8 Sheets—Sheet 1.

G. A. NICOLLS.

Locomotive Steam Engine.

No. 5,787. Patented Sept. 19, 1848.

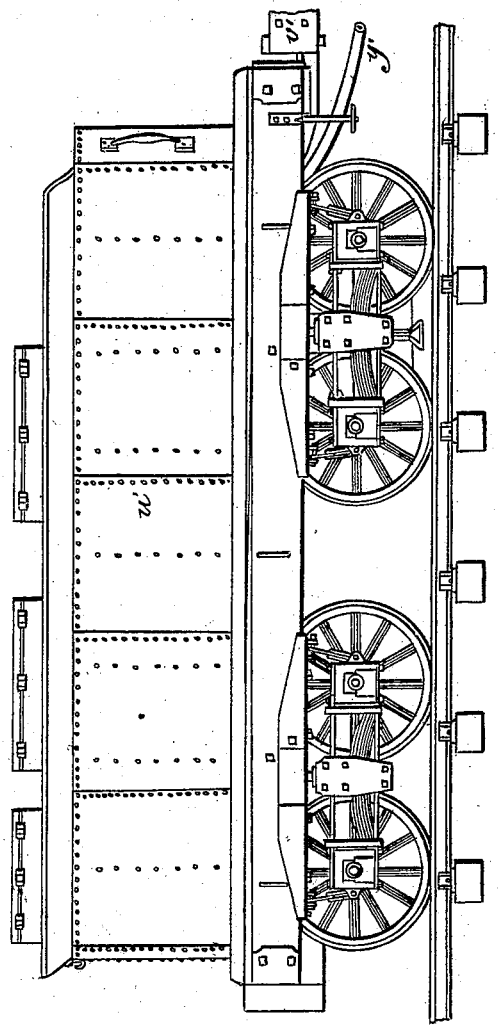

Fig. 1. Continued on Sheet 2.

8 Sheets—Sheet 2.

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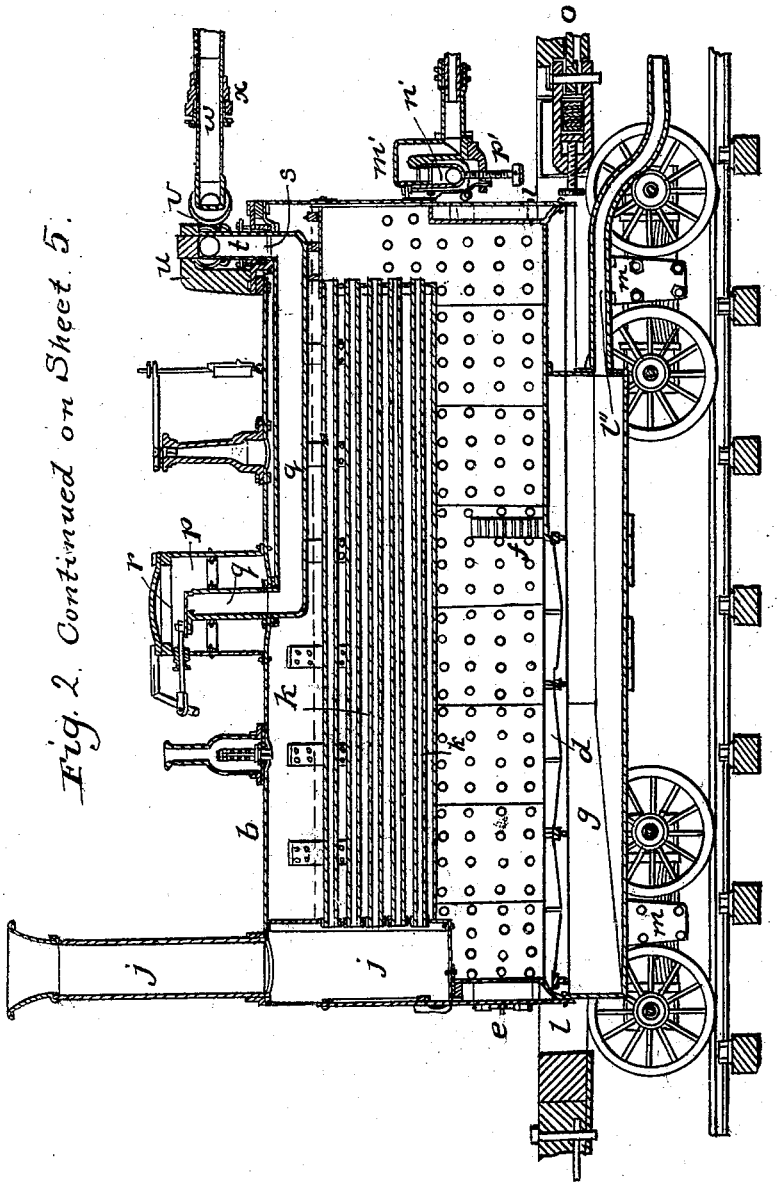

Fig. 2. Continued on Sheet 5.

