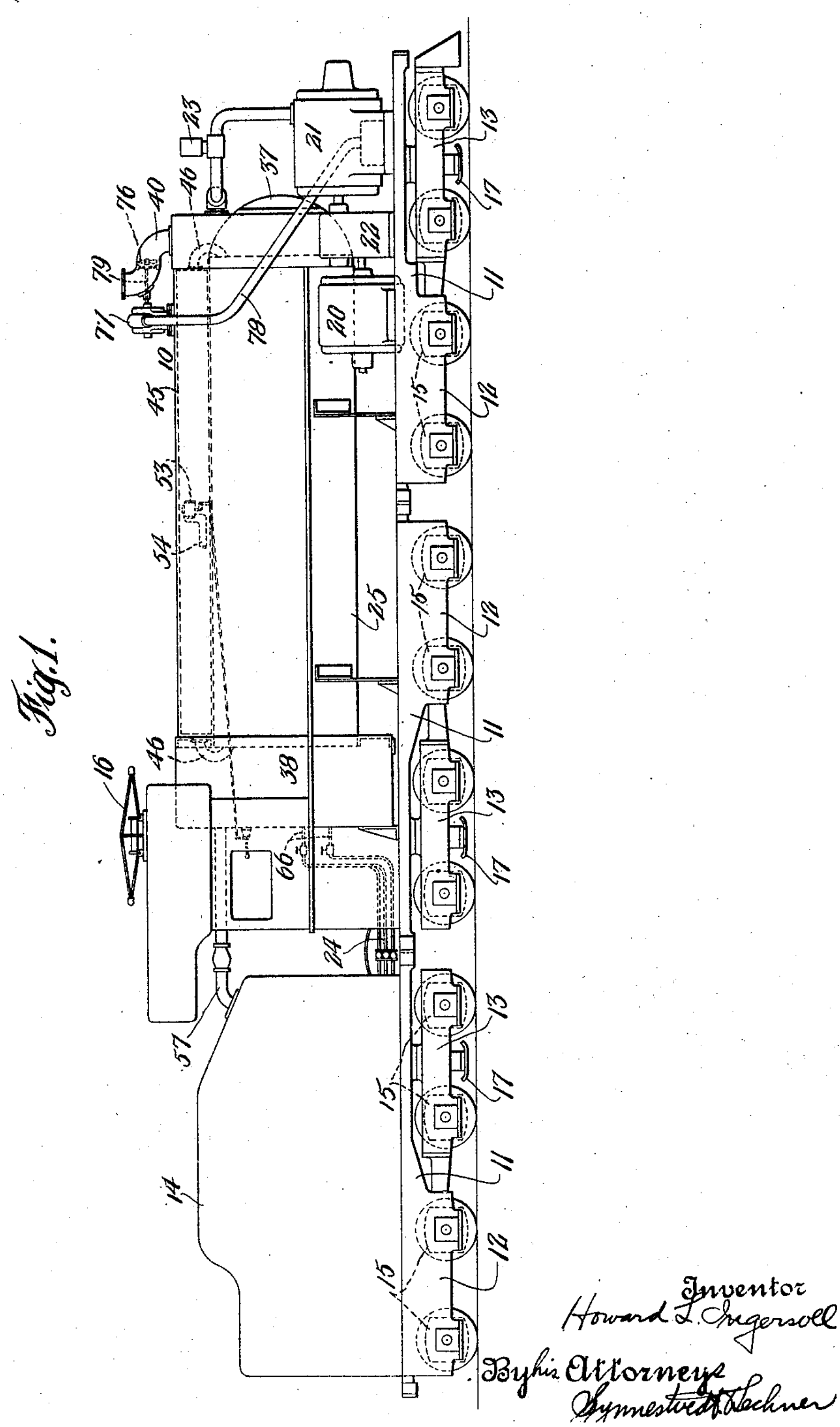
June 16, 1931. H. L. INGERSOLL 1,810,709

LOCOMOTIVE

Original Filed Nov. 23, 1923 3 Sheets-Sheet 1



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Original Filed Nov. 23, 1923 3 Sheets-Sheet 2

