Aug. 19, 1958 J. E. McDONALD 2,847,952

DRIVES FOR FORCED DRAFT FANS IN STEAM PLANTS

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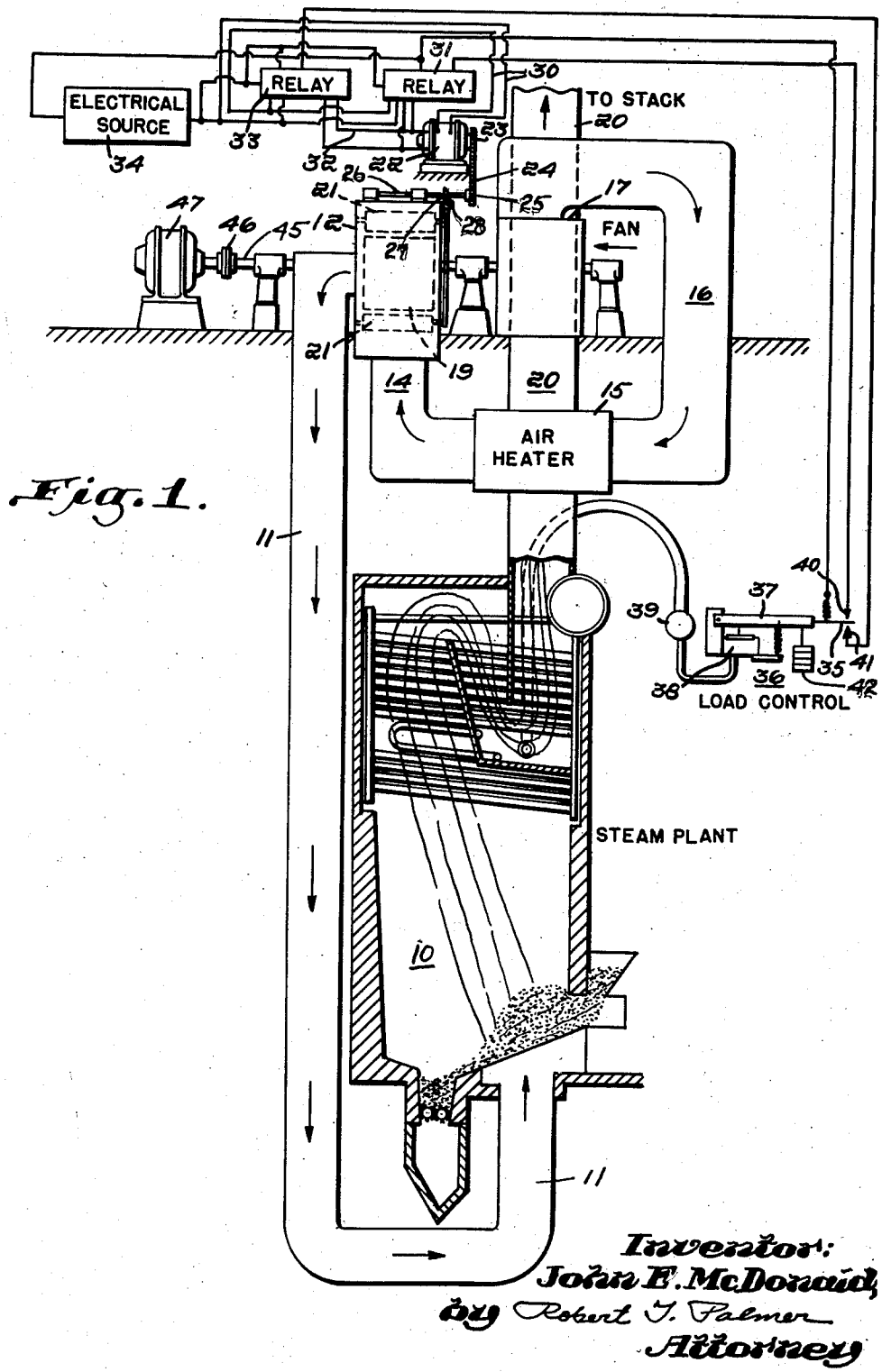



Fig. 1.

