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Lecture on Fertility of Resource in the Engine Room

By Mr. J. G. HAWTHORN (Hon. Min. Sec.)

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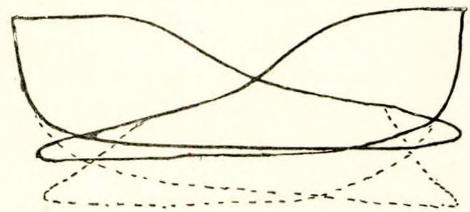
Mr. Hawthorn: A very eminent engineer, one of the most beloved members of our profession, the late Mr. John Macfarlane Gray, once said that "breakdowns at sea were providential ways of educating marine engineers," and perhaps that sentence might form a text for the few remarks I shall put before you. I propose that we shall imagine certain breakdowns to happen in the case of an ordinary marine triple expansion engine, and see how best to get over the difficulties. I shall not specify any particular kind of engine, neither shall I expect any of you to say "we could not do that on our ship, we have not the same facilities," but I should like to put before you a few general hints as to what might be done if certain things happen. Whenever anything goes wrong it is the engineer's duty at all times to look for the symptoms, and from them to diagnose the fault.

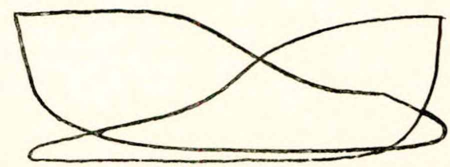
Commencing with that bugbear of the engineer's existence, namely the engines bringing up suddenly, let us imagine a case where the engines are brought up very quickly to within 3 or 4 revolutions from full speed. The first thing I would suggest doing is to prove that the stop valves and throttle valve are in good working order, by opening the drains, and blowing the steam through. A clean blow through proves whether or not these valves are right—they have been known to have the seats lift, or the spindle to strip. Let us suppose we have the steam blowing through all right; our next duty should be to reverse the link motion and see if the engines will go astern. Should they not go astern, we may safely assume that the slide valve is adrift on the spindle; but should the engines reverse and go astern, we then know that it is in ahead gear where the fault lies, and we should trace it from valve spindle down to eccentric sheave. We may find the rod bent, due to an overheated strap; thus the valve would not probably reach high enough in its travel to give a free exhaust from the top of the piston (taking a direct acting valve), and closing again so soon would thereby increase the compression on the top of the piston so that the engine could not get over the top centre; or we may find the key of the eccentric sheared off with the possibility of the shaft revolving inside the sheave. Should the H.P. valve become injured beyond repair, I would then suggest, having removed the broken parts, to shut down the engine stop valve till the pressure by the intermediate gauge showed about 80 to 90 lb., and go on working as a compound engine. I would also suggest that the piston rod and connecting rod of the H.P. engine be removed, or the connecting rod only be taken down together with the eccentric rods, putting on a stop plate to hold up H.P. piston and rod. I also suggest that this should be adopted in the case of a broken piston rod or piston, connecting rod or shaft. Regarding the pressure carried, I should say that it would be better to maintain the full boiler pressure, and by wire drawing through the engine room stop valve, to reduce the pressure; this would entail an easier time for the boilers; besides, the throttling of the steam would tend towards superheating. I would also suggest that links be kept in full gear. In the event of the H.P. ahead eccentric rod being broken, we may resort to slinging up the link at the astern end, substituting the astern way rod for the ahead rod, but great care should be taken to see that the valve setting is the same and the rods are of the same length ; this would enable the engines to still be maintained triple expansion, but we could only go the one way, so that upon approaching our port of destination we could then remove the ahead rod, taking out the valve ; working the engine as a compound engine for manœuvring purposes.

