Specification of Richard Willcox : steam-engine furnace or boiler and air pump.

Contributors

Willcox, Richard.

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A.D. 1802 . . . . . N° 2574.

SPECIFICATION

OF

RICHARD WILLCOX.

STEAM-ENGINE FURNACE OR BOILER AND AIR PUMP.

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
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1854.

A.D. 1802 . . . . . N° 2574.

Steam-Engine Furnace or Boiler and Air Pump.

WILLCOX'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, RICHARD WILLCOX, of the City of Bristol, Engineer, send greeting.

WHEREAS His most Excellent Majesty George the Third, of the United Kingdom of Great Britain and Ireland, King, Defender of the Faith, and so forth, by His Letters Patent under the Great Seal of the United Kingdom, bearing date at Westminster, the Twenty-third day of January, in the forty-second year of His reign, and in the year of our Lord One thousand eight hundred and two, did give and grant unto me, the said Richard Willcox, my executors, administrators, and assigns, His especial licence, full power, sole privilege and authority, that I, the said Richard Willcox, my executors, administrators, and assigns, and every of us, by myself and themselves, or by my and their deputy or deputies, servants, or agents, or such others as I, the said Richard Willcox, my executors, administrators, or assigns, should at any time agree with, and no other, from time to time and at all times thereafter during the term of years therein expressed, should and lawfully might make, use, exercise, and vend my Invention of "FURTHER IMPROVEMENTS ON THE STEAM-ENGINE FURNACE OR BOILER AND AIR PUMP, PART OF WHICH MAY BE APPLIED TO THE MANUFACTURING OF SUGAR AND SPIRITS BY STEAM, AND TO A VARIETY OF OTHER USEFUL PURPOSES," within that part of the said United Kingdom of Great Britain and Ireland called England, the Dominion of Wales, the Town of Berwick upon Tweed, and also in all His Majesty's Colonies and Plantations abroad, in such manner

as to me, the said Richard Willcox, my executors, administrators, and assigns, or any of us, should in my or their discretions seem meet; in which said Letters Patent there is contained a proviso, whereby it is declared, that if I, the said Richard Willcox, should not particularly describe and ascertain the nature of my said Invention, and in what manner the same is to be performed, by an instrument in writing under my hand and seal, and cause the same to be inrolled in His said Majesty's High Court of Chancery within six calendar months next and immediately after the date of those His said Letters Patent, that then the said Letters Patent, and all liberties and advantages whatsoever thereby granted, shall utterly cease, determine, and become void, anything therein-before contained to the contrary thereof in anywise notwithstanding.

NOW KNOW YE, that in compliance with the said proviso, I, the said Richard Willcox, do hereby declare that my said Invention is described in manner following (that is to say):—

First, my improvements in the boilers and furnaces of steam engines consist in making the bottom plate of the boiler considerably thicker than usual, and disposing or fixing the same in an horizontal or gently inclined position. Secondly, I construct the sides of the boiler in such a manner that an interstice or space shall be formed for the purpose of containing a thin wall of water surrounding the said bottom plate, and carried below or raised above the same, or both below and above, as may be required, as is more particularly shewn in Figures 17 and 18, and whilst the said interstice or space is filled with water a very thin sheet only is made to cover the said horizontal or gently inclined bottom plate. Thirdly, in manufactories where ground is not of such importance, I construct boilers without sinking or raising the sides, as before described, but I enlarge the bottom plate of the same to a much greater extent in length than hath been heretofore done with any boilers of steam engines of similar power; and I place the interior float, by the subsidence of which the feeding pipe is usually made to operate, much lower than hath heretofore been practiced; or otherwise, when any other mode of supply shall or may be adopted, I place the lower apertures of the gage pipes, if used, much lower than hath heretofore been practiced; and, in order to ascertain at all times the true and precise depth of water in my boiler, I make and use a peculiar gage, consisting of a pipe which communicates with the interior space of the boiler beneath the surface of the water, and another pipe communicating with the interior space above the surface of the water, and I connect the said two pipes by a tube of glass, properly secured, in which glass tube a portion of the water must consequently enter and remain, and shew the true

