PLATE No. 15: Showed a pumping plant of the same type, supplied to the Lahore Waterworks, India, the duty of which was to raise 200,000 galls. of water per hour against a total lift of 125ft. from 12 wells, 1,650ft. distant, together with supplying 65,000 galls. per hr. through existing main, the remainder being taken from a well close to the engine house.

In this plant steam consumption was 11.8 lbs. of steam per H.P. per hr., whilst the slip of the pumps was only 1.73 per cent.

The author had to acknowledge information supplied by Mr. J. T. Rutter, engineer-in-charge of the pumping station.

In conclusion, the author recognised that probably much more could be said upon the subject of this paper, but calls upon his time in other directions prevented his giving little more than a brief summary, which, whilst intended to be comprehensive, must necessarily include many faults and omissions; he, however, submitted it to the Association in the hope that it might prove interesting, and possibly instructive to the Members.

Discussion.

Mr. A. J. Arnot said, like himself, everyone who had the privilege of listening to the very interesting paper which had been read by Mr. Saunders was filled with a sense of the keenest pleasure, and was also deeply grateful for the facts which had been so efficiently placed before them. The illustrations which appeared upon the screen had enabled them to grasp the various points of interest in connection with the plant at Walka, for which Mr. Saunders had been responsible. and the information supplied by the author was of the real vital nature that we, as engineers, were naturally interested in, and he

thought they would agree with him that Mr. Saunders was deserving of their deepest thanks, which, he moved, should be accorded to him.

He would also like to mention one or two little matters which occurred to him during the reading of the paper. He could not help thinking—while the author was referring to the old slow-speed engines which had been running at Walka during the past 27 years—of the fact that many engineers were now commencing to realise the unquestionable advantages which this type of engine possessed. Most of us were familiar with the high-speed type of engine, and if we were to plot out a curve showing the efficiency of the same during 27 years, he thought they would find that the line would rise very rapidly, and would represent a fairly steep hill; whereas if one plotted out a line showing the efficiency of either of the engines referred to that evening—or of some of those good old-fashioned, but substantial. slow-speed engines which ran at 70 or 80 revs. per minute—he thought one would find that the line would be fairly constant. He knew of engines of that class which had run for 22 years without any great increase in their steam consumption, while high-speed engines had increased their steam consumption by something like 100% in seven years. The old type of engine, and also those which had been shown on the screen that night, were remarkable for their durability and long service with high economy. The high-speed machine that afforded us high economy for one year was of little use; it was wanted for 20 years. The efficiency of 12.3 lbs. was an exceedingly good one. The firm which built these engines must be recognised as one of, if not the, best in the world as far as that particular class of work was concerned and, if they could not get the best efficiency, he presumed it was not in the power of anyone else to do so. The lubricating difficulties referred to were rather unfortunate. He should have thought that, with separate pumps to each cylinder, or with only the feed for the H.P. cylinder, the trouble could have been overcome without inserting those valves between the cylinders. The degree

of super-heat, as they had heard, was not large at the cylinders, and the whole of the super-heat would disappear at the H.P. cylinder, so that the I.P. and L.P. cylinders would be correspondingly relieved. The position of the exhaust feed water-heater did not appeal to him, but he would be the last to criticise such a well-known firm as Hathorn-Davey. At the same time, it must be recognised that the temperature of the exhaust steam with a vacuum of 27 inches must be somewhere in the neighbourhood of 125°.

Perhaps a little live steam could have been used to increase the temperature of the feed-water before it entered the economiser to something like 180°, which would be a decided advantage over 120°.

The oil filter, too, was, of course, very desirable with such a plant using such a large quantity of oil, and the separator introduced would undoubtedly trap something like 80% to 90% of the oil, but the balance which escaped should be trapped in an oil filter of some of the recognised types on the market to-day. and which were used in marine practice. He thought that that would prevent the oil from getting into the boilers, and thus cause trouble.

Reference had been made to the boilers and the amount of smoke which issued therefrom. Well, if any of those present had looked at the coal which was being used, he thought they would, without difficulty, have appreciated the situation. It was not coal, it was absolute "muck," and he defied any man to fire the boiler without producing dense volumes of smoke. The difficulty in connection with the boilers was owing to a want of appreciation on the part of those concerned of the class of coal which was being used. They knew that small black coal was to be employed, but not of such a bad quality as that obtainable at Walka. When the boilers were started. the quantity of air required to afford reasonable combustion could not possibly pass through the fire-box, owing to the dense, thick mass of fine dross lying there. Consequently

explosions occurred owing to the presence of C.O. in the flues. This had now been surmounted by the admission of the necessary quantity of air. The plant was now, he thought, satisfactory from the Government Engineer's point of view, and he was sure it would prove creditable to those who had been associated with it.

