valve, together with the air, if however the nests of tubes were placed in series without valves between, it would be a risky thing to fill the economiser when hot, as the mixed elements of water and steam formed, would be sure to give rise to water hammer.

Mr. R. Sinclair said that the fact that advantages were to be gained by heating the feed water before entering any boiler, were generally recognised by engineers, but the difficulty usually was to get users of engines and boilers to appreciate that these advantages would more than compensate for the outlay in installing a heater. A discussion on the subject would, therefore, have good result if it provided fresh ideas or arguments.

The direct economy to be gained by heating feed water for a boiler could be found by the following formula :—

$$\frac{100\ (T - F)}{H - F}$$

H = Total heat of steam at boiler pressure.

T = Temperature of feed after heating.

F = Temperature of feed before heating.

The gain in economy with feed water of say degs. by heating to 140 degs., would be 5·3 per cent. rising to 10·6 per cent. if the feed water was raised to 200 degs., so that it might safely be reckoned that, with ordinary non-condensing engines, heating feed water would give 6 per cent. economy of fuel, and in condensing engines, where the temperature of feed before heating would be about 100 degs., about 5 per cent. could be depended on

On a plant using say 10 tons of coal per week the saving at 12s. per ton for coal would be 6s. per week, or fully £15 per year, and the cost of installing a feed heater of suitable size would be about £35, so that the economy would soon cover the expense.

Apart, however, from the economy of fuel, there were other advantages to be gained by adopting a feed heater, which to his mind were more important, these being the purification of the feed water by the elimination of grease, scale forming matter, and especially air.

As regards the extraction of air, this was an item which was too often overlooked, and if owners could realise the savings in repairs to boilers by extracting air, there would be less difficulty for engineers in getting them to agree to the expense.

To the presence of air in the water could be debited most of the corrosion which went on inside, as iron would not rust in contact with water unless there was free oxygen or air present, and that water contained a large percentage of air was of course, well known. This could only be eradicated by distilling and afterwards heating to a boiling point. He might point out that for the making of clear ice the water was kept boiling for a period which drove off all the air. A great deal could be said on the subject of corrosion due to air—he did not mean pitting so much as a general corrosion all over—and he would like to hear the experiences of some other member on this point. He had known the plate of a furnace wear dangerously thin where there was no sign of local pitting or anything to point to a direct cause of decay, and he put it down to a general corrosion due to air in the water. Air of course was one of the causes of pitting.

The extraction of grease could be effected to a great extent in a good feed heater.

The different types of heaters might be put down as:—

1. Economisers, using waste heat of fuel gases.
2. Tube heaters, where the steam passed through tubes, and water outside and vice versa.
3. Tank heaters, where the steam came into direct contact with the feed water.

Economisers were, of course, the best where the flue gases were escaping at a sufficient heat to give off heat to the feed water, but care must be taken that the flue gases were not cooled too low. Heavy corrosion often occurred with this type of heater from the deposit of carbonic acid gas in moisture on the outside, and he had seen an economiser built of wrought iron tubes completely destroyed, in one year from this cause.

Of the second type of tube heaters there were many varieties, principally, however, of two classes, one for exhaust steam the other for live steam. Small tubes were a great deal better than large ones. Where fitted to take exhaust steam, it was better that the exhaust go through the tubes as it broke up the steam better.

Live steam heaters were better for surface condensing engines, usually being made strong enough so that the feed water was delivered by the pump through the heater and the steam passed in through the tubes. Theoretically this system of heating would not show any economy, but it actually did, because the boiler was able to do its work better, in imparting the heat from the furnances to the water, when it started with higher feed water. In other words, a greater economy could be obtained by heating water with steam than with fuel, so that using steam, after having once been made into steam, to help the evaporation gave the gain. By using live steam there was the further advantage that a temperature could be got in the heater practically equal to the temperature in the boiler, and where the pressure was considerable this could be well above the ordinary atmospheric boiling point, and, thus, by a judicious use of the air cock on the heater, practically all the air could be eliminated from the feed water and the grease attracted to the coils. He considered that all surface condensing engines should be fitted with a live steam heater, and that it should not be looked upon as an extra, but as an absolute essential to the machinery, the same as the boiler was itself.

Of the tank heaters, the most common was a square tank into which the exhaust from the engine was directed, the tank being kept about half full of water. This might almost be called the Australian feed heater. It was, undoubtedly, the most ineffective and poor appliance possible, but it had (what to most Australian users was the prime factor) cheapness in its favour. This type of heater was of no value in extracting grease or air from the feed water, because the constant disturbance of the water by the impact of the exhausting steam prevented the grease separating from the water.

A modification of this type could, however, be made which gave fairly good results. If the tank was divided into three spaces, horizontally, and the middle space had a number of tubes passing through it from the top to the lower space, in this space the feed water being placed, the exhaust steam taken into the top space in passing through the tubes into the lower space would heat the feed water as it passed and condense itself. From there, by a pipe, the exhaust passing back into the middle space, would encounter the feed water in the form of a jet, or spray, so that the apparatus would form a heater, a jet, and a surface condenser. He had found that some such an arrangement as this converted the ordinary tank heater into a fairly useful apparatus.