level within, and in the use and application of boilers and furnaces so improved my intention and practice are, that the depth of water over the horizontal or gently inclined bottom plate should be as small or as shallow as possible, at the same time that the depth of the water in the interstices or space round the sides shall be much more considerable, but that the thin sheet of water upon the horizontal or gently inclined bottom plate should nevertheless be sufficiently deep as in no case to allow the bottom plate to acquire so elevated a temperature as would, particularly with iron boilers, cause the water and metal to act upon each other, so as to produce a quantity of permanently elastic fluid. Secondly, my improvements do further consist in æconomising steam when generated and applied to the engine by causing that fluid, after it has performed its usual operations on the piston, instead of passing off to the condenser, as is usual, and there being destroyed by condensation, to perform two other distinct operations, first by causing it to surround the cylinder, and thereby keep it constantly up to its proper temperature; and secondly, to produce an equilibrium on or under the upper piston of the air pump, so as to work that and the under piston of the pump either connected with the engine or detached from it. In either case the engine is not deprived of any portion of its power as it is at present, consequently an increased power is obtained. In other cases I retain a part of the steam by opening a communication with another vessel, and permitting the steam to pass freely into that vessel till the steam is of equal density and spring with that in the cylinder, and then, upon shutting the communication with the said vessel, the steam left in the cylinder is suffered to pass to the condenser, whilst the fluid reserved is permitted to enter freely on the other side of the piston, as in a double engine. Hence, with one cylinder full of steam, I am enabled to produce a power each and every stroke equal to the power that is now produced by a quantity of steam sufficient to fill one cylinder and a quarter, whilst in double engines I retain a portion of the steam each time the cylinder is exhausted, and apply it to work the air pump, or to other useful purposes, and this without the least detriment to the engine. For a description, see Figs. 7, 8, and 12. Thirdly, my improvements further consist in rendering the engine more efficient and simple by dispensing with the whole of the external apparatus for opening and shutting the valves, whereby all risque and liability to derangement from air or steam escaping by the spindles, which so frequently deranges the operations of engines (more particularly those of the smaller kind) are avoided. For a description, see Figs. 5 and 6. Fourthly, my further improvements consist in regulating the engine in a more perfect and regular manner than has hitherto been practiced, by more effectually guarding against

the different degrees of elasticity to which the steam is now liable to be raised by placing an horizontal slide, or other most convenient formed valve, capable of being counterpoized either by a weight or column of mercury or other fluids, which being placed between the boiler and the engine, where the throtle valve is now usually placed, will, by the pressure or elasticity of the steam in the boiler, upon its being increased (from the irregular combustion of fuel) diminish the aperture between the boiler and the engine. Hence whenever the equilibrium is destroyed by the rarity of the steam, and thereby the aperture more or less closed, a proportional quantity of steam is permitted to act on the piston; the said regulator likewise indicates or exhibits the power of the steam as effectually as the usual gage. Therefore, having provided against the inequalities of the engine arising from the different pressure of steam on the piston, I apply my second regulation by means of the centrifugal power of balls which govern the position of a piece or part of my aparatus for opening and shutting the valves, so as to produce the same effect in shutting off the steam from the engine during its stroke, as could be done by the hands of the engineer, and is more particularly explained in the description of Figs. 12, 13, and 14. Fifthly, my other improvements consist in applying steam to the extraction of sugar from the cane, instead of passing it through rollers, and likewise for manufacturing of sugar and spirits. Fig. 1 is the vertical section of a single engine, in which the steam performs three offices. A, the steam cylinder and piston; B, the case surrounding the cylinder; C, the valve communicating to the boiler; D, the valve leading to the case; E, the hand geer, as usual; F, the lever beam and parallel motion, as is usual; G, a pump for supplying the condensing cistern; H, the improved air pump; I, the upper piston; J, the lower one; K, a valve counterbalanced, opening outwards, to permit air and other fluids to pass from between the pistons; L, L, two foot valves; M, the valve communicating with the condenser; N, the condenser, immersed in a cistern of water; O, the injection valve; P, the hot water pump; Q, the lever for opening the valve to the condenser and injection valve. The engine being thus constructed, the following will be its operation. The three valves C, D, and M, being opened, the steam from the boiler will blow out the air, &c. from the whole of the engine, condenser, and pump through the foot valves L, L. The piston at starting is supposed to be at the top of the cylinder. The valve D is then to be closed, whilst the valves C and M are opened, consequently the steam and other fluids underneath the piston case and at top of the piston of the air pump I, rushes into the condenser, and there meeting with a jit of water, is reduced to its primitive state; the valves C and M are then closed, and the valve D is opened; the steam that occupied the upper

