From what has been said, it will be realised that a screw propeller, although it has been perfectly balanced by a static or standing balance, may not be in running balance, and such has been found to be the case. Every propeller so far tested has been proved to be out of running balance, and some very considerably, and some two score of propellers have been dynamically balanced. Propellers at Cockatoo Island, which had been manufactured by the latest approved methods, to ensure their being as symmetrical and as perfect as possible, when tested in the balancing machine were found to be sadly out of running or dynamic balance.

Attention was first drawn to this matter by the amount of vibration experienced on the trial of the first of the destroyers built at the Commonwealth Naval Dockyard, Cockatoo Island. It was concluded that this vibration could not be due to the turbine engines, as these were running without a perceptible tremor. What could cause the vibration? was the next question. If it was not the turbines, it could not be anything else but the propellers. If the propellers, was it due to the interferences of one propeller with the other in the water, or to water or other causes? Were the propellers as manufactured, running at the high speed they were, viz., over 800 revolutions per minute, in perfect running balance? To determine this, a propeller was tested in the balancing machine, and found to be far from perfect. It was then balanced, and also two others to make up the set of three required. The original and only statically balanced propellers were then exchanged for the dynamically balanced set, and further trials were carried out, when, to our great surprise and gratification, it was found that the vibration had been most materially reduced.

At this time there was no instrument available to measure the vibration. A Schlick vibrometer was tried, but when adjusted sensitively enough to record the small

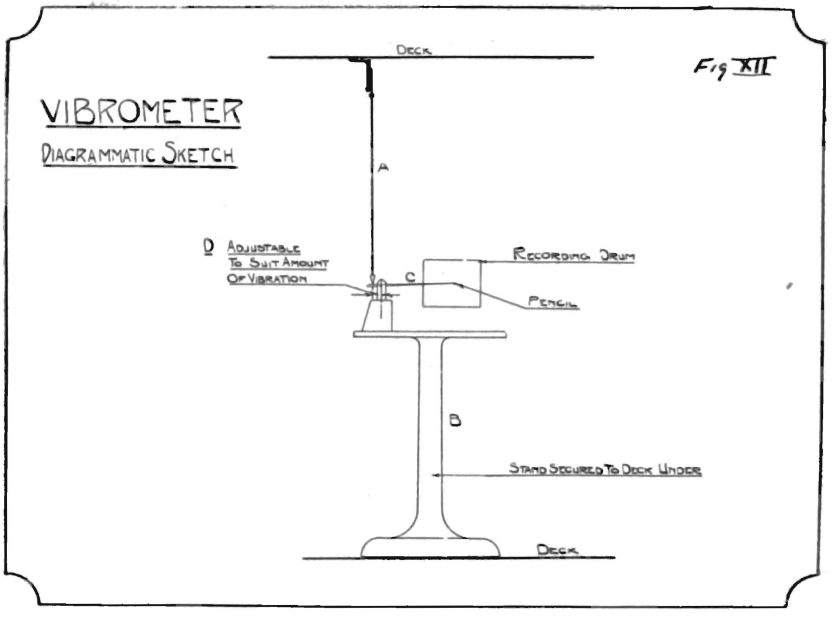


Fig XII
VIBROMETER
DIAGRAMMATIC SKETCH
DECK
A
D ADJUSTABLE TO SUIT AMOUNT OF VIBRATION
C
RECORDING DRUM
PENCIL
B
STAND SECURED TO DECK UNDER
DECK

Fig. 12.

