work. The formula makes it proportional to boiler pressure, and assumes a uniform piston speed for engines of any stroke; so it fails in completeness, but it aims at giving a definite meaning to calculated horse-power instead of the absurd imaginary quantity we are familiar with.

The third rule proposed was $\text{N.H.P.} = \dfrac{(d^2 + D^2)\sqrt[3]{S}\sqrt{P}}{C}$ d being high, and D low-pressure cylinder diameter in inches, S stroke in inches, P boiler pressure in lbs. per square inch, and C varying from 200 to 800 according as engines are quadruple, triple or compound. The square of the high pressure cylinder might very well be omitted entirely, but in his opinion the other factors are the right ones to take for our purpose. In practice piston speed is roughly proportional to $\sqrt[3]{S}$, and mean pressure referred to low pressure cylinder to $\sqrt{P}$. But if P is introduced in any form, there may be no need for varying the divisors for different sorts of engine; and if a constant applicable to all classes of engine can be found, it would be preferable. He would propose $\text{E.H.P.} = \dfrac{D^2\sqrt[3]{S}\sqrt{P}}{100}$ for all engines, E.H.P. being real Nominal or Normal Horse-Power, and not the fictitious N.H.P. of the former rule.

The normal piston speed in feet per minute of any engine may be assumed to be 167 $\sqrt[3]{S}$, S being stroke in inches. The normal revolutions per minute will then be

$$\frac{167 \times 12}{2S}\sqrt[3]{S} = \frac{167 \times 6}{S}\sqrt[3]{S} = \frac{1000\sqrt[3]{S}}{S} = \frac{1000}{S^{2/3}}$$

This rule then assumes neither the same piston speeds nor the same revolutions, per minute, for all engines, but makes these quantities depend by a simple rule on the stroke.

Suppose a compound engine with cylinders 10 and 20 ins. diameter by 16 ins. stroke and boiler pressure of 121 lbs. then

$$\text{E.H.P.} = \frac{20^2 \times \sqrt[3]{16} \times \sqrt{121}}{100} = \frac{400 \times 2\frac{1}{2} \times 11}{100} = 110$$

By the "B. of T." rule $\dfrac{d^2 + D^2}{30}$, N.H.P. would be $\dfrac{500}{30} = 16\cdot6$, but whether this is one-fourth or one-tenth of the power to be expected no one can say; 110 would be about what such an engine would actually work at. Its piston speed would be $167 \times 2\frac{1}{2} = 417$ feet per minute, and it would make $\dfrac{1000 \times 2\frac{1}{2}}{16} = 156$ revolutions per minute.

E.H.P. of a triple expansion engine, cylinders 25, 41, and 68 inches by 48 inch stroke, and 169 lbs. pressure, would be $\dfrac{68^2 \times \sqrt[3]{48} \times \sqrt{169}}{100} = \dfrac{4624 \times 3,6 \times 13}{100} = 2164$, or about 9 times N.H.P. by the $\dfrac{\Sigma d^2}{30}$ rule, although only about 75 per cent. of what might be got on a short trial trip. Piston speed would be 167×3.6 or 600 feet per minute, and revolutions $\dfrac{1000 \times 3\cdot6}{48} = 75.$

A quadruple expansion engine with the same size of L.P. cylinder and the same stroke would go at the same normal speed, but the power would be greater proportionally to the square root of the boiler pressure. If this pressure was 210 lbs., or $14\frac{1}{2}^2$, the power compared with the triple engine with 169 lbs. or 13^2, would be increased in the ratio of $14\frac{1}{2}$ to 13, or about 11 per cent.

To determine the boiler power he suggests the formula $G \times \sqrt[3]{P} \times 2$ for natural draft, or $\times 3$ for forced draft, G being grate area in square feet. Lloyds and the North East Coast proposed rules take H or heating surface as the criterion, but grate area is much easier to measure, and is a truer measure, for an excess of tube surface may actually depreciate the power of the boiler. Grate area alone would be a good measure of the steam-generating capacity of the boiler, but we are concerned with power, and the work obtainable from a given weight of steam is roughly proportional to $\sqrt[3]{P}$.

A triple expansion engine of sizes given above would have a grate area in boilers of about 192 square feet with natural, or 128 with forced draft, and if P is 169, $\sqrt[3]{P}$ is

5.53; and 192 x 2, or 128 x 3, will both = 384; so boiler E.H.P. will be 384 x 5.53 = 2123, against the 2164 engine power.   The N.H.P. combined, would be the mean of these (2164 + 2123) ÷ 2 = 2144.

The full formula would be—

$$\text{N.H.P. (estimated)} = \left(\frac{D^2 \sqrt[3]{S} \sqrt{P} + (G \sqrt[3]{P} \times 2)}{100} \right) \div 2. \text{ for}$$

natural draft, the final '2" within the brackets being 3 with forced draft.

If an engine is carefully balanced so as to be able to run safely at a higher speed than the normal, and extra boiler power is provided to let it take advantage of this, it would be credited with extra power by thus including the boiler formula.   Take for   instance the twin   screw O.R.M.S.S. "ORSOVA," with two L.P. cylinders each 84 inches diameter, stroke 60 inches, pressure 210 lbs., and grate area 728 sq. feet.   Engine power would be

$$\frac{2 \times 84^2 \times \sqrt[3]{60} \times \sqrt{210}}{100} = \frac{14112 \times 3 \cdot 9 \times 14 \cdot 5}{100} = 7980$$

and boiler power, $728 \times \sqrt[3]{210} \times 3 = 2184 \times 5 \cdot 94 = 12,973$, the mean of these being $(7980 + 12973) \div 2 = 10,476$.   Her actual indicated horse power on a 10 hours' run was 11900.