part of the cylinder then passes between the case and outside of the cylinder, where it not only restores the equilibrium on the upper side of the piston but likewise acting upon the surface of the piston of the air pump I, which, being double the contents or area of the piston K, and a vacuum being constantly between the two pistons, enables me to force out the water and air into the hot well through the foot valve L, and the next ensuing stroke upon the ascent of the pistons I and J, the water and air in the condenser drops or falls into the lower part of the air pump, whence it is driven out by the succeeding stroke. In this manner the alternations will be incessantly continued. Figs. 2d and 3d exhibit the air pump differently applied, as in Fig. 2; a constant vacuum is maintained underneath the lower piston J, in which is placed a small valve K, opening upwards, first, to permit the air inclosed in the lower part to escape; and, secondly, in case of the lower piston leaking, it passes through the said valve upon the descent of the piston, whilst the water and air are excluded by the upper piston I, it being evident that the water and air contained in the large part of the cylinder cannot be compressed into the smaller, and therefore must be forced into the hot well, as in Fig. 1, through the foot valve I. Fig. 3 differs from the two former Figures, inasmuch as the condenser is dispensed with. I is the upper piston, in which are two valves opening downwards, whose weight is counterpoised either by a weight or spring. J is the lower piston, under which, as in Fig. 2, is maintained a constant vacuum. O, the injection valve; L, L, the foot valves, the upper one being placed in the end of the steam pipe to prevent the injection water or other fluids from entering the engine, the said pump being applied to the outside end of the lever beam of a single engine; the operation will be as follows:—When the engine is blown through, which is performed by opening the whole of the valves, as is usual (the injection cock excepted), the piston of the engine being at the top of the cylinder, and the two pistons I, J, necessarily at the bottom of their respective cylinders, a jet of water is then introduced through the injection cock, which, rushing into the upper part of the cylinder of the air pump, and there meeting with the steam, reduces it to its primitive state as fast as it enters, till the whole of that fluid underneath the piston is completely condensed, at which time the steam regulator is opened and the steam permitted to enter freely on the upper side of the piston, and the engine makes it stroke, during which the pistons I and J ascend, and as there is a vacuum above as well as underneath, the pistons are permitted to rise without any resistance, and the water and air that were admitted during the stroke are prevented from entering the engine by the upper foot valve, and passing through the valve or valves in the upper piston J, which opens downwards for that purpose, occupy the space

between the pistons, and upon the descent of the piston is excluded thro' the lower foot valve L. Fig. 4 exhibits another method of applying steam to work the common air pump after it has performed its usual operation on the en gin instead of its passing off into the condenser, as is now generally practised. A, the steam cylinder; B, the piston, as usual; C, the steam valve; D, the medium valve; E, the exhausting valve; F, a cylinder, secured to the bottom of the steam cylinder, in which are two apertures, the upper one G terminating into the condenser, the lower one H into the steam pipe; I, the piston, communicating by a piston rod to the air pump, working through a stuffing box; J, the common condenser and air pump and appendages. The operation of the engine, and its advantages, are the following:—The air and other fluids being first driven out of the engine by blowing thro', and the piston B having completed its stroke, and being at the bottom of the cylinder, the valves C and E are shut, and the medium valve D is opened: consequently the steam in the cylinder A is permitted to pass underneath the piston B, so as to restore the equilibrium, and thereby suffer the piston to ascend freely by its counterpoise, whilst, as a vacuum is always maintained above the lower piston, the steam at the same time acts by its elasticity under the lower piston I, makes a stroke, and by its connection with the air pump excludes the water and other fluids as when attached to the engine, and upon the ensuing stroke, the valve D being shut, and the valves C and E being opened, the former to permit the steam to enter freely above the piston, whilst the latter opens to the condenser and thereby exhausts the whole of the spaces underneath both pistons, the lower piston being no longer supported, sinks by its gravity, and is thus prepared for the ensuing stroke. Hence it is evident that the power of the engine is increased one fourth, and that without any complex machinery and without any additional valves. Fig. 5 is the vertical section of a double engine, to work without any external apparatus, excepting at first starting. For the more clear elucidation. Fig. 6 is the bird's eye view of the top of the cylinder and case, where the same letters denote the same things. A, the steam cylinder, with a flanch projecting on each side; B, the piston; C, the piston rod, which is made or bored so as to admit the rod D to work freely into it. Upon the top of the said rod is forged or fixed a ball larger than the rod itself, which is introduced into the piston rod, and then prevented from being drawn out by a plate screwed on the latter part of the cone, having an aperture in its centre equal to the size of the rod only, through which the said rod may slide easily until it comes in contact with the ball, which, being larger, cannot pass, and therefore the said rod is lifted upwards, and being attached to the lever E, opens and shuts the valves as required; and again, upon the descent of the piston, the

