DISCUSSION ON DON'S PATENT SMOKE PREVENTER AND FUEL ECONOMISER.

MR. W. D. CRUICKSHANK said that the subject under discussion was one of considerable importance to us all, embracing, as it did, a problem which, up to the present, was practically unsolved, a fact which, so far as it concerned us, should act as an incentive towards its successful solution. The author of the paper had given us a clear practical account of Don's Smoke Consumer, and had explained in detail the principle of its action as an economical appliance. The paper was supplemented, and, he thought, very sensibly, by the trial on board the steamer "Narrabeen," where members had ample opportunities of seeing for themselves and judging accordingly. The "Narrabeen" was a thorough good smoker, one of the best, or rather the worst, in Sydney. She burnt small and highly bituminous coal and was specially selected for the purpose in order to make the test as severe as possible.

Smoke consumption, or prevention, had for the last 40 years occupied a large amount of public attention, and this was due in a sense to the fact that like the poor it was always with us. Many able men had spent a large amount of time and money over it, but the results of their labours had been comparatively barren. All or nearly all the schemes proposed and patented with this object had been more or less similar in design, and in a very large majority of cases where they partially succeeded in preventing smoke this was almost always attained by sacrificing and impairing the evaporative efficiency of the boiler. What was wanted, and what Don's appliance claimed to have accomplished, was to have smoke consumption in happy combination with economical working. Mr. Key had in a very interesting and instructive manner explained how (in his opinion) this came about, and with your permission, he (Mr. Cruickshank) wished to make a few general remarks having a direct bearing on the subject before us.

which would perhaps be of some interest. The knowledge that at least 30 per cent. of the heat in the coal was lost in the furnace was ample justification for the many efforts made to prevent, or at all events lessen, the waste, and, so far as he could judge, what had been done with this appliance was undoubtedly a step in the right direction. It had four prominent qualities which must and would go a long way in recommending it. It was exceptionally simple, wonderfully cheap, easily applied to any boiler, and last, not least, there was nothing in it or about it to wear or get out of order. Many engineers had expressed the opinion that they had seen the same thing tried 30 years ago, but that nothing came of it. No doubt this was in a sense true; they had and he had himself seen steam applied in a somewhat similar manner to effect the prevention of smoke, but with this essential difference, that there never had been any appliance that he had seen or read of which had the power of forcing anything like the quantity, or even a fraction of the quantity, of air into any furnace at such a velocity, and of distributing it in such a manner as would result in the compulsory combustion of certain constituents in the coal, which but for this would pass away unconsumed. This to him seemed the secret of the whole affair, and all the recent experiments made confirmed this. Let us look for a moment at the combustion which took place in an ordinary furnace and consider it from a practical standpoint. A British unit of heat was the amount of heat required to raise 1lb. of water one degree Fahr. (from 39° to 40°), and if we converted that heat into work, it would be equivalent to 772 pounds raised one foot high. Now one pound of pure coal (carbon) had 14,500 units of heat in it, and as each unit was capable of raising 772 pounds one foot, we had 14,500 heat units

772 foot pounds = 11,194,000 feet, the height to which the pound would be lifted. Or, to put it another way, if we could convert all the heat in a pound of coal into useful work, it would develop power enough to raise one pound weight over 2,000 miles. Following this up, let us see what the actual amount of work is, in a pound of coal, expressed as horse-power. Assume it takes one hour to lift this pound weight to the above height, then all we had