Mr. R. R. Ferrier said he had very much pleasure in seconding the vote of thanks. Mr. Arnot had just about taken the wind out of his sails in regard to the remarks he was about to make, but he thought that the chord struck by the gentleman referred to in connection with slow and fast running engines was of extreme importance. Now that we had passed from the slow reciprocating to the fast reciprocating, and from these to the turbine engine, it was very interesting indeed to have these figures placed before them. He thought most of them were agreed that the slow running reciprocating engine was the best. He had had a great deal to do with the different speeds of engines, and he had arrived at the conclusion that the last type mentioned was the most satisfactory in the long run.

It was also exceedingly interesting to have been afforded an opportunity of noting the various points of design as applied by firms like Hathorn-Davey & Co., Ltd., as well as the slow speeds through the different passages, and the clever arrangement of suction and delivery air vessels which had a great dealt to do with the smooth running and high economy obtained in the plant dealt with by the author.

Like the previous speaker, he questioned the advisability of placing a feed-water heater between the L.P. cylinder and the condensor. It would have been interesting to learn what the loss of vacuum was as caused by inserting that resistance in the passage between the L.P. cylinder and the condensor. He fancied it would be found that all the gain from the point of view of a rise in temperature of the water would be lost in the resistance set up by bringing the low temperature exhaust steam through the

feed water. He would like to ascertain from the author if they took the vacuum temperature before and after the feed water had passed through, as it would be interesting to learn what loss occurred. He thought that all the gain would be lost in not giving the L.P. cylinder the full advantage of the vacuum obtained. The plant was a very fine example of the class of pump built by Hathorn-Davey & Co., Ltd., and, personally, he felt it would be a good thing if it were possible to obtain the results of that plant and set them side by side with the low geared pump about to be installed at Ryde.

Mr. J. Shirra said it afforded him the keenest pleasure to support the motion put before the meeting.

He thought the author's concluding paragraph had been fully realised. Not only the description of the engines, but the detailed information in reference to the difficulties encountered—such as the explosion in the economiser—was very valuable to them, and he was sure they were all deeply grateful to Mr. Saunders for the apparent trouble he had taken to furnish them with something interesting and original. They were always hearing about successes, but very seldom were made acquainted with the difficulties and failures which might from time to time occur, and an explanation of the causes of these was obviously of the highest value to everyone professionally or otherwise concerned.

Mr. Arnot referred to the efficiency of the slow-speed engine. Well, as a mechanical contraption it no doubt worked all right for a long time, but as a general rule—if you took the coal bill as a measure of efficiency—it was pretty low down in the scale.

During a visit to the Homeland he met an engineer who used to be in the old "Arabia," which possessed an old-fashioned side lever engine. He asked him if he had ever been in a screw-boat, to which he replied in the negative, and added that he had much pleasure in not having been. In his opinion they went too fast, and he preferred the type that ran at about 17 or 18 revs. per minute.

He recollected hearing in that room a description of the sewage-pumping plant at Botany. The old-fashioned engine there worked very sweetly, but it used something like 30 lbs. of steam per H.P. hour. Nobody could explain this. The only thing to which it could be attributed was condensation in the long length of steam pipe. They were all aware that when water got into an engine it affected the coal bill very heavily.

The reference made to the feed heater was one worth noting. Exhaust heaters had been tried in marine engines, but with poor result, because a satisfactory temperature of feed was obtainable by working with a vacuum of 25 or 26 inches. In the case of turbine engines, where a high vacuum was necessary it was imperative that a large quantity of supplementary steam be employed in order to heat the water. Doubtless the warm water could be heated by auxiliaries, but there was no need to condemn the exhaust heater on that account. He thought a rise of 60° was not to be neglected. What was the temperature of the water in the rising main? Did the condensor heat it to any extent? Some water temperature was pretty high to begin with, and unless there was plenty of time to cool it must have a corrosive effect upon the mains, far greater than would be the case with cold water. The difficulty with the boilers was interesting. It was remarked in the discussion on water-tube boilers we had a few years ago that they were the champion smoke producers, that is, the land-type of B. and W. boiler, anyway, for this had no combustion chamber, and, with volatile coal, the flame was immediately extinguished by passing among the comparatively cold tubes. With the marine type of B. & W. boiler, where the tubes slope upwards from the boiler fronts, such a chamber was formed, and this had good effect in diminishing smoke. Possibly this type might be found more effective in future extensions of the plant.

