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INCREASING THE POWER OF INTERNAL COMBUSTION ENGINES

By Georg Prayer

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INCREASING THE POWER OF INTERNAL COMBUSTION ENGINES.*

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Since the appearance of four-stroke cycle sleeve-valve engines, no important innovations were made in the field of light internal combustion engines, until the first appearance of an engine, in which, by means of a preliminary compression of the gaseous mixture, a higher volumetric efficiency was obtained than in normal engines. The idea of increasing the efficiency of engines by preliminary compression is not new in itself and, even during the war, it was the basis of the airplane engine types in which it was sought to prevent the power losses, due to the reduction in the mass of the explosive charge in the cylinders at high altitudes, by supplying the engine with the requisite mass of air by means of a supercharger of the turbo-blower type. The difference between these supercharged aircraft engines and the present supercharged engines consists chiefly in the fact that the endeavor in the former case was simply to retain constant power, but in the latter case, to materially increase this power. The result of this fundamental difference is that the aircraft supercharged engine is subjected to no increase in stress, since it functions at normal flight altitudes or on the ground as a normal engine, i.e., without the supercharger's functioning. The present supercharged engine, on the contrary, is

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subjected to a considerably greater stress, due to the fact that, by the addition of the supercharger, an engine dimensioned for a given power is made to yield from four to five times as much ? power as an engine of the same size without a supercharger.

We find the most important progress, in this direction, in the supercharged engine at the Daimler Engine Works in Untertürkheim, the first firm in the world to build, after years of experimenting, an engine suitable both for ordinary use and for racing purposes.

"La Vie Automobile" of December 10, 1923, contains an article on engines with preliminary compression. Experiments with such engines extend back to 1902, when Renault took out his first patents. During the war, airplane engines in France were provided with preliminary compression devices of the Rateau type, as shown in Fig. 1. The left side of the drawing shows a turbine, which is driven by the exhaust gases of the engine and which, in turn, drives the turbo-blower on the right.

The turbo-blower supplies the engine, through the carbureter, with the requisite quantity of air. According to the formula PV^n = a constant, the turbo-blower must deliver an increased amount of air. In this way, the constancy of both the load and the engine power is maintained. The advantage of the Rateau system consists in the fact that, at high altitudes, the power of the driving turbine is automatically increased by the exhaust gases, because of the fact that the back pressure on the exhaust decreases as the altitude increases, while the pressure in the cylinder remains practically constant. Thus the blower receives greater energy through the greater pressure decrease of the turbine. Hence it is possible, without further changes, to keep the engine power constant within certain limits. As Chauviere very correctly remarked in the article in "La Vie Automobile," the question of increasing the power of a modern engine is fundamentally the problem of introducing more of the fuel mixture into the combustion chamber in the short space of time available. In ordinary engines the volumetric efficiency is about 0.85. This decreases considerably, as the crank-speed increases. Fig. 2 gives an approximate idea. The horizontal line a represents the desired volume and the curve b represents the decrease in mean pressure with increase in crank-speed. The fall of the curve b is due to the increased flow resistance and to the impossibility of sufficiently accelerating the gas flow in the brief time available. This makes it necessary to increase the size of the pipes and valves. Herewith there is naturally connected the timely expulsion of the burned gases, necessitating the enlargement of the exhaust pipe. The structural difficulties, involved in increasing the cross-sections, are known. The requisite valve cross-section can be obtained only by increasing the size or number of the valves. Here we soon reach the structural limits, since the other possibility of a greater valve-lift is self-prohibitory on account of the great forces of inertia. At crank speeds of 5000-6000 R.P.M., customary in racing engines, the gas has such a velocity in the intake pipes, that it is impossible to attain the desired intake volume under any conditions. Hence, the only possibility of improvement is to increase the pressure in the intake pipes. This consideration led to the construction of supercharged engines. In the cited article in "La Vie Automobile," the operation of a Fiat supercharged engine is explained (Fig. 3). Since, as already mentioned, an overpressure must prevail in the intake pipes, the fuel intake must also be adapted to the conditions. There are several ways of doing this. The air and the fuel could be injected into the cylinder simultaneously. This method has been tried, though without much success, due to the difficulty of rightly apportioning the fuel in such small quantities. Another method consists in subjecting the regular carbureter to the same pressure as the air-intake pipe. In the Fiat system (Fig. 3), this is effected by means of a branch pipe from the compressor pipe to the fuel tank, with the regular fuel pipe from the latter to the float-chamber of the carbureter. A branch from the pipe, connecting the compressor pipe with the fuel tank, also opens into the float-chamber, which is air-tight on all sides. Thus the surface of the fuel in the tank and in the float-chamber will both be subjected to the pressure produced by the compressor. The flow into the float-chamber is then due simply to the difference in level, which may be conducive to trouble in practical operation.