Coming now to the intermediate engine : should the valve be broken we have no other choice than to exhaust from the H.P. engine round to the L.P. engine ; or, should the piston be so fractured that we could by no means repair the same, we should have to do the same thing. It is interesting to see for a moment what would be the result of this. In the first place, when the H.P. engine opened for exhaust there would be a considerable drop of pressure in passing round to the L.P. valve box ; and we should probably find that the H.P. engine had considerably increased the horse power by the reduction of back pressure. Let us presume a case, steam entering the H.P. at 180 lb. by gauge, cutting off at or about ½ stroke, giving a terminal pressure of about 75 lb. by gauge in H.P. cylinder. Upon opening the exhaust at about eight-tenths of the stroke, I should then expect the pressure to fall say to about 20 lb. on the L.P. gauge, a heavy knocking action being experienced in the H.P. engine through the want of compression. And here I would now suggest that if we can link up the L.P. engine only, to do so and so force up the pressure in the L.P. valve box, this would also tend to equalize the horse power. I am presuming that the pump levers are driven by L.P. engine. Should the levers be on the intermediate engine, I suggest that the intermediate engine be run idle in order to keep the pumps going. It is interesting to see the cards in a case of this kind. I was very fortunate in seeing a pair of cards taken under these circumstances and will sketch them for you.

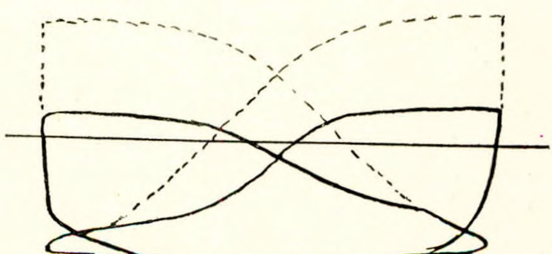
Although I have marked the scale on the cards they are not drawn to scale, but are only sketches to show the effect of exhausting round to L.P., the dotted lines show the cards under the altered conditions. In the case I am quoting from they had at first a pressure of 25 lb. in the L.P. valve box, with 120 horse power more in the H.P. engine, and by linking up the L.P. till the pressure went up to 35 lb., they practically equalized the power. Should an intermediate shaft be broken or flawed, if there is no spare one at hand I suggest that it be changed, if possible, for the H.P., putting the flawed journal forward; and here I would say at all times it is better to rob the H.P. engine for the L.P. and



H.P. CARDS. SCALE 1/64" = 1 lb.
(FIG 1)



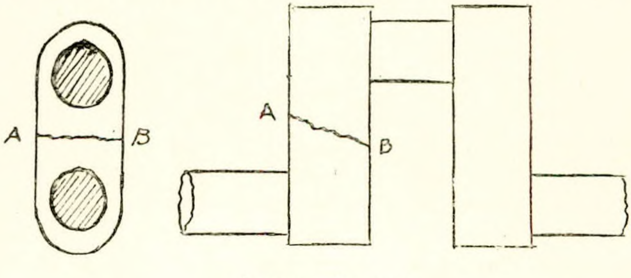
I P. CARDS. SCALE 1/32" = 1 lb.
(FIG. 2)



L.P CARDS. SCALE 1/12" = 1 lb
(FIG 3)

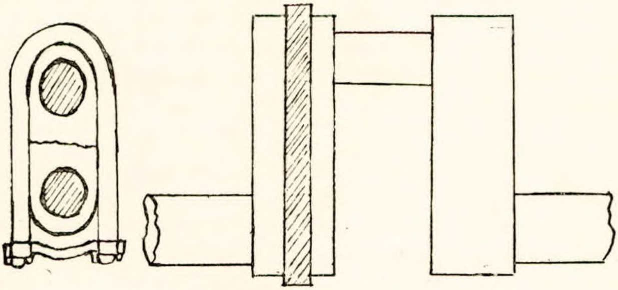
go on as before compounding, than to exhaust from H.P. to L.P., and so avoiding the stresses set up in the shafting by the unequal turning moment.