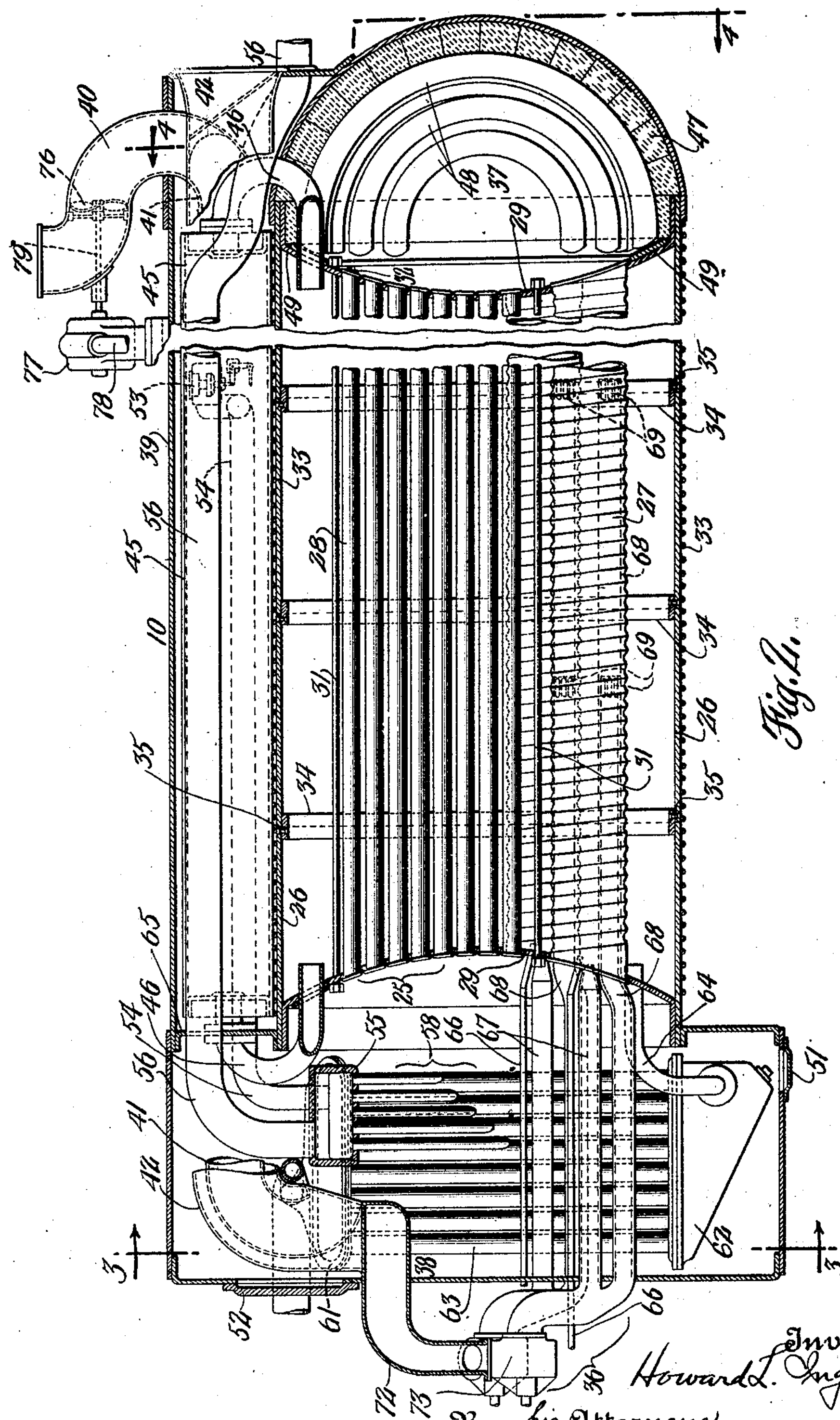

Fig. 2.

