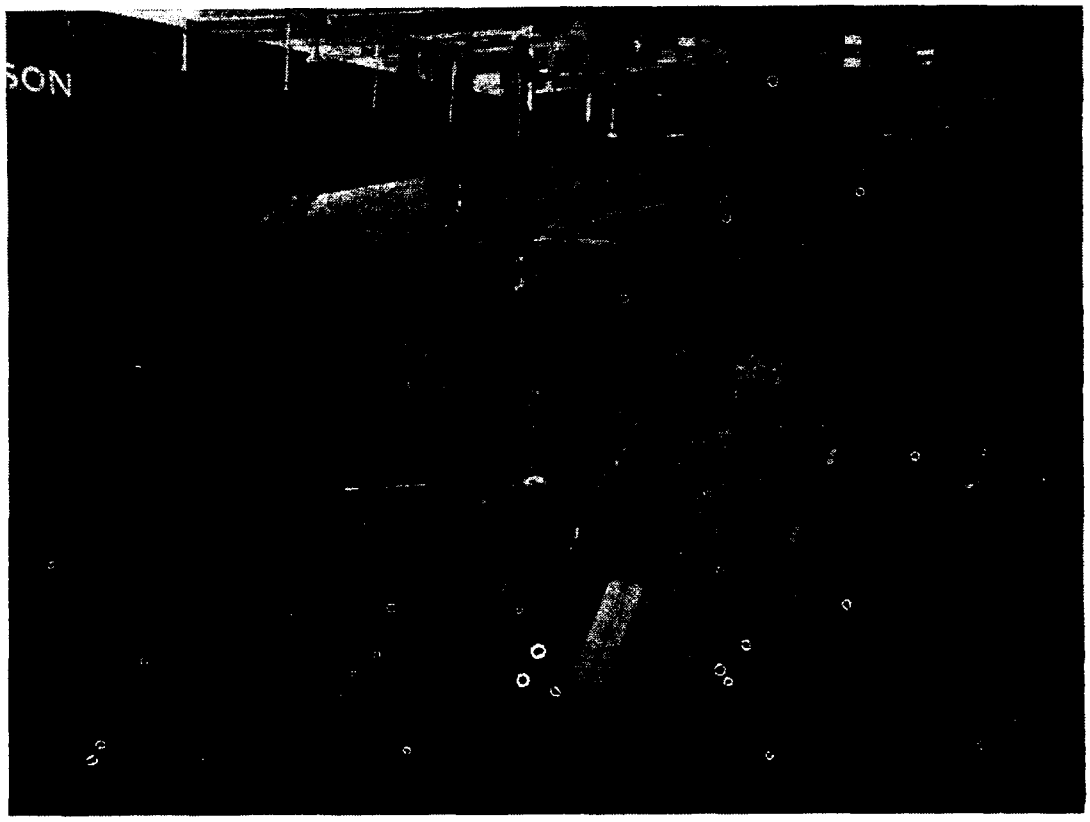
damaged. The after fin, which supports the rudder and after hydroplanes, was bent slightly forward and about six inches to port. All these portions were renewed.

The rudder post was slightly bent and repair was considered impracticable ; in any case a spare rudder was available. The rudder gland housing was forced from its seating in ' Z ' tank and the tank plating had given slightly. It was hoped that the existing plate could be reshaped satisfactorily but this proved impossible ; the whole plate was, therefore, finally cut out and a new one welded in its place. The hydroplanes were not in position at the time of the accident, but the operating gear suffered bends and strains from the deformed after fin. The effect of the force on the rudder had bent the connecting rod between crank and piston guide, and strained the operating cylinder seating, cracking some of the welding seams.

ALIGNMENT OF SHAFTING

The visible damage sustained did not really present any great difficulties. Of far greater moment, was what had happened to the hull shape and the ' A ' brackets under the tremendous forces to which they had been subjected. These considerations might well decide the fate of *Talent*.

