THE AUTHOR'S REPLY.

Mr. Harricks, in reply, said that he had to thank Mr. Stobo for bringing forward the table showing the corresponding degrees of vacuum for varying temperatures. It was a useful addition to any paper on the subject of condensers. Furthermore, when dealing with condensers for sugar factories, the table helped to show more conclusively the great advantage of working with a high vacuum and thus keeping down the boiling temperature.

With regard to the triple effet apparatus and surface condenser illustrated by Mr. Stobo, his experience with this plant was interesting, and he (the speaker) could certainly bear him out as to the efficiency of the whole plant. It was one of the most satisfactory of its kind that the Company had installed. As to the liquor occasionally boiling over from the third pot into the condenser, it certainly would seem to be due to the rather sudden acquisition of a greater vacuum in the latter. The analogy that Mr. Stobo drew with regard to the explosion of the boilers of a ship when it sank was, as Mr. Stobo said, rather outside the scope of the paper, but nevertheless he agreed that it was a sufficiently interesting matter upon which to ask for an expression of opinion from the members. He could only express an opinion somewhat diffidently upon the subject, but it was that the boilers would not explode, and he thought the disturbance that occurred when a ship sank was due more to the escape of steam from ruptured steam pipes and from the sudden quenching of the boiler fires. In fact, he thought the very action described by Mr. Stobo when he referred to the greatly increased circulation of massecuite in a vacuum pan upon the introduction of a number of steam jets in the bottom thereof, was analagous. These jets were generally made from an ⅛″ to 3/16″ in diameter.

Mr. Stobo: Don't you mean $\frac{3}{4}''$?

Mr. Harricks: No, the actual size was, he felt sure, not more than the sizes quoted, viz., $\frac{1}{8}''$ to 3/16″ in diameter, and when it was considered that such small jets of low pressure steam made quite a commotion in the heavy massecuite, probably 10 ft. deep in a pan, it can be imagined the effect of the escape of steam from say one 10″ diameter steam pipe from boilers carrying probably 250 lbs. steam pressure.

With regard to the sudden contact of the hot shells and furnaces of the boilers with the icy cold water, Mr. Kidd had quoted the extensive experiments that were made some years ago to prove that the consequences were by no means dangerous.

Mr. Stobo then suggested that the boilers might be ruptured and subsequently explode as the result of water hammer.

Mr. Harricks said that it was quite probable, as Mr. Stobo suggested, that water hammer occurred, but he thought it would be more liable to cause damage to the steam pipes than to the strong boiler shells. In the case of the "Titanic," the ship when disappearing practically stood on end and it could then certainly be understood that the boilers would leave their seats and crash downwards. In such a case, of course, such impacts would be caused that the shells of the boilers might be badly strained and their explosion follow. As already stated, he was unable to advance any definite theory, but, as the matter had been mentioned, he felt reasonably sure that whatever occurred was not due to the creation of a vacuum within the boiler shells, for, if this was the case, there would practically be no great disturbance.

With regard to the table Mr. Stobo showed in Figure 3, it certainly explained the disadvantage of very deep pans. The differences in temperature were, of course, due to the "head" of massecuite in the pan, and with the steep bottoms shown, the circulation was not so good as in a shallow bottomed vessel, and which, of course, carried a lower depth of massecuite. The steep bottom, he might mention, was undoubtedly designed with the object of enabling the material in the pan to be boiled to a very high density, and yet be easily run out of the vessel.

Mr. Stobo referred to the disease in sugar cane called "Gumming," and it may be said that this still existed in certain parts of the country, and it caused endless trouble in the boiling and evaporating process in the factories that had to handle such cane. The gum was quite easily discernible when a stalk of cane was cut, as the pithy cells exuded a yellow substance which was decidedly sticky and gummy to touch.

The use of steam jets for circulating the massecuite in vacuum pans was by no means general, but was very useful in such a case as mentioned above.

With regard to the tests Mr. Stobo had shown to illustrate how rapidly the rate of evaporation dropped as the boiling proceeded, these were undoubtedly interesting, but were explained by the gradually increased density of the material. The figures were certainly useful, as they showed clearly the rate of evaporation that could be expected at various periods of the process.