Coming to the L.P. engine, in the case of any casualty happening here, it is more interesting still to see how we could meet the difficulty. First let us suppose that the slide valve is broken, then we shall have to exhaust from the I.P. into the condenser, and if the levers are driven by the L.P. engine, drag the L.P. round idle in order to work the pumps. If the valve spindle or eccentric rods be broken, then, if possible, rob the H.P. engine and go on compound, or if the shaft should be flawed, change, if possible, forward, remembering that the L.P. shaft has to transmit the horse power of the three engines, and therefore there is three times the stress in that shaft as in the H.P. shaft. I have an instance of a L.P. piston rod being broken short off at the crosshead. The engineers set to work, and, drawing the slide valve, removed the broken rod and piston, blocking the steam ports, and dragging round the connecting rod with their crosshead attached, worked their pumps, thus keeping their engine a surface condensing engine. I cannot impress too much upon you that at all times, with modern marine engines of high pressures, it is better to keep the condenser surface condensing, and so obtain fresh water for the boilers, sacrificing anything in the shape of vacuum, etc., to obtain it; and I think it would not be out of place here to recount an actual breakdown that occurred to a large vessel bound for the colonies. Falling into bad weather, the engine raced heavily for some two or three days, and eventually one of the top end bolts gave way, and the engine, so to speak, took a long stroke, or, in other words, the piston and piston rod left the connecting rod, striking the cover and fracturing it, splitting the cylinder, breaking the caps of the rocking shaft of the levers, doubling up the levers and generally smashing up the pumps. Here their salvation lay in having a separate independent circulating pump. The first thing they did was to lift the L.P. valve box cover and exhaust from the I.P. into the atmosphere, putting cold sea water into the boiler, while patching the eduction pipe. As soon as they could exhaust into the condenser they did so, and by cutting a 4-inch hole in the bottom of the condenser and connecting the independent feed pump to it they managed to obtain fresh water for their boilers. On the passage home, they worked High and Intermediate on to the condenser and dragged the L.P. connecting rod round with crosshead attached to work their levers and pumps, doing without the L.P. engine. They obtained fairly good results upon the passage home. I would also tell you of how a knowledge of the early history of the engine came to the aid of engineers in a serious breakdown in an ordinary tramp steamer homeward bound across the bay in fine weather but with a heavy rolling sea. The boats had been cast adrift from their lashings in order to give them a coat of paint, when by some means the man at the wheel allowed the ship to fall off into the trough of the sea, and a big sea coming on board amidships lifted one of the boats, and dropped it on to the skylights, which were of the old-fashioned wooden type. The skylights gave way, and the result of the accident was a broken low pressure cylinder cover. The engineer, having a knowledge of how Watt first moved in the development of the engine, determined to try and work the L.P. engine as an atmospheric engine. First they removed the broken cover, and, blocking the top steam port to prevent a loss of vacuum on the upstroke, they then cut off the bottom lap of the valve ; and, putting the eccentric back till nearly at right angles to the crank, they set her away, carrying steam the whole length of the upstroke, exhausting at the end of the stroke into the condenser, the work of the downstroke being accomplished by the atmosphere. I should now like to bring before your notice several cases of how shafting has been repaired by engineers at sea with little or no tools at their command or material to work with. In the first case great fertility of resource was shown, the shaft was fractured across the web in a position as shown in the sketch. It was a built shaft, the sides of the web being parallel and the ends rounded, the fracture appearing



BEFORE REPAIR
(FIG 4)

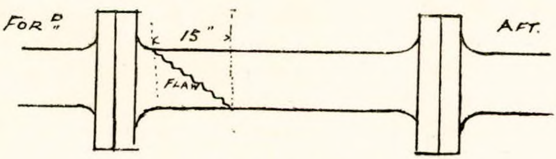
straight across the web as marked AB in the sketch. The engineer casting about for something to make a strap with suddenly hit upon the novel expedient of removing a stay from the steam space of one of his single-ended boilers and bending it round the web. He then cut a plate out of one of his flooring plates, and putting three thicknesses of this plate across the web firmly bolted it together, heating the strap up to a bright red before tightening up the nuts.