8 Sheets—Sheet 3.

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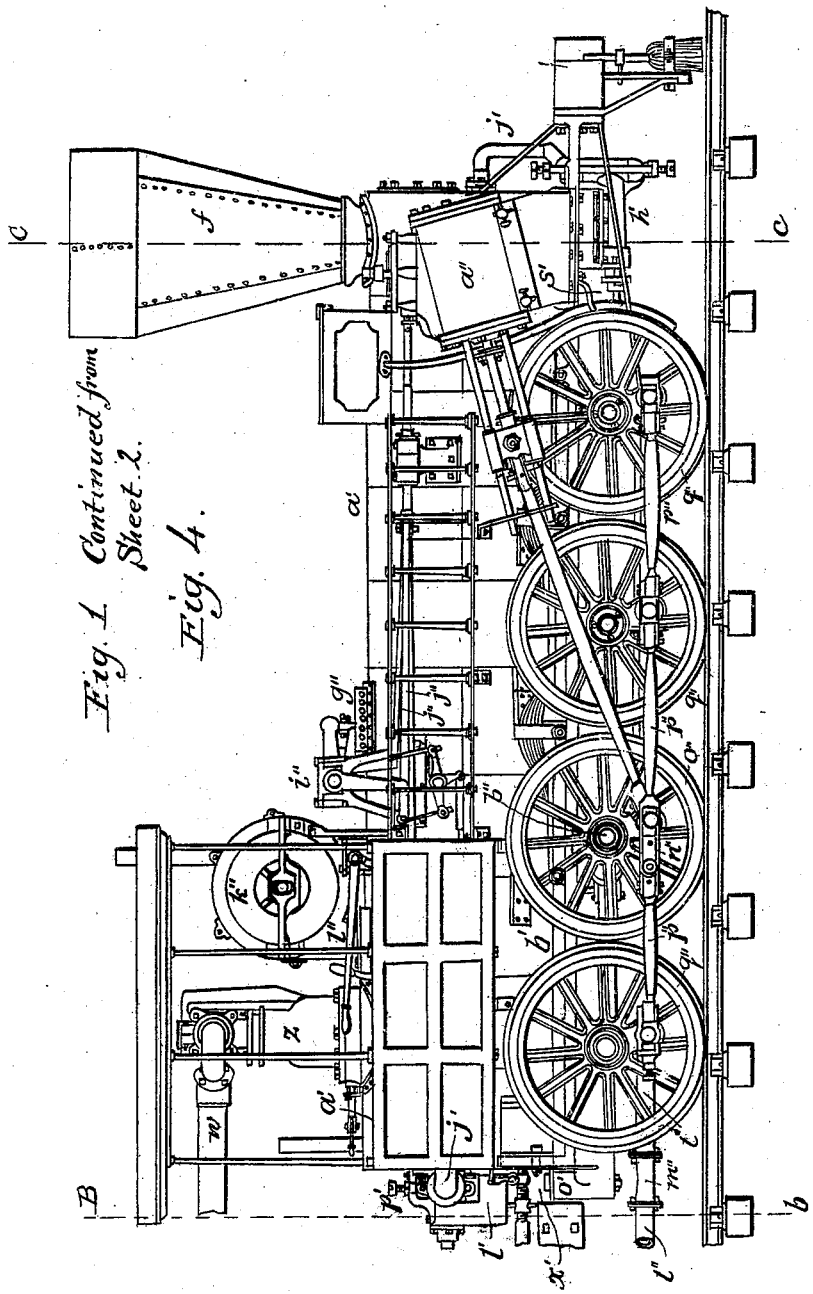

Fig. 1 Continued from Sheet 2.

Fig. 4.

8 Sheets—Sheet 4.

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Locomotive Steam Engine.

No. 5,787. Patented Sept. 19, 1848.

Fig. 1. Continued from Sheet 1.

Fig. 3.