to do was to divide the height 11,194,000 feet by 33,000 pounds × 60 minutes, and we got 5·65 horse-power, which exerted for 60 minutes would raise this weight. Compare this with our best modern practice, and we got a result which taught us a wholesome lesson. In triple expansion engines, carrying a working pressure of 160 pounds steam, and where the principle of expansion was utilised to the greatest possible extent, we were doing what was considered real good work when we got one horse-power from 1¾ pounds of coal, and as it had been shown that the total heat in 1 pound of coal would (if entirely utilised) develop 5·65 horse-power; then, if we set our most modern engine to do this work—develop the same power—we had 5·65 horse-power × 1·75 pounds = 9·88, or say 10 pounds of coal required to do what could be done with 1 pound, provided we could convert all the heat into work; but the above results showed very clearly that with all our modern improvements we could convert about only 10 per cent. of the available heat in the coal into useful work. Then came the question: 1st, where did it go to? and 2nd, could we not do something to prevent, or, at all events, lessen this enormous waste? As before stated, at least 30 per cent. was lost in the furnace, some by radiation, but the greatest loss (so far as the heat was concerned) was in the engine itself, and this took place when the exhaust steam entered the condenser or the atmosphere. As an example, take the boiler pressure at 100 pounds per square inch, the total heat in steam was 2,117° Fahr., and assume it worked the engine in the ordinary way, and was expanded down so that it entered the condenser at atmospheric pressure, the total heat in it then would be 1,178° Fahr. The difference between 1217 and 1178 was 39°, so that in working the engines we had just managed to utilise and convert into work about 3¼ per cent. of the total heat in the steam. All this immense amount of heat in the exhaust steam was wasted (less the amount which is represented by the temperature of the feed water) and the best of the joke was that we had to construct expensive condensers, pumps, levers, and all other gear, to assist in working this heat, and so far as could be seen from the present state of our knowledge, we were to keep on doing it. To return to the furnace:

how came it we lost so much there? In an ordinary furnace the chemistry of combustion taught us that when 1 pound of pure coal (carbon) combined with 2·66 pounds of oxygen, we then got perfect combustion in the form of carbonic acid, but when carbon was burned (as it always was in ordinary practice), with an insufficient supply of oxygen, we got imperfect combustion in the form of carbonic oxide, the coal having taken up only one half of the required proportion of oxygen, resulting in a loss of at least 30 per cent. Experiment showed this very clearly, for as we had seen, the heat generated by the perfect combustion of one part of carbon to carbonic acid was equal to 14,500 units, whereas the heat generated by the imperfect combustion of carbon to carbonic oxide was equal to only 8,800—a difference and of course a loss of 5,700 units. Now, it was these 7,500 units that we must get hold of, and Don's appliance claimed to be able to do this, to some extent, at least, by instantaneously supplying the required amount of oxygen, thereby compelling and therefore increasing the formation of carbonic acid, and as a natural consequence decreasing the amount of carbonic oxide. So far as he could judge, the appliance did do this to some considerable extent; and from what he had seen of it, the conclusion had been forced upon him that when properly fitted and carefully regulated, it would not only consume the smoke, but would do it economically. Respecting the motive power which supplied the injector, the question would naturally be asked, would not the amount of steam used by the instrument counterbalance or reduce the economy shown? The answer to the question was simply this, practical experiment went to prove that the extra and more efficient combustion in the furnace was sufficient, and more than sufficient, not only to pay for all the steam used, but to leave a balance to the good. As a smoke consumer, many present had had an excellent opportunity of seeing its practical application and of watching its effect, and he felt quite sure its exceptional efficacy in this respect could scarcely be questioned, and he was confident that its future development as an economiser of coal would be watched with keen interest, not only by ourselves, but by the public generally. In conclusion, it might be pointed out that the

burning of liquid fuel with success and economy had only been rendered possible by utilising the principle of the injector, and also that the process of injection into the furnace was very similar to Don's, with this difference—that there was a mixture of oil and air instead of air and steam. Don's appliance was certainly not perfect; it might, and no doubt would be improved chemically and mechanically, but all that had been done with it proved that it did embrace a principle which was in accordance with the theory of combustion, and if properly handled would result in decreasing to some extent the present enormous waste of heat.