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Original Filed Nov. 23, 1923 3 Sheets-Sheet 3

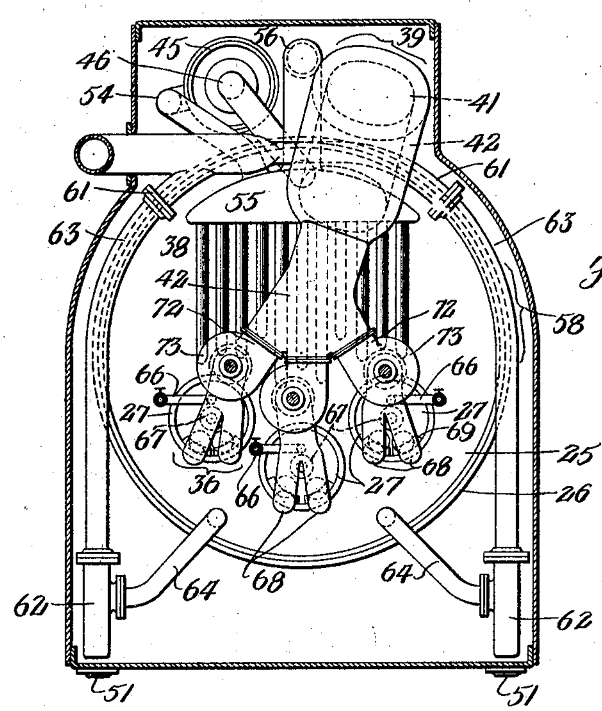

Fig. 3.

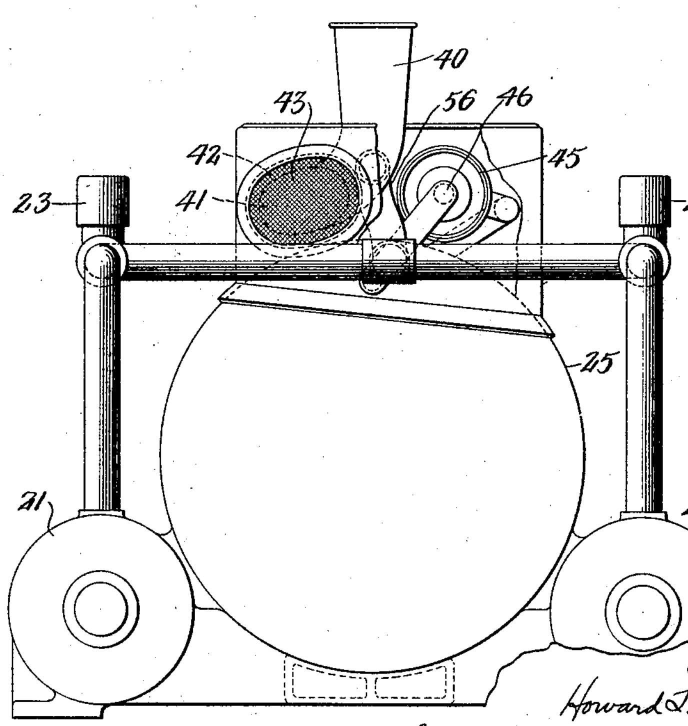

Fig. 4.

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UNITED STATES PATENT OFFICE

HOWARD L. INGERSOLL, OF STAMFORD, CONNECTICUT

LOCOMOTIVE

Original application filed November 23, 1923, Serial No. 676,497. Divided and this application filed November 22, 1926. Serial No. 150,005.

My invention relates to steam locomotives and the like, and is more especially concerned with increasing their power, efficiency and life, and, at the same time, in saving wear and tear on rails and equipment. I have discovered that greatly increased efficiency and power can be secured without corresponding increase in size and weight, by employing a special drive or transmission between the prime movers or engines and the drive wheels, instead of the usual direct connections, and using substantially higher boiler pressures than heretofore. By means of a steam-electric drive, I can overcome the practical limitation on boiler pressure heretofore imposed by the limited adhesion of drive wheels to track under a given deadweight load (i. e., the "factor of adhesion", as it is commonly termed), so that I am enabled, with suitable boiler construction, to employ very high steam pressures and temperatures indeed: e. g., double or treble the present working pressure of about 200 lb. per sq. in.

The increase in power and efficiency obtainable by such high boiler pressures will readily be appreciated by steam engineers. The electric drive is well adapted to such pressures (as already intimated) for several reasons: e. g., it gives uniform torque at the drivers; its flexibility allows the drivers to be of the most advantageous sizes, and permits drivers and prime movers to operate at the speeds most favorable for each; and it allows any or even all the wheels of locomotive and tender to be used as drivers, and thus reduces the torque that must be utilized at each without slippage,—especially in starting.

