DESCRIPTION OF CRADDOCK'S PATENT UNIVERSAL CONDENSING STEAM ENGINE

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OF

CRADDOCK'S

Patent Universal

CONDENSING STEAM ENGINE;

Being Improvements upon his first Patent, which Patent bears date March 16th, 1840. The Patent to which the following description relates, bears date the 3rd December, 1846, the specification thereof being enrolled on the 3rd June, 1847.

TO WHICH IS APPENDED, IN A CONCISE TABULAR FORM,

THE RELATIVE ECONOMY IT WILL PRODUCE

UPON THE

PRESENT MODES OF GENERATING AND USING STEAM.

From the evidence adduced in the Tables, and the other obvious advantages it possesses, it may be stated as a fact, which experience will verify, that on the whole Steam-power of Great Britain, it will realize

A SAVING EQUAL TO TWENTY MILLION POUNDS STERLING PER ANNUM.

But great as is the above recommendation, it possesses another of no less importance, viz., all but

PERFECT SECURITY FROM THE DREADFUL SACRIFICE OF LIFE AND PROPERTY

WHICH HAS HITHERTO ATTENDED THE STEAM ENGINE.

The strictest theory, with the most rigid experiment and experience, unite in the attestation of its

BEING BY FAR THE SAFEST MODE OF GENERATING AND USING STEAM

No man whose opinion is of any weight on this subject will deny that fluids act equally in all directions, or that the force they exert on any given portion of the surface is transmitted to every other part of such surface; hence the conclusion that the strain upon the Boiler is represented by multiplying the pressure per square inch into the number of square inches contained in the interior surface which encompasses the sectional area of any part of the Boiler, is a necessary consequence from the principle above stated. With this brief enunciation of the abstract principle of fluid pressure, I give the following tabular illustration of the danger to be apprehended on the two systems.

Pounds pressure per square inch.	HEAD I. Tabular Boilers on the principle of those given in the drawings, having 3-inch Tubes. The following numbers shew the strain on any given part of the surface of such cylindrical tubes.	Pounds pressure per square inch.	HEAD II. Common Cylindrical Boilers of 4-ft. diameter, including those constructed as the present Locomotive and Marine. The following numbers shew the strain on any given part of such cylindrical boilers.
100	900 lbs. rending force.	6	900 lbs. rending force.
150	1350 lbs. " "	36	5400 lbs. " "
200	1800 lbs. " "	200	180,000 lbs. " "

From the above table it must be obvious how very far such Boilers as set forth in the drawings surpass, in point of safety from explosion, those of the common kind given under the second head. Yet the recommendation of the Patent Boiler becomes still greater if we go into the effects of the bursting of both. But for the illustration of this, space compels me to refer the reader to my published Lectures, pages 20 to 24 and 36 to 40, in which also will be found my reasons for giving the strain at 200 lbs. in the last example of the common boiler.

LONDON:

SIMPKIN, MARSHALL AND CO.

MDCCCXLVII.

The Lectures referred to in the following pages, entitled "The Chemistry of the Steam Engine practically considered," which were delivered by the Patentee in the Theatre of the Philosophical Institution, Birmingham, and published by Simpkin, Marshall and Co., London, may be procured through any bookseller, either alone or bound together with this Description of the Condensing Steam Engine.

E. C. OSBORNE, PRINTER, BIRMINGHAM.

DESCRIPTION &c.

OF

CRADDOCK'S PATENT UNIVERSAL

CONDENSING STEAM ENGINE.

Being Improvements upon his first Patent, which Patent bears date March 16th, 1840. The Patent to which the following description relates, bears date the 3rd December, 1846, the specification thereof being enrolled on the 3rd June, 1847.

INTRODUCTORY.

THE Steam Engine has already done much towards realising what was once considered Utopian, viz. the bringing of the various nations of the earth together, and tending to unite them in one common bond of brotherhood; dissipating their national jealousies, vivifying their intellectual perceptions, and conducing more than anything else to open man's understanding to the fact, that the highest interest of each is the good of all. It is not too much to say, that the Steam Engine in its multifarious applications to the service of humanity, has become the greatest civilizer of the age.

The conditions requisite to any comprehensive improvement and extension of so valuable a discovery are easily perceived, when we reflect upon the laws and properties which by their combination and modifications are the source of all its power. A brief enumeration, therefore, of these leading characteristics will enable any one, *a priori*, to draw a highly probable conclusion as to the merits of an invention which professes largely to extend this so essential an element in human progression.

