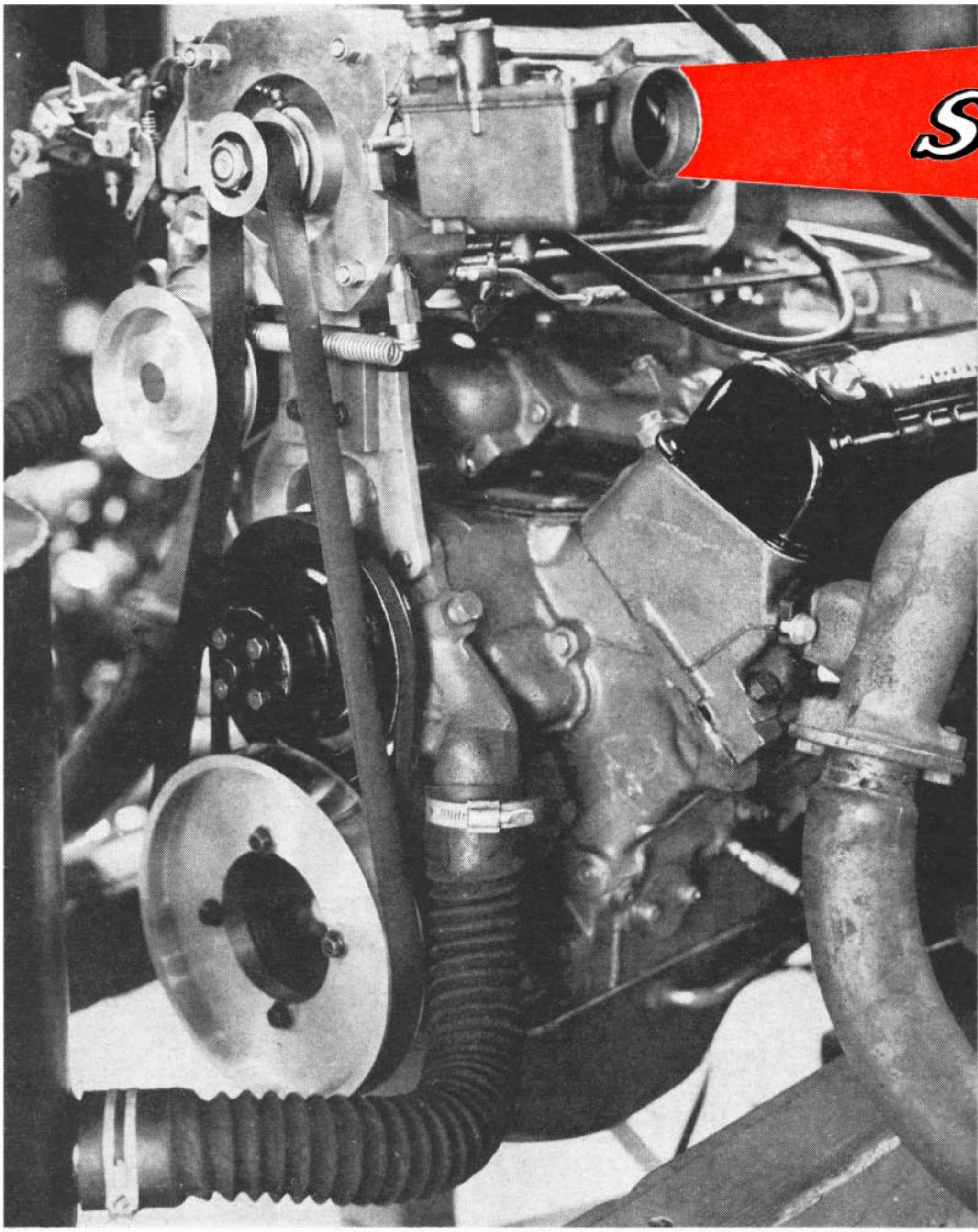
SUPER



Drive of Latham axial flow blower is simple and efficient flat belt.

