loosely in the bracket J; this wheel is caused to revolve, and thus the supplementary valve raised or lowered by the handle K, and shaft L, and the additional bevel wheels.

The object of the invention is to arrest, more or less, as circumstances require, the passage of the steam through the equilibrium valve from one side of the piston to the other, and, consequently, of regulating the descent of the plunger.

The utility of the arrangement will be at once apparent; it obviates the necessity of adopting the old and tedious process of adding and removing heavy weights, while, in case of any breakage, or other accident occurring to the pumps in a mine, the damage likely to occur from sudden shocks is prevented by the facility of adjusting the valve to regulate the descent of the plungers.

It is in Cornish engines, when used for water works, however, where the utility of this invention may be brought into practice most advantageously, especially in those works where a stand pipe is used to obtain the necessary head of water; in this case the fluctuation in the level of water is necessarily sudden, and of considerable extent, causing a similar variation of load on the engines, and rendering the machinery most unsafe and uncertain in its action.

Should the head of water in the stand pipe be low, the plunger would have a tendency to descend with a dangerous rapidity, which is checked in a moment by turning the handle K, so as to raise the supplementary valve F, thereby arresting the steam on its passage from one side of the piston to the other, the plunger consequently descending with a safe and gradual motion.

Should the head of water, on the contrary, be high, the valve F is instantly withdrawn from the seat, and a free passage given to the steam, the head of water being in itself sufficient to ensure an easy descent of the plunger.

Although the apparatus is shown in the sketch as regulated by hand, it is proposed in some instances to allow the variations in the head of the water to be the means of adjustment, an application which might be made by a simple arrangement of machinery.

It is, I am informed, Mr. Birkinbine's intention to apply his supplementary valve to the large engines he is now erecting for the West Philadelphia Water Works.

Stockton House, Philada., Jan. 10th, 1854.

For the Journal of the Franklin Institute.

The French Line-of-Battle Screw Steamship Charlemagne. By B. F. ISHERWOOD, Chief Eng., U. S. N.

The *Charlemagne* is an old French ship of war, altered to a screw propeller steamship, in 1851, in accordance with the plans of Mr. Barnes. After this transformation, she was tried by a government Commission, which experimented with her in the Mediterranean, between Toulon and Spezzia, and from whose report, principally, the following elementary data was obtained; where it was deficient, I have completed it from other

sources. I have used the report of the Commission no farther than to select from it such observed data as was requisite for basing my own calculations and deductions.

Engines.—The engines were four in number, condensing, and direct acting, making one double stroke of piston for each revolution of the screw. The steam was cut off in the cylinders by lap on the slide valve at $\frac{7}{10}$ ths of the stroke of piston from the commencement, and by cams and independent cut-off valve at $\frac{6}{10}$ ths, $\frac{5}{10}$ ths, $\frac{4}{10}$ ths, and $\frac{3}{10}$ ths the stroke of piston from the commencement.

Diameter of cylinders,	4 feet 3 $\frac{1}{2}$ inches.
Stroke of pistons,	3 " 3 $\frac{3}{8}$ "
Space displacement of all pistons per stroke,	188·014 cubic feet.

Boilers.—The boilers are four in number, with horizontal tubes returned above the furnaces. They are arranged in pairs, facing each other, with their backs against the sides of the ship, having one fire room in common, extending between the two pairs of boilers in the fore and aft direction of the vessel.

Screw.—The screw is placed in the stern of the vessel, and is fitted with the usual hoisting-out apparatus, so that it can be lifted up through a trunk in the stern, when the vessel is under sail alone. The screw makes one revolution to each double stroke of engines' pistons, and is of uniform length in the direction of the axis from hub to periphery.

Diameter of the screw,	16 feet 4·8 inches.
Pitch,	22 " 11·5 "
Number of blades,	2.
Fraction of the pitch used,	2·7.
Length of the screw in the direction of the axis,	3·28 feet.
Helicoidal area of the screw,	79·523 square feet.
Projected area of the screw on a plane at right angles to axis,	58·952 "
Diameter of the hub,	2·5 feet.

Weights of the Machinery.

Weight of engines and boilers, &c., with tools, but not with water in boilers,	217 tons.
Weight of water in boilers,	48 "
Total weight of machinery,	265 tons.

