increased efficiency, and boilers that were difficult to steam were much improved by fitting heaters to them.

The latest type of heater fitted to our boilers was of the contact or spray class similar in action to the Weir contact heater, and he was inclined to the opinion that whether fitted inside the boiler or in a seperate vessel immediately alongside the boiler it was the most effective class of heater, and where the feed water contained much scale-forming materials in solution, the Babcock & Wilcox or the Stirling type of feed heater was also an excellent feed water purifier.

In a recent paper read before a society of German Engineers, on a Lancashire boiler of special design, the special feature was the fitting of a feed heater and a third flue under the two furnance flues, into which the hot gases from the upper flues could be led into it when getting up steam. A test made with this boiler showed that steam could be raised in 56 minutes, whereas it took 90 minutes to raise steam without the third flue. The feed heating device was arranged to spray the water into a V-shaped trough running nearly the whole length of the boiler. The feed-water flowed along the shoot and overflowed near the end. The arrangement was intended to heat the feed water to the temperature of the steam in the boiler, promote active circulation, and also to arrest any deposit of mud and lime in the trough from which they could be removed by blowing out. He would say, in concluding these remarks, that every boiler should be fitted with a feed-water heating device, and the nearer the temperature of the feed-water was raised before mixing with the water in the boiler the greater the economy and the less the wear and tear of the boiler.

Mr. John Tcder said that no doubt the heating of the feed-water supplied to steam generators (no matter what type or form the generator might be) was a matter of great importance to team users, and he believed that one of the most essential points was that the feed-water be heated to as near as possible the temperature of that of the water in the generator, in order to protect it from undue stresses.

The temperature at which the feed-water entered the boiler affected different designs of boilers in different ways. He should say that should the feed-water not be brought up to a high temperature, and be fed into a boiler of rigid design (he spoke more especially of water-tube boilers than shell) the more severe would be the stresses set up, but boilers of a flexible design would accommodate themselves to the variations in temperature without tke risk of serious fatigue to their general strength.

No doubt the advantages of feed-water heating depended largely from what source the heating was derived, and it was interesting to hear different opinions on this matter, but even if the steam was taken from the boiler itself to effect this purpose there no doubt, was considerable economy due to the increased efficiency of the heating surface, and this he believed, would be felt to a much greater extent with boilers of a very sluggish circulation.

In many steam plants which he came across, there were other sources of heat going to waste which no doubt in most cases could be used with considerable economy. One of the most common of these, and one which was early recognised and taken advantage of by engineers, was that of utilising the waste flue gases leaving the boiler, by passing them through a fuel economiser of Green's or Lowcock's make. By this means a saving might be effected varying from 8 per cent. to 20 per cent. of the fuel consumption.

Mr. R. S. Vincent said that in any system in which steam was used and the consequent replacement of water evaporated, it was necessarily—one of the greatest essentials—to have that water put into the boiler or evaporator at as high a temperature as could possibly be arranged, always subject to the controlling point, or that point which would render it uneconomical to heat the in-going water to a greater degree. This was a fact that was patent to all engineers; but also of greater consideration was the manner in which the feed-water should be heated.

One of the most common types of feed-water heater was that type in which the steam exhaust was utilised by passing through some receptacle, the steam space of which was separated from the water channels by as thin a separating medium as possible, and by coming into contact with these surfaces allowing the feed water which was circulated in the opposite channels to absorb as much heat as possible from the exhaust steam, the steam then passing to the atmosphere or to the condenser for further treatment.

Another method was only in detail different, inasmuch as the steam passed through the tubes, and the water surrounded them. Both these systems were cheap, and as heating systems were economical in their way, but they had their disadvantages. The first disadvantage he would like to point out, was one that the practical engineer had, at many times, demonstrated to him, and that was the incrustation of the tubes or heating surface due to the deposit of foreign solids from the water. In all cases this incrustation reduced the efficiency of the machine, in many cases the tubes through which the water had passed were scaled to such an extent as to almost close up, necessitating renewal of tubes in some cases, and in all cases, considerable trouble and expense in cleaning. One advantage which this system had, and which was loudly proclaimed by the manufacturers of this type of feed-water heater, was that the exhaust steam being absolutely separated from the feed-water, there was no possibilty of oil, or any greasy matter being introduced into the boiler or evaporator, and one must allow that in these days of high pressures, the presence of greasy compounds in the boilers was dangerous to a degree.