Some basic facts and a test of a New Type of SUPERCHARGER

Of all the various practices and methods used to increase engine power output, perhaps the most fascinating is that of supercharging. The practice of supercharging dates back to 1902 when French automaker Louis Renault patented an arrangement in which a centrifugal fan blew air into the mouth of the carburetor. As far as is known, this device was never used and it was left to two Americans, Lee Chadwick and John Nichols, designers of the Chadwick cars, to produce the first successful supercharged car in 1905, which, incidentally, was the first catalogue model to achieve an honest 100 mph. We are currently witnessing a national revival in the interest of supercharging, which is due in part to engines of greater efficiencies, relative freedom from detonation and great improvements in available fuels. All of these factors have rendered modern engines capable of withstanding the intensity of heat flow that supercharging involves.

To properly define supercharging, we must state that the practice consists of forcing a greater amount of the combustible fuel/air charge into an engine than could be forced in by atmospheric pressure and the pumping action of the pistons. The engines of 20 or more years ago could barely stand normal atmospheric density of the fuel/air charge and in many cases, these engines were deliberately or inadvertently throttled at the carburetor, valves or both. As engine efficiencies improved and the proportion of destructive waste heat diminished accordingly, so the breathing capacity of engines increased. Today, the waste heat has been reduced to the point that we can afford to view in earnest the possibilities of supplementing the normal atmospheric charge density. In other words, to supercharge. However, merely because we know that one engine of good modern design can withstand the effects of supercharging, it is the sheerest folly to believe that another engine of inferior design will do likewise. To couple a supercharger to an inefficient engine is courting disaster.

While we are discussing supercharging in general terms, it is advisable to dig below the surface a bit to see what goes on in a supercharged engine and how it differs from its normally-aspirated brethren. First, one must realize that an engine-driven supercharger for use in an automobile is without question the most difficult of all supercharger installations. This arises from the fact that an automotive engine must be supremely flexible within its limitations, and that there is an infinite number of engine speed-to-load

CHARGE

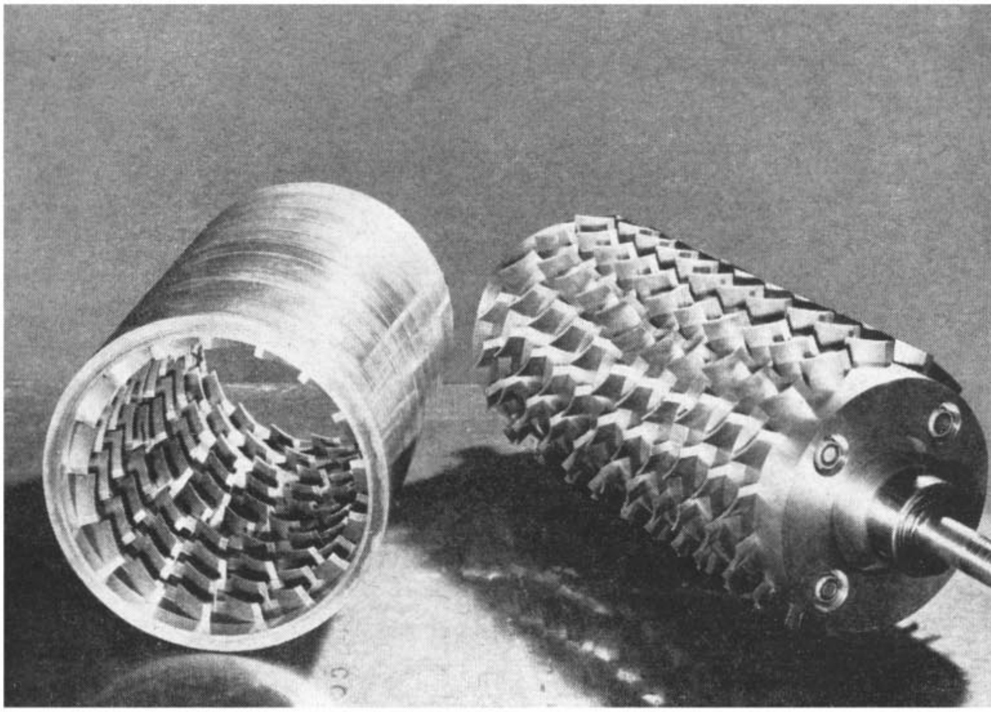
FOR POWER!

variations encountered in everyday driving. This makes very compelling demands upon the mechanism used to drive the supercharger from the engine. And these demands upon the supercharger drive system are never met without power losses and inefficiencies. For this reason and others covered later, a supercharger installation on a passenger car using gasoline as a fuel is, of necessity, a compromise between what we want and what we can get.