Mr. Wilson said he was sorry that he had been unable to be present at the tests on the "Narrabeen." Some reports had been prevalent to the effect that it was not a new invention; but it was at all events a great improvement on the systems at present in vogue. He had seen some experiments conducted with the view of consuming smoke, and a patent had been taken out for introducing steam above the furnace bars, but it was not followed up. He had also seen another method, by which steam and air were conducted over the bridge, which was made of metal with the sides perforated. It appeared Mr. Don's invention was effectual both as a smoke consumer and as a fuel-economiser.

Mr. Briggs was greatly astonished at the celerity and thoroughness with which Mr. Don's invention worked on the "Narrabeen." He had seen and made many smoke-consumers, and could corroborate Mr. Wilson's remarks as to the superiority of the method under consideration.

Mr. Wilson wished to know whether any harm could happen to the furnace-bars.

Mr. R. Sands said that the process was in operation at his factory, where it acted very satisfactorily, and saved three bags of coal out of every twenty. The furnaces were also kept cleaner with half the trouble which had formerly to be taken. The Inspector of Nuisances was satisfied with the smoke-consuming power of the invention. He should be glad to show any members the apparatus working at his factory.

Mr. R. Pollock said that gentlemen of scientific attainments in the city thought that the effect of the Don apparatus would be very great on the bars; but that was a question for time and observation to solve.

Mr. Norman Selfe instanced the case of an injector at the Kerosene Works, which had been in use for a long time, where the refuse oil was used, which would be a much severer test than this process of Mr. Don's; and considering the slight effect the oil injector had, he thought Mr. Don's would do but little harm. He might mention that two months ago a patent had been taken out in this colony for a split bridge. The invention under discussion would be of use to the owners of the innumerable small vessels plying in this harbour.

Dr. Storer was pleased at the manner in which the apparatus had done the work on the "Narrabeen."

Mr. Trevor Jones had applied the process to the Crown Street engines, and in cutting off smoke it was successful. He hoped it would be a success in other places. In Great Britain, especially Glasgow, there were many smoke-consumers at work.

Mr. G. Fischer showed some diagrams relating to smoke consumption in Germany and elsewhere, and spoke of the difference between Mr. Don's invention and others which were in operation. Sufficient consideration was not paid to the training of firemen.

The President said he was glad to see Mr. Don's invention so far successful, but he was not prepared to say that it could not be improved; for instance, the apparatus might be made automatic. He (Mr. Nelson) and some other gentlemen were at present conducting a series of experiments with water-gas, and he thought that this gas might in some way be made to serve the purpose of a smoke-consuming apparatus.

Mr. Key said he had been asked to write the paper, and as he was Engineer to the Company, he had simply described the apparatus and the facts connected with it. He was sure that he would nowhere meet with a more intelligent body of engineers than the New South Wales Association. He had advised that the invention

TABLES REFERRED TO IN OUR REPORT OF 27TH MARCH, 1889.

Test Trial of the Don's Patent Smoke Preventor and Fuel Economiser on board s.s. "Narrabeen," 22nd March, 1889.