In other words, a drive or transmission that is flexible in the sense of allowing prime movers and drivers to operate at different speeds makes the factor of adhesion of the locomotive practically independent of and unaffected by the high boiler pressure. In the ordinary locomotive, this is not the case, because the piston thrust that determines the driver torque varies directly according to the boiler pressure.

The maximum of power from the old reciprocating drive direct to the wheels has probably been reached. With such drive it has been impossible heretofore to make use of very high boiler pressures, for the reason that, as the pressure increases, the torque increases, especially in starting, and a too greatly increased pressure means a "slippery" locomotive. Of course, the factor of adhesion can be and has been raised by increasing the weight on the drivers, but this process has about reached its limit.

I overcome the difficulty, as indicated, by using a steam electric drive with very high boiler pressure. In this way, the factor of adhesion will not be affected, as it were, by the high boiler pressure. In other words, I use a pressure which would normally cause slippage in any old type locomotive with direct reciprocating drive.

I prefer to use a turbine or turbines to generate the current because they eliminate reciprocating motion, and, thus, save wear and tear. Furthermore, a turbine operated by the high pressure steam which I propose constitutes a prime mover which is sufficiently efficient to warrant its adoption. In all turbo-electric locomotives hitherto suggested, insofar as I am aware, the use of a condenser has always been attempted in order to avoid the loss of efficiency due to the turbine as against a reciprocating engine when using steam at ordinary pressures. The condenser for a locomotive of a few hundred horse power would not be preposterous, but one for a 3500 horse power locomotive would be entirely out of the question. The amount of water required to condense for such a machine would be tremendous, or if, on the other hand, an air cooled condenser were adopted, it would take several car loads of pipe racks.

Furthermore, by my invention, I am enabled to use the exhaust steam from the turbine for draft purposes, a feature which, of course, would be impossible with low pressure turbines and condensers.

In order to derive the fullest advantage from the high boiler pressure, I also aim to enable such high pressure to be carried without making the boiler shell, etc., excessively thick and heavy. I also aim to adapt the locomotive to operation with fuel burned in suspension (such as oil) in a novel manner.

The use of oil as fuel favors the compactness of steam generating plant so essential in a locomotive. In the case of a boiler of the general "Scotch drum" type, such as hereinafter particularly shown and described, the use of such fuels, as above mentioned, favors reduction in the diameters of combustion flues and fire-tubes, so as to stand the high pressure without excessive thickness and weight.

How all these and other advantages can be realized through my invention will appear from my description hereinafter of the best embodiment known to me, comprising a turbo-electric locomotive equipped with my preferred type of boiler adapted for pressures of 400 to 600 lb. per sq. in. or upward.

In the drawings:—

Fig. 1 is a side view of such a locomotive conveniently embodying my invention.

Fig. 2 shows a vertical fore and aft midsection through the boiler of the locomotive shown in Fig. 1.

Fig. 3 shows a transverse section through the boiler at the firing end, taken as indicated by the line 3—3 in Fig. 2.

Fig. 4 is a fragmentary head-on view of the locomotive, with certain parts broken away and in section, as indicated by the line 4—4 in Fig. 2.