HULL.—

Length on load water line,	197·08 feet.
Breadth extreme,	53·28 "
Draft of water at the commencement of the experiments, taken below the first false keel and the stem and stern posts,	23 ft. 0·7 inches.
Mean,	24 " 2·7 "
Aft,	25 " 4·7 "
Area of immersed amidship section at above draft,	986·31 square feet.
Displacement in tons of 2240 pounds at above draft,	4680

At the above draft of water, the vessel had on board her complete armament, (90 guns,) and the following stores, viz:

Sixty days' provisions for 864 men, estimated at	85 $\frac{1}{2}$ tons.
Thirty days' water for 864 men, estimated at	78 "
Newcastle coal,	260 "

During the trials, the topmasts were on end and all the sails bent.

Experimental Results.—The data contained in the following table is a summary of the observations made by order of the Commission, noting every

half hour the number of revolutions made by the screw, as registered by the counter; the pressure of the steam as indicated by two gauges placed on the steam pipes; the amount of opening of the throttle valves, the point at which the steam was cut off in the cylinders, the quantity of coal consumed, the speed by log, and, finally, the state of the wind and sea.

The mean effective pressure throughout the stroke of pistons was obtained by an indicator, but the Commission, in presenting their results, subtracted from that *gross* mean effective pressure $1\frac{1}{2}$ pound per square inch of pistons for the friction of the machinery, and gave the remainder as the mean effective pressure in their report. This $1\frac{1}{2}$ pound per square inch I have restored, and have made the friction deduction in another manner, which I consider to be more exact.

Table of Results of the Trials of the Charlemagne.

Total distance run in metres,	49993	233301	122205	112392	185075	49903
Total distance run in geograph. miles of 6082½ feet,	26-966	125-843	65-918	60-624	100-153	26-966
Total time in hours and minutes of running the total distance,	3 4	14 30	8 0	8 40	10 31	3 4
Mean speed per hour in geo. miles or knots, by the distances,	8-793	8-679	8-240	6-995	9-523	8-793
Mean speed per hr. in knots by the log,	8-360	8-500	8-200	6-980	9-410	8-800
Total number of revolutions of the screw for the run, by the counter,	9186	42524	22608	20490	32980	9330
Mean number of the revolutions of the screw per minute,	49-77	40-88	47-10	36-43	52-26	50-70
Slip of screw in per cents. of its speed, calculated for speed of vessel by the distances,	22-22	21-59	22-75	21-00	19-54	23-42
Steam pressure in boilers in pounds per square inch above atmosphere,	7-06	3-19	2-94	3-68	5-14	5-14
Proportion of throttle open,	.5	Wide.	Wide for 7 hours.	.3	Wide.	Wide.
Steam cut off at from commencement of stroke of pistons,	.7	.7	.7	.5 for 1 hr. 30 min. .7 for 7 hrs. 30 min.	.7	.7
Mean effective press. throughout stroke in pounds per sq. inch of pistons,	11-35	11-06	10-18	8-41	12-09	12-09
Horses power developed by the engines for the above mean effective pressure throughout stroke,	926-87	850-75	786-73	502-71	1036-70	1005-76
Resistance of the hull, or thrust of the screw, in pounds by dynamometer,	18531	17949	16483	13341	20000	20000
Horses power expended in propelling the simple hull by dynamometer,	500-57	469-85	417-24	286-68	585-10	540-25
Immersed amidship section of the hull in square feet,	979-96	971-33	963-90	958-54	953-19	949-97
Number of boilers under steam,	4	4	4	2 for 2 hrs. 3 for 40 mins. 4 hours.	4	4
Pounds of coal consumed per hour,	5247	5181	5181	3064 2659	5733	5733
Coal consumed per 24 hours in tons of 2240 pounds,	56-218	55-511	55-511	32-829 28-490	61-425	61-425
State of the sea,	Calm.	Calm.	Calm.	Calm.	Dead calm.	Smooth.
State of the wind,	Light br. aft.	Light aft breeze.	Calm.	Calm.	Calm.	Light brz ahead.

Friction of the Screw Surface on the Water.—The foregoing data allows a calculation to be made of the power absorbed by the friction of the screw surface on the water. For this purpose the data will be taken from the 5th, or next to the last column of the above Table of Results, because as in that column will be found the most profound calm of wind and sea, no corrections will be required for a disturbed state of those elements.