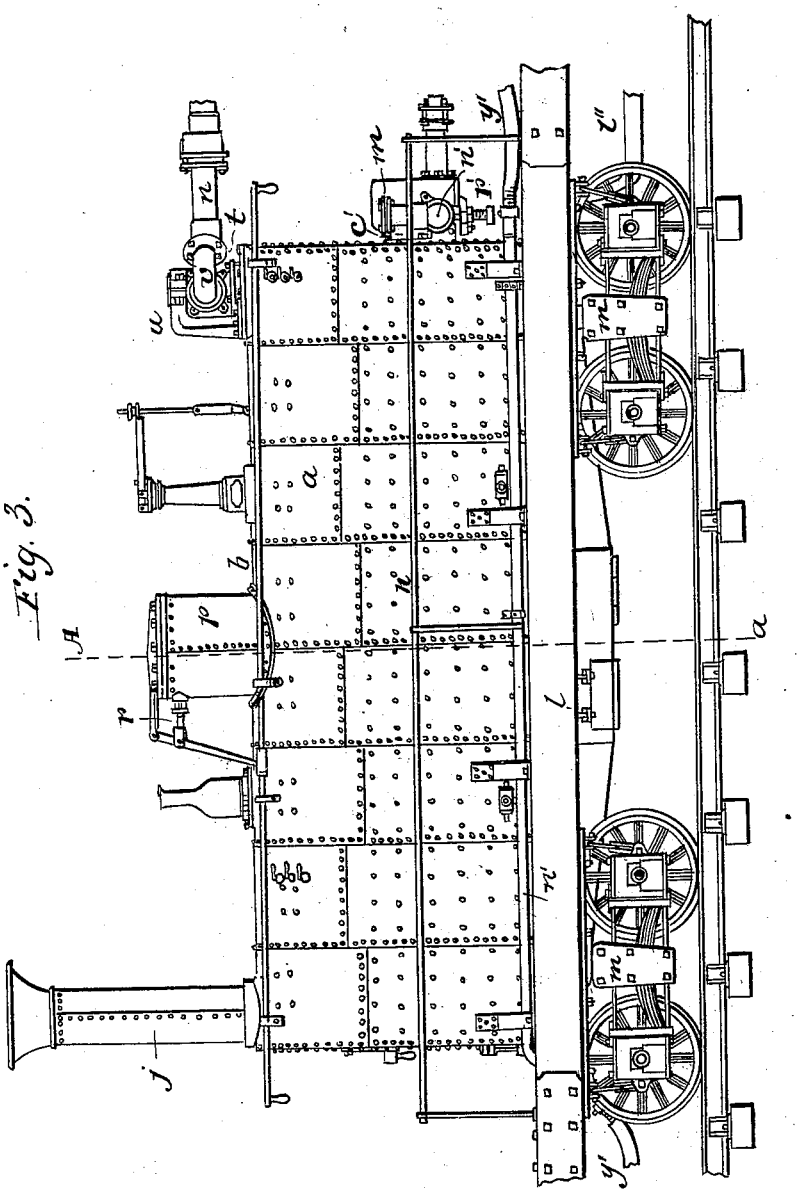

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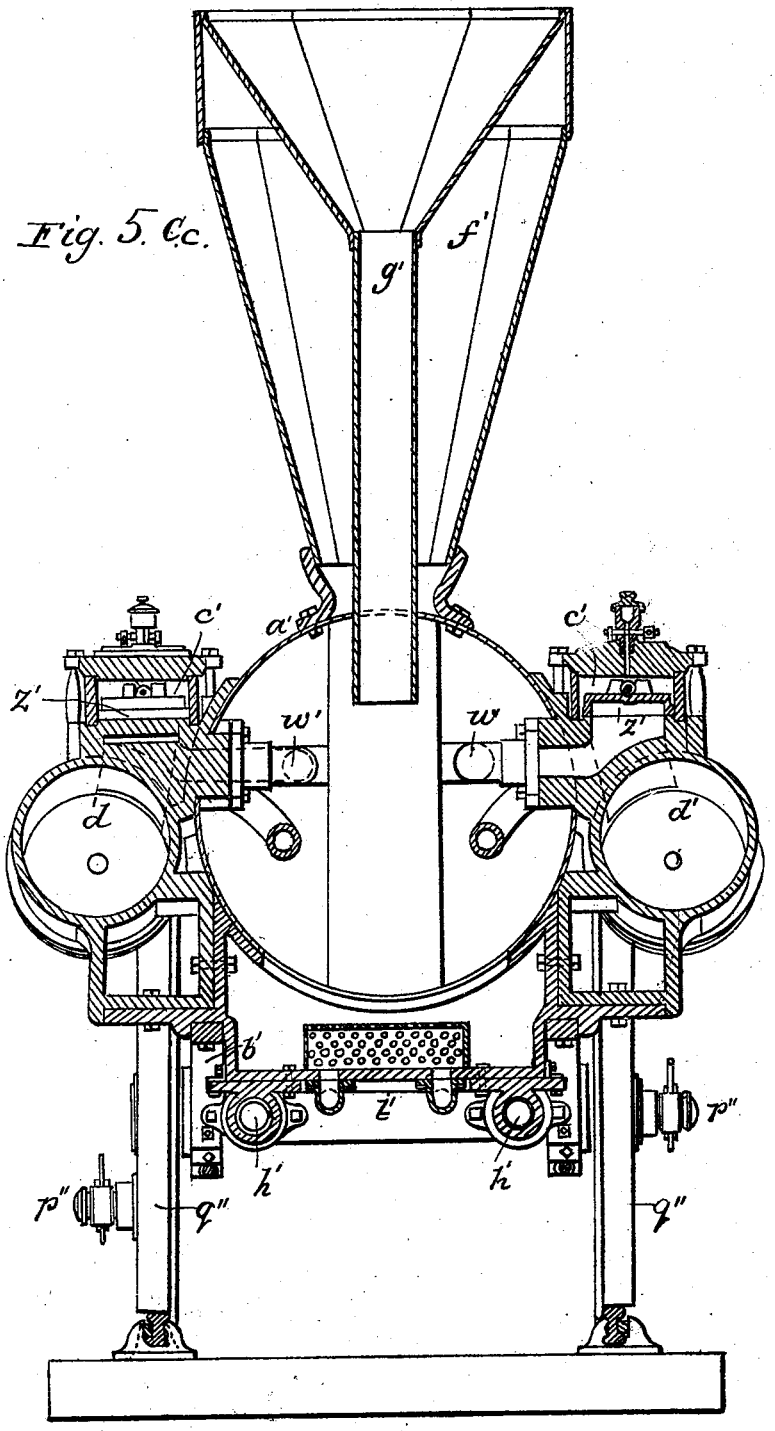
Fig. 5. Cc.



