May 16, 1950 S. M. UDALE 2,508,311

EXHAUST DRIVEN SUPERCHARGER FOR AUTOMOTIVE VEHICLES

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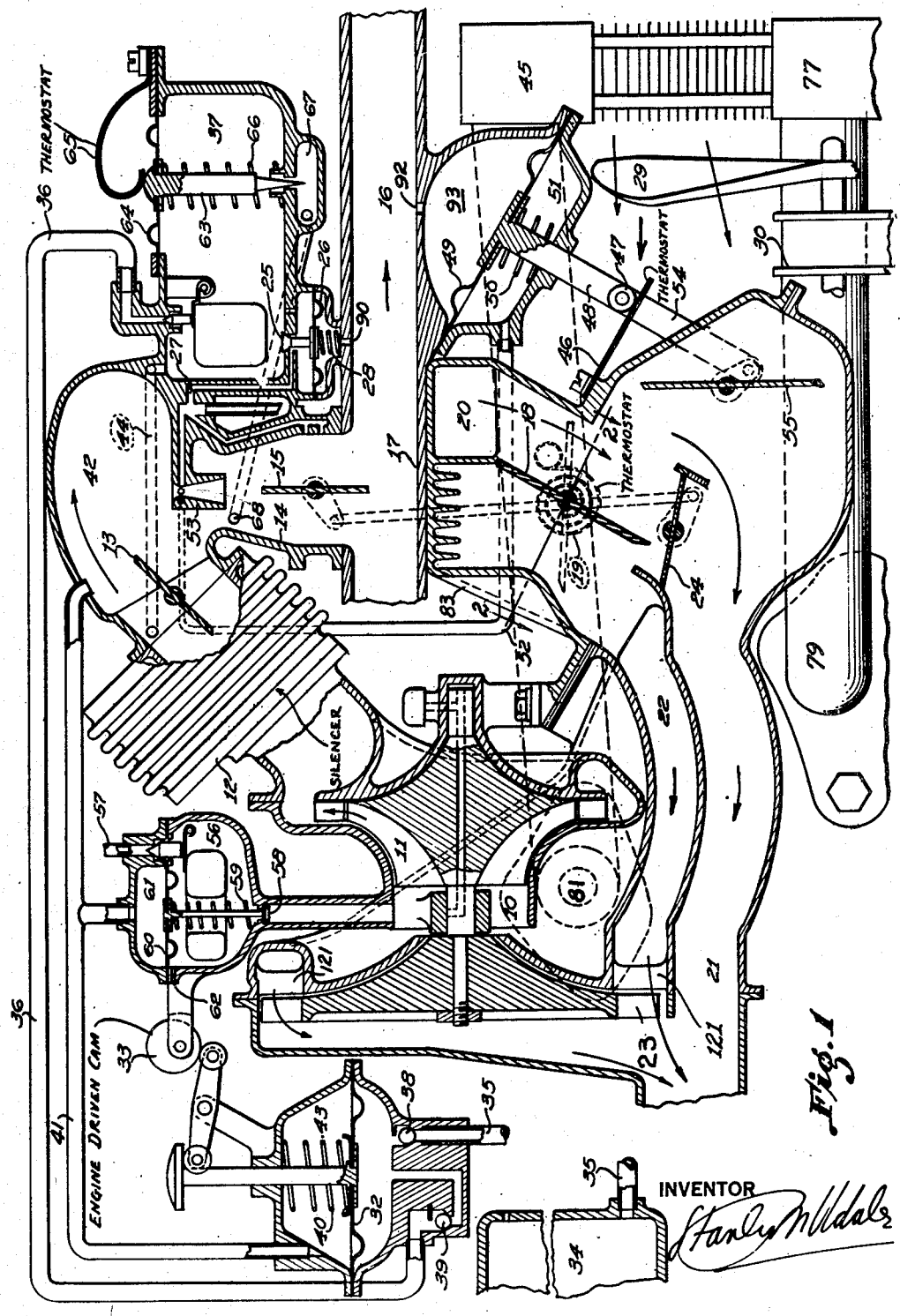


