REPORT No. 4.

The undersigned members of the Committee on the Horse-power of Steam Boilers, disagreeing with the views expressed in the report presented, ask leave to submit the following report.

After reconsideration of the subject referred to the original committee, no good reason appears for modifying the preliminary or final report of said original committee, in the definite conclusion that the horse-power of boilers for stationary engines and for heating purposes is properly defined as the *capability to evaporate a cubic foot of water per hour from and at the temperature of* 212° *Fah.* This, as stated in our previous report, should be effected with a fair average economy of fuel.

The Committee are confident that three-fourths of all stationary boilers are made and sold upon the basis of "horse-power," although many if not most of them are further qualified by some specification of dimensions which govern and control the *nominal* horse-power of the makers and the purchasers.

Upon inquiry, it seems there is generally attached to the number of horse-power at which boilers are rated, somewhat of the value given to arbitrary numbers in numbering machines of different sizes; but yet *by tradition* some length, diameter, number of flues or of tubes, with sizes of same, size of fire-box, or other particular dimensions, correspond to certain numbers of horse-power in the minds of the makers. In reply to the question as to "what constitutes the horse-power," the general response is referred to the heating surface, which is taken out in very different values for different kinds of boilers, and with sometimes other additions or deductions for supposed efficiency of surface.

Makers have generally an ideal or assumed grate surface, flue area, chimney or other condition appertaining to any of their boilers of a given size, but it does not seem that any definite rules are admitted. With this uncertainty of positive laws of proportion, boilers of any nominal horse-power of any fixed type are supplied by old and known boiler makers, of much the same weight, proportion and capacity. If cross-questioned too closely as to the surface, cubic contents, weights, exposures, *the practical boiler maker* contents himself with the assertion that such and such a boiler is 20, 30 or 50-horse-power, either for buyer or seller.

The relations of buyer and seller in the purchase and sale of a

boiler are the offer of so much money by one to pay for material or work by the other, both understanding that the boiler should have certain capability, which is rated as "horse-power."

Nor do the Committee find any reason to modify the nominal value of the horse-power of steam boilers to be based on any supposed improvement of engine, use of higher steam or discoveries of absolute dynamic force of evaporation of water (or heat used in evaporating water).

The average *stationary engine* of America and of to-day does not probably produce a horse-power in impulse of machinery or raising of water, with so little fuel as the average engine of Watt's time.

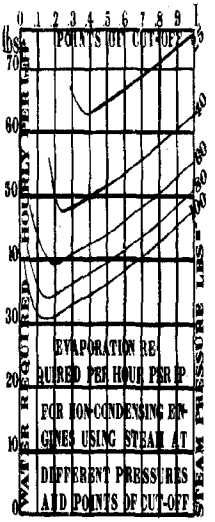
Cheapness of original construction and direction of service without cost of repair, are more studied, as a rule, than economic effect.

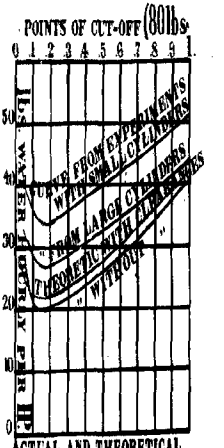
High-pressure non-expansion slide-valve engines predominate greatly, and they are far below, in economy of fuel, the condensing engine, worked expansively with double-beat valves, in use in England, where the value of a "horse-power" of the boiler was estab lished.

The thermo-dynamic effect of the evaporation of a cubic foot of water from and at 212° is about 23-horse-power, but no practical result coming near that figure has been considered possible.

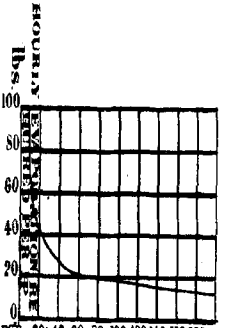
There can be quoted instances where the *effective or actual* horse-power is produced with the combustion of 2 lbs. of coal per hour, and the Committee can quote one instance in the United States of such performance by 2·13 lbs. of coal (under 2 lbs. of fuel *burned*). This instance is equivalent, with a fair boiler, to the evaporation of less than one-fourth of a cubic foot of water for an *actual* horse-power. Such examples are too infrequent to disturb the general rule. Besides, the purchaser of a boiler by a rating of horse-power expects to receive the boiler that custom has established, and that any special advantage derived from construction of engine or economical use of steam will inure to him. Suppose improvement of engine to reach one-half the theoretical limit, the absurdity of the proposition that a boiler maker could supply the owner of such an engine on a contract for a 50-horse-power boiler, with a 5-horse-power one, is too manifest for discussion.