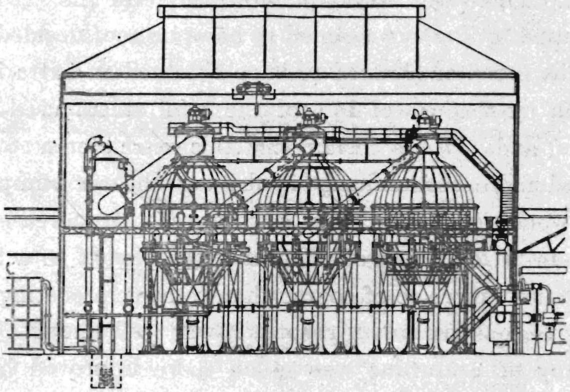
As to entrainment, he could hardly agree with Mr. Stobo that this was only likely to occur during the earlier period of the evaporating process, for, it had been proved that even with sugar solutions of the greatest density, heavy losses could still occur. With regard to the extent of the loss, he could quite appreciate Mr. Stobo's remarks, for it had certainly been believed by a great many engineers up till quite recently, that the loss from this cause was by no means great. To prove this, in very many sugar factory evaporators, no attempt at entrainment prevention had been made beyond designing the vessels so high that it was less likely the particles of sugar projected upwards from the boiling mass would be carried over to the condensers. However, this state of affairs was partly due to the fact that no thoroughly effective test had been available to prove the extent of the loss. For some years a substance known as Alpha Napthol gave a fairly true re-action to prove the presence of sugar in the waste water from the condensers, but it was not considered sufficiently accurate for the purpose. Quite recently, however, a true chemical re-agent had been discovered which was most sensitive in its re-action in the presence of sugar. This purely chemical substance was known as "Thymol," the name probably being derived from the fact that traces had been found in the oil of "Thyme" (or Time).

Although he knew the matter was rather irrelevant to the subject of his paper, he took the liberty of referring rather fully to it, as he believed that the test would be of some interest to members. He then showed that by taking two volumes of water suspected of containing sugar and by adding half a volume of the "Thymol" solution, and then adding thereto 2½ volumes of strong sulphuric acid, which created sufficient heat to set up the desired re-action, it was observed that the mixture turned a very dark pink colour, showing conclusively that there was quite a large percentage of sugar in the water. When it was mentioned that the sensitiveness of this substance was equal to 1 in 100,000, it would be realised at once what a valuable aid it would be in the sugar factory.

Turning to the "Augmenter" referred to by Mr. Stobo, and his attempt to make use of a similar device, it was impossible for the speaker to suggest why the latter was unsuccessful. There was no doubt, however, that the "Augmenters" used by Parsons seemed to have been of decided benefit. The inventor claimed to have obtained an extra inch of vacuum by the use of $1\frac{1}{2}\%$ of the total steam used in the turbine, and if it was certain that this extra steam could not be used more economically in driving the air pump, then there would appear to be an advantage. An increase of 1″, say from 28 to 29″, would be of great benefit to a turbine installation; more so of course than to a reciprocating plant. Owing to constructional reasons, it was well known that the economy of a turbine was much more improved by very high vacua than was the reciprocating plant.

As to the size of the air pipe from the condenser to the pump, it is quite probable that in the instance referred to by Mr. Stobo, this was found to be on the large side, but many engineers erred on the large side in this respect for the reason that probably for a very small additional expense, it could be insured that no restriction or loss of vacuum through friction of the air would occur therein. Quite possibly an orifice of much smaller diameter would not restrict the flow of air to any very appreciable extent, whereas a long pipe of the same diameter would do so. He believed it was wise in this matter to err on the safe side, although of course there must be a reasonable limit beyond which it would be unprofitable to go.

Mr. Kidd referred to the many industries in which evaporators were largely used and in which also high temperatures would be injurious. His remarks caused the speaker to remember a particularly interesting evaporating plant that had recently been built for a large salt works in England. The evaporating plant in question was quite the largest that he had ever heard of and he thought was so striking that members would probably like to see an illustration of it. This was shown in Figure 6, and it may be mentioned that



SECTION ON B.B.