The power required to overcome the friction of the engines, as ascertained by actual experiment on an engine of about the same size and speed of piston as one of the *Charlemagne's*, will be taken at 1.25 pound per square inch of pistons, and the coefficient for the friction of the load,

according to Morin's experiments, at 0·075, which, as the mean effective pressure is 12·09 pounds per square inch, will be $(12·09 \times 0·075 =) 0·91$ pound per square inch, making a total of $(1·25 + 0·91 =) 2·16$ per square inch for the friction resistances of the engines and load, which is 17·87 per centum of the total power developed by the engines, or 185·26 horse power. The power employed in the propulsion of the simple hull was 585·10 horses by dynamometer, and as pressure and resistance are equal and in opposite directions, the power lost in slip will bear to that utilized in the propulsion of the vessel the same ratio that the speed of the slip (or in other words, the velocity with which the water is driven back by the recession of the screw) bears to the speed of the vessel. Now, the slip of the screw was 19·54 per centum of its speed, leaving the speed of the vessel to be expressed by $(100·00 - 19·54 =) 80·46$; therefore, as $80·46 : 19·54 :: 585·10 : 142·09$, the horses power lost by the slip of the screw. After deducting the power 585·10 horses employed in propelling the simple hull, the power 142·09, horses lost in slip, and the power 185·26 horses expended on the friction resistances of the engines and load—total, 912·45 horses, from the total power 1036·70 horses developed by the engines, there remains $(1036·70 - 912·45 =) 124·25$ horses power, which is the amount absorbed by the friction of the screw surface on the water.

Collecting the above, we have the following disposition of the power, viz :—

	Horses Power.	Per Centum.
Propelling the simple hull of the vessel, . . .	585·10	or 56·44
Expended in the slip of the screw, . . .	142·09	“ 13·70
Expended in the friction of the screw, . . .	124·25	“ 11·99
Expended in the friction of the engines and load, .	185·26	“ 17·87
Totals,	1036·70	or 100·00

Explanatory of the Losses of Power by Slip of the Screw.—In observing the above disposition of the power, a clear distinction must be kept in view between the power expended in the slip of the screw, 142·09 horses, or 17·87 per centum of the total power developed by the engines, which is the amount of power employed in merely giving a backward motion to the water passed by the screw, and the power actually *caused* to be lost by the slip of the screw. This latter is equal to the per centum of the screw's slip, and in the present case would amount to 19·54 per centum of the total power 1036·70 horses developed by the engines, or to 202·57 horses power : because by the reason of the screw having a slip of 19·54 per centum, and as the mean effective steam pressure on the engines' pistons continues the same, the speed of the engines has to be 19·54 per centum greater to give the vessel an equal speed in equal times than if there were no slip. Of course, this *causes* a loss of 19·54 per centum of the power required to work the engines—of the power expended in the friction of the screw surface on the water, and in the power required to propel the simple hull of the vessel. But the sum of the powers *non-utilized*, viz : those expended in slip, in friction of the screw, and engines, and load, total 451·60 horses, will remain the same, however divided ; and the power 585·10 horses *utilized* in the propulsion of the vessel, will consequently remain the same also.

The foregoing disposition of the power, in connexion with the following table of calculations on the screw of the *Charlemagne*, enables us to determine the friction in the pounds avoirdupois of the square foot of the screw surface moving in its helical path with the velocity of 10 feet per second. For this purpose, the screw surface in the following table has been divided into a number of parallel strips, or *elements*, 0.25 foot wide; the length of the central helix of each of these elements has been taken as the length of the element, and the "expression for the friction of each element" has been computed separately as the friction is in the ratio of the squares of the velocities. This calculation for the expression of the friction has been made for convertibility into horse power, supposing the friction of each square foot moving with a velocity of ten feet per second to be an *unit* of weight. After the total friction of the screw for a speed of ten feet per second has been ascertained in horses power for a *unit* of weight, it is easily resolvable into the *true* friction in pounds, by dividing it into the "friction of the screw surface on the water" in horses power, as ascertained by the preceding "deposition of the power." For the rest, the table of calculations carries its own explanation.

This determination being made, gives for the value of the friction of one square foot of screw surface moving through water, in its helical path, with a velocity of ten feet per second, 0.7796 pound avoirdupois.

Calculations on the Screw of the *Charlemagne*.