Mr. J. Scoular said that it was generally recognised that a great saving was obtainable from heating boiler feed water, and even to use live steam for that purpose had been strikingly demonstrated by experts that it was more economical than putting cold water in a boiler.

But it might frequently be a perplexing problem to determine the best means of heating due to first cost of installation, interest, and maintenance.

It might be said, however, that for all plants of a size too small to justify the use of an economiser it was good practice to employ heaters in the exhaust pipes of the engines, absolutely regardless of the condensing question, and though the exhaust steam from many plants, in recent years, may have been used for innumerable purposes, there are none of the arrangements so economical as those employed for the utilisation of steam in heating and purifying feed water. No matter what the conditions of a plant might be, if this could be carried out it would produce economy in the use of coal, preserve the life of the boiler, by removing the evil effects of unequal expansion, improve the circulation, give steadier steaming, and a greater efficiency of the engines, and there was no doubt many of the exhaust steam feed water heaters on the market at the present time came very close to fulfilling these requirements.

In cases where feed water contained scale, forming salts that were precipitated below a temperature of 200 deg. F., the open type of heater had the advantage of assisting to purify the water to some extent, still it had this objection, that unless the oil contained in the exhaust steam could be eliminated it would be returned to the boiler, which was very undesirable.

Properly proportioned closed heaters using exhaust steam from auxiliaries would raise the temperature of feed water from 60 to over 200 degs. F., with steam at atmospheric pressure, and when new they would do much better than this, however, the fact cannot be overlooked that heaters of this kind taking exhaust direct from the engines to a certain extent became coated with grease on the steam side, and as it was claimed by authorities on the subject that a film of grease one-hundredth part of an inch thick offered as much resistance to the transmission of heat, as that of scale one-tenth of an inch thick, the efficiency must then be somewhat impaired.

Though feed heaters might have slight disadvantages, the fact could not be denied that they were very profitable investments, and if by appliances of this kind, involving a comparatively small expenditure, feed water could be raised to a temperature of 210 degs. F., or over, it was quite sufficient to warrant their application for that purpose.

In bearing out these statements, it was only necessary to take as an example a large plant running condensing throughout, having all the auxiliaries electrically driven, and assume that the condensed water was taken from the hotwell for feeding purposes, at a temperature of probably not more than 110 degs F. If, under those circumstances, this plant developed 6,000 I. H. P. on a steam consumption of 15lbs. per horse power, then 90,000lbs. of water would have to be made into steam per hour. If, however, 350 horse power was absorbed by the auxiliary plant, and this was changed from electrically to steam driven, on a steam consumption of 30lbs. per horse power for this portion, then, by applying feed water heaters, to raise the temperature of the feed from 110 to 210 degs. F., and using this exhaust steam for that purpose, the total amount of steam required for the whole plant would be $5650 \times 15 + 350 \times 30, =$ 95,250lbs. per hour, less the heat conserved from the exhaust of the auxiliary plant, and as a pound of exhaust steam would practically give up 966 heat units, then the amount required to raise the temperature of feed 100 degs. F., would be

$$\frac{95250 \times 100}{966}$$

= 9,860lbs. required, and having a supply of $350 \times 30,$ = to 10,500lbs. of exhaust steam available from the auxiliary plant; this would be easily accomplished, leaving a margin of 6 per cent. for radiation, &c. If then we deducted 9,860lbs. from 95,250lbs., the gross total, we would get 85,390lbs. as a nett total of the heat required for generating steam, as the equivalent of 90,000lbs. per hour. That was to say instead of having to burn coal to evaporate 90,000lbs. of water per hour when the plant was running condensing throughout, it would only be necessary to burn the coal that would actually be required for evaporating 85,390lbs. of water, showing a saving of 4,610lbs. per hour, by running the auxiliaries with steam, and using the exhaust steam for the purpose of heating the feed water. He would like to mention that if an open type of heater was used, in preference to an economiser, there would be less cost of installation and maintenance, no deterioration of the heating qualities, and a certain amount of purification for the feed supply, and even better results than those mentioned should be obtained by a properly proportioned and well regulated system of this kind.

Whilst giving this subject consideration, it had occurred to him that there were other means by which a certain amount of feed water could be obtained at a very high temperature, which appeared to be applicable to large plants, and would, he thought, prove practicable also. He referred now to what was known as the "steam loop," and was, he understood, used in some parts of America. By the application of this arrangement, all condensation taking place in re-heater receivers and long lines of steam piping between the boilers and engines of a large plant, might be entrained and returned to the boilers direct, by simply constructing the piping in such a way that a water column was produced near the boiler of sufficient height to balance the difference of pressure that might exist between the boilers and separators in the main steam pipes, and if the variation of pressure was not more than five or six pounds, a system of this kind, in addition to feed water heaters, should prove economical, as the only expense necessary would be in providing suitable piping, with a stop valve in the riser near the separator, and a stop, check, and blow-off valve near the boiler in the down or return tube.

