SUMMARY.

In summing up, the whole question of boiler plant testing I should like to emphasise again that the first necessity of any International Code is that it must be practical, consistent with reasonable accuracy, so that testing of boiler plant can be carried out regularly all the year round.

Such a code in my opinion should include the following, as already discussed in detail:—

1. The separation of boiler plant testing from every other form of testing, especially that of steam engines.

2. The duration of the test to be 800 hours, and longer if possible, six hours to be allowed if peculiar local conditions demand it, but no test to be less than this.

3. In every case a long check test of one week (168 hours) or longer, to be essential, so as to include night and week-end performances.

4. The dried fuel to be analysed in a bomb calorimeter and a calculated heat value be taken based on the percentage of water and taking the temperature of the boiler plant exit gases as 212° F. The determination of hydrogen, with the corresponding calculated lower heat value, to be abandoned.

5. The use of a CO₂ Recorder for the whole duration of the trial to be regarded as essential.

6. The gases to be analysed for CO and unburnt gases, either by the use of the "Duplex Mono" or by taking automatically a very large sample, say 20,000 c.c. at the rate of at least 2000 c.c. per hour, and analysing this sample with the "Orsat" or other hand apparatus.

7. In measuring the boiler feed water approved makes of water meter be allowed, provided they are fitted with a calibrated test tank, or tested before and after the trial.
8. The determination of the moisture in the steam be abandoned until reliable methods are discovered.

9. The specific heat of superheated steam be taken according to Knoblauch and Jakob's work and the figure of 0.18 be disregarded.

10. All the steam used auxiliary to the production of steam must be determined with great care, and deducted in calculating the efficiency. In the case of steam jets, either a steam meter or some form of surface condenser to be used.

11. The new figure of "lbs. of water from and at 212° F. per 1,000,000 B.Th.U." be included in the test figures.

12. The method of calculating the results shall be essentially from the heat of the fuel, and not by the "heat balance sheet" method based on the flue gas analysis.

The general testing methods in vogue in the world to-day are academic and unpractical, although very few tests indeed can ever have been carried out according to the "Civils" Code.

Certainly most of the boiler plants of Great Britain are small, say two or three "Lancashire" boilers, yet an International Code must be applicable to all plants, no matter how large, and the larger the plant the more urgent is the necessity for continual testing. The impossibility of the "Civils" Code methods is best represented by taking an average fairly large-sized, factory boiler plant, of, say, ten "Lancashire" boilers burning 10,000 tons of coal per annum, with a fairly complete array of accessories in the way of economisers and mechanical stokers, but without superheaters, and with two different, high and low, boiler pressures.

In the first place, the instructions are to insert steam driers in the steam pipe circuit of the plant, and then to determine the moisture in the steam. This means on the given plant, with, say, two 8-in. steam mains, high pressure and low pressure, that the whole factory must be shut off, whilst two lengths of the main steam pipes are taken down and two 8-in.
steam driers fixed in the circuits, with special "making-up" pieces, a formidable job itself. Huge water tanks to measure the feed-water have to be carted in, and in most cases the greater part of the boiler feed pipe circuit will have to be dismantled to fit in the tanks. If we are to assume that definite instructions are given to determine the amount of steam used by the 150 or so steam nozzles of the mechanical stokers, then either apparently all the small steam pipes supplying these stokers are to be dismantled and a fresh steam pipe circuit connected up to one of the boilers, which has to be tested separately; and the evaporation measured, or else each of the nozzles must be measured for area and a crude empirical formulae used. That is to say, there are really two boiler tests, which means a separate smaller set of water measuring tanks. In addition to this, samples of flue gas have to be taken in small tubes filled with mercury, and a continual series of CO₂ analysis carried out by "Orsat" apparatus, and at the beginning and end of the trial every one of the twenty fires has to be measured for thickness by means of the "tools" already discussed. Then there is a complete chemical analysis of various samples of coal to be carried out, that is, the determination of the carbon, oxygen, hydrogen, etc., in addition to the heating value by means of a bomb calorimeter.

Such a test would dislocate the usual working of the boiler plant for at least a month, and on the actual test at least a dozen trained observers would be required, whilst, as an anticlimax, three hours is sufficient for the test! It is therefore not to be wondered at that boiler tests are not carried out according to the "Civils" Code, and that boiler testing is not popular when such methods are regarded as necessary.

It should be the endeavour of an International Code to avoid such mistakes. We have got to remember that there must always be a considerable margin of error. Thus the coal and water, whether by mechanical or laborious hand means, cannot be weighed to within 1 per cent. of absolute accuracy, and certainly the percentage of CO₂ cannot be
determined to within $\frac{1}{2}$ per cent., if only because of the difficulty of obtaining a true average sample. It is therefore no use going to a lot of trouble over points that are of no practical importance, and what is necessary is to concentrate particularly on the points that matter, such as the weight of the water evaporated, the weight of the coal used, the proper sampling and analysis of the fuel, and the auxiliary steam or power.

I am sure that the combined experience of American, British and French engineers, who have had actual practical experience of boiler plant testing would soon formulate a practical and accurate International Code which would be of immense benefit to the engineering profession in all the countries concerned, and if this book is a help towards such a deserving object its success will have been achieved.