Fig. 6.

the leading dimensions of this huge triple effet vacuum apparatus were as follows:—

Inside diameter of evaporator vessels—20′ 6″.

Total height from ground level to tops of vessels—66′.

The condenser for this plant was no less than 10 ft. in diameter and about 22 ft. in height, while the pumps, which were illustrated in the next figure, No. 7, were of the twin

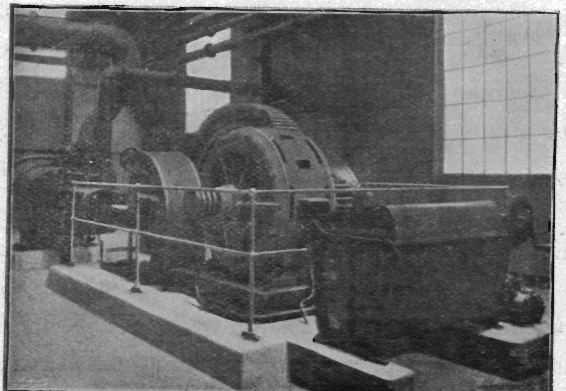


Fig. 7.

horizontal dry slide valve type, each pump being 32″ in diameter and 30″ stroke, the pair being driven through cut gearing by a 150 B.H.P. electric motor. This plant was made by the Mirlees Watson Co. of Glasgow.

He was pleased that Mr. Kidd had supplemented his (the speaker's) description of the quadruple effet apparatus shown in Figure 1 of the paper, as both he and Mr. Shaw drew attention to the fact that such an apparatus was practically a series of surface condensers, each successive pot acting as a condenser for the vapour from the preceding one. The economy of multiple evaporation was unquestionable, and although the figure referred to showed a quadruple effet, this was not the limit of stages, for sextuple effets had been used. However, the range of temperature between the vessels became so little with more than four stages that the expense of the plant practically outweighed the increased economy obtained. Mr. Kidd's description of how a certain air pump which was hardly large enough for a triple effet containing 3000 sq. ft. H.S. had afterwards successfully maintained a higher vacuum when working with a plant 4½ times its size, was explained by the fact that in the first instance it had to handle all of the waste injection water, the air that came in with such water and the condensed steam and air, whereas, in the latter case, the pump had only to handle the condensed steam and air from the surface condenser. There was no doubt that a surface condensing plant called for a smaller sized air pump than any other type. Mr. Kidd remarked that the counter current jet condenser was one of the most efficient, as far as quantity of water was concerned. He (the speaker) would say that with a well designed counter current jet condenser the air could be taken off at practically the same temperature as the injection water, and the waste injection water at a temperature corresponding to the vacuum in the condenser. If this was the case, then it would be impossible to obtain greater efficiency with any other form of condenser. Even the surface condenser was not quite so efficient as there had to be a difference of temperature between the water on the inside and the steam on the outside of the tubes in order to obtain the necessary transmission of heat. With regard to drawing off the air at various points of a counter current condenser, he would mention that he knew of tests that had been made which went to show that practically no improvement was brought about by drawing the air or vapour off at various points in the condenser. He could hardly agree with Mr. Kidd that in counter current condensers it was unnecessary that the diameter should be much greater than the vapour pipe. He quite believed that this was the case for parallel current condensers, such as were shown in Figures 6 and 7 of the paper, but he thought there was little doubt trouble would occur if the velocity in the counter current condenser was too great. In fact he felt sure that a high velocity current of steam, vapour and air would lead to a large quantity of the finely divided water being carried over to the air pump. It was, in fact, almost analogous to the question of entrainment referred to earlier in the evening. It was purely a question of the relative weight of the drops of water compared to the pressure set up in the opposite direction by the current of steam, etc. Although, as described by Mr. Kidd, there was undoubtedly a large proportion of the steam condensed almost immediately it entered the condenser, and met with the injection water, the higher the degree of vacuum required the longer it was necessary to keep the steam, vapour or air in contact with the water so as to bring the air at the final point of discharge down, if possible, to the temperature of the entering water.