Various expedients have been tried for utilizing the exhaust gases to drive the compressor. In the Rateau system employed on airplane engines, the atmospheric back pressure of the exhaust-gas turbine would here be too great, so that any seeming gain in power would only be illusory. Hence "La Vie Automobile," in the article referred to, suggests the idea illustrated by Fig. 4. Each cylinder is provided with two intake and two exhaust valves, so that one exhaust valve corresponds to a normally-timed exhaust valve, while the other valve opens considerably sooner. The object of this arrangement is to deliver to the turbine, during the power stroke of the engine, a small quantity of the combustion gas under higher pressure. The second valve opens at the regular time, so that there would be no excessive back pressure from the turbine to the piston, while, on the other hand, the working pressure, previously supplied to the turbine, does not greatly affect the power of the engine. In this connection, it should be remembered that it is very difficult to time the valve openings for the exhaust turbine, so as to correspond exactly to the required engine power, without considerably lowering the efficiency of the engine. It might therefore be better to eliminate the regulation of the exhaust turbine for different crank speeds.

Another way to drive the compressor is by means of a battery carried in the car (Fig. 5), the battery being charged in the usual manner by an electric generator. This would require such a large battery, however, that it would be expedient only for special purposes. It would be entirely impracticable for racing, on account of its great weight.

Another solution is found in Zoller's compressor which is the subject of numerous patents. In contrast with previous compressors, Zoller's compressor functions continuously with the engine and distributes its load to every individual cylinder. Since the compressor also produces a higher pressure at a given crank-speed of the engine, a constant load is conveyed to the engine. This arrangement of the blast enables the retention of a constant engine power and also its increase at any given crank-speed.

Fig. 6 shows a cross-section of the compressor. In a housing (1) a drum (8) is provided with six vanes (9) and revolves eccentrically. These vanes move radially in the revolving drum. The sliding members (17), to which the vanes are attached, run in the race (20). This race is turned in the groove (18) of the housing cover by the friction between the race and the sliding members (17). The individual segments of the revolving drum (8) create a suction from channel (6) and a pressure toward channels (5) and (2). Fig. 7 shows the Zoller compressor attached to the flywheel of a three-cylinder two-stroke engine.

As already mentioned, with Zoller's compressor the requisite quantity of air or fuel mixture is delivered under pressure to each cylinder. For this purpose, the compressor has as many vanes as the engine has cylinders. These vanes are arranged in such a manner that they deliver the air under the maximum pressure at the instant when the intake valves open the way to the cylinder. The position of the vanes with respect to the cranks is adjusted accordingly. In order to obtain an overload, a second compression stage can be provided. The Zoller compressor makes it possible to increase the efficiency of two-stroke engines, by introducing scavenge air and blast air through the compressor, which can be regulated to a certain extent. The difficulties of the Zoller compressor reside chiefly in its rather complicated design, though the fact that these difficulties are not insurmountable seems to have been demonstrated by the success of a German automobile factory which has operated motor-cars with supercharged engines of the Zoller type.

As already mentioned, we find the only practically successful supercharged engine is the one now made in quantity by the Daimler Engine Company at Untertürkheim. The most important detail in a supercharged engine is the fuel-delivery system.