He thought the above a fair rule for finding the real working full power, which is what we ought to mean by Nominal Horse-Power; it is adapted from one of the rules put forward twenty years ago, which, however, gave a vague "Commercial" N.H.P.

No decision was arrived at or recommendation made at that conference, chiefly because the chairman, who was the Senior Engineer Surveyor of the Marine Board, reminded the Committee that the method of expressing power as N.H.P. was the Law, and could only be altered or expunged by Act of Parliament. He hardly admitted this; the expression is sanctioned by Act of Parliament, but its definition is only a matter of Board of Trade regulation. He thought that if the Engineering Technical Societies were to combine and

ask the Board of Trade to define N.H.P. as the estimated full power under working conditions, calculated by some such formula as that just given, no one would object. It might indeed be necessary to get Parliamentary sanction to alter the figure 100 in the clause of the Merchant Shipping Act, relating to certificated engineers on steamers into say 600, but that would be the only interference with the Imperial Act. In our New South Wales Navigation Act there is also a reference to 50 N.H.P. in the clause relating to third-class engineers that would need altering to say 300 N.H.P. if N.H.P. was defined as above. But this Act is likely to be superseded ere long by the Commonwealth Navigation Act, and it behoves everyone to see that this Act will not perpetuate obsolete and meaningless expressions. In the latest draft of this Commonwealth Bill there is no reference to Nominal Horse-Power, except in a schedule relating to engine-room manning, but here the expression is used, and formulae given for calculating it, a thing no Legislature has ventured on before.

These formulae are :—

$$\text{For reciprocating engines, N.P.H.} = \frac{\text{sums of the squares of all engine room cylinders}}{30}$$

$$\text{For rotary engines, N.H.P.} = \frac{\text{Grate area in square feet}}{\cdot 8}$$

He thought this a characteristic specimen of the looseness of modern parliamentary draftsmanship. What is the square of a cylinder? If the square of the internal diameter is meant, are we to measure it in feet or inches or millimetres? And what are "all engine-room cylinders?" Steam cylinders are no doubt intended, so that the air-pump is not included, but are the steam reversing gear cylinder or the slide-valve balance cylinder? Cylinders of auxiliary steam engines seem to be meant, so that if there is hydraulic cargo machinery the steam accumulator cylinder will be of as much account as the main high-pressure cylinder usually. Why are the steam cylinders on deck, the steam winches, &c., omitted from the tally, and why are auxiliary

engines not counted with rotary as well as reciprocating engines? The formula for rotary engines is at least intelligible, but why divide both for natural and forced draft by .8, which indeed was printed in a former draft bill without the decimal point? For the purpose of this schedule grate area in square feet might as well be taken at once as the equivalent of N.H.P. and this for both rotary and reciprocating engines. The purpose is to define some unit for measuring the work and responsibilities of the engineering staff, which is a reasonable enough desire; but we should protest against any unit or quantity found by such rules being called Horse-Power, Nominal or otherwise. There is enough confusion about the matter already, and if more is thus introduced we shall be compelled to abolish the Horse altogether, and measure our engine-powers in kilowatts.

But as Engineer Rear-Admiral Little told the British Institute of Marine Engineers at their annual dinner last year, "the tank boiler and the reciprocating engine, so dear to the heart of McAndrew, are practically things of the past"; so we ought to preen our wings for our new environment, instead of trying to creep again into the chrysalis shell of obsolete rules.

For the different types of steam turbines it will be difficult to devise a rule based on rotor dimensions; and until these get standardised by practice, we must be content to fix the N.H.P. by the boiler power, that is, by the grate area; the rule proposed above for reciprocating engines in this respect, should serve for turbines also—N.H.P. $= G \times \sqrt[3]{P}$ $\times$ 2 or 3 accordingly as natural or forced draft is used.

But the increasing use of oil fuel requires consideration, and grate area will not serve with oil-firing. We must fall back on heating surface, and if we assume that with natural draft $G = \dfrac{H}{30}$, or with forced draft $G = \dfrac{H}{36}$, and substitute these expressions for G in formula $G \sqrt[3]{P} \times$ 2 or 3—we get N.H.P. $= \dfrac{H}{15} \sqrt[3]{P}$ and $\dfrac{H}{12} \sqrt[3]{P}$ for natural and forced draft

respectively. These functions of H are the same as are used in Lloyds rule, but here they are multiplied by cube root of boiler pressure to convert Lloyds' arbitrary N.H.P. into the actual estimated working horse-power.

There is more difficulty in devising a N.H.P. formula for motors when we dispense with boilers altogether, and use internal combustion engines. The chief difficulty is to determine a normal piston speed for oil motors and such, or to say how the stroke should influence the formula. He thought we could make the assumption made by James Watt himself, in his formula for N.H.P. of steam engines, that the cube root of the stroke is a function of the piston speed, and so of the horse power. He will not enter on this subject, however, as his paper is already too long, and probably contains nothing new, although he has endeavoured not to merely compile other's ideas. He must, however, acknowledge the information given by Mr. A. E. Seaton in his works for Marine Engineers, as having been found useful.