Another very efficacious system of feed-water heating was by the deservedly so-called "economiser" type in which the water was passed through tubes, the outside of the tubes being so arranged that the waste flue gasses gave off their heat to the water passing through the tubes. This system had many advantages and in the most modern types the facilities for cleaning were very commendable. But even these had the great disadvantage of scaling very rapidly, and it was found necessary to duplicate either a portion of the feed main or the economiser plant itself, in consequence of the tubes bursting from time to time.

Another system was that which, by admitting live steam at high pressures and consequently high temperatures, gave off the heat to the water, but this system needed little comment, as it had been proved to be uneconomical, and the depositing of the lime and other foreign solids in the water caused the heating surface and piping to scale. It appeared, therefore, essential that in any feed water heating system there were two points that must be looked to very carefully, viz.—The deposit and consequent danger of scaling, and, if exhaust steam was used, the obvious danger of admitting oil into the boilers.

He desired to call attention to the Webster system of feed-water heating, the special features of which appeared to be so valuable.

The system in its different stages was that the feed water, whether direct from the main or hotwell, was admitted at the top of the apparatus on to trays which allowed of the water skimming from one to the other, and thus formed a water surface of more or less depth according to the requirements. Below these trays was an opening for exhaust steam which entered the heater after passing through an oil seperator. The oil separator internally contained a series of corrugated plates against which the steam impigned, the obvious result being that any oil or greasy particles were at once deposited on the plates and gravitated to the lower portion of the oil separator, and were drained off periodically. The exhaust steam was then brought into contact with the water gravitating over the plates so arranged that the flow over the surface was from the upper to the next, and so on over the whole surface. With the correct amount of exhaust steam compared with the feed-water, and this could be readily regulated according to the number of auxiliaries that were available, the whole of the exhaust steam admitted was condensed by the water, and the heat given off easily, brought the feed water up to 200° or 210° F. This temperature was sufficient to throw down the impurities in the water.

The whole of the water then gravitated to a settling chamber at the bottom of the machine, fitted with a drain valve, which allowed the sediment to be run off from time to time.

The next action was the filtering process—the water passing upwards on its way to the feed pump through a coke or charcoal filter chamber. This chamber was fitted with a large door for removing and renewing the coke or charcoal periodically. The water was then led to the feed pump which should be placed a few feet below the filter outlet. Then the pump could distribute the feed water either direct to the boilers at say 200 to 205 degrees F., or through economisers at whatever temperature could be gained by the waste gases, but with this very important feature that the water was freed from the grosser impurities and oil. The filter could be cleaned out and ready to operate in a very short space of time, according to its size. The apparatus was fitted with self-regulating gear for admission of water, for overflow, for air, and for excess pressure. One great feature of this machine was that by condensing the exhaust steam the back pressure was taken off the auxiliaries.

Mr. James Kidd said that he had recently made a number of trials with two economisers of the Lowcock and Green type. One of the economisers experimented with, consisted of 400 cast iron pipes arranged in two sets ; the pipes being $4\frac{5}{8}''$ diameter and 9 feet long, and the total heating surface 4000 square feet. The pipes were placed in a vertical position, connected at the top and bottom by longitudinal headers, termed boxes, which were connected by top and bottom branch pipes arranged on opposite sides of the economiser, on the outside of the brickwork with which it was encased. The feed-water was pumped through the economiser, entering at the lower branch pipes, and emerging at the top, on the opposite side to which it entered. He thought that the average speed of the water through the pipes should not exceed 3 inches per minute in order to obtain a high efficiency. The mechanism that the economiser was fitted with, by the makers, for keeping the outside of the pipes free from soot, did the work well, and gave no trouble. The workmanship put into these economisers was of the best description, the ends of the tubes were slightly tapered and forced into the headers, metal to metal, without any jointing material.

The number of boilers in connection with this economiser (which was of the Lowcock type) were 17, of which 14 were of the Cornish and 3 of the Lancashire type, the total heating surface being 10,000 square feet, and the grate area 400 square feet. The consumption of coal per square foot of fire grate varied from 12 to 25 lbs., and the amount of feed-water from 4,000 to 8,000 gallons per hour. He had copies in his hand of the results obtained from about 40 trials recently carried out, a fair average of which were :—

LOWCOCK'S ECONOMISER.