To the further requirements of the Institute, that your Committee shall report directions for ascertaining the quantity of feed-water and its temperature, and the temperature of the steam generated, and the method or figures necessary to reduce the result to equivalent values with feed-water and steam assumed to have been at 212°, so that the

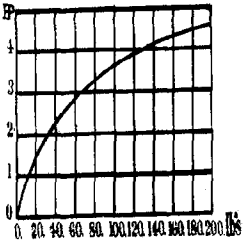




ACTUAL AND THEORETICAL EVAPORATION AT 80 lbs. PER SQ.^{in} REQUIRED PER HP FOR NON-CONDENSING STEAM ENGINES



VARIATIONS IN W'TS. OF WATER PER HP REQUIRED FOR NON-CONDENSING ENGINE USING STEAM OF DIFFERENT PRESSURES



VARIATIONS IN HP OF NON-CONDENSING ENGINES USING EQUAL W'TS. OF WATER IN STEAM OF DIFFERENT PRESSURES.

NO: 8.

LBS. PRESS.	TEMPERATURE OF FEED WATER FAH.°										
	32	50	68	86	104	122	140	158	176	194	212
212	18	17	15	13	11	10	08	06	04	02	00
230	20	18	16	14	12	10	08	06	04	02	00
248	20	18	16	14	13	11	09	07	05	03	01
266	21	19	17	15	13	11	09	07	05	04	02
284	21	20	18	16	14	12	10	08	06	04	02
302	22	20	18	16	14	12	11	09	07	05	03
320	22	21	19	17	15	13	11	09	07	05	03
338	23	21	19	17	16	14	12	10	08	06	04
356	23	22	20	18	16	14	12	10	08	06	04
374	24	22	20	18	17	15	13	11	09	07	05
392	24	23	21	19	17	15	13	11	09	07	05
410	25	23	22	20	18	16	14	12	10	08	06
428	25	24	22	20	18	16	14	12	10	08	07

NO: 9.

TEMPERATURES IN FAHRENHEIT DEGREES.

LBS. PRESS.	32	50	68	86	104	122	140	158	176	194	212
212	18	17	15	13	11	10	08	06	04	02	00
230	20	18	16	14	12	10	08	06	04	02	00
248	20	18	16	14	13	11	09	07	05	03	01
266	21	19	17	15	13	11	09	07	05	04	02
284	21	20	18	16	14	12	10	08	06	04	02
302	22	20	18	16	14	12	11	09	07	05	03
320	22	21	19	17	15	13	11	09	07	05	03
338	23	21	19	17	16	14	12	10	08	06	04
356	23	22	20	18	16	14	12	10	08	06	04
374	24	22	20	18	17	15	13	11	09	07	05
392	24	23	21	19	17	15	13	11	09	07	05
410	25	23	22	20	18	16	14	12	10	08	06
428	25	24	22	20	18	16	14	12	10	08	07

LBS. PRESSURE PER SQ. INCH ABOVE ATMOSPHERE.

number of horse-power of a boiler can be readily ascertained in accordance with the rule by *practical engineers*, your Committee answers:

1st. The quantity of water.

Having ascertained by the gauge cocks or the glass gauge the level of water at the time of commencing the trial, and having the same level at the moment of completion, the water used can be measured by a meter or in a tank (the capacity of which may be easily computed); or, in the absence of either of these, the supply of the boiler may be taken from any vessel by a temporary connection, which vessel shall be supplied with water from time to time, *weighed in*.

A cubic foot of water at 212° weighs almost exactly 60 lbs. If the temperature of the feed-water is between 45° and 70° (limits rarely exceeded), there is to be added 4¼ per cent. to the measured quantity of water (when it is measured, not weighed) for expansion between the temperature of feed and 212°.

2d. The temperature of feed water and of steam.

The temperature of feed-water can be taken by an ordinary thermometer. That of steam is practicably that of the boiler at any point not far removed from the surface of the water, and can be ascertained by inserting at such a point a well or little open cell of wrought or cast iron filled with mercury, in which mercury bath the bulb of a high temperature thermometer can be inserted. The loss of heat in conduction from the steam to the bulb is insignificant, and the thermometer will indicate, within a fraction of a degree, the proper temperature of the steam.

But the more ready way is to take the temperature as a deduction from the pressure gauge. (Of course it is necessary to have a verified pressure gauge on the boiler in such a case).

