PART III.

SUGGESTIONS FOR NEW FEATURES WHICH MAY BE ADDED IN THE FUTURE TO AN INTERNATIONAL CODE AS THE RESULT OF FURTHER DISCUSSION AND INVESTIGATION.

1. The Question of the Use of a Special Factor, Depending on the Quality of the Fuel, to be Used in Calculating the Net Working Efficiency of the Plant.—Up to the present time, in most boiler plant tests the efficiency has been calculated simply from the actual amount of heat present in the fuel, and no allowance has been made for different qualities of fuel, and for the different theoretical efficiencies possible.

For example, if one plant is using the finest washed nuts with, say, 3 per cent. ash and 14,000 B.Th.U. per lb., and another plant is using merely refuse coal with, say, 35 per cent. ash and 7000 B.Th.U. per lb., and no auxiliary steam is used in each case, the efficiency is calculated in the same way in both instances, that is, on the amount of heat actually present in the coal. Thus, the first plant may be working at 72 per cent. net working efficiency, and the other at 59 per cent., and according to the methods of calculation generally adopted, the first plant is regarded as doing very much better than the second. Stated in this way the results are completely misleading, because the fact is ignored that with the good coal the price may be, say, £2 10s. per ton, and the possible efficiency 80 per cent., while with the inferior coal and the same amount of skill and attention, the efficiency can only be 65 per cent., but the price is £1 5s. per ton.
SUGGESTIONS FOR NEW FEATURES

The reason is, of course, that with inferior coal the percentage of ash is so great that, even with mechanical stokers, it is not easy to prevent excess air passing through the fires, it is much more difficult to burn the coal with the evolution of radiant heat, and an excess of heat is lost in the ash.

This is, however, very unfair to the plant using inferior coal, both scientifically, as well as from a practical and business point of view. For example, to look at the matter in another way, take a case of a plant burning 200 tons a week of the inferior coal at 25s. per ton, with a net working efficiency of 59 per cent., and with an annual coal bill therefore of £12,500. If expensive coal of 14,000 B.Th.U. at £2 10s. per ton is substituted, it is quite true that the efficiency is increased to 72 per cent., and the amount of coal burned is only 163 tons per week, yet the net result of this is to increase the fuel bill of the factory from £12,500 to £20,375 per annum. According to the usual methods adopted, however, as in both the Codes, the plant is now doing better, in spite of the fact that the practical result would be to lose £7,875 per annum! This, of course, is an absurdity, and I have in the past tried to get over this difficulty to some extent by always giving the cost of evaporation of 1,000 gallons of water, although this has the defect that it is dependent on prices of fuel, which vary considerably in different neighbourhoods. I would suggest, however, that this item be included in the International Code.

Some makers of appliances for steam generation understand the point very well, and many of the remarkable results that are published as having been obtained with various appliances will be found, on investigation, to be really due to the fact that especially good quality coal has been used. If such coal had been used on the original plant, the same results might have been obtained without the appliance at all.

Thus, it is a favourite method to take, for example, a hand-fired plant with natural draught, and simple fire-bars burning average coal of moderate price and quality, and to fit on some appliance to burn cheaper fuel with the object of showing a
saving. The only fair and reasonable method of proceeding is to burn the same quality of coal as before, and if further trials are carried out with cheap refuse coal or expensive good quality coal, then to have at the same time analogous trials with these coals on the plant as originally working. It is amazing the number of tests published that trust to the steam user to ignore these elementary facts. A given furnace stated, for example, to save, say, 30 per cent. of the coal bill, will be found on investigation to have been tested with cheap refuse coal, of which only a limited supply is available, as against average priced coal on the original plant. If, in the later case, the same refuse coal had been used, whilst the results might not perhaps have been as good as with the special furnace, the real saving would have been about 10 per cent. instead of 30 per cent. When this is pointed out the reply is usually, as I know from experience, that the test has been carried out according to the usual practice, and sufficient allowance has already been made in calculating the efficiency from the actual heat value. On pressing the point, however, refuse is then as a rule taken in the “Civils” Code, in which no allowance has been made for different qualities of fuel, although in the test in dispute no attempt has been made to carry it out according to this Code.