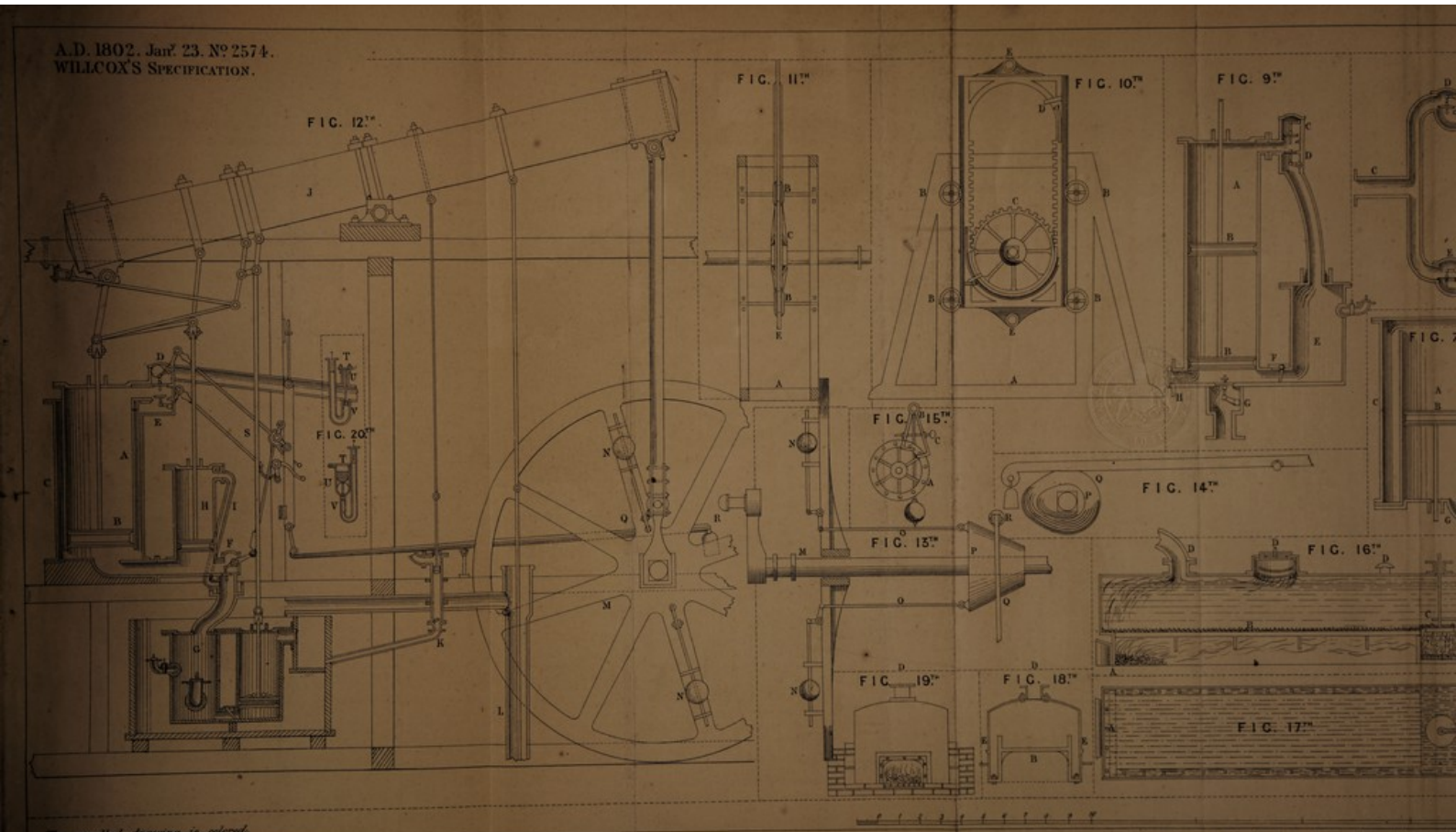
same rod coming into contact with the top of the hole bored in the piston rod, depresses the same levers and produces the requisite contrary action upon the valves. F is the pipe communicating with the boiler and to the case, which is divided into two parts, as is more distinctly seen in Fig. 6, one side of which is marked F, is constantly filled with steam from the boiler, in fact, it is the steam pipe, whilst the other G is open to the condenser. G, the pipe from the case communicating to the cylinder. H, I, J, K, four valves for admitting the steam in and out alternately under and over the piston, as in double engines, the valves of which constitute part of my new improvements, and are solid plungers, packed, working in a brass barrel, bell-mouthed, and so adjusted that the apertures for admitting the steam above and below the piston are at no time to be opened together, and the same is the case with regard to the valves opening to the condenser. My other improvements on the valves consist in preparing two metallic plates, one of which is to be placed against each aperture leading to the cylinder, the other to be suspended by a joint or other simple means, when used vertically, against the back of which works in a recess or groove a wedge, which is wrought by a rod as in the design, or by any other simple means from the external part, through a stuffing box, so that by the ascent and descent of a rod, with inclined planes at proper intervals, the apertures are shut as the case may require, and by placing the plates before the apertures leading from the boiler to the cylinder, so that upon the removal of any of the said wedges the steam shall open the valve by its elasticity, and thus, by keeping the wedge between the cylinder and condenser, or behind the plate or valve, so that the steam in its passage to the condenser shall open the same, I appropriate to the inclined plates the office of shutting off the steam at proper intervals. The operation of this engine being the same as is common in double engines, its becomes unnecessary to describe its action excepting at first starting. For that purpose a pipe is introduced from the steam pipe into the upper part of the cylinder with a valve working through a stuffing box, so that upon stopping the engine the piston is to be at the bottom of the cylinder by shutting off the steam (by a cock or valve), which, when started, must of course be opened, and the valve before described, whereby the air, &c. is driven out from the upper part of the cylinder through the blow valve, as is usual consequently, upon shutting off the steam in the upper part of the cylinder, as described, and admitting a jet of water unto the condenser, the engine immediately is set to work. Fig. 7 exhibits the section of a steam engine in which the steam which now passes to the con-denser is reserved and made to act on the other side of the piston, as in double engines. A, the steam cylinder; B, the piston; C, the case surrounding the