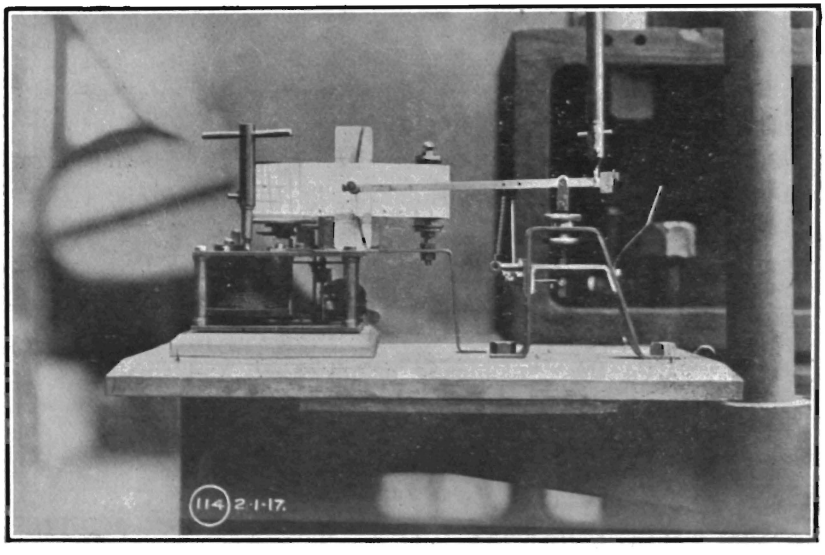

114 2-1-17.

Fig. 13.

vibrations, it was found to be utterly useless on account of the motion of the vessel in a seaway, so that no actual records of the difference of vibration between the two sets of propellers could be then obtained; but I can only assert, on my own word and that of all my officers, also that of the ship's officers, that the reduction in vibration was not only very marked, but was also most comforting to the ship's officers and crew. The matter was then further extended, and after much cogitation, a very simple means of recording the small vibrations in a ship was devised.

Fig. XII shows the principle of this instrument, and Fig. XIII shows a picture of it as it was roughly made. The principle depended upon recording the difference of vibration of two adjacent portions of the structure of the vessel. It was thought that if a rod was attached to the deck over, and another rod to the deck under, and if these rods were pointed towards each other so as to meet, and made to slide over one another at their meeting point, the difference of the vibrations of the two decks could be measured by the relative motion of the ends of the rods, and, by a simple lever, multiplied and recorded on a drum driven by clockwork. This instrument fulfilled all that was expected of it, and gave most satisfactory and astonishing results.

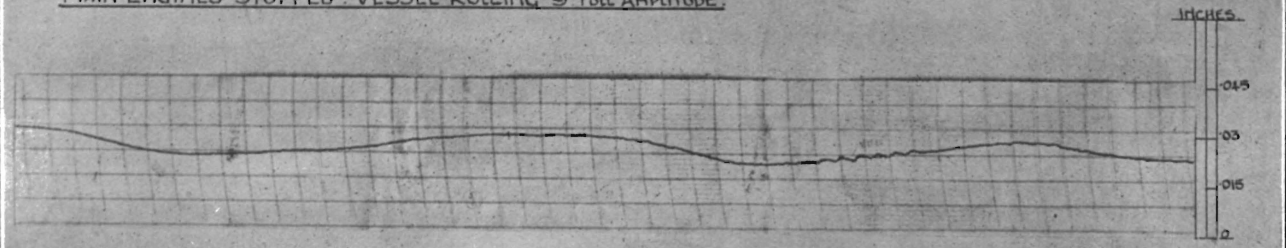
Figs. XIV, XV, and XVI show the records obtained by it in a vessel of some dimensions, viz., over 5000 tons displacement, which had four propellers, driven by turbines at about 500 R.P.M. These records were obtained when she was fitted with the propellers as made by one of—if not the leading propeller makers in England, and had been passed by the Admiralty as being as perfect as it was thought necessary, and I will add, possible to make them.

It will be noted that the records show a great deal of vibration, which every two or three seconds rose to considerable violence; the vibrations were sufficient to cause everything on the cabin table to shake off, pretty quickly, too.