AFTER REPAIR

(FIG 5)

Here you see he had already the ends screwed and nuts to fit, going slow with reduced pressure. The second case is where a short intermediate length of tunnel shafting fractured abaft the coupling, the fracture extending, as in sketch, for

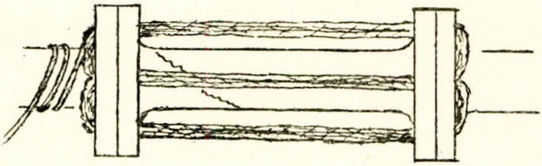


BEFORE REPAIR

(FIG 6)

15 inches fore and aft. The diameter of the shaft was 12½ inches, with eight 2½-inch coupling bolts in each coupling. Fortunately it was fitted with a stern way collar against the aft main bearing in the tunnel, which prevented the shaft from running aft. The engineer's first thoughts were to sink three keys into the shaft and endeavour to make clips to go round them afterwards; but he abandoned this idea in favour of the following method of splicing the shaft. He first removed the bearing to the forward side of the coupling, packing

it up with logs of wood and shoring it from each side of the tunnel. Removing four coupling bolts from each coupling, he then utilized the steel towing or mooring hawser in the following manner. Passing the hawser, after belaying it on the forward



AFTER REPAIR

(FIG 7)

side of the coupling, fore and aft through the holes he had removed the bolts from, until he had five ply of the hawser through each hole, giving him twenty ply in all, to take up the torsion, then strapping round the shaft till made up solid with the couplings, he informed the captain he would not risk reversing the engine, but went away ahead, gradually working his speed up to nearly full speed. Many of you will no doubt remember several other cases of broken shafts brought before the notice of the Institute from time to time.

Passing on to the condenser and pumps, there is no part of our engines that we can diagnose faults from symptoms so readily. An engineer in the engine-room is somewhat like a medical man in the sick-room with the human engine before him. He feels the pulse, looks at the tongue, obtains the temperature of the body, and from the information derived from these, he fixes the complaint from which the person suffers. Now the engineer feels the pulse, that is the beating of the valves, feed checks and others; looks at the tongue, that is the steam and vacuum gauges; obtains the temperature of the body, that is the temperature of the circulating water, and from these he is prepared to say what is wrong should anything occur. Now let us suppose upon entering the engine-room we find the vacuum gauge going back to 18 inches or 20 inches vacuum and the engine slowing down. Our first duty should be to ascertain that the circulating pump is doing its duty correctly by getting the temperature of the circulating water. If very cold, then I should assume that one of the division plates in water way of the condenser had given way, and the water was not going through the tubes ; this would give a cold discharge and loss of vacuum with one end of the condenser fairly hot.

Again, say we find the temperature of the discharge hotter than normal but feeding going on regularly, I should at once say there was something wrong with the circulating pump. We should then set to work and find the fault. Should the air pump give out, what are the first indications of it going wrong ? It would show a loss of vacuum, an intermittent feeding, with occasionally overflowing from the hot well. We should experience little or no trouble with leaky foot valves if the head and bucket were tight and in good working order. Should the foot valve or valves give out and air is being admitted under the head valve for cushioning purposes, I suggest that the air valve be shut down so that the pump will make better vacuum on the downstroke than in the condenser. If the head valves are giving out, I suggest that the foot valves be robbed if possible to supply the head valves. Should the bucket become broken, I would suggest making a wooden bucket and packing it in the ordinary manner with manilla rope. As time is getting on, and as I would like to get up a discussion on the hints I have thrown out, I shall be pleased to answer any question that any of you may put to me. Many of you no doubt have had experience of breakdowns in your engine-room and may like to give your ideas on the matter.

Mr. J. H. Redman (Assoc. Mem.) : You referred to the *Londonian* as being lost because she did not have separate circulating pumps ; I understood the reason was the wheels of the steering gear getting choked, the cargo shifting and causing the injection to get out of the water.

Mr. Hawthorn : In that particular case waste got into the steering gear chains and into the mitre wheels ; the cargo rolled, bringing the injection out of the water. The main engines could not stand the strain, but if she had had a separate circulating pump it might have been all right.

Mr. Redman : She would have been drawing her water from the same place ; that is to say, the same level.