The Daimler supercharged engine may be briefly described as follows: It is represented diagrammatically by Fig. 8. A vertical shaft is driven by bevel-gears through the multiple-disk clutch k on the crankshaft. On the lower part of the shaft there is a Root valveless blower G. On the upper extension of the vertical shaft, a rotary fuel pump is driven through a coupling. The fuel is passed through a strainer and then through the hollow upper end of the shaft to the pump. The bottom of the fuel pump is held tightly against the housing by means of a spring. The lubrication at this point is effected by a Stauffer spring lubricator, the shaft above the blower also being lubricated in the same manner. Any fuel leaking from the pump is caught in a cavity under the pump and conducted through a pipe a into the outside air. The vertical shaft is firmly held by ball bearings. The power transmission from the engine shaft m to the vertical shaft is in the ratio of 1 : 3.4. The fuel pump is automatically started simultaneously with the starting of the blower. From the blower G, the air is delivered to the carbureter intake pipe V St and the fuel through the needle-valve into the float-chamber. When the clutch k is disconnected, the fuel flows in a normal manner through the hole b, likewise to the float-chamber. The latter is closed on all sides and the "tickler" F connected with it is also closed. The clutch is connected through the levers h_1 and h_2 with the lever of the throttle-valve D, in such manner that the latter can be entirely opened by the accelerator pedal up to a certain pressure point, beyond which the valve c is closed and the compressor clutch k is thrown in by the lever h_1. The valve c closes the air-intake pipe which is open under normal conditions. A check-valve prevents the return of the air into the compressor. The air nozzle d can be removed from the outside and calibrated. It is held against the fuel nozzle d, by a spring. In starting the engine, fuel can be allowed to escape from the fuel nozzle by releasing the tickler by means of the accelerator pedal.

Fig. 9 shows the carbureter side of the supercharged engine, which was victorious at the "Targa Florio" Contest. It differs only in certain details from the regular Mercedes supercharged engine shown in Figs. 9-11, which were taken from an article by Dr. Heller, as published in the "Münchener Illustrierte Presse," No. 37. The Mercedes engine is admirably suited for use with a compressor. It shows that the knowledge acquired by the Daimler Company from their experience with aviation engines has been substantiated in their supercharged type. The steel cylinders and jackets are welded together in a block. The camshaft, on top, is driven by bevel-gears and the valves are operated by rockers. The vertical shaft has unbushed, light-metal bearings. The whole arrangement of the Mercedes engine shows clearly that a supercharged engine must be specially designed in all its details and that allowance must be made for the considerable increase in stress.

The immediate use of supercharged engines in ordinary motorcars is rendered inexpedient by the fact that not every driver, even of an ordinary car, understands the ordinary engine. It is naturally much more difficult to operate a supercharged engine. The compressor is not intended to be used for increasing the engine power for long periods of time but only for special purposes. Cars with supercharged engines are not intended, therefore, for ordinary use, but only for racing, where, in the hands of expert drivers, they give excellent results. This statement applies, of course, only to the present stage of development.

In the use of compressor engines, as in the last Baden-Baden contest, defects occur in the spark-plugs which result in failures. This fact, by no means, condemns the supercharged engine, but only shows that the spark-plug problem must be more thoroughly investigated. Naturally, in such an engine, more heat is developed and the solution of the problem will depend largely on how successfully this difficulty can be overcome. The possibility of further development has, however, been established and it can reasonably be prophesied that, even for ordinary motor-cars, a revolution in engine construction is not very far off.

Likewise in other countries, automobile manufacturers are giving more attention to supercharged engines. Though last year only the Fiat Company (Italy) and the Düsenberg (America) installed such engines in their racing cars, in this year's French contest, five of the seven different makes were supercharged engines. The twelve-cylinder "Delage" has a compressor for each group of six cylinders; the "Sunbeam," a continuously running compressor; the "Alfa Romeo," a compressor with two speeds; the "Fiat," a continuously running compressor, as likewise the American "Miller." The victory of the "Alfa Romeo" and the winning of the second place by the "Delage" demonstrate that the greater complexity of supercharged engines does not prevent automobile builders from using them in racing cars, in order to obtain the maximum power in international contests. Compressors have been used for increasing the power of even the smallest engines. As reported in "La Vie Automobile," this year's motorcycle contest was won by a French two-stroke two-cylinder engine of 175 cm (10.7 cu.in.) cylinder capacity (the "Rovin"), which was equipped with a turbo-blower. This engine is reported to have reached the extraordinary crank-speed of 7500-8000 R.P.M. and the compressor, with a multiplying-gear of 4 : 1, a speed of about 30,000 R.P.M. In this type, the compressor supplies a mixture from a special carbureter, while the two cylinders are also supplied by two other carbureters.