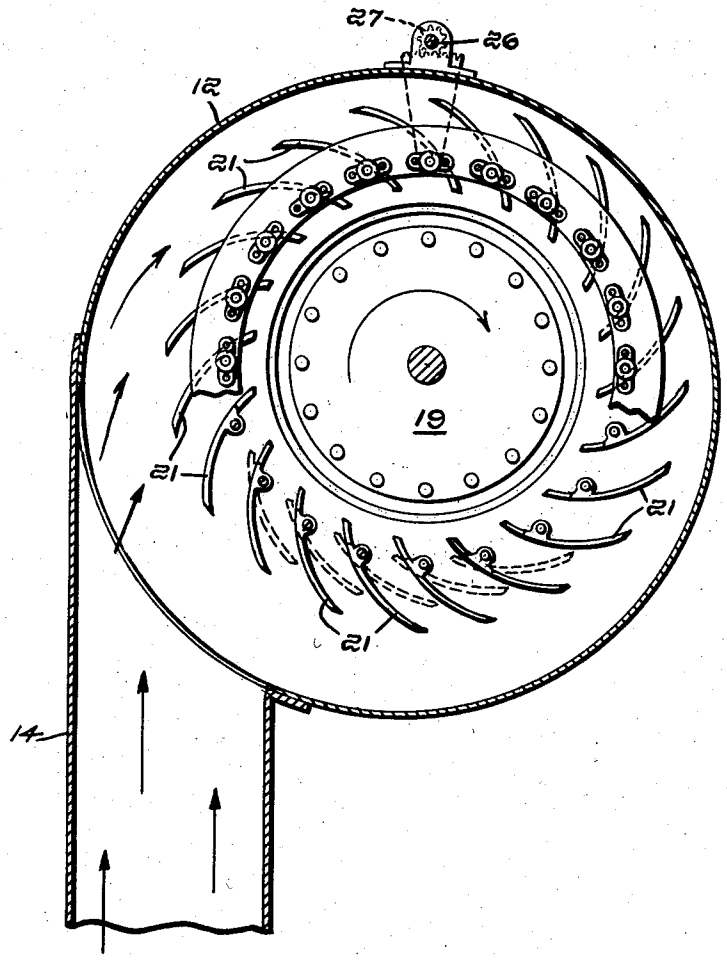
Inventor:
John E. McDonald,
by Robert J. Palmer
Attorney

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Fig. 2.




Inventor:
John E. McDonald,
by Robert J. Palmer
Attorney

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# DRIVES FOR FORCED DRAFT FANS IN STEAM PLANTS

John E. McDonald, Newton, Mass., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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3 Claims. (Cl. 110—56)

This invention relates to steam plants having air heaters and forced draft fans, and has an object to increase the efficiencies of such plants.

It is customary to preheat the air supplied by a forced draft fan into the combustion chamber of a boiler of a steam plant by passing it in indirect contact, in an air heater with the flue gases. It is also customary in such a plant to vary the volume of air supplied by the forced draft fan, in accordance with changes in the boiler load.

Such an air heater increases the temperature of the air passing through it. This invention uses such temperature increase to operate an air turbine which aids in driving the forced draft fan. In one embodiment of this invention, an air turbine and a forced draft fan have their driving shafts connected together and to the driving shaft of an electric motor which drives the forced draft fan. The turbine is located between an air heater and the combustion chamber of a boiler so that the heated air from the air heater has to pass through the turbine. The forced draft fan blows air for combustion through the air, heater and turbine, into the combustion chamber. The temperature added to the air in the air heater is partially absorbed in the turbine which aids in driving the forced draft fan.

A feature of this invention is that instead of adjusting the output of the forced draft fan as load changes take place, for varying the volume of air supplied into the combustion chamber in accordance with the load changes as is conventional, spin vanes in the inlet of the turbine are adjusted as load changes take place. At maximum load, the spin vanes add some spin in the direction of rotation of the turbine rotor to the air entering the turbine for increasing the efficiency of the turbine. As the boiler load is reduced, requiring less air for combustion, the spin vanes in the inlet of the turbine are adjusted more towards closed position producing more spin in the air entering the turbine. This causes the turbine rotor to absorb more pressure from the air. The increased pressue drop in the turbine results in the desired reduction in the volume of air supplied to the combustion chamber. On an increase in the boiler load, the spin vanes will be adjusted to provide less spin resulting in less pressure drop across the turbine rotor, and in an increased volume of air into the combustion chamber.

Another object of this invention is to reduce the power consumed by the prime mover driving the forced draft fan of a steam plant.

This invention will now be described with reference to the annexed drawing, of which Fig. 1 is a diagrammatic view of a steam power plant embodying the invention, and Fig. 2 is a section through the turbine of Fig. 1, showing the spin vanes around the turbine rotor.

The combustion chamber 10 of a conventional boiler is connected by the duct 11 to the axial outlet of the hot air turbine 12, the tangential inlet of which is connected by the duct 14 to the outlet of the air heater 15. The air inlet of the air heater 15 is connected by the duct 16 to the outlet of the forced draft fan 17, the inlet of which is



open to atmosphere or the pressure within the apparatus room.

The flue gases from the combustion chamber 10 after passing over the usual boiler tubes, pass through the air heater 15 into the duct 20 to the stack. The heater 15 may be a conventional one having horizontal tubes through the interiors of which the air for combustion passes, and over the exteriors of which the flue gases pass.

The rotor 19 of the turbine 12 has the spin vanes 21 therearound, which spin vanes are similar to those disclosed in the H. F. Hagen Patent No. 1,846,863. The vanes 21 are adjusted towards open or closed position by the electric motor 22 which has a sprocket 23 on its shaft which sprocket is connected by the chain 24 to the sprocket 25 on the shaft 26 to which is attached a gear 27 which is meshed with a gear 28 corresponding to the gear 48 of said patent. Rotation of the armature of the motor 22 in one direction causes, as disclosed in detail in said patent, the vanes 21 to be adjusted towards closed (spin increasing) position, and rotation of the armature of the motor 22 in the opposite direction causes the vanes 21 to be adjusted towards open (spin reducing) position. However, the vanes are never wide open but are adjusted at maximum load position to impart some spin to the air so as to increase the efficiency of the turbine 12.