The arrangement of the suction pipes mentioned by the author was also very interesting. In a ship he sailed in long ago there was a sanitary pump of the single-acting

type, which drew water from the sea through a comparatively long suction pipe. It used to make a frightful hammering noise, due simply to the water in the pipe being started and stopped in every revolution of the engine. He put a vacuum pipe on the suction pipe, and was informed that it was a foolish action, but it succeeded in curing the trouble just the same. Engineers were commencing to realise that a number of things which were supposed to be of little or no consequence were, in reality, of very much. It was by the arrangement of the pipes and valves that it was possible to run high speed engines or pumps. Unless the valves and inlets were properly set out, the resistance would render the pumps useless for high speed. The modern use of steam turbines and rotary pumps necessitated engineers studying dynamics as well as statics, to which latter they had too often confined themselves in the past.

Mr. Hutchinson said he had very much pleasure in supporting the vote of thanks of Mr. Saunders.

He thought he had furnished them with a very complete account—indeed, almost a full specification—of the results of the tests made, which must be considered as highly satisfactory. As the previous speakers had covered much of the ground upon which one might indulge in a little criticism, he would confine himself to one or two points which had occurred to him during the reading of this most interesting paper.

In regard to the matter of reducing the piston clearance to a minimum, a quarter of an inch was mentioned. It seemed to him that this was not the minimum when one took into consideration the shortness of the stroke and the slow speed of the machine.

It was also stated that the main pump stuffing boxes were water-sealed. He would like to ask the author if that was the only packing used, and if not, what other kind was employed in addition to that which had been mentioned. Like Mr. Arnot, he was somewhat surprised

to hear that the hand application rather than the mechanical arrangement was preferable in connection with the matter of lubrication. It would seem that something was radically wrong with the mechanical arrangement when the hand operation was more satisfactory. In reference to the quantity of oil, he thought that a lesser amount would be sufficient if it were mechanically supplied.

MR. W. SINCLAIR remarked that, after hearing the paper read, and listening to the interesting remarks of the gentlemen who had preceded him, it seemed that pumping might be divided into practically two sections. The other day he saw a high speed engine driving the gearing of a centrifugal pump. In this plant the whole box and dice evidenced the present tendency to get back to the old marine type of engine used in cargo boats.

He would have been glad to have seen more of the valve gearing in the engine which had been described by Mr. Saunders that evening. He took it that there were two in the top covers and two below. In turning up some English books on the subject of high-class vertical engines, he was impressed by the number that were fitted with drop valves—two vertical cylinders with drop valves at the top and bottom. He wondered if there was any difference between this particular type of engine and the Corliss valve type in favor of the latter. He expected mention would be made of the chain brake, and he assumed it was omitted in the specification.

The reference to the method of measuring water into the different reservoirs called to his mind a somewhat similar experience in Newcastle some time ago. The reservoirs were underground, and three men were stationed at various points, but, in addition to this, the engineer in charge had rigged up an arrangement of electric bells which worked very satisfactorily. He might remark that the hook gauge—which he recognised when Mr. Saunders explained it—was also in evidence at that time.

THE PRESIDENT said he had very much pleasure in conveying to Mr. Saunders the best thanks of the Association for the very valuable information afforded them that evening.

If he might be permitted, he would like to ask one question: he understood the author to say that all the water drawn to the pumps was drawn to the condensor. That was astonishing to him. It seemed less economical to do it that way than to have had the water circulated by a separate pump. It might be interesting to members present, and certainly to the speaker, if the author could explain whether it was done in the way referred to with economy as the object. It seemed to him that there would be an increase in friction by passing the water through the condensor.

MR. SAUNDERS (in reply) said he had to thank them very much for the vote of thanks accorded. He realised that much more might have been said, but that the limited time at his disposal had made it necessary to leave much unsaid in connection with the subject, a fact with which he was sure they would all readily agree. Mr. Arnot mentioned the qualities of economy and reliability in connection with the slow speed engine. Undoubtedly this was true, but he could not help thinking that, in regard to the question of economy, the later brother, so to speak, simply wiped them out of existence. There was one point in connection with the old beam engine which had been somewhat overlooked, and that was the cost of overhauling, when necessary, was found to be exceedingly heavy. The beam was an exceedingly weighty superstructure, which required to be hung up with a frame immediately it was disconnected, owing to its being out of balance. It was wonderful to him how the men on watch at night managed to keep awake when attending these old-fashioned engines running at about 15 to 16 revs. per minute. Only the other day he said to a leading engineer: "Well, how do you like the new plant?" "She's alright," replied he, "but no more naps for us while on shift, I am afraid."