What is required is that there should be added to the ordinary calculated efficiency a further quantity $X$, which would vary according to the heating value and quality of the fuel. The value of $X$ would be expressed as a curve, which I would suggest calling the Standard Curve of Efficiency Correction for the Diminishing Heat Value of the Fuel, so that the value of $X$ would increase as the value of the fuel decreased. This would put all boiler plants on a real comparative basis, and give proper credit to the man who is burning a cheaper and inferior fuel, and doing a national service as well. Such a curve could only be obtained experimentally, and this I suggest would be one of the points of investigation for the International Committees.
SUGGESTIONS FOR NEW FEATURES

What would be necessary would be for, say, twenty or so thoroughly representative coals to be taken from the highest to the lowest quality, and a complete series of experiments carried out under various conditions of steam generation on, say, "Lancashire," "Marine," and "Water-tube" boilers with, for example, (1) rated evaporation, (2) 20 per cent. overload, (3) 20 per cent., and (4) 50 per cent. below rated load, both with hand firing, and different types of mechanical stoker. If a whole series of trials were carried out in this way, on a well equipped experimental plant, sufficient data would be obtained to elaborate such a curve with a considerable amount of accuracy.

Based on the experience of over a thousand tests, I would suggest the curve as given in Fig. 21 (next page). I do not pretend that this curve is accurate, because, as already stated, it would need to be based on much experimental work, but it is of interest as illustrating the principle. Thus, in the Specimen Test, the value of X with coal of 11.715 B.Th.U. would be 50, and this would then be added to the figure of 59.4 per cent. for the net working efficiency. The result, 64.4 per cent., which would be called the C.D.H.V. net working efficiency (corrected for diminishing heat value). In the example just mentioned the plant with 14,000 B.Th.U. coal, and 72 per cent. efficiency, would have added the figure of 0.5, making 72.5 per cent. efficiency; and the plant with 7000 B.Th.U. and 59 per cent. efficiency would have the figure of 23.5, making 82.5 per cent. The latter plant would, therefore, be much the best by calculation, as it is in practice.

2. Labour, Attendance, Repairs, Upkeep, Interest and Depreciation.—Another difficulty is that of the cost of working the plant, quite apart from the fuel bill. If, for example, a plant of ten "Lancashire" boilers has only four men per shift looking after it, together with reduced labour at night, and a wage bill of, say, £20 per week, working on 60 per cent. efficiency, and the plant is then reorganised to work on an efficiency of 75 per cent., but the wage bill is increased to
£30 per week, this extra £500 per annum ought to be deducted in calculating the net result. In the same way, if many additional appliances and instruments are installed, so that the cost of repairs and upkeep is increased from, say,
SUGGESTIONS FOR NEW FEATURES

£200 to £500 per annum, then this extra £500 should also be deducted.

- In almost all boiler plant tests these considerations are ignored, and no instructions are given on the point in any code. This is particularly unfair in the reverse instance on a very large plant of, say, sixteen boilers, where mechanical stoking and mechanical coal and ash handling is installed. Twelve men per shift may have been working under hand conditions, and the installation of mechanical appliances throughout may save the labour of eight men, that is, several thousand pounds per annum in wages. It is unfair that this saving should not be added to the efficiency figures, since the steam or power used has been deducted.

There is also the question of interest on capital, and depreciation. A firm may have a boiler plant of ten "Lancashire" boilers which has cost complete, say, £25,000. If this plant is reorganised to improve the efficiency and a further £15,000 spent on economisers, water-softening plant, mechanical draught, mechanical stokers, instruments such as CO₂ Recorders, water meters, etc., then there must be deducted from the saving, interest on this £15,000 and depreciation on the new plant. If we take the interest as 6 per cent., and depreciation as 10 per cent., this corresponds to an annual sum of £2400, or, say, 1200 tons of coal to be deducted in calculating the real net saving, which makes a very substantial difference in the figures. This important practical point is also ignored in all boiler plant tests, and some of the published results of tests would look very different if such figures were included. I think that the whole question should also be investigated by the International Committees, but would suggest the following basis:

In every case the cost of the labour, attendance, repairs, upkeep, interest and depreciation be calculated, and then expressed as equivalent tons of coal per annum. For example, if in a boiler plant of ten "Lancashire" boilers, burning 10,000 tons of coal valued at £20,000, the total cost was
£35,000, the interest at 6 per cent. and the depreciation at 10 per cent. would correspond to £5600 per annum, and the cost of labour, attendance and repairs was £2000, the total cost would be £7600, that is, 3800 tons of coal per annum or 38 per cent. of the coal bill. I would suggest that the final efficiency figure would then be the C.D.H.V. net working efficiency, less 38 per cent. of this figure, that is, if the C.D.H.V. was 85 per cent., the final figure would be

$$85 - 29.75 \left(\frac{38 \times 85}{100}\right) = 55.25 \text{ per cent.}$$

Some such method as this would get over many practical difficulties, and bring into true perspective the real practical value of plant, machinery and appliances constituting a boiler plant, including all the important items of capital outlay, repairs and labour and attendance. It would do away also with the absurdity of a large boiler plant being worked at a very low evaporation so as to get a high efficiency. If, however, the interest and depreciation on the capital outlay of this large plant was included, the proper value of such a proceeding would then be apparent at once.

3. Dust and Grit in Chimney Gases.—In connection with the difficult question of recording the amount of black smoke, nothing is ever mentioned about dust and grit in the chimney gases, and this point is now becoming important since the modern power station practice is to have very short steel chimneys. Although there may be no smoke, the amount of such grit and dust given off can be easily a serious matter, as it is thrown out over a very restricted area. I am of the opinion that the International Committees should devise some standard method of testing chimney gases for dust and grit, so that this would be included in the International Code. One idea that suggests itself is to insert a bent pipe with an expanding vertical nozzle in the chimney base, so that the area of the nozzle could be made a standard proportion of the inside area of the chimney at this point (say 5 per cent.). The other end of the pipe would be connected to a metal box kept
by means of a small fan (hand or motor driven) at a standard section (say 10 per cent.) above that of the chimney base. Consequently 5 per cent. of the chimney gases would be pulled through the box, which could be provided with baffles and a cloth bag to collect the solid material, which would then be weighed and expressed as so many ounces per hour, or by some other convenient term.

4. Steam Meters.—Another point for investigation by the International Committees is the question of using steam meters to measure the output of the plant instead of, or in addition to, the measurement of the water evaporated. The “Civils” Code does not mention steam meters at all, whilst, as already seen, the American Code permits their use for testing auxiliaries. There is no doubt that the logical method of determining the output of a boiler plant is to measure the useful steam actually passing into the factory, if only this could be done with sufficient accuracy. Steam meters have already been referred to on page 103 in connection with the measurement of auxiliary steam, and since this—in averages—is, say, 6 to 10 per cent. of the production, a steam meter is very satisfactory for the purpose. The matter is not, however, quite so easy when the total output and the net working efficiency of the boiler plant have to be calculated.

There is no doubt that the invention of a simple and reliable form of steam meter has been one of the most difficult problems in engineering. The steam may contain different amounts of water, and, if superheated, the temperature may vary considerably, whilst the amount of steam passing may fluctuate suddenly through a wide range, and there may also be a pulsating action. Further, as already stated, the steam often has a violent swirling motion in the pipe, so that it is very difficult to get a true figure for the average velocity. However, these difficulties have now in general been surmounted, and there is at present on the market seven different makes of steam meters.

Steam meters can be divided into two general classes.
The first consists of meters in which the whole of the steam passes through the body of the meter, as represented by the "Bayer" and "St. John" meters. In these meters a cone or disc is lifted off its seat according to the amount of steam passing, and a recording mechanism is actuated by this means.

The second class consists of meters in which a disc or plug is inserted in the steam pipe line, and connected to the recording mechanism. In the "British Thomson-Houston," "Curnon" and "Sarco" meters the disc or plug is a "Pitot" tube, whereas in the "Bailey" and "Kent" meters the principle is that of a "Venturi" tube. The amount of steam passing is proportional to a small difference of pressure shown either by these "Pitot" or "Venturi" tube devices, and this pressure varies from zero to say \( \frac{1}{2} \) lb. per sq. in. In measuring this small pressure and expressing it as lbs. of steam passing in the pipe the "Bailey" meter uses a sealed cell floating in mercury, the "Curnon" and "Kent" meters a diaphragm, and the "British Thomson-Houston" and "Sarco" meters a modified "U" tube with float.

The makers of most of these meters claim an accuracy of 1 to 2 per cent., but the trouble seems to be that most meters are not as accurate when the passage of the steam is fluctuating. I think that, subject to further investigations, steam meters ought to be included in the International Code as a useful addition to the measurement of the steam output of the boiler plant.