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Locomotive Steam Engine.

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Fig. 4. B.b.

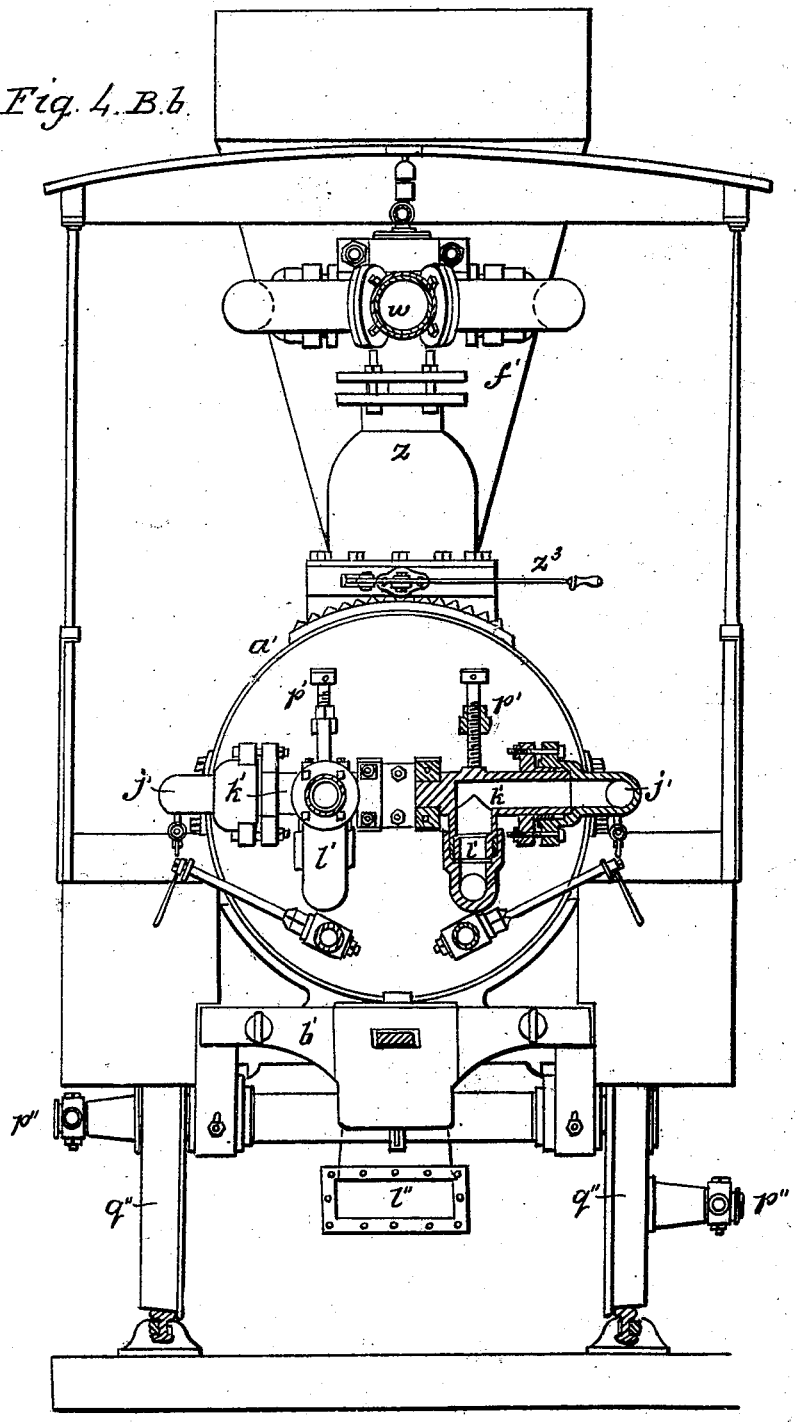

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