Fig. 1

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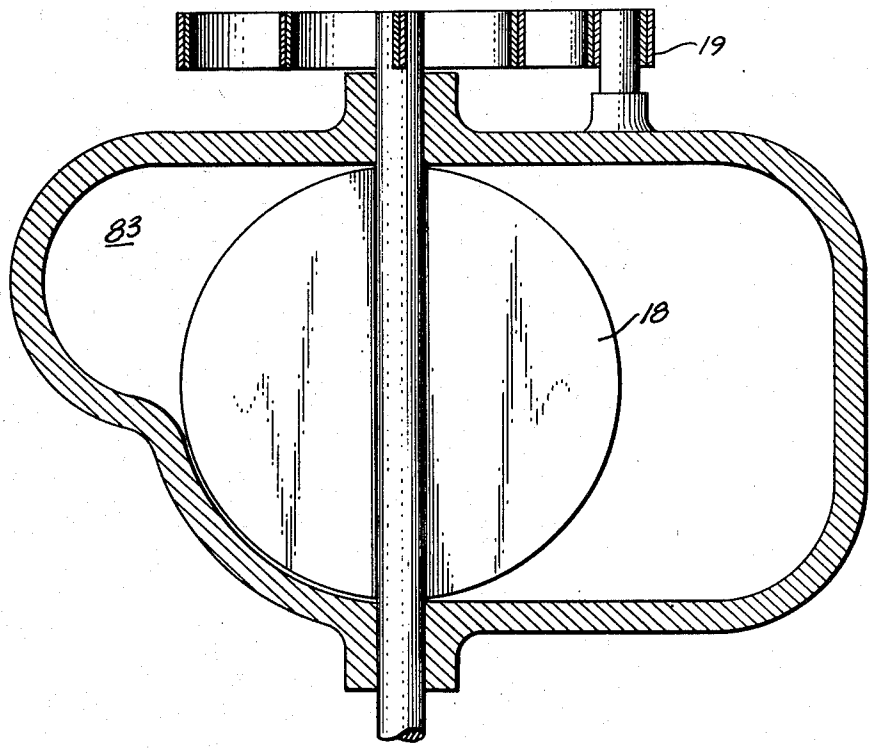


Fig. 2

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EXHAUST DRIVEN SUPERCHARGER FOR AUTOMOTIVE VEHICLES

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Application July 15, 1944, Serial No. 545,101

6 Claims. (Cl. 60—13)

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The object of this invention, which is a continuation in part of Serial Number 510,842, filed November 17, 1943, is to permit the operation of an exhaust driven supercharger in normal weather at normal engine speeds and to prevent excessive operation in hot weather at high engine speeds so as to prevent the blades of an exhaust driven turbine being destroyed by excessive temperature and to protect the engine from excessive loads at high speeds. The object of this application and of Serial No. 510,842, now Patent No. 2,434,726, is to apply an exhaust driven supercharger to engines on automotive vehicles as distinguished from airplanes.

Fig. 1 shows the preferred form of my invention.

Fig. 2 shows a partial cross-sectional elevation on plane 2—2 of Fig. 1.

Another object is to operate the turbine most effectively at the lower engine speed and less effectively at the higher engine speed (over 1200 revolutions per minute) so as to give the greater torque at the lower engine speed where the need for a supercharger is greater and where the danger of burning the blades is less compared with the danger at the higher engine speeds. Engines generally are more reliable at low engine speeds than at the higher speeds.

The figures show the preferred form of my invention.

In Figure 1, 10 is the air entrance, 11 is the exhaust driven supercharger which supplies air under pressure to the silencer 12, from which the air flows by a choke valve 13 and through a venturi 14. The air flow is controlled by a throttle valve 15. The air then flows through an inlet manifold 16 in the middle of which is the hot spot 17, controlled by the eccentrically mounted, thermostatically controlled valve 18. When the engine is first started and is cold then the exhaust gases flow out of exhaust outlet 20 and flow over valve 18, across the hot spot and down the passage 83 into the passage 22 or into the passage 21 when either of the valves 24 or 55 are open. After the engine has run for some time the valve 18 is rotated counter-clockwise into the position shown in Fig. 1 which rotation is determined by a coil spring thermostat 19. Fig. 2 shows the valve 18 in its starting or cold position. Valve 18 is thus opened by exhaust

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pressure and closed by spring 19. Spring 19 is made of bimetallic material so that it weakens at high temperatures and the valve 18 is opened by relatively low pressures at high temperatures and vice versa. The lower left-hand side of valve 18 is longer than the upper right. Hence, when closed, that is, when horizontal, the left-hand side overbalances the right, and the valve turns anti-clockwise into the position in which it is shown in response to an increase in exhaust pressure, that is, in response to an increase in revolutions per minute, providing the temperature of the thermostat 19 is high enough. When cold, the thermostat 19 resists the turning movement on the valve 18. When the valve 18 is horizontal, the exhaust is directed against the hot spot 17 in a well-known manner

22 is an exhaust outlet, 21 is another outlet forming a bypass to and in parallel with the outlet 22. 23 is an exhaust driven turbine driving the supercharger 11 and operated by the exhaust gas flowing in passage 22. 24 is an exhaust valve controlled by the throttle 15. When throttle 15 is open, exhaust valve 24 is closed and vice versa.