All these facts go to show that fundamental changes may be expected to take place before long, especially in the construction of engines for racing cars.

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.

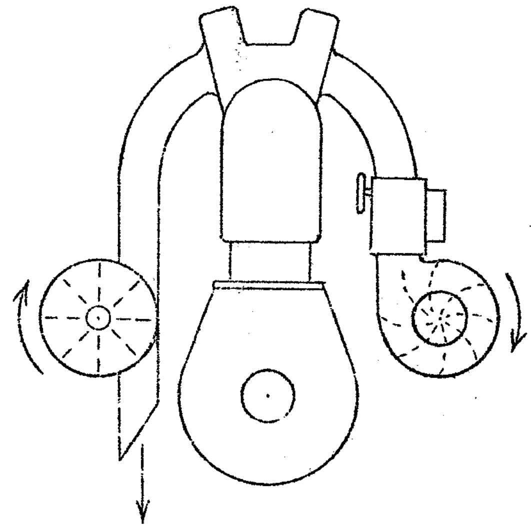

Fig.1 Rateau preliminary compression system.

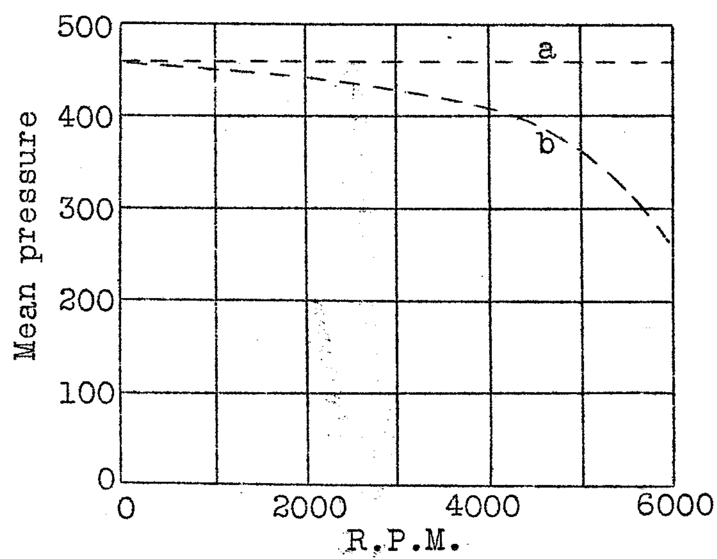

Fig.2 Fall in load with increase in crank speed.

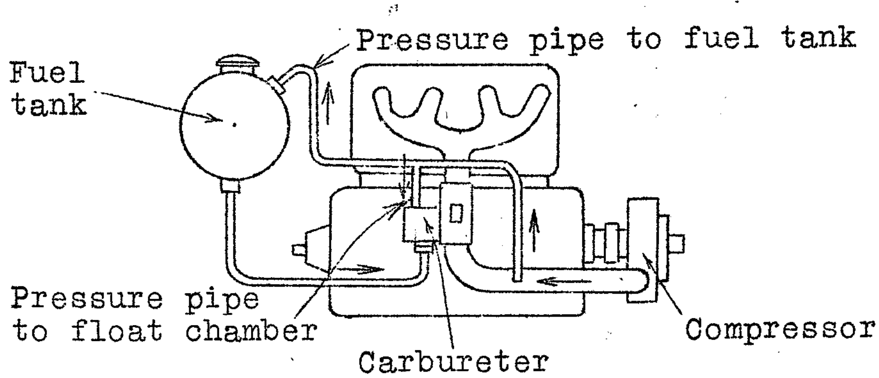

Fig.3 Diagram of Fiat supercharged engine.