Pitch.	Radius of elements.	Circumferences normal to radii of elements.	Fract'n. used of the pitch.	Lengths of elements for one contribution of the thread.	Lengths used of the elements.	Breadths of the elements.	Helical surfaces of the elements.	Speeds of the elements per second.	Speeds of the elements per minute.	Expression for the friction of both sides of the elements.
A	B	C	D	E	F	G	H	I	J	K
		2B × 3.1416		$\sqrt{A^2 + C^2}$	$\frac{E}{D}$		F × G	$\frac{I}{60}$	E × 52.26	$\frac{I^2}{10^2} \times J \times 2 \Pi$
Feet.	Feet.	Feet.		Feet.	Feet.	Feet	Sq. Ft.	Feet.	Feet.	
22.957	1.375	8.639	2.7	24.528	7.008	0.25	1.762	21.364	1281.83	20583.0
	1.625	10.210	"	25.125	7.179	"	1.795	21.884	1313.03	22507.0
	1.875	11.781	"	25.807	7.373	"	1.843	22.478	1348.67	25117.6
	2.125	13.351	"	26.557	7.588	"	1.897	23.131	1387.87	29500.9
	2.375	14.922	"	27.380	7.823	"	1.956	23.848	1430.88	31835.2
	2.625	16.493	"	28.267	8.076	"	2.019	24.620	1477.23	36156.8
	2.875	18.064	"	29.212	8.350	"	2.087	25.444	1526.62	41252.9
	3.125	19.635	"	30.208	8.631	"	2.158	26.311	1578.67	47168.0
	3.375	21.205	"	31.252	8.929	"	2.232	27.220	1633.23	54019.2
	3.625	22.776	"	32.340	9.240	"	2.310	28.168	1690.09	61963.2
	3.875	24.347	"	33.464	9.561	"	2.390	29.147	1748.83	71017.2
	4.125	25.918	"	34.623	9.892	"	2.473	30.157	1809.40	81388.8
	4.375	27.489	"	35.814	10.233	"	2.558	31.194	1871.64	93172.1
	4.625	29.059	"	37.033	10.581	"	2.645	32.256	1935.34	106520.0
	4.875	30.630	"	38.278	10.937	"	2.734	33.340	2000.41	121584.0
	5.125	32.201	"	39.546	11.299	"	2.825	34.444	2066.67	138531.0
	5.375	33.772	"	40.836	11.667	"	2.917	35.568	2134.09	157506.3
	5.625	35.343	"	42.145	12.041	"	3.010	36.708	2202.50	178662.6
	5.875	36.913	"	43.470	12.420	"	3.105	37.862	2273.74	202235.0
	6.125	38.484	"	44.813	12.804	"	3.201	39.032	2347.93	228418.4
	6.375	40.055	"	46.167	13.191	"	3.298	40.211	2424.69	257319.2
	6.625	41.626	"	47.536	13.582	"	3.395	41.404	2504.23	289165.0
	6.875	43.197	"	48.918	13.977	"	3.494	42.608	2586.45	324319.0
	7.125	44.767	"	50.310	14.374	"	3.593	43.820	2670.20	362790.0
	7.375	46.338	"	51.712	14.775	"	3.694	45.041	2752.47	405045.0
	7.625	47.909	"	53.122	15.178	"	3.795	46.270	2776.16	451113.0
	7.875	49.480	"	54.550	15.586	"	3.896	47.513	2850.78	501462.0
	8.125	51.051	"	55.980	15.994	"	3.999	48.759	2925.52	556280.6
	8.375	52.608	"	57.126	6.350	0.15	2.452	49.757	2985.41	362462.4
$\frac{5259145.4}{33000} = 159.368, \text{ and } \frac{124.250}{159.368} = 0.7796$										5259145.4

Relation between the Piston Pressure and the Thrust of the Screw.—It is evident that, in general, every pressure or power must be balanced by an equal and opposite resistance. The mechanical effect of a pressure is estimated by multiplying that pressure by the space through which it acts; and the mechanical effect of a resistance is estimated by multiplying that resistance by the space through which it acts. Hence, any pressure exerted on the piston of a steam cylinder, and multiplied by the space through which it acts in a given time, must exactly equal or balance the resistance multiplied by the space through which it acts in the same time. It is plain that this *general* law is entirely independent of the absolute velocities of the pressure and resistance, and that the equality will always obtain, be those absolute velocities relatively what they may.