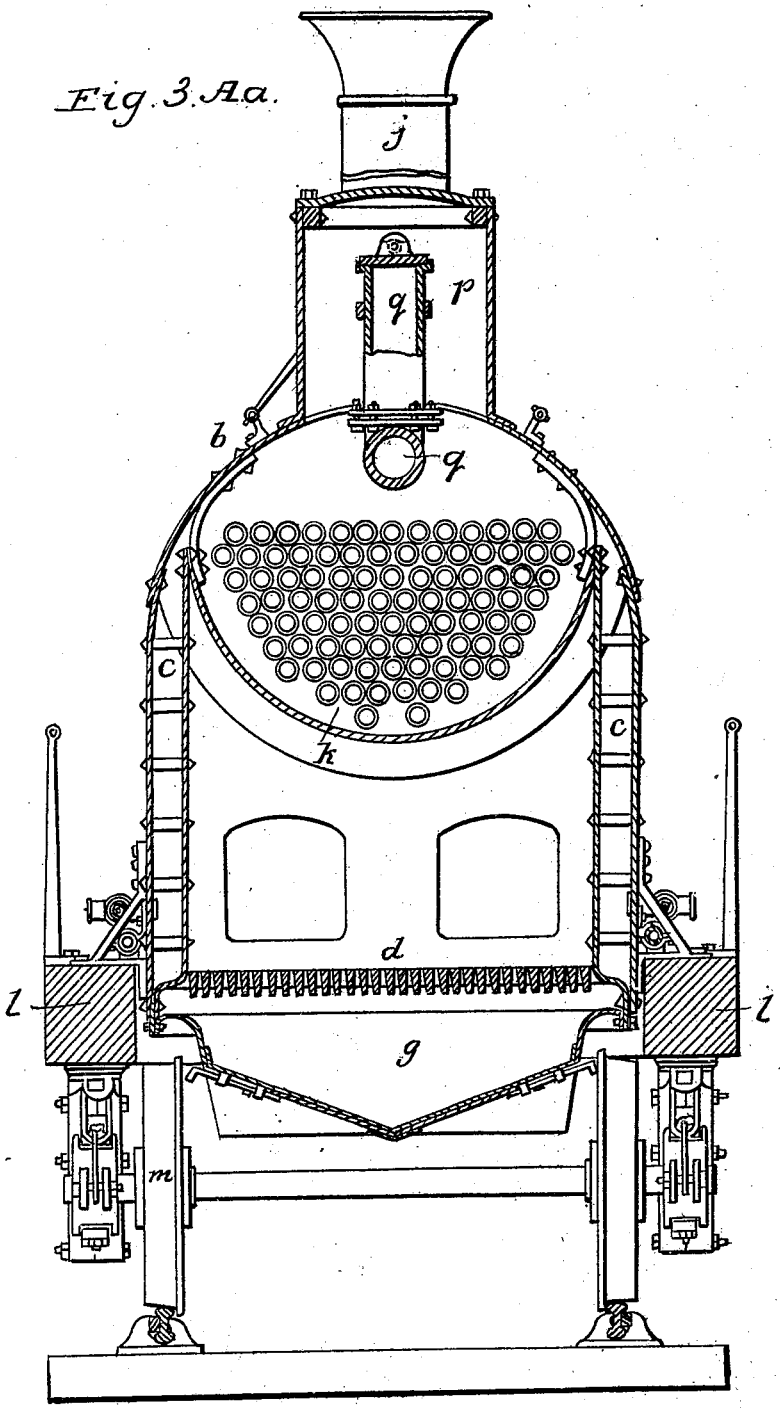
Fig. 3. Aa.



8 Sheets—Sheet 8.

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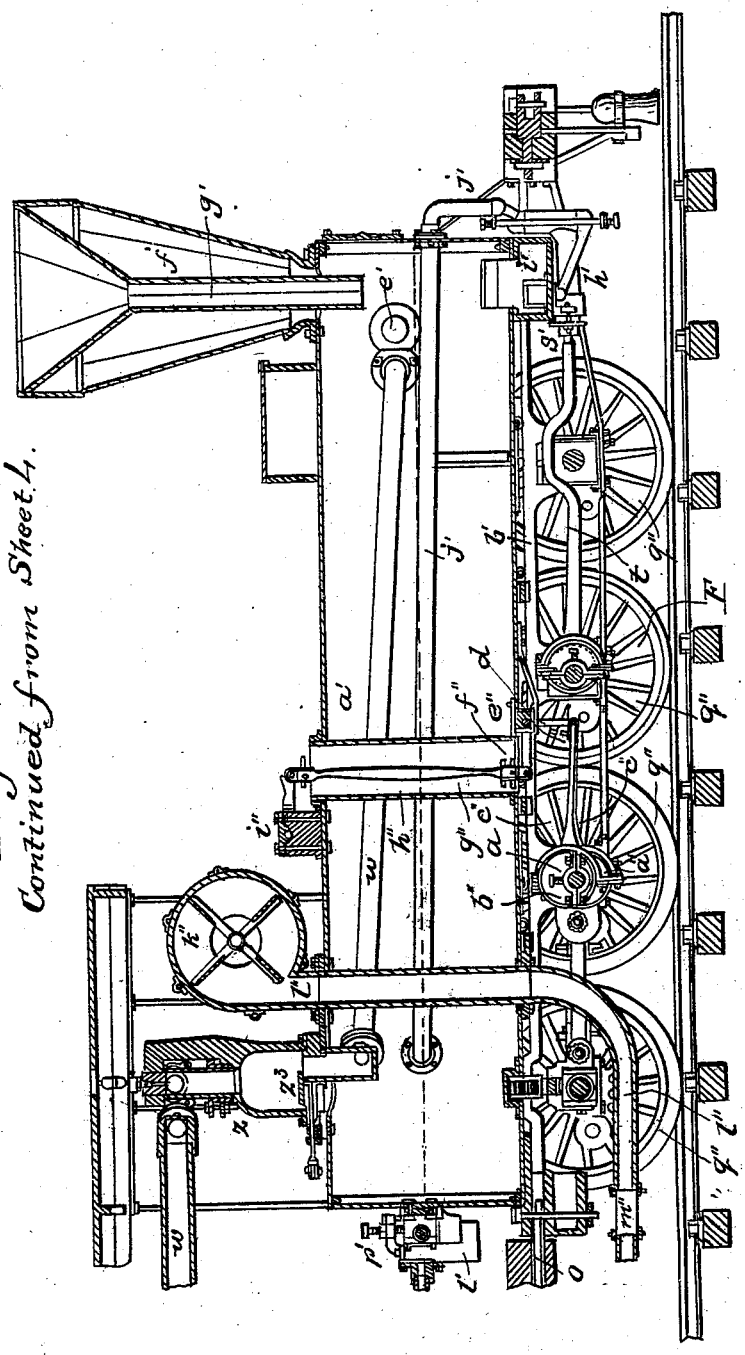

Fig. 2.
Continued from Sheet 4.