Quantity of feed-water pumped per hour	6·740 gals.
Temperature of feed entering economiser... ...	61° F.
Temperature of feed leaving economiser to boilers	211° F.
Average boiler pressure, per square inch	49 lbs.
British thermal units absorbed by feed-water ...	10,110,000
Temperature of gases entering economiser ...	932° F.
Temperature of gases leaving economiser... ...	534° F.

Reduction of temperature of waste gases by passing through economiser	398° F.

Another series of trials, made with a different economiser, showed a very high rate of economy.

GREEN'S ECONOMISER.

Quantity of feed-water pumped per hour	522 gals.
Temperature of feed-water entering economiser ...	131° F.
Temperature of feed-water leaving economiser ...	294° F.
Temperature of water in boilers at 52 lbs. pressure	300° F.
Temperature of waste gases leaving boilers ...	664° F.
Temperature of waste gases leaving economiser...	423° F.

It would be seen that the temperature of the water leaving this economiser was within 6° of the water in the boilers, and the high efficiency obtained might be explained by the larger heating surface and the rate at which the feed-water passed through the pipes.

In the first series of trials the speed was about 7 ins. per minute and the heating surface of the boilers 10,000 ft. to 4000 ft. of the economisers, whilst in the second series the heating surface of the boilers was 1200 ft. to 960 ft. of the economiser and the speed of the feed-water $2\frac{1}{2}$ ins. per minute.

Some authorities gave the speed from $\frac{1}{4}$ in. to 1 in. per minute and the heating surface of the economiser as 25 square feet to each square foot of fire-grate; but, in his opinion, it was a question of conditions and what was required.

Another advantage gained by using economisers was that the temperature of the feed-water was raised to nearly that in the boilers—as pointed out in the figures given in the second series of trials,—with the result that grease, impurities and scale-forming matter were released from the feed-water and collected in the economiser, and could be readily blown out by opening the blow-down pipe of the economiser.

It might interest members to know that the boilers in connection with the economisers he had mentioned work night and day for 156 hours, evaporating 740,000 gals. of city water per week, no condensed water being returned to the boilers, and were run out every eight weeks. The blow-down cocks were not even opened in the interval, notwithstanding which the water when it left the boilers was only slightly discoloured.

There was also another advantage to be gained by using economisers, inasmuch that they saved or took up a very large percentage of the heat that would otherwise go away in the waste gases when the boilers were being forced, owing to their larger absorbing power, due to the difference between the temperature of the feed-water entering the economiser and any increase of temperature of the flue gases.

Mr. J. S. O. Roberts said that it was now generally conceded that, where space was available and other conditions favourable, for economy of fuel and upkeep the Lancashire and Cornish type of boiler held the front rank. But to maintain this position it was necessary that there should be installed therewith a suitable form of economiser in order to reduce the temperature of the gases escaping up the chimney, and the heat thus saved be utilized in heating up the feed-water. Now, though information in regard to the Cornish type of boiler was most prolific, that in regard to its most useful adjunct was correspondingly meagre, and if conditions arose that were outside the normal there was found a want of analogous cases from which to draw conclusions and make comparisons.

There had come under his notice an installation of Lancashire and Cornish boilers with a total grate area of 387 square feet, burning 19 lbs. of fuel per square foot of grate and evaporating 9·5 lbs. of water per pound coal from and at 212°. These boilers had their feed-water heated by two economisers of a similar type to Green's, with a total heating surface of 4000 square feet equivalent to 40 per cent. of boiler heating surface. These two economisers, though working in series, were placed side by side in parallel flues; and the whole twenty rows of tubes of each were fed in parallel instead of, as was the usual, being bunched together in two or three nests and fed in series. When such an arrangement was adopted it was necessary that the outside supply and delivery pipes should be of ample proportions, otherwise friction in the pipes will cause retardation in the flow of water and an unequal range of temperature would result. The smallness of the outside pipes in the case under view made it possible, however, to vary the temperature in the different rows of tubes, and thus test the economiser under various conditions. For by adjusting the valves drawing off the feed at either end of the economiser, each end could be made correspondingly hotter or colder according as the valve was shut or open; and a fairly equable range of temperature could be obtained by opening both ends. A large number of temperature readings was taken to ascertain whether any difference of efficiency took place when the tubes were—(1st) hottest in front (2nd) hottest at back and (3rd) all of fairly equal temperature. The result seemed to show that the amount of heat absorbed by the economiser in each case was almost the same, the variation being very little. With thirteen readings taken of eac h case with other conditions similar the figures worked out :—