RECORD OF VIBRATIONS

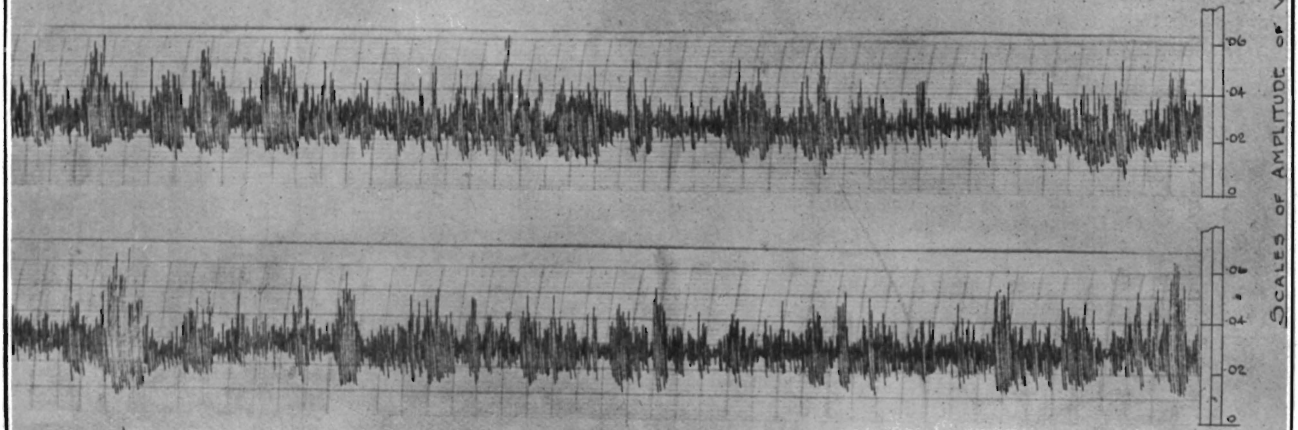
PLATE XXV.

MAIN ENGINES STOPPED. VESSEL ROLLING 9 FULL AMPLITUDE.



PROPELLERS STATICALLY BALANCED.

MEAN REVOLUTIONS OF MAIN ENGINES - 489 PER MINUTE.



SCALES OF AMPLITUDE OF VIBRATIONS.