Starting Time.	Steam.	Vac.	Compound Gauge.	Revolutions per minute.	Temperature, Hot Well.	Smoke.	Pyrometer.		Coals.	Total Revolutions from 1 p.m. till stopping.	REMARKS.
							FIRING.	BEFORE FIRING.			
10.50 a.m.	92 lbs.	23 inches.	6¼ lbs.	40½	...	Very light.			2,333 lbs.	...	Starting from wharf. Fires very light.
11.0 „	90 „	22¾ „	5½ „	40	106 deg.	„			...	...	Commenced to make up fires.
11.15 „	90 „	22½ „	6 „	39½	...	Grey.			...	...	Water in starboard, 7⅜ inches; port, 7¼ inches.
11.30 „	90 „	22¾ „	6 „	40¼	110 deg.	Light.			...	...	Fires bright: bars well covered, about 6 inches thick.
11.45 „	92 „	22¼ „	6½ „	40½	...	Nil.	Deg.	Deg.	...	...	Water in boiler when underway.
12.0 p.m.	89 „	23 „	5½ „	39¾	110 deg.	Very light.	990	890	...	...	Starboard, 8¼ inches; port, 9 inches.
12.15 „	90 „	23 „	5¾ „	40	...	„	...		...	...	Light S.E. breeze and freshening; 10.55 turning round heads.
12.30 „	90 „	23½ „	5½ „	40	112 deg.	Nil.	950	800	2,246 lbs.	...	
12.45 „	89 „	24 „	5¼ „	39½	...	Light.	...	...	...	...	Turning round Cockatoo Island at 11.45.
1.0 „	85 „	23½ „	5 „	39	108 deg.	Nil.	950	800	...	...	Turning inside Heads at 12.20.
1.15 „	87 „	23½ „	5 „	39½	...	Very light.	...	...	...	...	Turning round Cockatoo Island 1.15 with fresh S.E. wind.
1.30 „	92 „	23 „	6 „	40½	112 deg.	Light.	900	875	...	...	
1.45 „	89 „	23 „	6½ „	39	...	„	...	...	...	...	
2.0 „	89 „	23 „	5½ „	40	110 deg.	Nil.	900	850	...	...	
2.15 „	88 „	23½ „	5 „	39½	...	Very light.	...	...	...	...	Turning inside Heads, 2.15.
2.30 „	89 „	23¼ „	5½ „	39¾	108 deg.	Nil.	950	830	...	...	Turning round Clark Island, 2.50.
2.45 „	88 „	23 „	5½ „	39½	...	Light.	...	...	2,189 lbs.	...	
3.0 „	90 „	23 „	6 „	40	109 deg.	„	980	850	...	...	Turning inside Heads, 3.0.
3.15 „	90 „	23 „	5½ „	40	...	Very light.	...	...	...	...	
3.30 „	89 „	23 „	5½ „	40	108 deg.	Light.	...	...	...	...	Turning round Clark Island, 3.30.
3.45 „	87 „	23¼ „	5¼ „	39½	...	„	...	...	...	...	
4.0 „	85 „	23 „	5 „	39¼	108 deg.	Very light.	...	...	...	...	Turning round inside Heads, 4.10.
4.15 „	82 „	24 „	4½ „	37½	...	Light.	...	...	424 lbs.	...	
4.30 „	89 „	23½ „	5¼ „	40	109 deg.	„	...	...	...	...	Still fresh S.E. wind. Revolutions vary slightly with and against breeze.
4.45 „	84 „	23½ „	5 „	38½	...	„	...	...	...	...	
Averages...	88.6 lbs.	23 11 ins.	5.53 lbs.	39.66	109.16 deg.				7,192 lbs.	9,011	Rounding Clark Island, 4.45. Finished with fires well burned down, showing bars at back. Water in glass, 7¼ inches and 8¼ inches.

Taking into account the extra revolutions got on 23rd inst., viz., 217, which is equal to 9,228
9,011

9,228 ÷ 21,700 = 2.35 per cent. loss, showing a net percentage of 13.6
2.35

11.25 per cent. gained.

W. D. CRUICKSHANK.
ROBERT POLLOCK.
G. A. KEY.
JOHN STORER.
JAMES RICHMOND.
JOHN WILDRIDGE.
NORMAN SELFE.
W. H. WARREN.

TABLES REFERRED TO IN OUR REPORT OF 27TH MARCH, 1889.

Test Trial without the Don's Patent Smoke Preventor and Fuel Economiser on board s.s. "Narrabeen," 23rd March, 1889.