Hottest in front	... 9,680,000	BT.U	per	hour
Hottest at back	... 9,876,000	,,	,,	,,
Fairly equable	... 9,862,000	,,	,,	,,

By having the two economisers parallel it gave an opportunity of testing the efficiency of the economisers when fed with water at a low or high initial temperature, for in this arrangement, the feed water entered the first economiser cold, was heated up by it and then passed into the second economiser. The second economiser thus received its feed water with a high initial temperatare. An average of twenty-seven readings gave a difference of temperature in feed supply and delivery, of 90·5 in first economiser and 66 in the second, being 57·8 per cent. in first, and 42·2 per cent. in the second, but as the average readings of flue gases were 5 per cent. lower in second economiser, the first economiser did not excel its partner as it first appeared. This closer equality in the efficiency of the two economisers was strengthened by the fact that the reduction of temperature of flue gases was in each case the same. The two economisers under notice passed 6220 gallons of feed water through them per hour, fluctuating at times from 3000 to 7000. The feed was varied from 59·5° to 216° F., which gave an efficiency of 14 per cent. of total boiler power. "Actually a much higher efficiency should be recorded to the economiser because of the higher efficiency given to the boilers by the activity of the hot feed.

When using an economiser the feed should enter the boiler at a slightly lower temperature than that of the water in the boiler at the boiler pressure. How large a difference there should be between them, depended largely on the amount of fluctuation in the quantity of water evaporated per hour. It also depended on the temperature of the water in the hottest tube of the economiser, which should never be allowed to rise to that temperature when steam would be formed. Hence it was an advantage to have equal temperatures in each tube, which temperature could then be little below that of the boiler if the feed were regular; but should a great range of temperature exist between the tubes, the average temperature was low and the feed could not be brought near to that of the boiler temperature without the formation of steam in the hotter tubes with the serious risk of water hammer caused by the mixed elements of steam and water. The feed to the boiler should be as regular as possible, for intermittent steam might form at the time of minimum supply and great difficulty would be found in pumping water into the boiler. The flue gases entering the economiser should not be of too high a temperature. It was not good practice, in his opinion, to much exceed 700°, otherwise decomposition of the tubes, which was always in evidence, more or less, became much more aggravated. He had found that the greater the difference between the temperatures of outside and inside of tubes the greater the decay. Should the flue gases be too high, it was better to first reduce them by supplying more boiler heating surface, than by increasing the number of tubes in the economiser to absorb the additional heat. The economiser should not do the duty of a boiler, it was not to raise steam, but merely heat feed water.

With an even distributed temperature and regular feed economisers gave little trouble, but if the water was intermittent, water hammer and steam formation were liable to occur. One of the greatest advantages of an economiser that should not be lost sight of, was the part it played in filtering the water before entering the boiler. All sediment and other impurities were precipitated in the economiser, and the boilers though only blown down at long intervals, showed little discolouration in their water. Economisers should be blown right down empty at least once a week. To do this effectively, the feed from pumps should be shut off, and the bottom blow-off valve opened, while the economiser was under heat from gases. If there was a bye-pass into the top delivery pipe of the economiser from the pumps, the operation was more effective. It was useless blowing off the economiser when working, as the water simply passed along the outside feed pipes to the blow off without cleansing the internal tubes and boxes in the least. When the rows of tubes were in parrallel it was not necessary to cool down the economiser in order to fill it. It could be filled through the hot gases when passing around it, if the precaution was taken of closing down the valve leading to the second economiser or to the boiler before pumping water into it. For if this was done the water simply found its own level against the pressure of air and steam generated, which latter was not formed in dangerous quantities, and could be blown off by careful opening of the safety