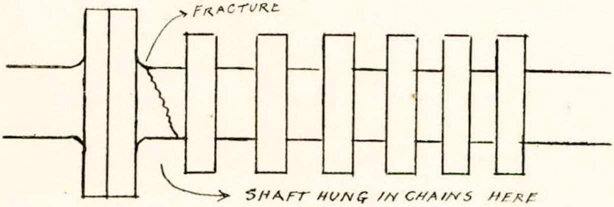
Mr. Hawthorn : The point was they could not work the circulating pump from the main engines in addition to the work she was doing. If she had had a cool condenser it would not have been so bad; if things get so hot they can be cooled down with a second pump. I instanced that as a case which I thought would be a good one to bring before your notice, showing the necessity of circulating pumps being detached from the main engines.

Mr. Redman: You referred to the advisability of having the condenser as high as possible: I have seen it 10 or 12 feet above the level of the cylinder bottom.

Mr. Hawthorn: There is a great tendency to put the condenser up, but that is higher than I have seen them. With regard to the condensers, some two or three years ago I saw it stated by one gentleman that we should work the three cylinders, H.P., I.P., and L.P., all above the atmosphere, exhausting into the condenser and condensing above atmospheric pressure—at a pressure of about 10 lb. above the atmosphere. There are cases on record of the whole of the vacuum being gone and the engine bringing up in two, three or four revolutions. In one ship a division plate was broken and they could not mend it. In that case they managed to pump the feed water direct from condenser. In another notable case the connecting rod of the intermediate engine was broken. They took down the intermediate connecting rod and took out the valve, and found that by doing this they could run a knot faster on the same consumption, with the result that they lined up the intermediate cylinder, reducing the diameter 2 inches (this was before we were properly acquainted with the proper ratio of cylinders), and treated every one of their ships in a similar manner. Here again is an instance where a breakdown was a providential way of educating the engineer; in this ship, with the intermediate engine off duty, the engine ran all right, and the proper ratio of the cylinders was not known until this accident happened.

Mr. Redman: There is a difference of opinion as to the number of collars on the forward thrust. In the case of two ships I know of, of almost similar dimensions, with a 15-inch shaft, there were four collars on the one, while on the other there were fourteen. One was an old ship, about thirty years old, while the other was entirely new.

Mr. Hawthorn: I am a great believer in having plenty of thrust collars, but there is a great difference between fourteen and four in a small size job. The effect of the total number of collars should be to bring down the pressure to about 45 lb. per square inch. There was one case where the shaft broke between the thrust collars and the crank shaft, the fracture being a scarph one, as shown in the sketch. The engineers, seeing that the shaft could not part in a fore and aft direction,



(FIG 8)

simply supported it by running it in chains and came along dead slow to port. If a tunnel shaft should break at all it it preferable for it to give way somewhere between the thrust and crank shaft, as the thrust block then will prevent it running out aft, and if the fracture extends any length in a fore and aft direction it is only necessary to support the weight of the shaft and come along slowly. The crank shaft cannot fail to turn the other shafting round. The great thing is to get the torsion, the twist in the shaft. The scarph breaks are undoubtedly the best to deal with.

Mr. S. Anderson (Member): We are all much indebted to Mr. Hawthorn for his lecture, and with the exception of one little point I quite agree with everything he says. With regard to the question of compounding, in one company I was in, just when the subject was being discussed by naval architects and marine engineers, we got instructions to compound on the ground of economy in steam consumption. In the ship I was in, the chief engineer blocked up the steam ports and tried compounding, but it never worked, the steam was too great for the exhaust passage. We took her home on a lower consumption than on the voyage out. I asked him what consumption he wanted and said I would give him the best possible speed for that consumption, so we gave the consumption required and went faster, proving that theory was not right in that case. One of the late Mr. Macfarlane Gray's favourite maxims was "try a compound," but it didn't work in that case.