Let us apply the above to the case of a screw actuated by a steam engine, and propelling a vessel; and let us first examine the manner in which the power of the engine is employed, premising that we know the total indicator pressure on the pistons. That total pressure is the primitive force of the steam, without loss from its transmission by the machinery. That transmission, however, cannot be effected without one loss common to all machinery, and independent of any waste in function of the machine itself, viz: the loss by *friction*. It is plain, that before the engine can move at all—that is, before it can develop power—the pressure on the piston must be more than sufficient to overcome *all* the friction resistances acting against it. In the case of propelling a vessel by the screw, which is a simple and perfect machine, operating no loss of useful effect in function of form, *all* these friction resistances will be the friction of the engine, *per se*, the friction of the load, and the friction of the screw surface on the water. It is then only what remains of the total piston pressure after deducting all these friction resistances, which is transmitted by the engine to the screw for the propulsion of the vessel; the application of this remainder of the pressure causes the screw to revolve, and thus transmit this pressure to the water in which the screw acts. The screw, therefore, transmits to the water *all* the pressure it received from the engine, and this pressure will, for one revolution of the screw, act through the length of the screw's pitch. Hence, the resistance per revolution of the screw will equal the pressure in pounds exercised by (or the result of) the screw, multiplied by the pitch of the screw, or the distance through which the resistance acts per revolution of the screw. From the foregoing it is also clear, that the power exerted to balance this resistance will be that aggregate pressure in pounds on the piston, which is left after deducting for all the friction resistances, multiplied by the space through which it acts; while the screw is making one revolution. This space will be the length of a double stroke of piston, when the engine is connected directly to the screw shaft without gearing.

From the above it is also plain, that the more or less slip of the screw does not modify or destroy the equality stated, because as the pressure of the screw is simply upon the water, it is immaterial whether the water on which the screw presses yields, and is forced back by the screw, (to which the name of slip is given,) or whether it remains unyielding, and the screw advances forward with any load whatever attached—the ves-

sel for instance—therefore, the pressure or thrust of the screw in both cases must evidently be the same, because it is solely the effect of, and must be balanced by the piston pressure. Hence also follows, that the pressure exercised by the screw upon the yielding water, must also exactly equal the pressure exercised by the screw upon the vessel in forcing it forward; consequently the power transmitted by the engine to the screw will be divided relatively between the slip of the screw and the propulsion of the vessel, in the ratio of the spaces through which the slip recedes and the vessel advances in equal time. Thus it is seen that neither the slip of the screw, nor the absolute speed of the screw, engine pistons, or vessel, can modify or destroy the equality subsisting between the thrust of the screw and the pressure on the pistons.

From all the foregoing, then, we derive that *the thrust of the screw in pounds, by dynamometer, multiplied by the space through which that thrust acts in a given time, is always equal to what remains of the total piston pressure after deduction has been made of the pressure required for overcoming all the friction, resistance of engine, load, and screw surface on the water, multiplied by the space through which said remainder of piston pressure acts in the same time.*

The experiments with the *Charlemagne*, are arranged in the Table of Results, in six columns, and were made with different velocities of engines' pistons, and of vessel. They will furnish a very good practical test, not only of the truth of the above law, but also of the accuracy of both the observed data and of the calculation based on it. The *Charlemagne* has four steam pistons, whose aggregate area amounts to 8251·6 square inches; the length of the double stroke of piston is 6·562 feet. The pitch of the screw is 22·957 feet, and the screw makes one revolution to each double stroke of piston.

The computation for the pressure required to overcome the friction resistance for the following different volumes, has been made from the data of the 5th column. The pressure required to work the engine alone is taken to be the direct ratio of the speeds of the piston. The pressure required to overcome the friction of the load is taken at Morin's coefficient of 0·075 of the total indicator pressure. The pressure required to overcome the friction of the screw is taken to be in the ratio of the squares of the velocities of the screw. The following are the detailed results, viz :

FIRST COLUMN.