cylinder; D, D, two pipes communicating to the condenser; E, the steam pipe; F, the steam valve; G, lower exhaustion valve; H, the valve opening to the case; I, the upper exhaustion valve; K, the condenser, air pump, &c., as usual. The engine being thus constructed and blown through in the usual manner, with the piston at the bottom of the cylinder, the steam and upper exhaustion valves F and I being both opened, and a free communication opened between the boiler and the under part of the piston, whilst the upper and case is opened to the condenser and exhausted of all its fluids, the engine consequently makes its stroke, in which case the piston arrives at the top of the cylinder, when the valves I and F are closed, and the valve H is opened instantly. The steam is thereby permitted to fill the interstice between the case and cylinder, which is of equal capacity with the cylinder, and thereby half the steam passes into the case, when the valve H is shut and the lower exhausting valve G is opened, whereby the steam left under the piston rushes into the condenser and leaves a vacuum; consequently the steam left in the case and top of the cylinder immediately operates on the upper side of the piston, producing a power in the first instance equal to half the power of the engine, which diminishes in proportion to the space the steam has to fill, and will in all cases produce as much power as is now usually obtained by one cylinder and a quarter of steam from the boiler. And furthermore, although I have placed the case over the cylinder in order to keep the cylinder up to its proper temperature, nevertheless I do not mean to confine myself to that precise plan, for in order to accomodate this my improvement to different situations, I place the reservoir either above the cylinder, or in any other situation that may be most convenient or useful. Fig. 8 is the section of a double powered engine, in which the steam performs two distinct operations previous to its passing to the condenser. A, the steam cylinder; B, the piston; C, the steam pipe; D, E, F, G, H, and I, are the valves; J, the second cylinder and piston, which is attached to the air pump; K, the air pump, condenser, &c., as usual, with this difference only, that instead of a lifting pump I use a force pump, as answering my purpose best. The following will be the operation:—The engine being blown through, as usual, and both pistons at the bottom, the lower steam valve E is opened, and the upper medium valve and exhausting valves F and H are opened, whereby a vacuum is obtained in the upper part of both cylinders, and the engine makes its ascending stroke. The steam valve E is then closed and the medium valve G is opened, when the steam confined in the cylinder acts under the small piston and lifts it up to the top of its cylinder, at what period the lower exhaustion valve T is opened and both cylinders exhausted. The upper steam valve D is then opened and the steam permitted to enter freely