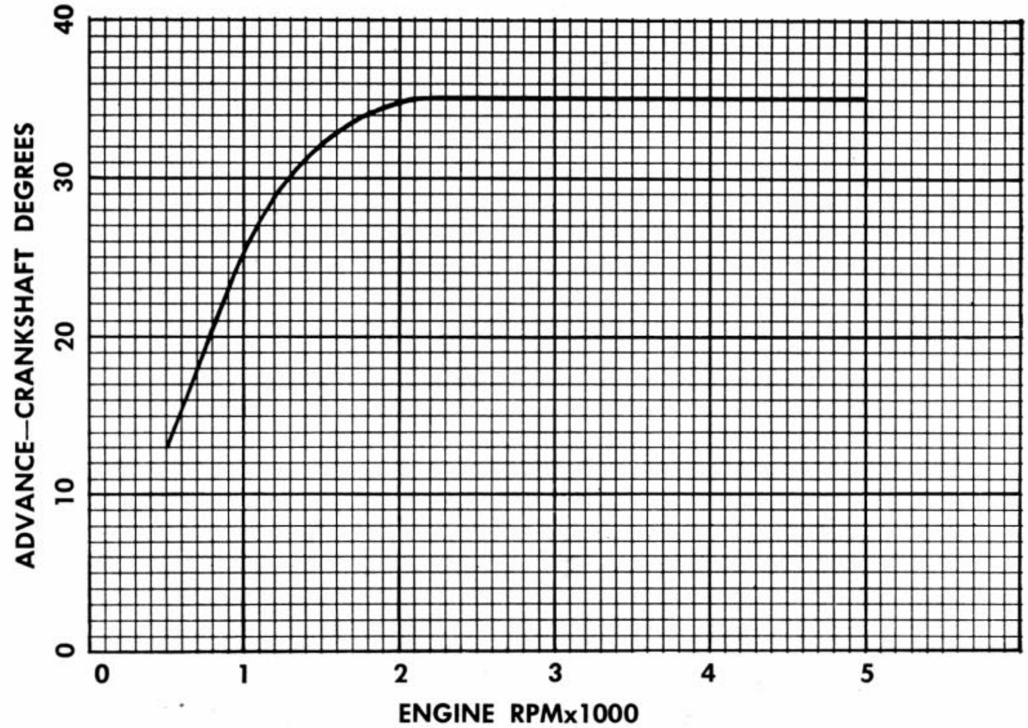
Next, we come to the point of measuring the amount of supercharge, or boost, and here arises an understandable dilemma. We hear of the number of inches of water or mercury, inches of mercury absolute, pounds per square inch gage, the number of atmospheres absolute, percentage of boost and so on. To eliminate most of the confusion, we will refer to supercharge pressures in terms of pounds per square inch gage (psig) and percentages above atmospheric pressure. In using percentage figures for our purpose, we will assume the normal atmospheric pressure to be 15 psi. In doing this, there will be those who believe that the supercharger pressure output should be expressed as "gross pressure output," which takes into consideration the fact that in all normally-aspirated engines, there is a vacuum or "negative pressure" in the intake system anywhere below the carburetor venturi, even when the throttle is wide open. It is true that in order to show a positive pressure, the supercharger must first overcome the manifold vacuum. However, the carburetor of a normally-aspirated engine and the carburetor or air inlet of a supercharged engine all operate under atmospheric pressure conditions, so we'll stick by our above-mentioned weapons.

The question also arises regarding the point in the intake system at which pressure readings should be taken. Most supercharger manufacturers specify pressure output that is measured at the supercharger discharge volute, believing that this will show their product to be more efficient than others. However, pressure readings taken at the discharge volute do not take manifolding restrictions into consideration and, in some cases, readings taken at the discharge volute may take advantage of the velocity of the fuel/air charge, which is converted into additional pressure. In dealing with relatively low supercharge pressures, as we are here, it will later be shown that maximum power and torque outputs vary substantially as the *intake manifold* supercharge pressure. However, as the intake manifold pressure increases above a certain point, the gains in power and torque diminish in terms of percentage. This shows that discharge volute pressure actually has very little in common with power output, and that intake manifold pressure and power output are quite closely related. For this reason, a hole was drilled and tapped in an intake manifold port branch at right angles to the flow of fuel/air charge so that actual intake manifold pressures were recorded and the velocity of the gases did not influence our pressure readings. Any other method of pressure measurement would merely detract from the efficiency of the supercharger in view of the pressure output in relation to the power increase.