Referring, first, to Fig. 1, it will be seen that the locomotive shown is of the general turbo-electric type set forth in my pending application, Serial No. 556,228, filed April 24, 1922, now Patent No. 1,615,454, granted January 25th, 1927. This locomotive comprises a boiler 10 mounted on interconnected "vehicles" or carriages 11. Each of these vehicles 11 comprises a couple of wheel trucks 12 and 13 with radius bar interconnection. The tender 14 that carries the supplies of water and fuel is similarly mounted on another carriage 11. As shown, similar ends of all adjacent vehicles 11 are interconnected. The foremost radially or laterally swinging trucks 13 of locomotive and tender lead, and the rear swinging truck 13 of the locomotive trails. Driving motors 15 are mounted on the axles of all the loaded wheels of locomotive and tender. These motors 15 may be operated by current taken from an ordinary trolley or third rail system by overhead trolley 16 or third rail contact shoes 17; or they may be operated by current from generators 20 driven by steam turbines 21 through reduction gearing 22. As shown, these latter parts 20, 21, 22, are all mounted on the platform of the forward vehicle 11, the turbines 21 ahead of the boiler 10, and the generators 20 and gearing 22 at either side. (See Fig. 4.) The turbines 21 take steam from the boiler 10 through piping equipped with regulators 23, such as shown in my aforesaid application. The locomotive is here indicated as equipped for firing with oil supplied from the tender 14 through flexible pipes 24. Referring, now, more especially to Figs. 2, 3 and 4, it will be seen that my improved boiler 10 here shown is of a modified Scotch drum type, comprising a main drum 25 with outer shell 26, helically corrugated combustion flues 27 in its lower portion, and return tubes 28 above the flues. The flues 27 and the tubes 28 may be expanded in the tube sheets 29 and flanged over to serve as stays; and stay rods 31 may be provided for areas of the sheets 29 around the flues and outside the tubes. If necessary, some tubes 28 may be installed above the usual level, with stay rods 31 within them; or some of the tubes 28 above the water level may simply be plugged off, as at 32, to leave them "dead" and prevent their burning out. As shown, the flue sheets 29 are curved or dished inward, to strengthen all areas not stayed by the tubes 28 or the rods 31.

Being fired with fuel burned in suspension instead of on grates, the flues 27 need not be so large as in ordinary Scotch boilers; e. g., they may be about 20″ inside diameter, and the flues 28 about 3½″. The outer shell 26 may be of steel plate corresponding in thickness to present practice for pressures of 200 lbs. or more, and may be externally girdled with steel wire reinforcement 33 of high tensile strength, to enable it to stand the much higher pressures that I contemplate. This reinforcement may be applied by placing the boiler in centers and winding the wire 33 on it (very much as in the manufacture of heavy ordnance), suitably securing the ends of the wire to the shell, as by welding the end convolutions. To avoid interference with the wire 33, the seams of the shell 26 may be butt seams with butt straps 34 on the inside, as shown, and the external rivet heads 35 may be countersunk. For like reasons, all fittings and connections may preferably be applied to the end sheets 29.

In the present instance, the boiler 10 is arranged to be fired from the rear end of the locomotive, by oil burning apparatus comprehensively indicated at 36; the combustion chamber 37 is at the front; and there is a smoke box 38 at the rear, to receive the products of combustion issuing from the return tubes 28. To make the locomotive conform to ordinary practice, the products of combustion may be led forward from the smoke box 38 through a casing 39 extending along the main drum 25, to a stack 40 above the combustion chamber 37; instead of discharging directly from the smoke box itself.

A draft is created, for example, by means of a suction fan 76 in the stack 40, which fan is driven preferably by means of a small turbine 77 conveniently located on some portion of the adjacent boiler structure. The exhaust steam from the turbines 21 is utilized through the conduit 78 to operate the fan. The stack is reversely curved, as shown in Figs. 1 and 2, in order to provide an arrangement which will make possible a horizontal disposition of the direct drive shaft 79. However, other fan arrangements might be employed equally well, and it is not my intention to limit the invention to this precise construction.

As shown in Figs. 2 and 4, there is a separate smoke conduit 41 in the casing 39; and an air supply conduit 42 for the burners 36 extends rearward around this smoke conduit 41 from a grated intake 43 at the front of the locomotive and of the casing 39 (Figs. 2 and 4). There is a separate steam drum 45 connected to the main drum 25 at either end by U-bent connections 46 taking into the ends of both drums.

The combustion chamber 37 is shown as consisting of a rounded metal shell with refractory lining of fire bricks 47. Against the inside of the latter are a series of water circulating tubes 48 bent in substantially vertical planes, with their lower and upper ends secured in the outer zone of the flue sheet 29, below the flues 27 and above the fire tubes 28. As shown, the outer zone of the flue sheet 29 that takes the tubes 48 is reinforced and strengthened with a sheet metal band 49. The tubes 48 not only help the steaming of the boiler, but also cool and protect the combustion chamber lining 47 against erosion or slagging. In the present instance, the smoke box 38 consists simply of a sheet metal shell without refractory lining: it is provided with clean-out openings 51 in its bottom, and with a conveniently located manhole 52.