The following table gives the temperature corresponding to pressure from that of the atmosphere to 100 lbs. above, varying 5 lbs. The intermediate temperature can be taken out by interpolation:

(After Rankine).

Atmosphere,	5	10	15	20	25	30	35	40	45	50	lbs.
	227	240	250	259	267	274	280	287	292	297	Fah.
	55	60	65	70	75	80	85	90	95	100	lbs.
	303	308	312	316	320	324	328	331	334	337	Fah.

3d. The factor for evaporation, &c.

Having the quantity of water, the temperature of the feed-water and that of the steam, the following table from Rankine gives the multiplier to be used in the several cases:

Boiling Point, Fah.	Initial Temperature of Feed-water.										
	32°	50°	86°	86°	104	122	140	158	176	194	212
212	119	117	115	113	111	110	108	106	104	102	100
230	120	118	116	114	112	110	108	106	104	102	101
248	120	118	116	114	113	111	109	107	105	103	101
266	121	119	117	115	113	111	109	107	106	104	102
284	121	120	118	116	114	112	110	108	106	104	102
302	122	120	118	116	114	112	111	109	107	105	103
320	122	121	119	117	115	113	111	109	107	105	103
338	123	121	119	117	115	114	112	110	108	106	104
356	123	122	120	118	116	114	112	110	108	106	104
374	124	122	120	118	117	115	113	111	109	107	105
392	124	123	121	119	117	115	113	111	109	107	106
410	125	123	122	120	118	116	114	112	110	108	106
428	125	124	122	120	118	116	114	112	110	109	107

4th. The steam issuing from the boiler should be dry steam.

No rule can be given to judge of this; but the practical engineer, in testing a boiler, will institute such means as he finds readiest to satisfy himself on this point.

The allowance for wet steam and for loss of efficiency of the boiler in this way (and apparent excess of evaporating from this cause) is purely a matter of judgment.

To ascertain the evaporative capacity of the boiler, the trial should be made under the usual conditions of draft and pressure of steam, also of a good quality of coal (anthracite or bituminous), for which the boiler is designed.

The boiler being put up to its working pressure, the fire should be clean, and at an average level at the time of starting, and be at the same level and condition at the conclusion. The ashes and clinkers in the ash-pit must be deducted from the coal used.

Another and more certain plan is to have the boiler up to its working pressure, draw the fire, and fire up with enough wood to kindle and fresh coal both weighed in, and at the conclusion draw the fire, and

weigh refuse ashes, clinkers and coal, for deduction. In this case, the evaporative capacity of the boiler should be estimated from the time the fire is bright, but for the economy, the total water evaporated from the commencement is to be divided by the total weight of combustible used minus the refuse.

The trial, if accuracy is desired, should not be less than of ten hours' duration. A longer trial would reduce the uncertainties to a smaller proportion.

EDWD. BROWN,
JOHN H. COOPER,
ROBT. BRIGGS.

Philadelphia, Oct. 15, 1873.

ON A NEW HYDRAULIC RAILROAD CAR BRAKE.

By WILLIAM M. HENDERSON, Philadelphia.

A paper read before the Franklin Institute Oct. 15, 1873.

The principle involved in the operation of this brake is that of hydraulic pressure, and the motive power is derived directly from the steam-boiler of the locomotive, and under the control of the engineer.

There is first a three-branch or two-way cock placed underneath the foot-plate of the engine, its plug actuated by a stem carried up through the foot-plate, and furnished with a horizontal lever at top, carrying an index pointer, traversing a quadrant plate marked *on* and *off*, with gradation marks between, as a guide to the engineer in operating the brakes; and there is also a small pressure gauge, placed conveniently before him, to show him the pressure he is applying. The nozzle of the cock, marked 1, is connected by a short piece of wrought iron pipe directly to the water space of the boiler; the opposite nozzle, marked 2, is connected by wrought iron pipe and flexible hose connections, furnished with valvular couplings between the cars, as usual in such cases, and leads directly to pressure boxes placed between the brake beams of each truck; the third nozzle, marked 3, is connected directly to the water tank supplying the boiler with water.

The construction of the pressure boxes is as follows: A cylindrical vessel of cast iron is furnished, having flanges at either end; it is about 9 inches in diameter and 3 inches deep, the inner diameter being about 5 inches. Two flexible dish-shaped diaphragms are next introduced, back to back, having about half an inch space between them, and are secured in position by rings bolted firmly to the drum,