SCALE FOR TIME

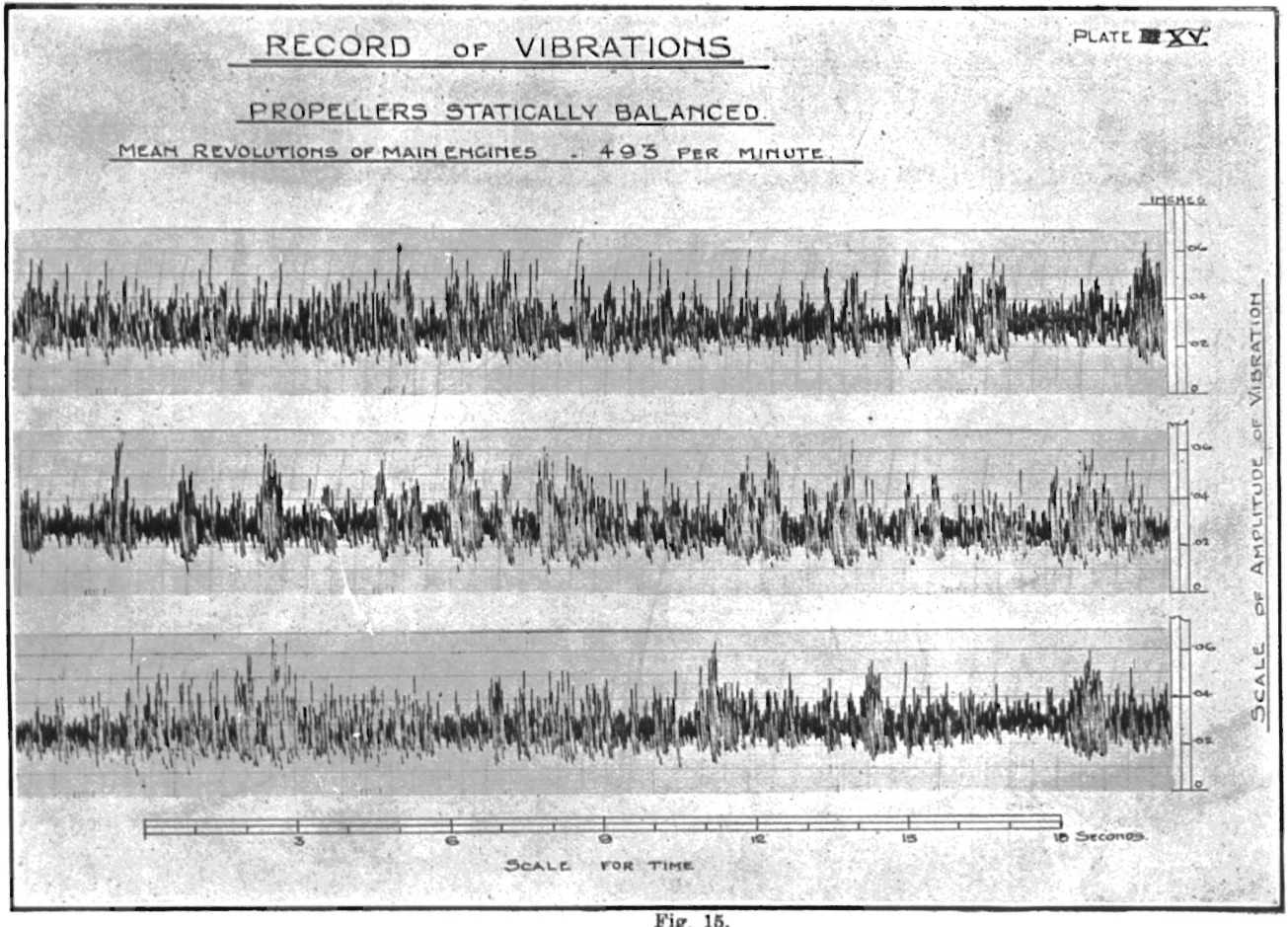

RECORD OF VIBRATIONS
PLATE XV.
PROPELLERS STATICALLY BALANCED.
MEAN REVOLUTIONS OF MAIN ENGINES . 493 PER MINUTE.
INCHES
0·6
0·4
0·2
0
SCALE OF AMPLITUDE OF VIBRATION
3
6
9
12
15
15 SECONDS.
SCALE FOR TIME

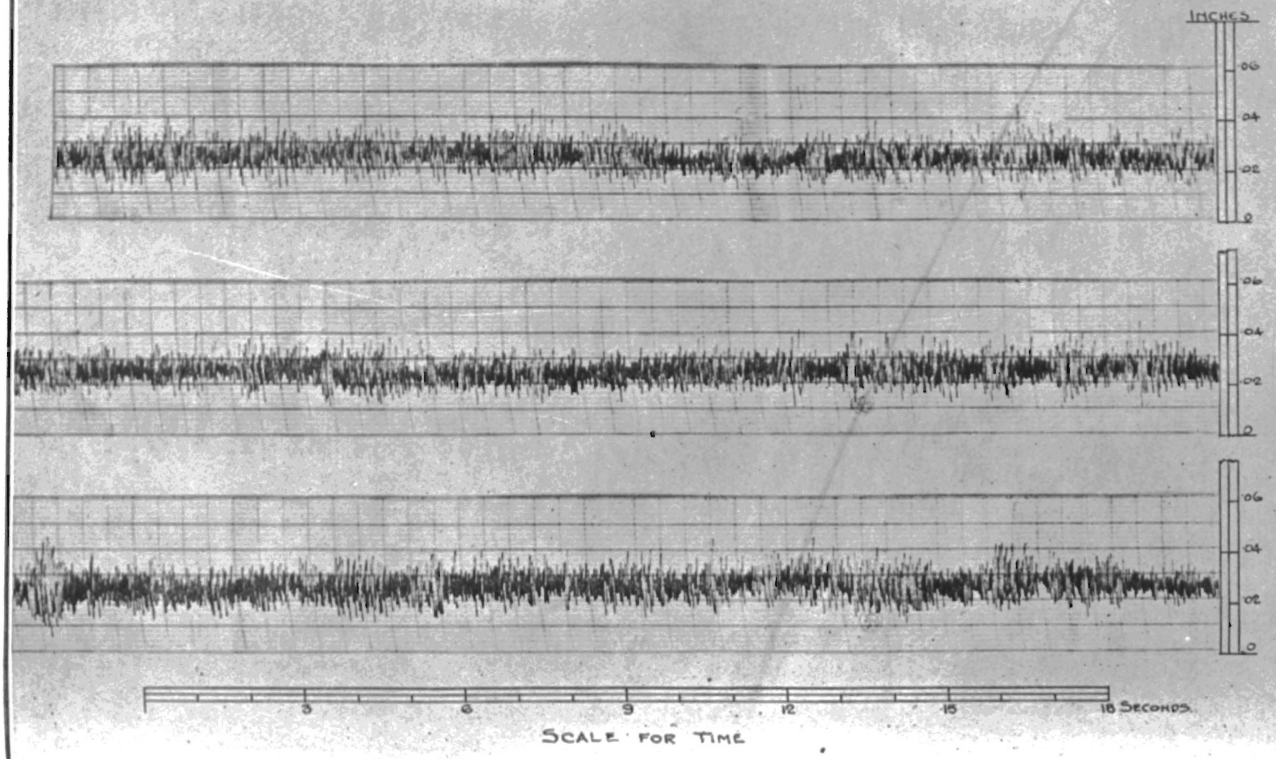
Fig. 15.