Theoretically, it is possible to increase the power output of an engine by as much as 236 percent by a 200 percent (30 psig) or more supercharge. In practice, this figure has been accomplished only with considerable freedom in the design of the engine and the choice of fuels. For the sake of reliability in some highly-developed racing engines, the amount of power increase due to supercharging is usually kept between 150 and 200 percent over a similar but unsupercharged engine. With a basically sound and properly modified competition-type passenger car engine using methyl alcohol as a fuel, a power output of the order of 100 to 125 percent of the normally-aspirated output is about



Stator case, left, shows rows of stationary vanes with clockwise helix. Rotor, right, has vanes in counter-clockwise helix.



Optimum ignition advance curve with Latham blower. Stock Ford advance curve was not suitable. This curve would be suitable for most good overhead valve engines with compression ratio below about 8½ to 1. This is a critical point because supercharged engines are quite sensitive to spark advance.

maximum for sustained full load operation, but this can easily be exceeded for short periods with a fair degree of reliability. With present-day gasolines and a basically sound engine, a power increase due to supercharging of 50 percent above the normally-aspirated output is on the borderline for sustained full load operation. A figure of from 35 to 45 percent above the normally-aspirated output will usually result in trouble-free performance with a good engine. Such power increases are accomplished by very substantial gains in volumetric efficiency and raising the point in the engine speed range at which maximum volumetric efficiency is obtained.

If such power gains are possible by supercharging, why is it that superchargers are not installed at the factories in order to raise the power of an existing engine or permit the use of a smaller engine with the same power output? One word—cost—answers this question. From this standpoint, it costs far less to make even major changes in existing designs than it would to manufacture and install a supercharger. Therefore, the widespread use of superchargers by automobile manufacturers has never and will never be a reality. This places the automotive supercharger as an accessory and, except for a few scattered examples, an accessory it will most likely remain. But accessory or not, the great possibilities of supercharged engines are powerful factors in their favor.

There are those who believe that a supercharger, in one fell swoop, will overcome all the inherent deficiencies of an engine and is the only answer to their prayers for more power. This is wishful thinking. While a supercharger will result in a power increase due to a great increase in volumetric efficiency, it brings with it some problems of its own that are sometimes extremely difficult to overcome. For example, let's look at the mechanical efficiency of a supercharged engine. As the intake manifold pressure is increased, the absolute friction losses within the engine itself increase only a slight amount. However, the power required to drive the supercharger varies almost directly with the manifold pressure and the net result is that the mechanical efficiency of a supercharged engine is, with rare exceptions, lower than a normally-aspirated counterpart. Also, as the manifold pressure increases, so does the temperature of the fuel/air charge. When this occurs, as it always does even with elaborate intercoolers between the supercharger and the engine, we run into a situation like this: At manifold pressures of about 50 percent above atmospheric, the temperature of the fuel/air charge increases substantially with gasoline, causing expansion of the charge, and although the manifold pressure may be fine, the density, or weight of the charge entering the engine is actually decreased. This is the point at which the rule of diminishing returns becomes effective, causing a levelling-off of the power curve in relation to manifold pressure. For all practical purposes, this is not encountered when straight alcohol is used as a fuel due to its much higher latent heat of vaporization and the extra-rich mixture ratios that can be used without losing power.

But such events are only the beginning. If we raise the manifold pressure to 50 percent above atmospheric (7½ psig), the maximum cylinder pressure will be increased almost 63 percent; the increase of heat flow to the cooling water, in terms of horsepower loss, will increase about 54 percent; the cylinder pressure at the time the exhaust valve opens (exhaust release pressure) will be increased about 100 percent. And many people believe that a 50 percent supercharge is identical with raising the compression ratio 50 percent from, say 8 to 12 to 1. From a detonation standpoint, a 50 percent supercharge is actually equivalent in effect to raising the compression ratio from 8 to about 10.3 to 1 in a normally-aspirated engine, or less than 30 percent. This interesting point is brought about by the increase of fuel/air temperature at a 50 percent boost pressure and the fact that the larger combustion chamber volume with a compression ratio of 8 to 1 and a 50 percent boost is, from a combustion efficiency standpoint, less efficient than with a normally aspirated engine and a 12 to 1 compression ratio. This is enough to confuse anyone but nonetheless can be substantiated. In somewhat simpler terms, this means that a 50 percent boost is roughly equivalent to a 29 percent increase in compression ratio, not in actual power output but in combustion efficiency and the tendency to detonate, both of which are more-or-less limiting factors of power output.