Mr. Rutter, the engineer in charge, told him that it was with extreme difficulty that he was able to keep awake with these old pumps rattling round at 14 revs. per min.

Mr. Arnot and other speakers had touched upon the question of lubrication. There was no doubt that a screw appeared to be loose somewhere. It certainly did leave a lot to be desired, and they had been some months now trying to fix the matter up with the makers. We had a man out from England, and a very excellent man he was, too, and even he had to admit that it was not satisfactory, as designed by the makers. Whether he knew what the trouble was and did not tell, could not be said, but the author failed to extract from him any information as to whether he had experienced the same difficulty in other plants. It was found that the mechanical arrangement gave far too much oil when coupled up. Mr. Rutter put forward a suggestion similar to the one submitted by Mr. Arnot that evening, viz.:—The adoption of two sets of pumps, one for the H.P. cylinder, and one to supply the I.P. and L.P. cylinders respectively. It was certain that something would have to be done. Mr. Rutter said that the fact of these engineers having to go up and give the hand pump a few strokes at certain intervals, would ensure their close attention; still, on the other hand, arose the question as to what would be the consequences if, owing to the engineers finding it necessary to attend some serious trouble elsewhere, the lubricating arrangements were neglected.

With regard to the feed water filter, he also thought that it would be a decided improvement, and understood that one would be put in.

Mr. Ferrier remarked upon the interest to be derived from a comparison between the type of engine under discussion and a turbine set. Of course, they were all aware that the turbine sets were a very sweet proposition. He believed that, when tenders were being considered in connection with this particular job, turbines were put forward—Parsons type, he thought—the pump being made

in Melbourne. Speaking from memory, the difference in the initial cost of these two respective plants amounted to something like £2,000. The turbine set was that much cheaper, but the guaranteed consumption of steam was 30 lbs., as against 32.5 in the case of the Hathorn-Davey plant. In view of the fact that coal could be bought so cheaply, it would take some years to cut out that £2,000, but he was given to understand that where the price of fuel was high, the difference would be considerable.

In reference to the matter of the vacuum, he was sorry to say he had not looked into it. He did not think that the cards on the L.P. cylinder showed any difference from the average vacuum obtained.

Mr. Shirra mentioned the temperature of the water being increased by passing it through the surface condensor on the suction side. He did not think it would be possible to detect it. It might be possible to detect it with a thermometer, but it was not perceptible by hand.

The President referred to the excess friction caused through drawing the water through the surface condensor. The water was taken through the surface condensor on the suction side, not on the delivery side, and as the percentage of slip on the pumps was only 1.48, it would go to show that there was not much to complain of in that direction.

In regard to the question of smoke. He thought there was no doubt about the fact that the Lancashire boiler was very much more suitable for dealing with that class of fuel—which Mr. Arnot has very properly described as "muck"—than the Babcock-Wilcox boiler, especially when they were hand-fired. It seemed to him that with the long flues in the Lancashire boiler, you had a better opportunity of getting it steamed when once the smoke got to the stack. At the same time he thought that if they fitted the chain grate, a great improvement would result. The low degree of superheat, as shown by tests, could also be contrasted with the very poor class of coal we had to use. The boilers, before being started, were

carefully cleaned down, but after a very short time, the superheater tubes were covered with a heavy coating of very fine soot. In regard to the difference in the superheat between the boiler and the engine, the drop seemed pretty heavy, and he had to confess to being unable to account for it. The mains were not exposed in any way to outside influence or atmospheric conditions, but were under cover, and it was very difficult indeed to state why that drop occurred. As a matter of fact, at the third test we obtained better results than at the first, but there was still a considerable drop which had appeared to him as unaccountable. Mr. Hutchinson drew attention to the fact that in the paper the stuffing-boxes were spoken of as being water-sealed. That was not the only provision made. They were also fitted with plain, greasy hemp, well soaked in graphite.

Mr. Sinclair observed that it would have been interesting had more particulars about the Corliss steam gear been forthcoming. It would have been a source of pleasure to the author had he been able to furnish further details, but unfortunately the makers would not give very much information in regard to little things like that. It would, therefore, be almost impossible for him to describe the action without the aid of slides.

Mr. Sinclair also referred to a vertical pump engine fitted with drop valves. He thought most of them realised that where a high degree of superheat was to be used, the drop valve was preferable to the Corliss, as much less trouble was likely to be experienced with the former. At any rate, such was their experience in Kalgoorlie.

In conclusion he begged to thank them once more for the very kindly manner in which they had received and discussed the paper.