Mr. HAWTHORN: The ships I referred to were a line of steamers running out of the Thames. They took a branch steam pipe from the intermediate valve box and went on compound. They did that part of the voyage from an economical point of view. They went slower and burnt a proportionate amount of coal less. They fitted a separate stop valve to the intermediate valve box, shut down the one on the H.P., compounded the intermediate and carried 95 lb. in the intermediate valve box by throttling at the stop valve. They were instructed to do that for the sake of going slower. There is one point to observe. If we throttle an engine up, or shut down the stop valve, the steam is superheated. If the steam in the boiler is at 180 lb. pressure, or 387° temperature or thereabouts, if it is throttled on the one side and the pressure is only about 60 lb. on the other side, yet the temperature is the same. It must part with all that heat before condensation can take place. We see that in the case of the water tube boilers working with reducing valves.

Mr. ANDERSON: Do you think them more economical?

Mr. HAWTHORN: No, I will not say that, but there are times when it would be better to compound, say to reduce the speed from 12 to 10 knots. I think in that case it would be much better to work as a compound or else throttle the three cylinders, giving a lower pressure of steam in the valve boxes. In my opinion that would be found to give greater economy.

Mr. REDMAN: It would mean a lot of work, if there was the usual high pressure steam in the boiler.

Mr. HAWTHORN: I think it would come out better than throttling the engine or linking up. There is no economy in linking the engine up—that is to reduce speed by it. Of course there is the question of circumstances necessitating the reduced speed, and of course in some cases it might be better to link up than to throttle, but it would mean doing a lot of heavy work against steam.

Mr. H. BASHAM (Visitor): We had a breakdown with our intermediate valve gear, fitted with Joy's valve piston. The piston came up right through the cover—she took a "long stroke." It was a broken eccentric bolt that caused it.

Mr. HAWTHORN: That is a frequent cause. If you have a broken eccentric strap there is practically nothing to prevent the piston valve coming up through the cover, providing there is sufficient clearance in the valve box, more especially if it is of the indirect type. One notable case of resourcefulness just struck me. This was where a ship went aground and another ship bore down upon her to get her off. The chief and second engineers altered the travel of the valve by lengthening the drag links and bringing the eccentric rod inside the valve spindle. They got nearly 300 more horse power and pulled the ship off.

Mr. H. BASHAM (Visitor): I believe there are some builders who build their spindles that way.

Mr. F. M. TIMPSON (Member): One of the worst breakdowns that I experienced was with the bilges. There was a severe gale blowing at the time and the ship was brought over on her beam ends. The pump suction was out of the water and the ship was leaking very badly. The bilge pump was choked with small ashes and we had to use the suction hose from the deck. It took about twenty to thirty hours before we got the job put right. Fortunately the gale cleared off before long. We jettisoned a good deal of deck cargo and got the vessel righted. In reference to throttling with full pressure on the boiler, I once had a good opportunity of testing the result of throttling the steam when fully linked up. The full boiler pressure was 160 lb., and we found the most economical pressure to be 140 with throttle well closed, which gave the maximum pressure obtainable in intermediate casing at this adjustment. We had natural draught and worked the funnel damper to suit the rate of combustion required.

Mr. HAWTHORN: Those boilers where the firemen are always hard at it are not doing justice to the coal, and another point is that the best results are always obtained from coal which gets the least knocking about.

Mr. TIMPSON: I know of an instance where an old compound job was altered. The pressure was 90 lb. originally and there were four single-ended boilers, i.e. twelve fires single-ended. Two single boilers were fitted with a pressure of 160 lb., and they reduced steam to 80 lb. through an 8-inch reducing valve. The ship has been running now for some time and the alteration has given very much more cargo space.

Mr. Hawthorn : There is a great controversy as to whether that course is economical or not.

Mr. Basham : In one telegraph ship I was in, with a set of triple expansion engines, the pressure in the boiler was 160, and they reduced her pressure to 40 lb. in the initial H.P. cylinder, 12 lb. by the card in the intermediate cylinder, and the L.P. card was practically on a line. It was all done by a 1½-inch valve. There was a long stop valve with a small valve in the centre which we used to open when we wanted to reduce the speed.

Mr. Hawthorn : That brings out the advantage of throttling for manœuvring purposes ; for getting in and out of port it is much better to work with the throttle open.

A hearty vote of thanks was accorded to Mr. Hawthorn on the proposal of Mr. Herbert Smith, seconded by Mr. C. B. Fraser.