Referring to the quantity of water that would pass through given sized holes, he had found that the actual rate of discharge did not accurately agree with the formula given in the paper, and in some cases the difference between the calculated and the actual discharge was as much as 15 %. In a condenser spray plate containing, say, 2000 holes, it was obvious what an error of 15% in the estimated capacity would mean.

He had spent a very considerable amount of time in making the tests, and felt reasonably sure that the results were as nearly as possible correct. He had not had time to estimate the volume of air leaking in to the pans during the tests referred to, but this would be arrived at very simply, although of course it would depend to a great extent upon the volumetric efficiency of the pumps. There was no doubt, as pointed out in the paper, that in sugar factory evaporating plant there was a very much greater likelihood of air leaking into the systems than in ordinary power plants. For instance, he had measured the lineal feet of actual jointing in an ordinary 12 ft. diameter vacuum pan, and found that it was no less than 300

It would be noticed in Figure No. 23 that the plunger rod of the reciprocating pump was water sealed, as was suggested by Mr. Kidd as being desirable, and he could assure members that although the class of pump illustrated was bulky and took up a large amount of ground area, it was a remarkably steady running and efficient type. There were probably from 70/80 such pumps in the Company's service, and many of them ran for very long periods without requiring repairs of any kind. Of course, with the increased value of space, the Edwards' pump was now almost invariably installed in preference to the larger type.

With regard to the air separating device in the injection water tank illustrated in Figure 12, the author could certainly state that from observation it was remarkable the quantity of air that seemed to be expelled from the incoming water; and there was no doubt that such a contrivance would be valuable to any large installation.

Mr. Shaw drew attention to the happy state of affairs that existed in a sugar factory, seeing that all the steam required for power purposes was absorbed in the boiling and evaporating plant, there being practically no loss of heat at all beyond radiation, etc. This was undoubtedly the case, but he would like to add that it was not considered as a result of this condition that the efficiency of the steam units could be neglected. In the Company's service the power units were closely watched and efficiency maintained. In several of the mills high speed engines, such as the Bellis Morcom, had been installed for driving groups of machines in place of separate engines, each of which required supervision and maintenance. Mr. Shaw had suggested that the cost of elevating the condensing water for use in barometric condensers might offset the advantage of dispensing with the wet pumps that would otherwise be required. However, seeing that the evaporating plant had usually to be a considerable height above the ground, if the condensers were placed low down very long and large vapour pipes would be required, and these, beside being costly, would increase the liability of air leakage. A much greater saving would be gained if lower vacua were considered satisfactory. As pointed out in the paper, if a 25″ vacuum was considered satisfactory instead of 28″ and the injection water in each case was 80° Fahr., the saving in water would be not less than 150 %.

With regard to the woven wire water breaks, he had to say that these were not costly, although made of brass. He thought they cost no more than 6d. per sq. ft., whilst he knew that they lasted quite a considerable time; in one instance of which he was aware the woven wire had been in use two years and was still perfectly good.

Mr. Shaw referred to the possibility of disintegrating the water to such an extent that there would be a liability of the smaller drops being carried over into the air pump. This point was undoubtedly one that had to be carefully considered for the reasons that he had mentioned earlier in reply to Mr. Kidd's remarks. There was no doubt that safety lay in the direction of providing an ample size of condenser.

The Chairman, Mr. Reeks, said that it was rather a unique experience in the annals of their Institution, for he did not remember an occasion before where a discussion had been postponed until another night, and an evening occupied so fully, and a discussion listened to with such interest as had been the case that evening. When Mr. Harrick's paper was read Mr. German had proposed and Mr. Stobo had seconded, a vote of thanks to him, which was carried by acclamation. As it was late, he would not ask two gentlemen to respectively propose and second a vote of thanks to those gentlemen who had done them the honour of coming here to discuss the paper, but if they would allow him to do so, he would put it direct to the meeting. He did so with a considerable amount of pleasure, on behalf of the Institution.