UNITED STATES PATENT OFFICE.

GUSTAVUS A. NICOLLS, OF READING, PENNSYLVANIA.

LOCOMOTIVE.

Specification of Letters Patent No. 5,787, dated September 19, 1848.

To all whom it may concern:

Be it known that I, GUSTAVUS A. NICOLLS, of Reading, in the county of Berks and State of Pennsylvania, have invented new and useful Improvements in Locomotive Steam-Engines, and that the following is a full, clear, and exact description of the principle or character which distinguishes them from all other things before known and of the manner of making, constructing, and using the same, reference being had to the accompanying drawings, making part of this specification, in which—

Figure 1 is a side elevation of the engine, boiler, and tender; Fig. 2, a longitudinal vertical section taken through the engine and boiler; and Figs. 3, 4 and 5 cross vertical sections taken at the lines (A*a*), (B*b*), and (C*c*) of Fig. 1 looking in the direction of the arrows.

The drawings are on a scale of $\frac{3}{4}$ of an inch to the foot; the same letters indicate like parts in all the figures.

Much as the locomotive steam engine has been improved within the short period of time since its introduction, to the investigating mind it still presents many glaring defects, some of which have been considered as necessarily resulting from the very nature of railroads, others from the tendency of the human mind to run into extremes in its efforts to devise means for the accomplishment of desired ends, without regard to that system of compensations which should ever be observed in all mechanical structures in which perfection cannot be expected. The desire to obtain the required traction to enable a locomotive to overcome high grades was for a time the leading object of engineers and engine builders, and their aim was so to construct the engine as to increase to the utmost the weight on the driving wheels, but in their zeal to accomplish this desired end they did not observe that by accumulating too much weight on the drivers for this purpose the engine would become very injurious to the road by the concentration of too much weight on the small portion of road acted upon under high velocities. This injurious effect was only perceived and appreciated after the cost of repairs of roads came to be considered. Again, locomotives were gradually increased in power without a corresponding increase in size, and while this increase of power has been going on the limit of size in the width has remained the same, and no effectual attempt has been made to alter the general structure with reference to this increase of power and the nature of the fuel used. Experience and the deductions of science show that anthracite coal can only be used with economy in thin layers and over an extensive surface, but from the mode of construction heretofore and now generally practised, the fire box was necessarily limited in width requiring the coal to be burned in thick layers and under so great an intensity, to generate the required amount of steam, as to be wasteful of the fuel, and highly injurious to the metal in contact or in close proximity to the fuel, the water ways on each side of the fire box being necessarily so limited as not to afford by the circulation of the water the extent of relief which could be given by water ways of greater capacity. The placing of the steam cylinders on each side of the boiler not only greatly limits the width of the boiler but also that of the steam cylinders, steam pipes, &c., thus rendering the use of steam of very high pressure indispensable, the objections to the use of which are too well known and recognized to be mentioned here. The great intensity of heat required led to the discharge of the exhaust steam from the cylinders into the chimney in small jets to increase the draft, the evil effects of which are the reaction of the steam on the piston, which necessarily reduces the effective force of the steam from the boiler, and the discharge of sparks from the chimney as well as the escape of the products of combustion in a highly heated state, thus increasing danger and wasting fuel, as it is a fact well known that the draft in a furnace, with a view to economy, should be produced by pressure and not by exhaustion, the former tending to retain the products of combustion within the flues with the flame impinging against the surface to be heated until the heat is given out, while the latter induces them to pass out in rapid streams. Under the present mode of construction the capacity of the engine is certainly limited by the width of road and by the length of the working capacity of a carriage made with due regard to the curves of the road.

To overcome the objections pointed out above I have varied in a great measure the system heretofore pursued in the construction of locomotive steam engines by placing the boiler and the engine on separate car-

riages connected together, and to this system I have applied my improvements. The first part of my invention consists in the employment of a boiler of greater width than heretofore used on railroads, that is to say to the full capacity of the width of the frame of the carriage, (leaving just room enough for a passage on either side), the said boiler having a long grate surface extending under a portion of the length of the boiler, with a horizontal flue space extending under the remaining portion to a vertical flue space at the end of the series of tubes that the flame and other products of combustion may act against the bottom of the boiler and against the sides of the water ways on each side and then pass to the ends of the flue tubes and back through them to the stack which is placed above the furnace door, when this is placed on, and carried by a separate carriage of six, eight, ten, or more running wheels, and combined with an engine on a separate carriage with driving wheels, by which arrangement and combination, I am enabled to obtain a large extent of fire surface to burn anthracite coal with the same economy as in stationary and marine boilers, and to extend the capacity of the boiler to the limits of the carrying capacity and size of a carriage independently of the cylinders and other machinery of the engine, at the same time avoiding the wear and tear to which the boilers of locomotives, as heretofore constructed, are exposed by reason of the working of the engine and the greater jar to which that carriage is exposed by reason of the action of the driving wheels, and also presenting the additional advantage of being transferable to any engine so that when the engine, which is most liable to derangement, requires repairs the boiler may be used equally well with another.