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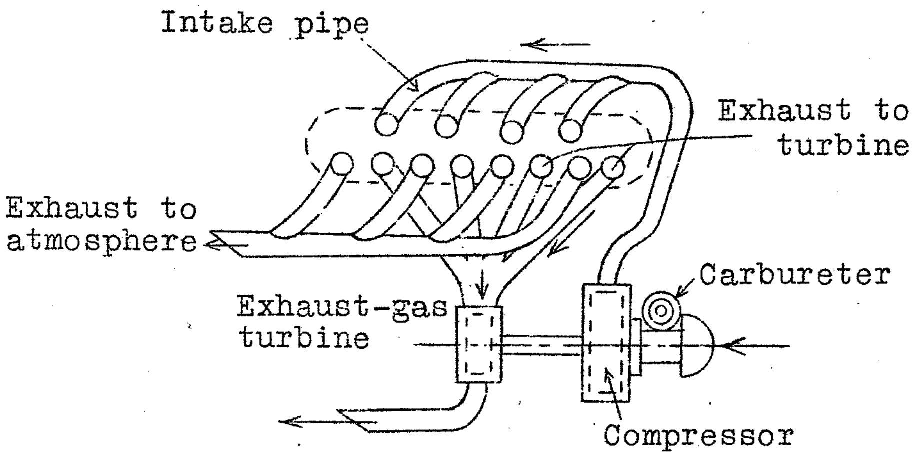

Fig.4 Supercharged engine with 2 intake and 2 exhaust valves in each cylinder.

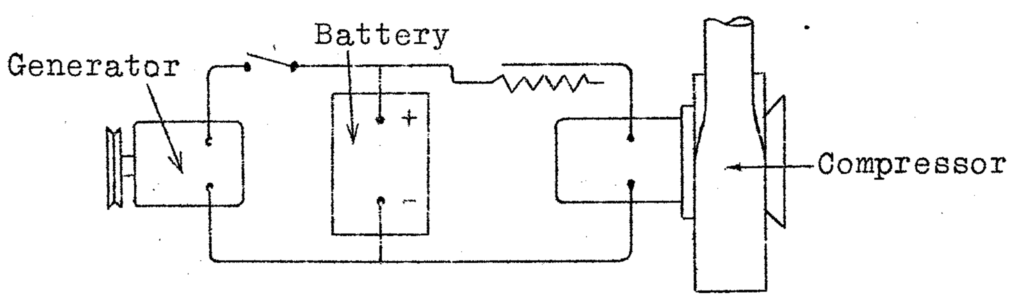

Fig.5 Operation of a compressor by a battery.