25 is the vacuum economizer valve which admits fuel only when the throttle 15 is substantially wide open. The diaphragm 26 controls the flow of fuel through the passage 27; 28 is a compression spring supporting the diaphragm 26. The pressure in the float chamber 37 is maintained at the pressure in the outlet from the silencer 12 by means of a passage 44. An opening 90 in the inlet manifold 16 allows the pressure in the inlet manifold 16 to act on the diaphragm 26 and thus open the valve 25 at high supercharger pressure.

The cooling of the engine is controlled by the fan 29 driven by the pulley and belt 30. The radiator 45 cools the water from the jacket of the engine and the air drawn through the radiator is blown by the fan 29 against the thermostatic element 46 (mounted on the exhaust pipe). The element 46 engages with the roller 47 carried by the rod 48, which is supported by the diaphragm 49 and the compression spring 50. Chamber 93, above the diaphragm 49, is connected through the opening 92 with the inlet manifold 16. The pressure in the inlet manifold thus acts on the diaphragm 49 when the supercharger pressure is high. The pressure below the diaphragm 49, plus

the pressure exerted by the spring 50 keeps the valve 55 closed until the air flow through the venturi creates a drop in pressure which opens the valve 55. Chamber 51 below the diaphragm 49 is connected through the pipe 52 with the throat of a small venturi 53. The upper side of the diaphragm is subjected to the inlet manifold suction or pressure as the case may be. The rod 48 is connected to the rod 54, which controls a valve 55, which permits exhaust gases to flow to the outlet 21 without passing through the gas turbine 23, when the throttle 15 is wide open and the temperature high. The fuel pump shown in the upper left-hand corner comprises a diaphragm 32 operated by the engine driven cam 33. Fuel is obtained from a tank 34 through pipe 35 past check valve 38 and discharges fuel past the discharge valve 39 through a pipe 36. The fuel flows through the pipe 36 to the float chamber 37. Air pressure pipe 41 connects the air entrance 42 with a chamber 43 located above the diaphragm 32. Chamber 43 contains the compression spring 40 which operates the diaphragm 32. The cam 33 raises the diaphragm 32 and the compression spring 40 depresses it pushing the fuel into the float chamber 37.

In order to prevent knocking at high engine speed, water is admitted from a second float chamber 56 supplied with water through passage 57. A valve 58 controlled by the spring 59 shuts off the flow of water when not needed.

The diaphragm 60 forms the lower wall of the chamber 61, which is also connected to the pipe 41 so that the valve 58 is only open when the pressure in the pipe 41 exceeds atmospheric pressure. The water float chamber 56 is vented to the atmosphere through an opening 62.

In order to provide extra fuel for the extra air admitted during the operation of the supercharger, the valve 63 is provided, controlled by the diaphragm 64, which is moved by the thermostatic spring 65 acting in opposition to the compression spring 66. An increase in temperature causes valve 63 to rise. When the pressure rises in the float chamber 37, the diaphragm 64 rises and fuel is admitted to the chamber 67. Fuel admitted to the chamber 67 is discharged through the opening 68 in the throat of the venturi 14. Thermostat 65 is arranged so that when the temperature of the circumambient air generally referred to as "under the hood temperature" rises, the spring 65 weakens and permits the valve 63 to open more than it otherwise would, the reason being that in hot weather the tendency for the engine to burn its exhaust valve is less with a rich mixture than with a lean mixture.

The valve 55 is eccentrically mounted so that the back pressure created by the exhaust flowing through the turbine 23 has a tendency to open the valve 55, which is sufficiently large so that a comparatively small opening will allow a considerable quantity of exhaust gases to escape. The turbine 23 and the guides therefor direct the exhaust so as to be most effective at comparatively low engine speeds (1100 R. P. M.).

The lower part of radiator 45 is numbered 77 and is connected through the pipe 79 to the engine. The pipe 79 is the return passage for the water cooled in the radiator 45—77. 81 is the exit pipe for the hot water from the engine to the radiator 45—77.