PLATE XV

RECORD OF VIBRATIONS

PROPELLERS STATICALLY AND DYNAMICALLY BALANCED

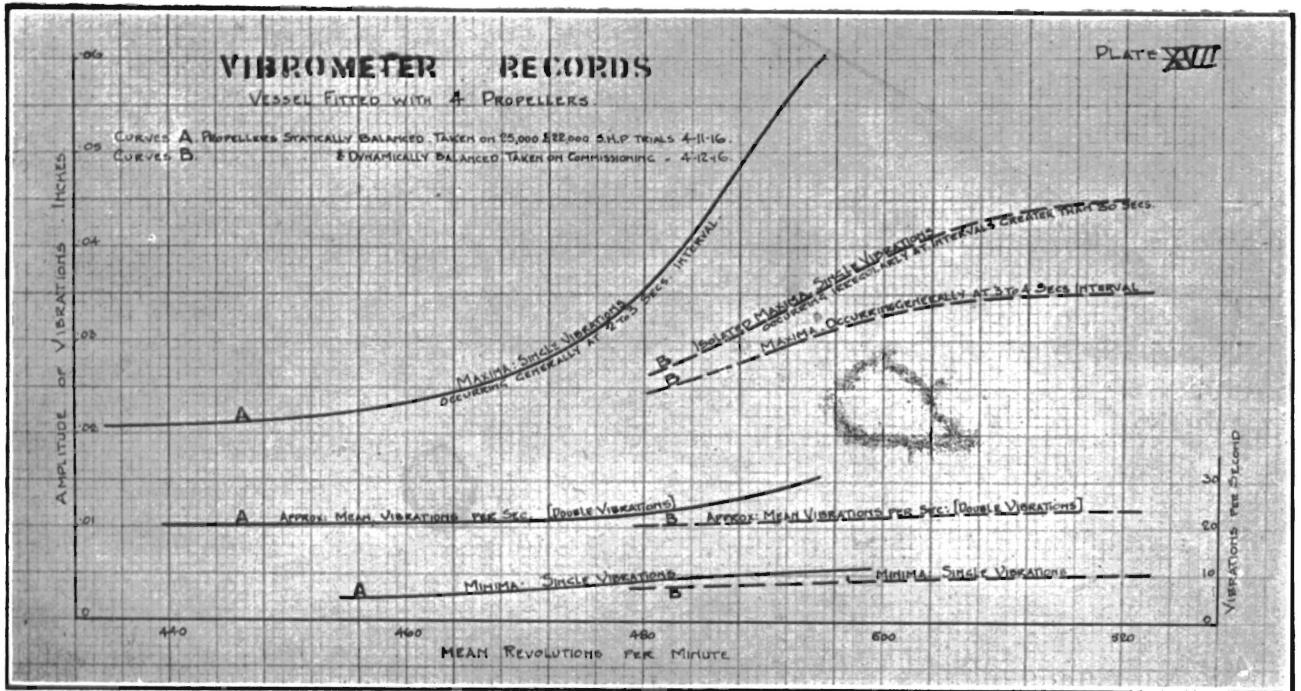
MEAN REVOLUTIONS OF MAIN ENGINES. 498 PER MINUTE.