The first of these leading principles is, that water charged with heat becomes an elastic gas or steam. Secondly, that any given weight of steam (a pound, for instance) contains at all pressures the same quantity of heat; so that by generating steam under high pressure, we consume no more fuel per pound of steam than we do at low pressures. To convey to the reader's mind, who may not have previously studied the subject, the importance of this fact in relation to the invention here presented to his notice, it is necessary to state, that as the pressure under which steam is generated is increased the volume becomes diminished, for any given weight, but by diminishing the restraining resistance, it will expand to an enormous extent; and what is of equal importance to a clear understanding of the matter is, that as long as no heat escapes from the steam, no condensation ensues. Hence the absolute mechanical effect of a pound of steam is, when used without expansion, the same at all pressures, for as it diminishes in pressure, it compensates by its increased volume, as may be illustrated in the following manner:—One lb. of steam, at one lb. pressure per square inch, is in volume equal to 579.726 cubic inches. Let us therefore suppose this pound of steam acting, as in the steam engine, against a moveable piston, the cylinder being $121\frac{1}{3}$ inches long, the piston having an area equal to 4778 square inches, as it will be found that a cylinder of $121\frac{1}{3}$ inches in length would require such a sectional area as that represented by the piston to contain the above volume of steam at such pressure; hence we have an absolute mechanical effect which is represented by 4778 lbs. lifted through $121\frac{1}{3}$ inches. But a pound of steam at 200 lbs.* per square inch is in volume but $2898\frac{81}{100}$ cubic inches, which volume will fill a cylinder of the same length; but the sectional area of the cylinder, or the piston of such cylinder, must now be but $23\frac{89}{100}$ square inches area. Hence we obtain the force exerted, by multiplying the area of the piston by 200, which gives us as before 4778 lbs. raised $121\frac{1}{3}$ inches, being the same absolute mechanical effect as in the former instance.

Carrying these primary facts with us to the Tables 1, 2, and 3, we at once perceive why in column 1, Table 3, the effect without expansion is in all the examples there given represented by the same numbers. The results shewn in those three tables are such, as cannot fail to convey to every unprejudiced mind, the great economy and other advantages which must arise, from such means as will enable us to avail ourselves of the expansive principle to a much greater extent than has hitherto been practicable; it being

* The volume of steam here to be understood by the reader, is that resulting from 200 times the quantity of water in the same volume of steam, taking the pressure at one pound on the square inch for the commencing or zero point, as that from which the calculation is made. Hence I exclude the increase of volume due to dilation of steam by the increase of sensible heat, as I take note of that separately, it being farther explained in the tables and in the explanation of the tables.

demonstrable from these three tables that 1 lb. of coal, used as in the first example given in Table 3, will produce *seven-fold* the mechanical effect to that which would result was the steam used without expansion, as given in Example 9 in the same table.

It must also be borne in mind, that the great saving in fuel thus apparent is not the whole of the advantage which would result from such extended application of the expansive property of steam, as the water or medium for condensation would not require to be more than *one-seventh* that required for the low-pressure steam. The air-pump, condenser, boiler, and in short, the whole engine would be, if not proportionate, still in a very great degree diminished.

But here comes that *bugbear* that has so long frightened mankind from a dispassionate consideration of the use of steam at such pressure, viz., *danger*. It is high time that *scientific* men at least should grapple with this *delusion*, and calmly consider whether, *with such boilers as are here submitted*, such pressure is not only as safe as the pressure now used in the common boiler, but very much safer than *any, even the low-pressure boilers*. I cannot enter farther here into the demonstrative proofs of this proposition, but may refer the reader to my published Lectures,* 20th and following pages.

In bringing before the mind of the reader the leading features of this invention, he will readily perceive that it furnishes us with those conditions requisite for the fullest developement of the expansive properties of steam, as it enables us to condense the steam in all situations, *by water, where it is obtainable*, and where water is *not* obtainable, *then by the atmosphere*. The steam being thus condensed without the admixture of any extraneous matter, the water, which in this case is *free* from *deposit*, is made to *circulate to* and *fro* between the boiler and engine. Here we have an *effectual* preventative of that deposit which acts so injuriously in all boilers, and which has hitherto been the great *practical* difficulty with tubular boilers. The great economy (see Table 2, Example 8) which results from the removal of the atmosphere, or the vacuum, is *no longer* confined to situations where water is abundant, but is by this invention rendered available everywhere. The foregoing acquisitions, though *important* in

* The Chemistry of the Steam Engine. Simpkin, Marshall and Co., London. 1846.

themselves, are *far* more so in the *consequences* which flow from them, as the reflecting mind need not be told that on the *introduction of a new* and *important principle* into the Steam Engine, its whole *prospective* character is changed, and that which before would seem to be the limit of its perfection and application, no longer appears such, but its whole structure becomes susceptible of renovation, simplification and compactness. Hence the simplicity and compactness given to the Wolff Engine, as illustrated in the following drawings, which I now proceed to describe.