As this loop (Plate I.) or system of loops, would have to put water into the boilers against resistance, a certain amount of energy must be expended, representing heat lost in operation, but this would probably be so small that not more than one-sixth of a horse power for every hundred exerted by the engines would meet the case.

For a plant such as the one already referred to, of 5650 h.p running condensing, and 350 h.p. for auxiliary and heating purposes, and putting the condensation down at $3\frac{1}{2}$ per cent. of the actual steam used, on a basis of 15lbs. per horse power for the condensing portion, and 30lbs. per horse power for the auxiliary plant, it would equal 3333lbs. of water per hour returned to the boiler, at a temperature of probably 280 degs. F., or practically

3570lbs. at 210 degs. F., the temperature of the feed water leaving the heater. Then if this be added to 4610lbs., the saving on the heater side, it would equal 8180lbs. as the actual saving of the combined system, and he was sure very much within the limits of what it was quite possible to obtain in the way of economy.

With regard to economisers, it was safe to say that where boilers were driven at a high rate, a greater proportion of the heat of the fuel passed up the chimney than would accord with good boiler practice, and an economiser would then intercept and return to the boiler a large part of the heat that would otherwise go to waste, and where fuel was costly, this was a a matter of some importance.

If the distribution of heat from the furnace to the boiler was good and a proper efficiency maintained without forcing the fires, the gases passing away into the flue would probably not have a temperature of more than 420 degs. F., and under those circumstances it would almost appear that an economiser would be ineffective by finally reducing these gases below a temperature of 300 degs.

Where exhaust steam was available for heating the feed water, there was less opportunity for an economiser to save fuel, and it would then receive the water that might be heated to 210 degs. F., and under those conditions it would require coal of moderate cost to render good economy. Owing to the reduction of flue temperature, and the resistance they offer to the flue gases, it necessitated the provision of ample chimney capacity or other mechanical means for producing strong draught.

Mr. J. S. Fitzmaurice said that the question of feed-water heating was one of very great interest and importance to all engineers who have steam plant under their control.

Some thirteen years ago our esteemed friend, Mr. W. D. Cruikshank read a most interesting paper by Mr. Blechynden on "A Review of Marine Engineering during the past Decade," and the question of feed heating was then discussed. On that occasion he (the speaker) contributed to the discussion, and gave results of efficiency tests made with an "Acme Feed Heater" at Parliament House Electric Lighting Station, and he had no reason to withdraw any of the statements then made in regard to the economy effected by the use of the Acme Heater, as they had been fully borne out by subsequent tests.

There could be no possible doubt as to the necessity of heating the feed water before allowing it to enter the boiler, and the wonder was that so few steam plants were provided with heaters. Not only should the water be heated, it should also be filtered, especially where Sydney and other waters containing solid matter are used. The water should, preferably, be filtered in as hot a condition as possible, as anyone who had studied chemistry in its simplest form would readily agree that liquids could be filtered much more rapidly when heated than when cold; moreover, any solid matter deposited by reason of such heating, would be arrested by the filtering medium and thereby prevented from entering the boiler. The heater should be placed on the delivery side of the pump (or injector). If a filter was used, it should be fitted between the feed heater and the boiler. The practice adopted in the electric lighting and power plant at the General Post Office was as follows:—

The feed water tank was placed at a height of about 8ft. from ground level, and all water separated from the steam in the steam pipes and in the separators was tapped back to this tank. The water in the tank was regulated by a ball valve, and gravitated to the feed pumps and injectors, and was forced through an exhaust steam feed heater, and a feed water filter before entering the boiler. The feedwater heater was one made by Mr. John Turnbull, of this city, and consisted of a series of spiral copper tubes fitted into an exhaust steam chamber, similar in design to that shown on Plate II. The feed water entered the upper end, and was discharged through the lower end of tubes, and did not come into contact with the steam. He might explain that the steam engines in use were of the Willan's compound non-condensing type, and the exhaust steam after heating the feed water was allowed to escape into the atmosphere. A considerable amount of condensed water could be saved, but as it was highly impregnated with mineral oil, he preferred to allow it to go to waste than run the risk of the oil accumulating in the boiler; this, notwithstanding the efficiency claimed by manufacturers and vendors of oil filters. The feed water after passing the feed heater was then forced through a Rankine feed water filter, and thence to the boiler. The filter was simple in construction and effective in operation. It consisted of a cylindrical cartridge round which was wrapped several layers of Turkey towelling, and through which all the feed water must pass. The filter was easily and readily cleaned, and was provided with a by-pass so as not to interfere with the feed water supply to the boilers. The feed water after passing through the boiler check valve had to travel nearly twice the length of the boiler, through a pipe fitted in the steam space, before it was discharged into the boiler; the discharge took place through a number of small holes in the upper side of the pipe at the extreme end; the water consequently entered the boiler at a temperature approaching that of the surrounding steam. The temperature of the feed water when leaving the exhaust steam heater was from 200° to 208° F.

The use of live steam heaters somewhat similar in construction to the one referred to above, had, he was informed, been attended with very satisfactory results, in every case having effected a substantial saving in fuel.

MR. A. E. LEA was in favour of outside heaters in preference to inside flues as being more reliable and less costly to maintain.