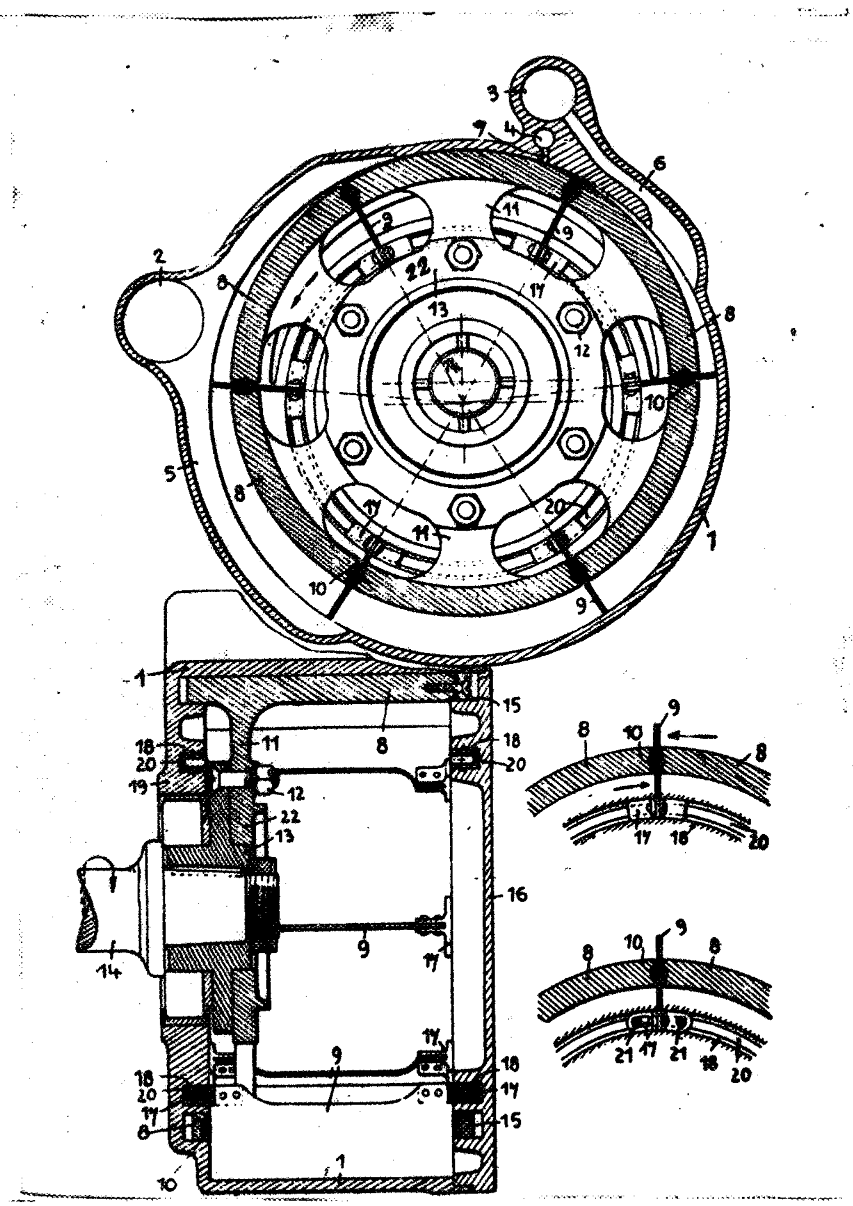

Fig. 6 Zoller Compressor

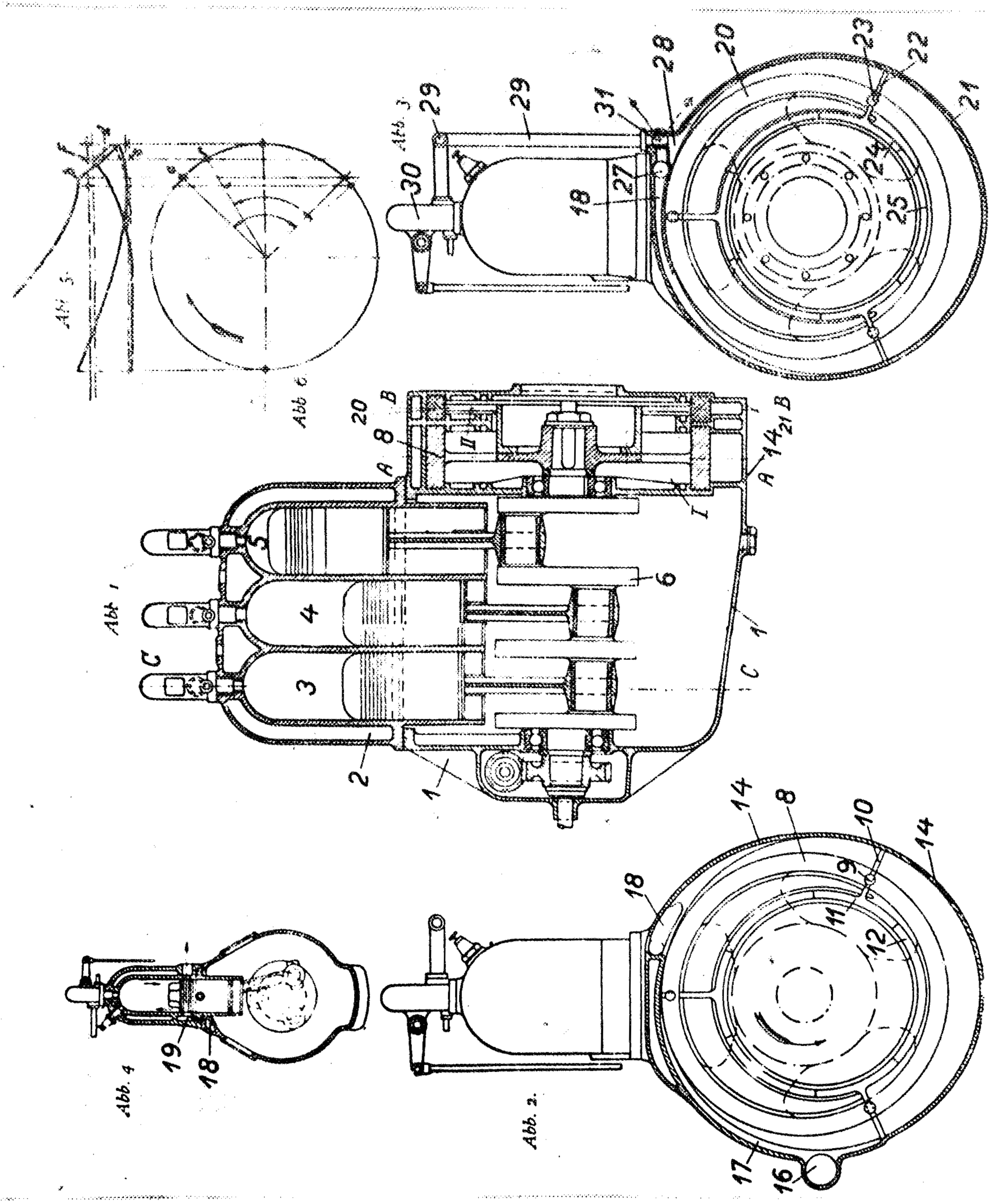

Fig.7 Zoller compressor on