As soon as the submarine docked, the shipwrights checked the alignment of the keel and found all correct. At the same time the engine fitters checked the alignment of the shaft bearings from the thrust block to the ' A ' brackets by using a wire. This method did not prove very satisfactory and is not recommended ; but it did serve to prove that no major misalignment had occurred and therefore that the ' A ' brackets had probably escaped damage, the hydroplane guards affording the necessary protection and taking all the punishment. The readings obtained from the wire, in comparison with earlier weardown



THE DAMAGED STERN (*M.C.D., Chatham*)

readings, did not suggest anything of value, and the calculation of the sag in the wire was not very convincing. In any case it was not certain that the length of shaft supported in the thrust bearing could be accurately positioned without reconnecting all the shafting on the forward side, as far as the main motors. It was decided to replace the tail shafting and bushes, which had already been re-metalled and machined to previous readings. This seemed the most positive way of checking and would, we thought, prove conclusively whether or not anything had happened to the shape of the hull.

In the meantime the shipwrights were removing the damaged part of the keel aft, which necessitated using extra shores and supports to take the weight of the after part of the submarine, about a quarter of its length. In order to have a means of checking any alteration in hull shape in the vertical plane, a five-position sight was erected on top of the after half of the pressure hull ; thus any tendency for the after part of the submarine to sag could be detected and counteracted, maintaining the correct hull form until the submarine was again sitting on its own keel. Movement in the horizontal plane was also consistently watched.

After bedding down the tail shafts in their bushes, it was found that they were out of line to port in the horizontal plane by between 0·004-0·006 in at the coupling flanges. This indicated that the stern had taken on a bend to port, but whether this was due to a permanent set from the impact of the caisson, or an unbalanced force produced by the shores, could not then be ascertained. The constructional side expressed the opinion that the submarine hull, which is simply a large steel drum, was not likely to bend permanently to such an extent under impact, but it was agreed that changes of temperature might produce hull deformation like this while in dock.

The only portions of the shafting that had not been affected by the accident were the crankshafts, which were now taken as a datum. But, before re-

alignment was started, it was considered advisable to get everything else as near normal as possible, that is, with the keel rebuilt and taking its share of weight, large weights, such as the after fin, in position and all unnecessary shores and supports removed. The method of alignment was the light beam. The main motors were now lined up accurately with the crankshaft coupling flanges. Each end of the hollow armature shaft provided the first two sights which enabled pinholes to be positioned at the stern tubes and ' A ' brackets. The results showed that the stern was sagging about half an inch at the ' A ' brackets, which would probably be corrected on re-floating ; the bend to port was confirmed, and amounted to about $\frac{1}{4}$-in at the ' A ' brackets. By neglecting the sag, it would still be impossible to machine the bushes eccentric to suit, as there was insufficient whitemetal to do this. It was felt that a fresh approach was necessary.

A great deal of discussion ensued, on the problem of shaft alignment and opinions were expressed freely on all known theories. It was considered that any degree of accuracy achieved would be temporary, as ships were subject to continued deformation from weather, temperature, launching and docking. Anyway, alignment was inadvisable while still on the chocks. One is conscious that these conclusions, or similar ones, have been common knowledge in the shipbuilding industry ever since Brunel's *Great Britain*.

There was really only one way to deal with this problem if lasting results were to be obtained ; that was to forget about remedies and start from scratch. Accordingly the tail shafts were positioned in the ' A ' brackets and stern tubes as near central as possible, and the bushes remetalled and machined to suit. The thrust block shafting was used to note the change of set of the tail shafts. The tail shaft couplings ended up by being about 0·05 in higher than the thrust couplings and about 0·02 in to port. The rest of the shafting, including main engines, will be re-aligned when the submarine undocks. It is sincerely hoped that it will be possible to use the existing main engine bedplates !

CONCLUSIONS

The real use and limitations of the megger were well demonstrated. It may not be until the Fourth Dimensional Age that instruments will be developed that will forecast insulation breakdown, but perhaps a megger working at very high voltage might be valuable for detecting weak sections in the normal 220-volt system.

One has been brought to realize the flexibility both of hull and shafting. Perhaps some other form of propulsion is the real answer, but in the meantime it is thought that, apart from other considerations such as propeller noise, opportunity should be taken at each docking to restore shaft alignment by remetalling (or fitting spare) stern tube and ' A ' bracket bushes to original sizes. The extra cost would be small in comparison with other docking expenses, and would be justified by less wear and tear both on main engines and hull fittings. An exchange of opinions and experiences would be most helpful and valuable.

My original conclusion, as I stood on the dockside that fatal day, was that *Talent* had sadly ended her days. But I was wrong. It is remarkable how easy the salvage work turned out to be, and how quickly everything has been restored to normal.