The top curve, Fig. XIV, shows the record obtained when the main engines were stopped, and only the auxiliaries running. It will be noticed that the line is not straight, but has a wave form, and also that right through it a small vibration is seen. This was due to the auxiliary engines, which shews the sensitiveness of the instrument; and in one place also there are larger vibrations, which were caused by the crew, on the deck over, leaving at the double. The wavy form was due to the motion of the decks on account of the rolling and pitching of the vessel. It will be noticed that this wavy form runs through all the records, but does not affect the records of the rapid vibrations.

After the records given were obtained, the propellers were exchanged for an exactly similar set, which had been dynamically balanced, and Fig. XVI shows the record of vibration obtained by them. It will be seen that there is a marked difference; this difference was not only perceptible to the recording instrument, but was very plainly felt by all on board, so much so, that one of the officers exclaimed, without stopping to think, "Oh, it is quite 100 per cent. better." It can only be said one wished that it could have been quite so perfect.

Fig. XVII shows the result of the two experiments plotted in curves, and from this it will be noted how rapidly the maximum vibrations were rising as the revolutions of the engines approached 500, and it will also be seen that, with the balanced propellers, the revolutions were higher. The whole of this increase is not due to the lessening of the vibrations, as on this trial more steam was available; but there is little doubt that the lessening of vibrations would help to increase the speed, as it must tend to reduce the friction in the A brackets and other bearings; and also, as the hull was vibrating less, that would tend to reduce the resistance of the ship through the water.


VIBROMETER RECORDS
PLATE XLII
VESSEL FITTED WITH 4 PROPELLERS
CURVES A. PROPELLERS STATICALLY BALANCED. TAKEN ON 25,000 & 22,000 S.H.P TRIALS 4-11-16.
CURVES B. " DYNAMICALLY BALANCED. TAKEN ON COMMISSIONING - 4-12-16.
AMPLITUDE OF VIBRATIONS INCHES
VIBRATIONS PER SECOND
MEAN REVOLUTIONS PER MINUTE
MAXIMA. SINGLE VIBRATIONS OCCURRING GENERALLY AT 2 TO 3 SECS. INTERVAL
MAXIMA. SINGLE VIBRATIONS OCCURRING GENERALLY AT INTERVALS GREATER THAN 30 SECS.
MAXIMA. OCCURRING REGULARLY AT 3 TO 4 SECS INTERVAL
APPROX: MEAN VIBRATIONS PER SEC. (DOUBLE VIBRATIONS)
MINIMA. SINGLE VIBRATIONS
440
460
480
500
520

The lessening of the vibration in a ship not only reduces the wear and tear on all the fittings of the ship, but also adds very considerably to the comfort of the officers and crew. I should, personally, have been very sorry to have had to live in the captain's cabin with the original set of propellers, as the noise and shaking was almost unbearable; but with the balanced propellers it was not so, though there was still a good deal of noise. At any rate, things would remain on the table, as we had lunch there whilst going at full speed, without any inconvenience whatever.

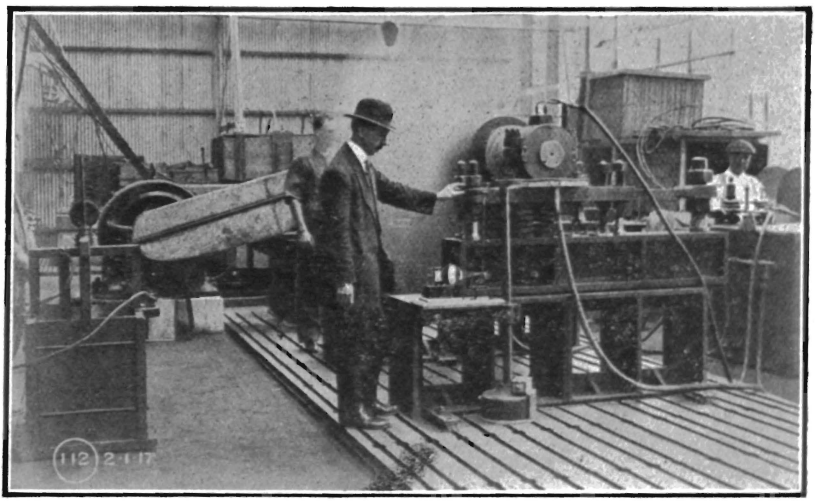


Fig. 18.