from the boiler on its surface till the stroke is made and the valve F opened. The elasticity of the steam and weight of the pistons combined then force the water and air out through the foot valve. The valves G and I are then closed and the lower steam valve opened, and so on alternately. Hence it is evident that a much larger air pump can be used than is at present for double engines, and that without any deduction of power from the engine; consequently the vacuum will be considerably more perfect, and thus not only the engine will be rendered powerful in proportion, but, as before observed, without reducing the power of the engine, as at present. This engine, as well as Fig. 7, is particularly calculated for raising water from mines, pits, &c. &c. Fig. 9 is the section of Capt^{n} Savery's engine further simplified and improved for raising water. A, the steam cylinder; B, B, two pistons serving to keep the cold water from coming into contact with the upper heated part of the cylinder. C, the steam valve; D, the exhausting valve; E, the condenser and injection valve; F, the foot valve; G, the ingress valve for admitting the water when a vacuum is produced; H, the egress valve for delivering the water. The engine being blown through, the steam valve C is shut and the exhaustion valve D is opened, and a jet of water thrown into the condenser, and thereby a vacuum is produced above the piston, and the counterpoise raises each pistons to the top of its respective cylinder, and the water and air in the condenser drops by its gravity into the cylinder, whilst the pressure of the circumambient air forces water into and fills the lower part of the cylinder. The exhaustion valve is then closed and the steam valve opened, and thereby producing an equilibrium on the upper side of the upper piston with the atmosphere. The water falls by its gravity thro' the lower foot valve H, and so on alternately. Fig. 10 is the front view of a rack and sector, for producing a rotative motion at once from the alternate action of the engine without the intervention of a lever, beam, crank, &c. A, the framing; B, B, &c., four friction wheels; C, the pinion wheel fixed on the fly wheel shaft; D, auxiliary teeth or cogs fixed on the rim of the framing and wheel to guide the cogs into the racks at the end and commencement of every stroke; E, E, apertures in the moveable rack to which the piston rod is attached, as a cylinder may either be placed above the framing or below. Fig. 11 is the side view of the said machinery, with corresponding letters of reference. Fig. 12 exhibits the section of a single engine complete, as applied to a rotative motion in the common way, with my improvements annexed, not only for increasing its powers, but regulating the application of force in a more complete manner than has ever yet been accomplished; A, the steam cylinder; B, the piston; C, the case surrounding the cylinder; D, the steam valve; E, the medium valve; F, the exhausting valve; G, the common air pump condenser, &c., as usual; H, a second cylinder, whose

piston is attached to the beam through the medium of its piston rod working through a stuffing-box; I, a small pipe communicating from the upper part of the cylinder H to the condenser; J, the lever beam, paralel motion, &c.; K, the hot water pump; L, the cold water d°; M, the fly wheel, on which is fixed the centrifugal balls for regulating the engine, as is shewn by a section through the axis in Fig. 13, with corresponding letters of reference; N, N, one or more balls fixed on the arms of the fly wheel, and communicating the power of their divergance by the means of a crank or other simple machinery to the horizontal rods O, O; P, a piece in some measure resembling the friction of a cone, which slides freely on friction rollers forwards or backwards on the shaft; the said piece P has an oval or oblong figure as to its section across the axis, as seen in Fig. 14; Q is a lever or rod which communicates the alternate motion to hand geer for working the engine as delineated; R, a weight that acts as a counterpoise for the plug tree; S, the plug tree and hand geer. The side view of the steam regulator and gage as is more explicitly shewn by Fig. 20, which is the front view with corresponding literal references; T, a chamber raised in the steam pipe, and faced accurately; U, an horizontal slide attached to a piston supported by a column of mercury in the tube V, on the upper end of which floats a light body that will indicate the elasticity of the steam as in the present steam gages. The use and advantage of this my new steam regulator are the following:—Whenever the steam increases its proper degree of elasticity it instantly acts upon the small piston, which is supported by the mercury or other proper fluid, and thereby destroying the equilibrium causes the slide U to descend through the same space, and more or less closes the steam passage, and consequently the fluid having to pass through a less space in the same time must produce a less effect, notwithstanding the increased power of the steam, and thus the engine is compleatly regulated. The engine being in this state of adjustment and blown through, the following will be its operation:—The valves D and F being open and the engine having made its stroke, as in the design, the said valves are shut, and the middle valve being open, the steam passes round the case, and not only produces an equilibrium under the piston, which permits its being brought out of the house by its counterpoise, but likewise (as a constant vacuum is always maintained on the top of the small cylinder H by the open communication to the condenser by the pipe T,) the steam will act by its elasticity when the piston is ascending with a power nearly equal to three fourths or eight pounds on each inch of the area of the piston H, and therefore produces a power equal to what is now deducted for the air pump; and, furthermore, as in most manufactories, the engine is sometimes required to work with a considerably less load than at others, and therefore works with more velocity.