Starting Time.	Steam.	Vac.	Compound Gauge.	Revolutions per minute.	Temperature, Hot Well.	Pyrometer.	Total Revolutions from 1 p.m.	Coals.	REMARKS.
10.38 a.m.	89 lbs.	24 inches.	5¼ lbs.	40	...		...	...	Water in glass at start: starboard, 5⅝ inches; port, 7½ inches.
10.45 „	91 „	23¾ „	6 „	40F	110 deg.		...	2,317 lbs.	Counter indicated at start, 3,021,856.
11.0 „	90 „	24 „	6 „	40	110 deg.		...	...	Fires at start well laid and burning brightly.
11.15 „	90 „	22¾ „	6 „	40F	...		...	...	Fresh S.E. wind, dull and raining, proceeding up and down.
11.30 „	92 „	22 „	6 „	41	120 deg.		...	...	Harbour same courses as yesterday; 11.30 steam blew off.
11.45 „	92 „	22 „	6½ „	40½	...		...	...	11.55 steam blew off.
12.0 p.m.	90 „	23¼ „	6 „	40F	118 deg.		...	...	Less wind.
12.15 „	93 „	23 „	6¾ „	41	...		...	...	
12.30 „	90 „	24 „	6½ „	40½	112 deg.		...	2,425 lbs.	
12.45 „	92 „	24 „	6¼ „	40¾	...		...	...	
1.0 „	90 „	24 „	6 „	40	114 deg.		...	...	Wind freshening. Rain holding off. Still cloudy.
1.15 „	92 „	23½ „	6 „	41	...		...	...	Water in boiler gaining. Tasted water slightly salt.
1.30 „	91 „	23¾ „	6¼ „	40F	115 deg.		...	...	Examined supplementary feed and sea cock—both shut.
1.45 „	92 „	24 „	6¼ „	40½	...		...	...	Steamer now on short runs round Clark Island, across Heads, inside Manly
2.0 „	90 „	23½ „	6 „	40	112 deg.		...	2,316 lbs.	Bay, and up again to Clark Island.
2.15 „	93 „	23 „	7 „	41	...		...	...	
2.30 „	90 „	23 „	6½ „	40F	112 deg.		...	...	During the day fires were made up in rotation every 8 to 10 minutes, and
2.45 „	90 „	23 „	6 „	40F	...		...	...	smoke was from a black to a light grey as fires burned down.
3.0 „	90 „	23 „	6¼ „	40F	112 deg.		...	...	
3.15 „	91 „	23½ „	6¼ „	40¼	...		...	...	Coal used was same as yesterday—well selected Newcastle nuts.
3.30 „	92 „	23½ „	6½ „	41	114 deg.		...	1,050 lbs.	
3.45 „	90 „	23½ „	6½ „	40F	...		...	...	At termination of trial a good deal of clinker was left on bars.
4.0 „	93 „	23 „	6¾ „	41	114 deg.		...	...	
4.15 „	91 „	23¼ „	6½ „	40½	...		...	119 lbs.	
4.30 „	89 „	23 „	6 „	40	114 deg.		...	97 lbs.	Finished trial at 4.38. Counter, 3,036,368
4.38 „	80 „	24 „	5 „	36	...		...	...	Total revolutions counter, 14,512.
Averages...	90.5 lbs.	23 36 ins.	6.19 lbs.	40.23	113 deg.	Highest reading 975 degrees. Lowest „ 875 „ Average 925 „	9,228	8,324 lbs.	Average revolutions per minute, 40.31. Water in glasses alongside wharf at 5 45 p.m.: Starboard, 11½in.; port, 12¼in.

Taking into account the extra revolutions got on 23rd inst., viz., 217, which is equal to 9,228

9,011

9,228 ÷ 21,700 = 2.35 per cent. loss, showing a net percentage of 13.6

2.35

11.25 per cent. gained.

W. D. CRUICKSHANK.
ROBERT POLLOCK.
G. A. KEY.
JOHN STORER.
JAMES RICHMOND.
JOHN WILDRIDGE.
NORMAN SELFE.
W. H. WARREN.

should be put on the market in Great Britain, where, by conferring with the various makers it might be improved and a better price obtained for it. The length of the lower part of the injector had a great influence on the velocity with which the air was delivered. He thanked them for the interest they had displayed in the invention.