The second part of my invention consists in employing a horizontal cylinder constituting the body of the engine into which the water produced by the condensation of the escape steam shall be discharged preparatory to its being transferred to the boiler, which cylinder is also to be connected with the tender to receive the supply water which is heated by the water of condensation, this vessel or cylinder being of such capacity as to contain the quantity of water necessary to graduate the weight of the engine to the amount of traction required and to the supporting capacity of bridges and other parts of the road.

The third part of my invention consists in providing this water heater or cylinder with an air condenser of steam into which the steam is to exhaust and to be condensed by contact with the metal surface of the condenser which is kept down to the required temperature by the action of the air, the said condenser being made hollow of thin sheet metal in form somewhat similar to the usual stack and spark arrester, so that on the discharge of the steam the air contained in this vessel is forced out and the steam then condensed which produces a partial vacuum, thereby rendering more effective the action of the steam from the boiler on the pistons. And the fourth part of my invention consists in combining the closed ash pan under the furnace grate of the boiler with a fan on the engine by means of a flexible connecting pipe whereby the required blast can be given from the engine on a separate carriage.

In the accompanying drawings (*a*) represents the external form of the boiler which is similar to what is familiarly called the wagon top boiler. Its top (*b*) is semi-cylindrical with vertical water ways (*c*, *c*) running along the sides from end to end and extending down to the grate (*d*) which is provided with a close fitting furnace door (*e*) at the back, and a fire bridge (*f*) about midway of the length of the boiler, thus constituting a fire chamber of great capacity with a closed ash pan (*g*) below, the space extending from the fire bridge to the other head of the boiler, constituting a flue space of great capacity which extends up near to the top of the rear part of the boiler to communicate with the ends of the series of tube flues (*h*), the other end of these tubes being made to communicate with the smoke box (*i*) surmounted with a stack (*j*) in the usual manner.

The bottom (*k*) of the boiler is an inverted arch the sides of which are secured to the upper edges of the inside plates of the water ways, the other arch forming the top being secured to the outside plates of these water ways so as to leave a free communication between the water ways and the body of the boiler which is nearly cylindrical and provided with the series of horizontal flue tubes, that communicate as before stated with the vertical flue at the forward end and the smoke box situated at the rear and just over the furnace door, so that the fire acts directly against the sides of the water ways, and the bottom of the boiler along their whole length, the products of combustion passing up the vertical part of the flue space, and through the series of tubes to the smoke box and then out at the chimney. The boiler thus constructed is properly secured to the side pieces of a carriage (*l*) which is supported on two trucks (*m*, *m*), leaving space enough outside the boiler for the engineer or fireman to pass from one end to the other, the side pieces of the carriage having an iron railing (*n*, *n*) for the protection of the men.

The boiler carriage is connected with the engine carriage by a draft link (*o*), in the

usual manner of connecting carriages, except that this connection is not to be elastic. Within the steam dome (p) of the boiler there is a steam pipe (q) to the upper end of which is fitted a throttle valve (r). This steam pipe runs along horizontally in the upper part of the boiler to the forward end thereof, and there turns up to form a collar (s), in which fits the lower end of a short vertical pipe (t) the upper end of which is closed and turns in a standard (u), and it is provided with two short branches onto which are fitted by packing boxes the curved branches (v, v) of a part of the main steam pipe (w) that connects with a packed telescope joint (x) with another part thereof, which is in turn connected by similar packed swivel joints with the upper part of a dome (z) attached to the upper part of the horizontal cylinder (a') which constitutes the body of the engine on the carriage (b'). The lower part of the dome (z) is also provided with a sliding throttle valve (z^3) to govern the aperture in the continuation of the steam pipe that passes inside of and along the upper part of the cylindrical body (a') to the forward end thereof where it branches off to conduct the steam to the two steam chests (c', c') placed together with the two steam cylinders (d', d'), one on each side of the forward end of the water cylinder (a').

The throttle valve (z^3) in the dome (z) on the engine gives the engine man, who can readily reach it, the means of conveniently regulating the admission of steam; but the one in the dome of the boiler, which is not so accessible, is required for cutting off the flow of steam whenever it becomes necessary to separate the boiler carriage from the engine.

The several joints in the steam pipe above described admit of the free play required between the two carriages in passing along the curves, and over undulations on the road, and in starting and stopping, at the same time that the packing of the joints prevents the escape of steam.