A.D. 1802. Jan.ʳ 23. Nº 2574.
WILLCOX'S SPECIFICATION.



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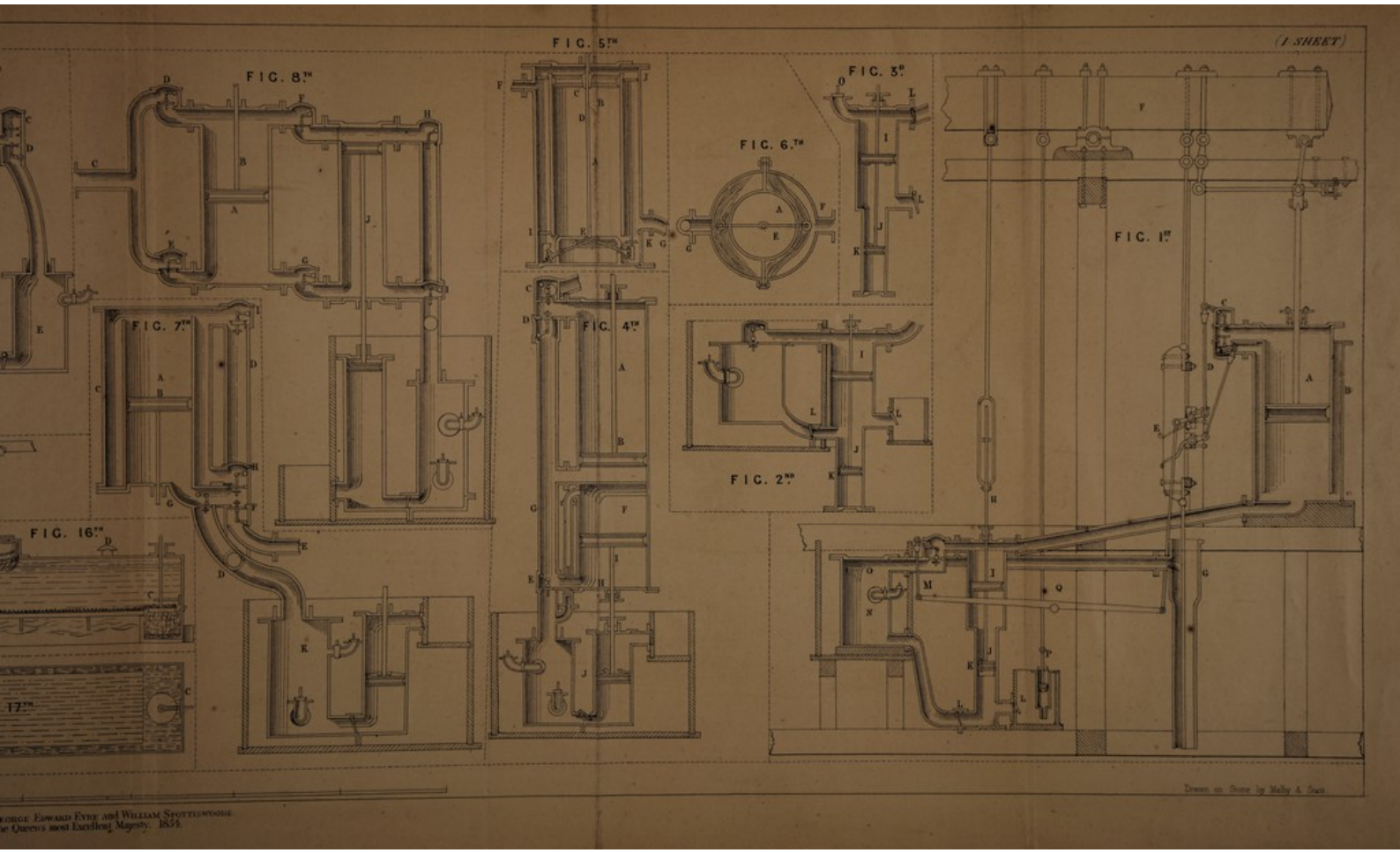