Speed of the vessel,	8·793 knots pr. hour.
Revolutions of the screw,	49·77 per minute.
Mean effective pressure per square inch of pistons,	11·35 pounds.
Friction of the engines per square inch of pistons, 1·19 pound.	
“ load “ “ “ 0·85 “	
“ screw “ “ “ 1·38 “	
Total friction resistances per square inch of pistons, —	3·42 pounds.
Mean effective pressure per square inch of pistons, after deducting friction resistances,	7·93 “
Thrust of the screw in pounds by dynamometer,	18531.
Expression for the power, $(8251·6 \times 7·93 \times 6·562 =)$	429335·7
Expression for the resistance, $(18531 \times 22·957 =)$	425416·2

SECOND COLUMN.

Speed of the vessel,	8.679 knots pr. hour.
Revolutions of the screw,	46.88 per minute.
Mean effective pressure per square inch of pistons,	11.06 pounds.
Friction of the engines per square inch of pistons, 1.12 pound.	
" load " " " 0.83 "	
" screw " " " 1.30 "	
Total friction resistances per square inch of pistons,—	3.25 pounds.
Mean effective pressure per square inch of pistons, after deducting friction resistances,	7.81 "
Thrust of the screw in pounds by dynamometer,	17949.
<i>Expression for the power, $(8251.6 \times 7.81 \times 6.562 =)$</i>	422888.1
<i>Expression for the resistance, $(17949 \times 22.957 =)$</i>	412055.2

THIRD COLUMN.

Speed of the vessel,	8.240 knots pr. hour.
Revolutions of the screw,	47.10 per minute.
Mean effective pressure per square inch of pistons,	10.18 pounds.
Friction of the engines per square inch of pistons, 1.13 pound.	
" load " " " 0.76 "	
" screw " " " 1.31 "	
Total friction resistances per square inch of pistons,—	3.20 pounds.
Mean effective pressure per square inch of pistons, after deducting friction resistances,	6.98 "
Thrust of the screw in pounds by dynamometer,	16483.
<i>Expression for the power, $(8251.6 \times 6.98 \times 6.562 =)$</i>	377946.1
<i>Expression for the resistance, $(16483 \times 22.957 =)$</i>	378400.2

FOURTH COLUMN.

Speed of the vessel,	6.995 knots pr. hour.
Revolutions of the screw,	36.43 per minute.
Mean effective pressure per square inch of pistons,	8.41 pounds.
Friction of the engines per square inch of pistons, 0.87 pound.	
" load " " " 0.63 "	
" screw " " " 1.01 "	
Total friction resistances per square inch of pistons,—	2.51 "
Mean effective pressure per square inch of pistons, after deducting friction resistances,	5.90 "
Thrust of the screw in pounds by dynamometer,	13341. "
<i>Expression for the power, $(8251.6 \times 5.9 \times 6.562 =)$</i>	319467.3 "
<i>Expression for the resistance, $(13341 \times 22.957 =)$</i>	306269.3

FIFTH COLUMN.

Speed of the vessel,	9.523 knots pr. hour.
Revolutions of the screw,	52.26 per minute.
Mean effective pressure per square inch of pistons,	12.09 pounds.
Friction of the engines per square inch of pistons, 1.25 pound.	
" load " " " 0.91 "	
" screw " " " 1.45 "	
Total friction resistances per square inch of pistons,—	3.61 pounds.
Mean effective pressure per square inch of pistons, after deducting friction resistances,	8.48 "
Thrust of the screw in pounds by dynamometer,	20000.
<i>Expression for the power, $(8251.6 \times 8.48 \times 6.562 =)$</i>	459166.6 "
<i>Expression for the resistance, $(20000 \times 22.957 =)$</i>	459140.0 "

SIXTH COLUMN.

Speed of the vessel,	8.793 knots pr. hour.
Revolutions of the screw,	50.70 per minute.
Mean effective pressure per square inch of pistons,	12.09 pounds.
Friction of the engines per square inch of pistons,	1.21 pound.
“ load “ “ “	0.91 “
“ screw “ “ “	1.45 “
Total friction resistance per square inch of pistons,—	3.57 pounds.
Mean effective pressure per square inch of pistons, after deducting friction resistances,	8.52 “
Thrust of the screw in pounds by dynamometer,	20000.
Expression for the power, $(8251.6 \times 8.52 \times 6.562 =)$	461332.4
Expression for the resistance, $(20000 \times 22.957 =)$	459140.0

The reader will not fail to observe how very closely in each case the “expression for the power” agrees with the “expression for the resistance.”