Operation

Assuming that the throttle 15 is wide open and the exhaust throttle 24 is closed, then at high speed above 2000 revolutions per minute,

there will be a tendency for the blades of the exhaust turbine 23 to burn out. However, the guide vanes 12 in the exhaust housing may be inclined at 30° so as to direct the flow of exhaust gases into the buckets in the turbine 23, and the supercharger is thus most effective at the lower engine speeds, wide open throttle, e. g., 1100 revolutions per minute. At higher engine speed, wide open throttle, the depression in the venturi 53 acts below the diaphragm 49, and the inlet manifold suction no longer acts above the diaphragm; hence, the thermostat 46 and spring 50 are the only elements holding the valve 55 closed. As the engine heats up, the thermostat 46 yields. The valve 55 being eccentrically mounted tends to open as the back pressure in the passage 22 builds up as the engine speeds up. The result is that when the engine is cold or in cold weather, the supercharger operates at its greatest power for a longer interval of time, but as the temperature increases, the element 46 collapses and becomes less effective as a spring and the maximum power is developed for a shorter period.

The spring 50 is located in series with the thermostatic spring 46. The result will be that the valve 55 opens at a lower number of revolutions per minute at high temperatures than it opens at low temperatures, so that spring 50 and the thermostatic spring 46 jointly protect the exhaust turbine 23 under all conditions and they give more protection in hot weather than in cold weather. The thermostatic spring 46 being cooled by the fan 29 will not lose its temper. The supercharger is thus more effective in cold weather than in hot weather and more effective at lower speed. Because at high speed with the throttle wide open the depression in venturi 53 is high relative to the pressure in the inlet manifold 16. At such high speeds with the throttle wide open engines have a marked tendency to burn up, as far too much power is then developed. The only useful purpose a supercharger can possibly perform on a car or truck engine is to increase the torque at low and intermediate speeds. The valve 55 is effective at higher speeds. At the higher speeds the supercharger is effective only at low temperatures; at lower speeds the supercharger is effective at all temperatures.

The depression in the venturi 53 responds to the square of the revolutions per minute of the engine; hence, at the lower speeds it is relatively ineffective as compared with the exhaust pressure.

In order to stop the engine from knocking when the supercharger is in operation, it is desirable to add water and in some cases alcohol and water from the chamber 56 through the air passage 10. This water (or water and alcohol) is admitted into the air entrance 10 and so to the supercharger 11 from a small water carburetor. The diaphragm 60 is connected to the valve 58, which controls the discharge into the air entrance 10. Valve 58 is held on its seat by spring 59 and is unseated by the supercharger pressure admitted to the chamber 61 on the top of the diaphragm 60 through pipe 41. Atmospheric pressure acts on the under side of the diaphragm 60, being admitted through the opening 62 into the wall of the float chamber 56, which contains the usual float mechanism, which regulates the level of the water admitted through pipe 57.

The diaphragm 64 opens the needle 63 and admits extra fuel through the orifice 68 when the supercharger pressure increases appreciably

above atmosphere especially in warm weather. The curved thermostatic spring 65 holds the needle 63 in the closed position and admits the fuel to the orifice gradually as the supercharger pressure increases. The spring 65 weakens as the temperature increases to increase the supply of fuel. This additional fuel combined with the water added by the water carburetor coupled with the thermostatically controlled bypass valve 55 cooperate to prevent the exhaust turbine 23 and the engine pistons and exhaust valves burning out on a hot day. The time interval before the thermostat 46 would become hot enough to permit the valve 55 to open would depend on the sequence of events prior to the moment the valve 55 opened. These events would include the manner in which the vehicle had been operated, the temperature of the atmosphere, the load on the vehicle, the grade, the speed and the road resistance. The operator would soon discover that the supercharger quit working if he failed to use common sense.

The ordinary automotive engine at maximum speed is stressed to the safe limit and it is only at wide open throttle, low engine speed, that it is safe to subject the engine to the stresses involved in supercharging.

The time during which the water in the radiator 45 requires to become hot is the time during which the supercharger can safely be operated at relatively high speeds. The temperature of the air leaving the radiator 45 and impinging on the temperature responsive element 46, hence represents the result of all the events involved in the operation of the vehicle. The position of the roller 47 is thus determined by previous events and determines whether the supercharger is in operation or is idle. When operating at wide open throttle, low engine speed, the exhaust temperature falls and the valve 55 closes.

With ordinary automotive engines, a supercharger is of most value at low engine speeds, as it is then that the engine stalls. More torque at low engine speed means less gear shifting. Fuel economy disappears once the engine is put into low gear and during the gear shift itself, stalling may occur if conditions are severe.