(1 SHEET)

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the Queen's most Excellent Majesty. 1854.

Now, in order effectually to guard against such irregularities, I apply the centrifugal force of the before-described balls to act on the inclined oval or oblong piece shewn in Fig. 12, 13, and 14; whenever, therefore, the fly wheel increases its velocity, the centrifugal power of the balls will draw the piece P nearer the fly wheel, and accordingly permit the leaver that works the plug tree to descend sooner than usual, and shut the steam valve when the cylinder is half or three parts only filled with steam, whence the engine must complete the remainder of her stroke by the expansion of the stream then received, or otherwise the same regulator may be applied to the exhaustion valve, and in either case it will produce the same effect on an engine as if a man were constantly at hand to work the geer; and furthermore, when a certain portion of the labour is thrown off the engine for any length of time, the engine is most readily proportioned to the power required by an adjusting screw in the horizontal rods O, O, Fig. 13; in which case the lever Q, Fig. 14, would continue to fall sooner, and thereby constantly shut off the steam when the cylinder is only partially filled, at the same time that it will have the same tendency to obviate any irregularities, as in the first case. Fig. 15 is the side view of the principal part of a scape ratchet and pendulum for regulating engines, in the use of which I cause the engineer to wind up a weight, or wind it up by some simple machinery by the engine. The end to be obtained by this apparatus is to regulate the engine as exhibited in the following figures:—A, the scape wheel, to the arbor of which is affixed, as in clockwork a rachet, wheel with a weight suspended on it; B, the pendulum and pallets; C, a bolt or screw, to which is affixed a rod communicating with the plug tree or valves; hence the valves of the engine being opened by the clockwork, and not by itself, as at present, will of necessity work as regular as time can be measured by a pendulum; and should its velocity require either to be accelerated or retarded, nothing more is required than to raise or depress the ball or pendulum by an adjusting screw or clip for that purpose. Fig. 16 is the vertical side section of my boiler for economizing fuel; A, the fire-place; B, the thick horizontal or inclined bottom plate; C, the well and float; D, D, &c., the man-hole, feeding pipe, &c. Fig. 17 is a bird's eye view of the cast iron bottom plate detached. Fig. 18 represents a section of the boiler as seen endways, with the interstice or wall of water E, E, each side the boiler above and below the plate B. Fig. 19 exhibits the front view complete with the flues exposed. The principal characteristic of this my improvement in the boiler consists in having a considerable quantity of heated surface, against which the fire impinges, as is evident from Fig. 18, and in keeping the water

as shallow as is practicable, I am enabled to retard the combustion of fuel, and thereby employ nearly the whole of its caloric, instead of permitting it to pass up the chimney as at present. Note, in the Figs 16, 17, 18, and 19, the same letters refer to the same parts in the different views of the boiler.

In witness whereof, I, the said Richard Willcox, have hereunto set my hand and seal, this Twenty-first day of June, in the year of our Lord One thousand eight hundred and two.

RICHD WILLCOX (L.S.)

ORD.

AND BE IT REMEMBERED, that on the Twenty-first day of June, in the forty-second year of the reign of His Majesty King George the Third, the said Richard Willcox came before our said Lord the King in His Chancery, and acknowledged the instrument aforesaid, and all and every thing therein contained and specified, in form above written. And also the instrument aforesaid was stamped according to the tenor of the several Statutes made in the sixth year of the reign of the late King and Queen William and Mary of England, and so forth, and in the seventeenth, twenty-third, and thirty-seventh years of the reign of His present Majesty King George the Third.

Inrolled the Twenty-second day of June, in the year of our Lord One thousand eight hundred and two.

LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1854.