Fig. XVIII shows a propeller rotating in the balancing appliance before being balanced. The vibrometer shewn in the lower left-hand corner was fitted with a white disc to enable the photograph to show up how it was vibrating.

Fig. XIX shows the same propeller after it was balanced, in which the white disc is seen to be quite stationary.

It stands to reason that a propeller which will vibrate so much in the shop must similarly vibrate when in the ship, and that such vibrations must be transmitted to the

ship; and it also follows that the elimination of such vibration must be beneficial to the ship in every way. It may be argued that in such a short fore and aft length as appertains in a propeller the moments of the out of balance weights would be too small to have any appreciable effect, but that such is not the case has, I think, been shewn fairly conclusively; and this has also been borne out by the report of the commanding officer of one of the destroyers, in which he had stated that he found material benefit from having balanced propellers.

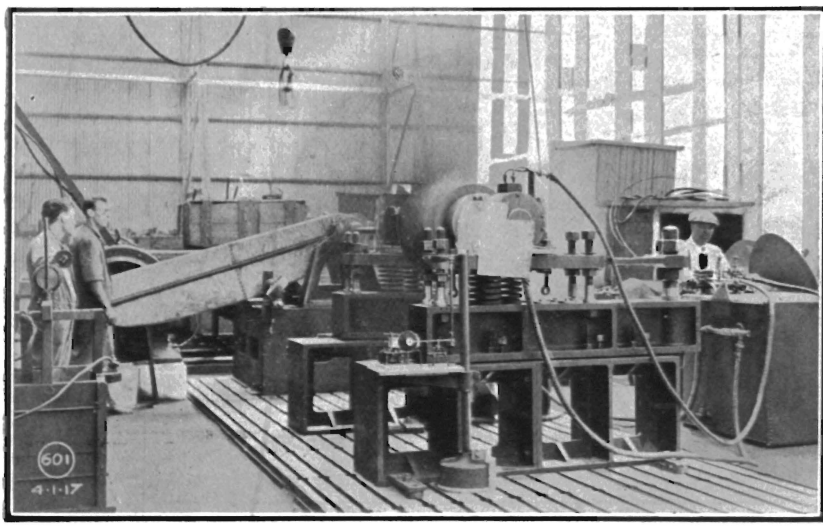


Fig. 19.

The time taken to build a propeller is not inconsiderable, and not a small portion of that time is taken in the statical balance, which, in my opinion, is so much time lost, and it did not ensure a perfect propeller, as it is impossible by such means to know whether the centres of gravity of each blade lies in a plane at right angles to the axis, which, as we have seen, is one of the conditions necessary for running balance. Moreover, there is a practical certainty that during the statical balance the metal removed will be taken

from the wrong place, and will introduce an out of dynamic balance, so that really, if a propeller is required to be in good running balance, the statical balance should be omitted, as it is not only unnecessary, but also most likely involves more metal being removed than is really necessary.

DISCUSSION

Mr. McEwin: Mr. President, Mr. King-Salter, and Gentlemen,—I have very great pleasure in moving a vote of thanks to Mr. King Salter for the valuable matter he has brought before us to-night. We are all indebted to him for coming here and giving us the benefit of his researches, which will, no doubt, be of far-reaching value, and will probably be very useful to many of us who are here. We are too apt to take for granted things that are happening around us; we travel in our ferry boats; we go to sea in large steamers, and we put up with vibration just as a matter of course—we put up with noisy trams in our cities; but after all, ships and trams and other appliances constructed by men are for the benefit of men—they are designed to secure his ease and comfort. As the general public is apt to take things for granted and make no attempt, and evidence no desire to improve existing conditions, so, too, is the engineer apt to take things like that put before us by Mr. King Salter as a matter of course. That makes the trouble he has gone to the more admirable, and makes us the more indebted to him; those who go to sea from now on will have reason to thank him for his patient research. The results of his work will always be appreciated by the engineering world.

I do not pretend to criticise the subject matter of the paper. The author set out to obtain certain definite results, and he undoubtedly attained his objective. The testimony of the naval officers mentioned in the paper is sufficient proof of that.