flywheel of a 3-cyl. two-stroke engine.

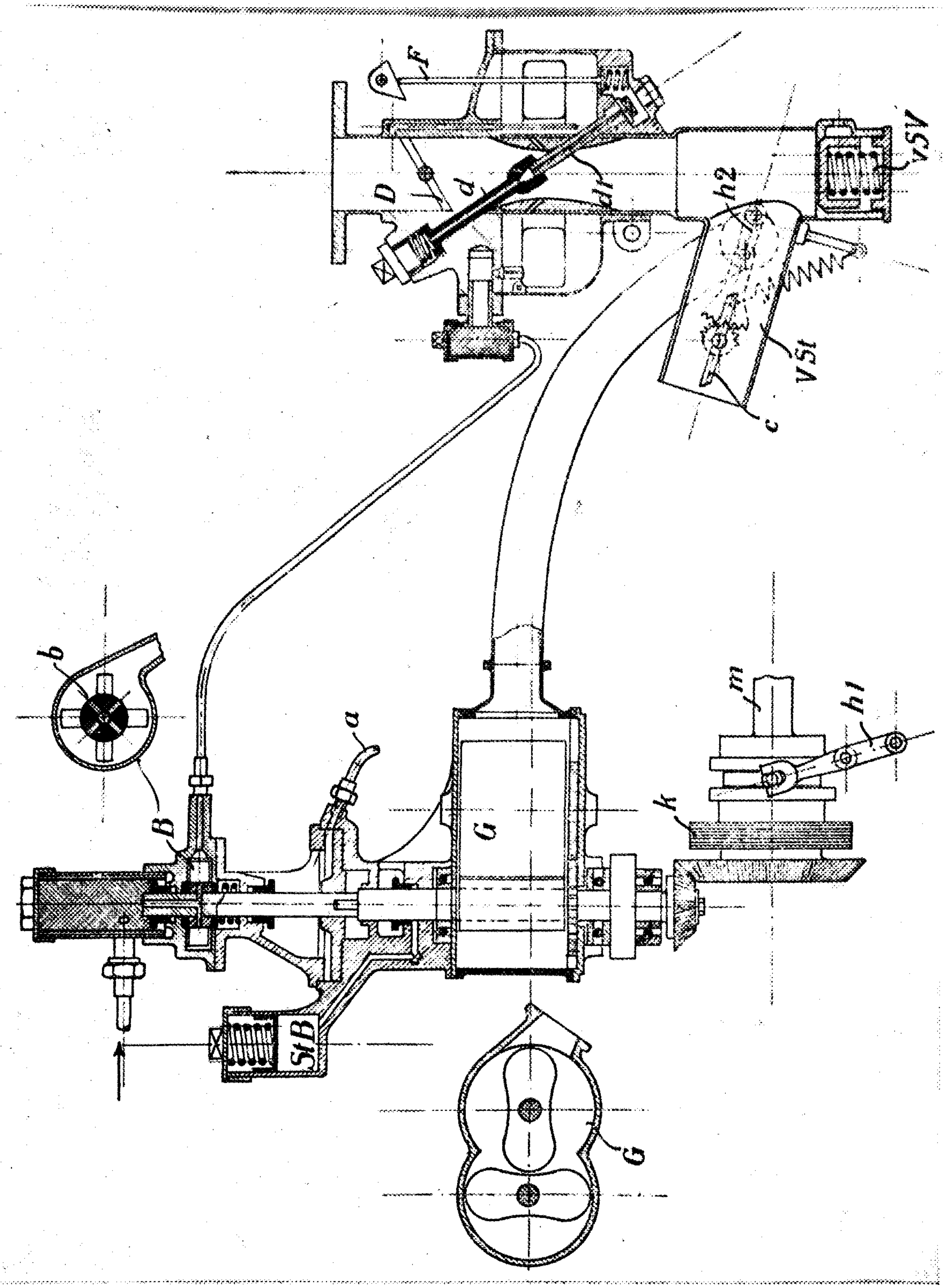

Fig.8 Daimler compressor and fuel delivery system.