As shown in Figs. 2, 3 and 4, the steam is led off from the drum 45 through a throttle 53 in the latter and a pipe 54 extending out through the drum side. Preferably, the steam is superheated before being led to the turbines 21, in order to improve the efficiency of operation still more by the higher temperature, etc. To avoid slagging troubles in the case of powdered fuel, and excessive thickness of flues, the superheater employed is preferably located in the smoke box 38 rather than in enlarged fire-tubes, as is the usual locomotive practice. Accordingly, the saturated steam pipe 54 extends rearward in the casing 45 to a superheater 55 located in the midst of the smoke box 38, right in the path of the products of combustion issuing from the flues 28. As shown, the superheater 55 is of the closed end and internal circulating tube type. From it, the superheated steam is led forward through a pipe 56 in the casing 45 to the regulators 23 and the turbines 21. After passing amongst the superheater tubes, the products of combustion rise to the opening of the downward and rearward curved smoke conduit 41.

Preferably, the feedwater from the tender 14 is led forward through a flexible connection 57 to a feedwater heater 58 in the smoke box 38. As shown, the feedwater heater 58 is double, consisting of headers 61, 62, and interconnecting curved tubes 63 at either side of the superheater 55. The water enters the upper headers 61, passes down through the tube banks 63 in parallel, and passes from the lower headers 62 to the rear end of the drum 25 at the bottom, through pipes 64 connected into the rear sheet 29.

In the present instance, it will be seen (Figs. 2 and 3), the smoke box 38 not only encloses the rear ends of the return tubes 28 and extends up to the top of the casing 39 (whence it is separated by a plate 65), but also extends down over the rear ends of the flues 27, and even below the bottom of the drum 25. Thus, the burners 36 are virtually in the smoke box 38. As here shown, the burner apparatus 36 comprises, for each flue 27, a suitably valved fuel pipe 66 and an air pipe 67 extending across the smoke box 38 from its rear wall and discharging directly into the rear end of the flue. There are also supplemental air supply pipes 68 extending forward in each flue 27 to suitable outlets 69. As shown, each of the pipes 68 is flattened to an arcuate cross-section within the flue 27, so as to lie snug in its bottom and obstruct the flue as little as possible, and there may be a number of them for each flue arranged to discharge at different points along the length thereof. In the present disclosure, I have illustrated two for each flue. The air pipes 67 and 68 for each flue 27 are supplied by a branch 72 of the main air pipe 42. Each of the branches 72 is provided with a rotary blower 73 of any suitable type driven in any preferred manner (not shown), to supplement or replace the air pressure resulting from the motion of the locomotive when the latter is running slow, standing still, or backing.

Attention is directed to the fact that this application is a division of my earlier application, Serial No. 676,497, filed November 23, 1923, and that, in the present application, no claims are made to the details of the boiler structure disclosed, since such subject matter is being claimed in the parent application.

What I claim in the present case is:—

1. In a locomotive, the combination of a plurality of driving axles with their wheels, electric motors therefor, an electric generator, a steam turbine for driving the generator, and a boiler for producing steam at a pressure upwards of 400 pounds whereby to run the turbine at an efficiency point which is high enough to overcome the necessity for using a condenser.

2. In a locomotive, the combination of a plurality of driving axles with their wheels, electric motors therefor, an electric generator, a steam turbine for driving the generator, and a boiler for producing steam at a pressure upwards of 400 pounds whereby to

run the turbine at an efficiency point which is high enough to overcome the necessity for using a condenser, together with draft creating means for the boiler utilizing exhaust steam from said turbine.

3. In a locomotive, the combination of a plurality of driving axles with their wheels, electric motors therefor, an electric generator, a steam turbine, speed reduction mechanism connecting the turbine and the generator, and a boiler for producing steam at a pressure upwards of 400 pounds whereby to run the turbine at an efficiency point which is high enough to overcome the necessity for using a condenser.

4. A high pressure steam locomotive in which the factor of adhesion is unaffected by the boiler pressure, said locomotive including in combination, a plurality of driving axles with their wheels, electric motors therefor, an electric generator, a high-speed, high-efficiency steam power means for driving said generator, and a boiler for producing steam at a pressure upwards of 400 pounds whereby to run said power means at an efficiency point which is high enough to overcome the necessity for using a condenser.

In testimony whereof I have hereunto signed my name.

HOWARD L. INGERSOLL.