Specifically, if 7 lbs. per square inch back pressure in the exhaust is created at 1100 revolutions per minute by the turbine 23, this will produce a supercharging of 7 lbs. per square inch in the supercharger 11 if designed for this speed. At 2200 revolutions per minute, this should fall to zero; that is, the valve 55 should be open sufficiently as shown so that the supercharger is inoperative at 2200 revolutions per minute in cold weather, 2000 revolutions per minute in warm weather and 1700 revolutions per minute in hot weather.

What I claim is:

1. In an internal combustion engine having a radiator, a fan therefor and an exhaust driven turbo supercharger, means for preventing the overheating of the exhaust turbine comprising a water chamber connected to the air entrance, a water outlet, a valve therein, a moving wall responsive to the supercharger pressure and connected to said valve, a spring adapted to close the valve and to engage with the moving wall in opposition to the supercharger pressure, an exhaust outlet from the engine to said turbine, an exhaust bypass, an unbalanced valve in said bypass designed to open under exhaust pressure to divert exhaust gases from said turbine, yieldable means tending to seat said valve against the exhaust pressure, temperature responsive means located in the path of the air drawn through said radiator by said fan constituting part of the yieldable means adapted to hold said unbalanced valve shut when cold and to permit said unbalanced valve to open when hot, means responsive to the supercharger pressure for admitting extra fuel when the supercharger pressure exceeds a predetermined value.

2. In an internal combustion engine having an air entrance, a throttle controlled carburetor therein and an exhaust driven turbo supercharger adapted to supply air to the engine under pressure, control means therefor comprising an exhaust outlet directed to said turbo supercharger, a second exhaust outlet acting as a bypass to first outlet, a throttle valve in said second exhaust outlet, control means therefor connected to said carburetor throttle so that when the carburetor throttle is open, the exhaust throttle is closed, an additional exhaust outlet located in parallel with first exhaust outlet also acting as a bypass to the first outlet and, a second exhaust throttle in said additional exhaust outlet, means responsive to the exhaust pressure for opening said second exhaust throttle valve, yieldable means for closing said second exhaust throttle valve, temperature responsive means located on the outside of said exhaust outlet adjacent said valve adapted to increase the closing effect of said yieldable means at low temperature, additional means responsive to the rate of air flow produced by the action of said supercharger for opening said second exhaust throttle at high air flows.

3. In a liquid cooled internal combustion engine having an air entrance, a throttle-controlled carburetor therein and an exhaust driven turbo supercharger, adapted to supply air to the engine under pressure, comprising an exhaust outlet directed to said turbo supercharger, a second exhaust outlet acting as a bypass to first outlet, a throttle valve in said second exhaust outlet, control means therefor connected to said carburetor throttle so that when the carburetor throttle is open, the exhaust throttle is closed, an additional bypass exhaust outlet located in parallel to the first exhaust outlet, an exhaust throttle valve in said additional exhaust outlet, automatic means for closing said second exhaust throttle valve including a cooling radiator for said engine, a fan associated therewith, a temperature responsive element located in the air stream from said radiator and connected to said exhaust throttle valve in said additional exhaust outlet so as to control the degree of opening of said exhaust throttle valve in said additional exhaust outlet.

4. In an internal combustion engine having an air entrance and a throttle valve therein, an exhaust driven turbine designed to be efficient at low speeds, a supercharger driven thereby connected to said air entrance, an exhaust passage leading from the engine to said turbine, an exhaust bypass, a valve in said bypass adapted when open to divert the flow of exhaust from said turbine so as to reduce the speed of said supercharger, means responsive to the speed of the air passing to the engine when the engine is operating with wide open throttle to open said exhaust valve so as to reduce the speed of said supercharger so that it is practically ineffective at speeds above 2500 revolutions per minute.

5. In an internal combustion engine having an air entrance, a venturi therein, an exhaust driven turbine and a supercharger driven thereby and connected to said air entrance, an exhaust pas-

sage leading from the engine to said turbine, an exhaust bypass, a valve in said bypass adapted when open to divert the flow of exhaust from said turbine so as to reduce the speed of said supercharger, means responsive to the depression in the throat of said venturi to open said valve to protect the engine from the effect of supercharging at high engine speed.

6. In a device as set forth in claim 5, in which there are temperature responsive means responsive to the temperature of the exhaust, said temperature responsive means being connected to the means responsive to the depression in the venturi so as to permit the opening of the exhaust valve at a lower engine speed at higher temperatures.

STANLEY M. UDALE.

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