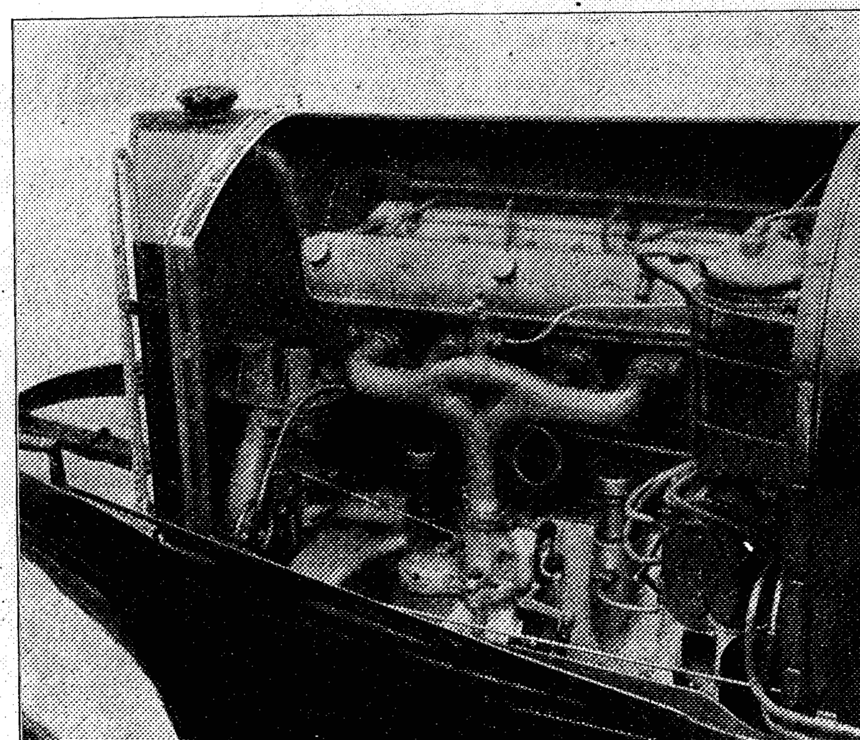

Fig. 9 Mercedes 2-liter victorious car (in the "Targa Florio" contest) compressor on the left, 70 mm bore, 125 mm stroke.

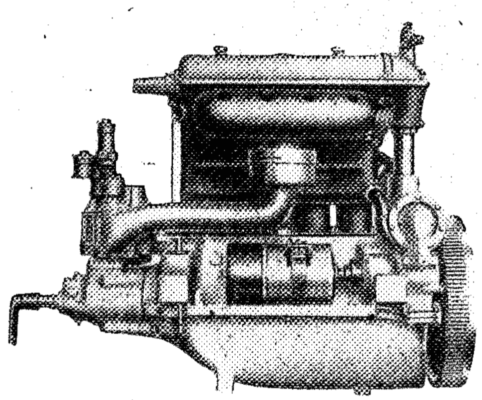

Fig. 10 4 cyl. supercharged engine of the 6/25 HP Mercedes motor car.

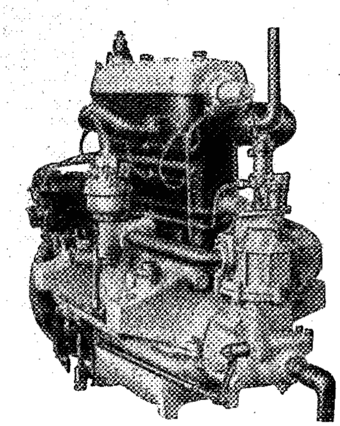

Fig. 11 Oblique view of engine from the compressor end.

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