DRAWING No. I.

ANGULAR-SET, DOUBLE-CYLINDER, DIRECT-ACTING STATIONARY ENGINE, FORTY-HORSE POWER.

Description of Engine.

Figures 1, 2 and 3, shew an arrangement adapted for a Stationary Engine. Fig. 1 is the engine, fig. 2 the boiler, and fig. 3 the condenser. In this arrangement the chimney is placed between the boiler and engine-house. The condenser is supposed to be standing on the top of the engine-house, the roof of which is made flat to receive it. In fig. 1, *a* and *b* are the two cylinders; *a* the high pressure and *b* the low. *h h h h* are the guide bars; *c* and *d* the connecting rods; *e* and *f* the pistons; *i* the air pump; *k* the boiler pump; *l* the weigh-shaft, which works the boiler pump and steam valves, which valves are of a peculiar construction, as shewn on an enlarged scale in Drawing No. 9, to the description of which drawing I must refer the reader; *g* is the crank, to the pin of which the *two* connecting rods attach. Fig. 2: *e* is the top chamber of the boiler; *f f* the tubes, which have the spaces between them filled in, as represented by the dark lines, with strips of cast iron, to within 18 inches or 2 feet of the top, thereby forming a fire box in the interior of the boiler, whilst the gases pass out through the open spaces and impart the remainder of their heat to the whole exterior of the boiler; *j* is the flue running all round the boiler, and *k* the passage into the chimney *m*; *h* is the ash-pit; *i* the brick-work; *c* is the pipe leading from the top of the boiler into the steam chest *a*, which is here shewn placed in the chimney, having an iron door opening for

Description of Boiler.

access thereto. I would remark here that the steam chest is a cylindrical vessel of 18 inches diameter, made of half-inch plates, the highest pressure of steam here proposed to be used being 100 lbs. on the square inch. *u* is the pipe which conveys the steam to the engine; *d* that leading to the safety valve; *b* a pipe which conveys any water which may accumulate at the bottom of the steam chest back to the bottom of the boiler; *l* is the hand damper; *r* the regulating damper; *s* the distilling apparatus, if it be desired to use one for the purpose of supplying the little loss by leakage, which I have found by experiment need not exceed one gallon of water per horse-power per day, and which being so small, I have never yet used a distilling apparatus, although I have worked a boiler on this principle for four years. Whilst speaking of the boiler, I will describe my regulating damper apparatus. It will be seen connected with the damper *r* through a chain and small beam, or lever *q*, and another chain to the piston *n*. At *p* and *o* are two taps, which communicate through a pipe to the bottom of the boiler; *m* is an air vessel, which, previous to being set in action, is full of air of an atmospheric density. On the steam rising in the boiler, and the tap being opened which communicates direct with the air vessel *m*, the water is allowed to rush into the air vessel from the boiler, until the steam has attained the desired working pressure, which will occasion a corresponding compression of the air in the air vessel *m*. This tap communicating direct with the boiler is now closed, and the tap *o* opened, which will be seen to communicate above the piston, in the small cylinder *n*. The action of the apparatus is as follows:—As long as the air in the air vessel and the steam in the boiler are of the same pressure no action ensues, but on the steam attaining a greater pressure in the boiler than the air in the air vessel, the piston in the small cylinder *n* descends, carrying with it the lever *q*, and thus closing the damper *r*, which checks the fire and occasions the pressure of the steam in the boiler to become lower. The pressure of the air in the air vessel now preponderating, again elevates the piston in the small cylinder *n* by which the damper *r* opens. The water in the air vessel and small cylinder *n* is cold, so as to admit of a leather bucket, and consequently small and uniform friction. This is a most efficient apparatus, not only

Description of Regulating Damper Apparatus.

Action of the Damper Apparatus.