The steam cylinder of the engine exhausts into the upper part of the water cylinder through the exhaust ports (e'), (one only shown in the drawing) and the steam is condensed by rising into an air condenser (f') which is attached to the upper part of the cylinder (a') in the form of a chimney, with an inner pipe (g), the upper end of which is connected with the upper end of the outer case by a funnel so that the steam, as it is exhausted rises in the space between the outer casing, and the inner pipe and funnel and is there condensed by the conducting qualities of the metal which is kept cool by passing through the air. The water thus produced falls back into the water cylinder (a') in a heated state to be pumped back into the boiler by the action of two feed pumps (h', h') that receive the water from a water chamber (i') at the bottom of the water cylinder and force it through two water piper (j', j'), that pass up through the water cylinder, out through the sides, and around to the rear end thereof where they are each connected with one end of an elbow pipe (k') by a packed joint that turns vertically; the lever end of the elbow is connected by a packed joint with a short inverted siphon formed pipe (l') the end of which is connected by a sliding packed joint with a like pipe (m') which in turn is connected by a turning packed joint with another elbow pipe (m'), that is again connected with a nozzle (o') from the boiler with a packed joint that turns at right angles to the other turning joints, so that by these means the two carriages are at liberty to vibrate in any direction, the joints of these pipes admitting of motions in all directions, and the joints being kept tight by bridles and screws (p', p').

The supply pumps are operated by two eccentrics (q', q') on the second driving axle (r'), the piston rods (s') being connected with the eccentrics by means of the connecting rods (t') only one of the eccentrics, pump rods, and connecting rods are represented in the drawings.

Water is supplied from the tender (u'), (which as usual is on a separate carriage, connected by a draft link (v') with the boiler carriage) by means of a pipe (w') that runs along by the side of the boiler to the water cylinder (a') where it is provided with a cock (x') by which the quantity of water to be discharged into the cylinder can be regulated—two sections of this pipe, at the junctions of the carriages as at (y', y'), being made of leather, or other flexible substance to yield to the vibrations of the carriages. By this means not only is the supply of water arising from the waste or imperfect condensation, supplied, but the weight of the steam carriage regulated at pleasure to suit the condition or circumstances of the road and the duty to be performed.

The valves (z', z') are operated by the eccentrics (a'', a'') on the main driving shaft (b''), the rods (c'', c'') of which are jointed to the arms (d'', d'') of a rock shaft (e'') below the water cylinder (a'); and the other arms (f'', f'') are in like manner jointed to connecting rods (g'', g'') (that pass up through a vertical tube (h'') that pass through the water cylinder) and operate a rock shaft (i'') above connected in the usual manner with the valve rods (j'', j'').

Above the water cylinder (a') there is a fan blower (k'') which is to be operated by a small rotary engine on its shaft; the ro-

tary engine and small pipe to supply it with steam not being represented, as this mode of operating fan blowers on locomotives is well known.

The blast pipe (l'') from the fan case passes down through the water cylinder and runs along below it to the junction of the two carriages where a section (m'') of the pipe is made of leather or other flexible substance, the pipe then continues to the forward end of the closed ash pan to blow the fire, so that the fire is excited and supplied with oxygen not by exhaustion, but by pressure, the effect of which is that the flame produced impinges against the bottom of the boiler, and the highly heated gaseous products of combustion then pass through the tube flues to the smoke box and chimney, first giving out the greater part of their heat to the flues which transmit it to the water. The connecting rods of the engines take hold of the crank pins (n'',) on the driving wheels (o'') of the main driving shaft (b'') which are connected by connecting rods (p'') with the driving wheels (q'') of the other three axles which also become drivers.

The steam cylinders (d', d') are connected with the sides of the water cylinder (a') near the forward end thereof in a firm and solid manner as shown in the drawings, and the water cylinder is properly and firmly secured to the top of the carriage (b') in the usual manner of making such connections. The driving shafts are also connected with their carriage in the usual manner.

I am aware that a locomotive was invented in the year 1838 for the Great Western Railroad in England in which the boiler and engine was placed on separate carriages, simply to obtain room on the engine carriage for cog gearing that the required velocity might be given to the driving wheels with the slow motions of the pistons to bring their motions down to the standard of moving velocity of steam pistons given by Watt, but no change was made or contemplated in the boiler, which is one of the leading objects of my invention. The only object contemplated in the production of this engine in 1838, has long since been attained in locomotives that have the boiler and engine on one and the same carriage by simply increasing the length and by other alterations in the arrangement of the parts to make room for the gearing required, but the purposes for which I place the boiler and engine on separate carriages was never contemplated or understood and require entirely different combinations and arrangements; and therefore, I wish it to be distinctly understood that I do not claim as my invention simply placing the boiler and engine on separate carriages; but

What I do claim as my invention and desire to secure by Letters Patent is—

1. The employment of a boiler constructed in the manner, and for the purposes and objects substantially as herein described, when combined with an engine on a separate carriage, substantially as described.

2. The employment of a cylinder to constitute the body of the engine carriage connected and combined with the steam cylinders, substantially as described, into which the steam cylinders exhaust to act as a hot well and partial condenser and to give the required weight to the engine that the traction of the driving wheels and the weight may be regulated and adapted to the load to be drawn and to the condition of the road, as described.

3. I claim the air condenser in combination with the steam cylinders and water cylinders for the purpose of condensing the exhaust steam, substantially as described, the condenser being cooled by the action of the atmosphere.

4. And finally, I claim placing the closed ash pan of the boiler furnace on the boiler carriage in combination with the fan blower placed on the engine carriage, the two being connected by means of an elastic or other yielding pipe, substantially as described.

GUSTAVUS A. NICOLLS.

Witnesses:
DAVID E. STOUT,
E. C. CALDWELL.