The motor 22 has the armature leads 30 connected to the relay 31, and has the field coil leads 32 connected to the relay 33. The energizing circuits of the relays are connected to the electric source 34 through the switch arm 35 of a conventional load control 36. The arm 35 is attached to the pivoted lever 37 which is connected to a piston (not shown) in the cylinder 38 which is connected to the steam header 39. The steam pressure in the cylinder 38 tends to move the lever 37 upwardly against the downward pull of the weights 42.

The switch contacts 40 and 41 are on opposite sides of the switch arm 35 and when the load on the plant is normal, the switch arm will be midway between the contacts so that the motor 22 will be de-energized.

An increase in plant load indicated by a decrease in steam pressure will cause the switch arm 35 to touch the contact 41 and energize the relay 33 which will connect the armature and field coils of the motor 22 together and to the electric source 34 in such a direction that the armature of the motor will rotate in a direction to adjust the spin vanes 21 towards open position. This will decrease the spin in the air entering the turbine 12 causing less pressure drop across the rotor of the turbine. The increased air pressure at the turbine outlet will cause a larger air volume to be supplied into the combustion chamber. When the air volume has been regulated to that proper for the larger load the switch arm 35 will return to its position midway between the contacts 40 and 41, and the motor 22 will stop.

A decrease in plant load will be indicated by an increase in steam pressure which will cause the switch arm 35 to touch the contact 40 energizing the relay 31 which will connect the armature and field coils of the motor 22 together and to the electric source 34 in such a direction that the armature of the motor will rotate in a direction to adjust the spin vanes 21 towards closed position. This will cause an increase in the spin in the air entering the turbine and will cause the turbine rotor to absorb more energy. This will cause a larger pressure drop across the turbine rotor and a corresponding reduced air volume into the combustion chamber 10. When the air volume has been regulated to that proper for the reduced load, the switch arm 35 will return to its mid-position, and the motor 22 will stop.

The load control 36 is shown symbolically. Any conventional load control could be used. The adjustment of

the spin vanes need not be automatic although that is preferred, since an operator could adjust them manually under guidance of instruments.

The turbine 12 and the forced draft fan 17 have a common shaft 45 which is connected by the coupling 46 to the shaft of the electric motor 47 which drives the fan 17. The motor 47 preferably is a constant speed motor so that it can drive the fan 17 at constant speed. The temperature of the air is increased by the heat in the air heater so that the energy in the air supplied from the heater into the turbine plus the energy of the motor is greater than that required to overcome the system resistance at any load. The pressure drop in the turbine reduces the volume of air reaching the combustion chamber to that required for proper combustion.

The pressure of the air in the turbine causes its rotor to rotate and to aid the motor 47 in driving the fan, thus reducing the power required by the motor 47, and increasing the efficiency of the steam plant.

Adjustment of the spin vanes towards closed position throttles the air from the air heater, but the rate of spin increase is greater than the rate of throttling. The throttling provides some back pressure but also increases the velocity of the air entering the turbine rotor, increasing the effect of the turbine far more than the load on the forced draft fan is increased by the throttling.

While one embodiment of the invention has been described for the purpose of illustration, it should be understood that the invention is not limited to the exact apparatus and arrangement of apparatus illustrated and described, since departures therefrom may be suggested by those skilled in the art without departure from the essence of the invention.

What is claimed is:

1. In a steam plant having a combustion chamber, an air heater connected to said chamber and through which the exhaust gases from said chamber flow for heating air for combustion, a forced draft fan having a rotary shaft, a prime mover connected to said shaft for driving said fan, said fan having its outlet connected to the air inlet of said heater, the combination of a hot air turbine having a rotary shaft and a rotor on said last mentioned shaft, means connecting said rotary shafts together, means connecting the air outlet of said heater to the inlet of said turbine, means connecting the outlet of said turbine to said combustion chamber, spin vanes around said turbine rotor, and means including means responsive to the load on said plant for adjusting said vanes towards closed positions upon a reduction in the load on said plant.



2. The combination claimed in claim 1 in which the prime mover is a constant speed motor.

3. In a steam plant having a combustion chamber, an air heater connected to said chamber for heating the air for combustion supplied to said chamber, a forced draft fan having a rotary shaft, a prime mover connected to said shaft for driving said fan, said fan having its air outlet connected to the air inlet of said heater, the combination of a hot air turbine having a rotor on a rotary shaft, means connecting said shafts together, means connecting the air outlet of said heater to the air inlet of said turbine, means connecting the air outlet of said turbine to said combustion chamber, spin vanes for spinning the air entering said rotor in the direction of rotation of said rotor, and means including means responsive to the load on said plant for adjusting said vanes towards closed position upon a reduction of the load on said plant.

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