It also follows from the foregoing law, that the thrust of the screw is always in the direct ratio of the effective piston pressure, and that it will always be the same with the same remainder of the piston pressure after deducting all the friction resistances, let the speed of the screw or the load upon it be what they may. It will be the same with the vessel under way, towing, or tied to the dock. This can be practically tested by taking from the six trials with the *Charlemagne* the thrusts by the screw, and dividing them by the mean effective pressure that remains after deducting the friction resistances, when the quotients will be found to be nearly equal. Had the data been exact, the quotients would have been exactly the same. The results are as follows, viz :

	Revolutions made by the screw per minute.	Mean effective pressure in pounds per square inch on the pistons after deducting all the friction resistances.	Thrust of the screw in pounds by Dynamometer.	
1st column,	49.99	7.93	18531	and $\frac{18531}{7.93} = 2336.82$
2d column,	46.88	7.81	17949	“ $\frac{17949}{7.81} = 2298.21$
3d column,	49.10	6.98	16483	“ $\frac{16483}{6.98} = 2361.46$
4th column,	36.43	5.90	13341	“ $\frac{13341}{5.90} = 2261.18$
5th column,	52.26	8.48	20000	“ $\frac{20000}{8.48} = 2358.49$
6th column,	50.90	8.52	20000	“ $\frac{20000}{8.52} = 2347.42$

Evaporation by the Boiler.—An experiment was made to ascertain whether any economy in fuel would be effected by slower combustion, and using more boiler. The result is given in the 4th column of the Table of Results, and it was found that by hard firing and burning at the rate of 32.829 tons of coal per 24 hours, *two* boilers could be made to

produce sufficient steam to maintain a boiler pressure of 3·68 pounds per square inch above the atmosphere, with 36·43 revolutions of the screw per minute; while with *three* boilers, or 50 per centum more, the same amount of steam was furnished by burning at the rate of 28·490 tons of coal per 24 hours, or $13\frac{1}{8}$ per centum less than the former amount, (32·829 tons.)

The following evaporation by the boilers has been calculated from the mean of the data in the 5th and 6th columns of the Table of Results, where the throttles were carried wide. The steam pressure in the cylinders, before cutting off (at $\frac{7}{10}$ the stroke from the commencement), averaged 1·6 pound per square inch above the atmosphere. The steam space comprised in the cylinder nozzles, clearance, &c., at *one* end of the *four* cylinders, is taken at 10 cubic feet. The loss by *blowing-off* is calculated for maintaining the sea-water in the boilers at twice the natural concentration, and is included in the evaporation. The temperature of the feed water is taken at 100° Fahr. Double stroke of pistons 51·78 per minute, and Regnault's determination of the latent heat of steam is used. The following are the results, viz :

Cubic feet of steam of atmospheric pressure furnished per minute under the above conditions,	} 18070·74
Pounds of steam evaporated per hour by one pound of coal under the above conditions,	
	} 6·95

Under the ordinary conditions of practice, there would be found a considerable decrease of the above evaporation, reducing the units of steam to about 6·50 per unit of coal, instead of 6·95; because during the above experiment, the longest run being only $14\frac{1}{2}$ hours, and the run from which the data is taken only $10\frac{1}{2}$ hours, there could have been but very little, if any, cleaning of fires, and also much less *blowing-off*, than in a long run of days, as the vessel would start with full boilers of sea-water of the natural concentration.

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Dudgeon's Patent Hydraulic Press.

This ingenious and useful apparatus was patented July 8th, 1852, and is becoming extensively introduced as a substitute for the old jack screw. The advantages it possesses are, 1st, Its lightness, which makes it easy for one man to shoulder a press capable of raising ten tons. 2d, The small power required to work it, every press being arranged so that one man can raise the weight for which the press is calculated. This advantage must be obvious, when we reflect that the friction of the old jack screw, which is enormous, particularly when the oil has been gummed by cold or dirt, is replaced by the very trifling friction incident to the passage of the fluid in the press through the openings. 3d, The ease with which heavy bodies may be lowered, which may be effected slowly or rapidly, as desired, by simply touching the relief valve with the working lever. 4th, The convenience of using it in confined situations, where it is difficult or impossible to turn the lever of the screw. To those who are accustomed to the use of the jack screw, and who are therefore acquainted with its inconveniences, the advantages of this press will be evident.