Another point that needs clarifying is that in a supercharged engine, the manifold pressure rises above atmospheric only as the carburetor throttle approaches the wide open position. Below a point of about 75 percent of full throttle, a supercharged engine, like a normally-aspirated engine, operates with a vacuum in the intake system; carburetor, supercharger, manifold—the whole works. Thus, positive manifold pressure is available "on demand" as the throttle opening increases because the throttle acts as a "gate," increasing or decreasing the amount of fuel/air mixture admitted to the engine. When operating under "cruise" conditions or others requiring a small amount of throttle opening, the fuel/air distribution in a supercharged engine is very apt to be worse than in a normally-aspirated engine because of the increase of distance to the cylinders and the fact that "wet spots" of condensed and collected fuel are not uncommon in the supercharger itself. As the manifold pressure increases, the fuel/air distribution improves, but only by virtue of the manifold pressure, not because the basic manifolding efficiency is any better.

For this reason, and others, a supercharged engine will always show improvements in power output as the engine's basic efficiencies are improved. Items such as intake manifolding, an efficient exhaust system, changes in valve timing, the matching and polishing of ports and manifolds and the polishing of combustion chamber surfaces should not escape attention if a "maximum effort" is to be made with a supercharged engine. These special parts and processes will show as much improvement in a supercharged engine as in a normally-aspirated engine. One item of supreme importance is the ignition system, which should be the best obtainable to withstand the increase in cylinder pressures without misfiring or other malfunctions. In the matter of compression ratios, as long as we're dealing with gasoline, the actual measured compression ratio should be kept at or below 9 to 1 with an efficient overhead valve engine and below 8 to 1 with a flathead. That is with a 50 percent boost. Higher ratios and boost pressures have been used together with gasoline to be sure, but in most cases, they haven't found all the pieces yet. So for maximum reliability and longevity along with very good performance, the compression ratio should be kept within these seemingly moderate limits.

The 1924 Duesenberg race cars contained a contribution to supercharging that had universal and far-reaching results. This consisted of merely placing the carburetor on the suction side of the supercharger. Until this development, a pressurized carburetor was always located between the supercharger and the engine. The effect of this simple maneuver was that the fuel/air distribution between cylinders was improved and the fuel was churned into a homogenous mixture with the air by the supercharger, greatly improving vaporization. But most important of all, the latent heat of vaporization of the fuel was utilized to limit the temperature rise within the supercharger and intake manifold. This meant a substantial increase in weight of the fuel/air charge delivered to the engine, a reduction of the power required to drive the supercharger and a reduction in temperature of internal danger points, such as exhaust valves and spark plugs. With a 50 percent supercharge and gasoline, the act of admitting the fuel and air together into the supercharger, rather than air alone, will reduce the temperature of the charge by about 30 percent. With straight alcohol, the temperature can be reduced to ambient or even below. In terms of peak power output with a 50 percent supercharge and gasoline, a gain of about 20 percent can be realized by placing the carburetor on the suction side of the supercharger. Below peak power, the difference is slightly higher. This practice also allows the carburetor to function in a normal manner and is, from an all around practical standpoint, better than pumping air only through the supercharger and into the carburetor.

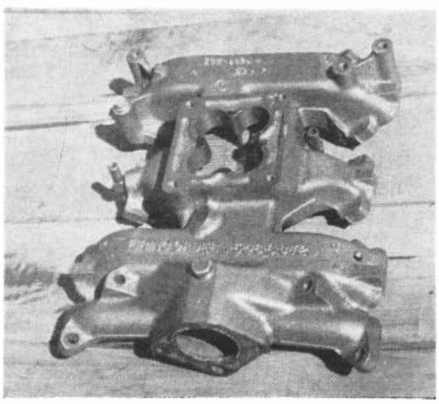
The method of driving the supercharger, by no means to be overlooked, is most certainly a critical point. Gears and shafts, chains, belts have all been tried and all have their limitations, especially if the supercharger is to be rotated faster than the engine. A positive gear and shaft arrangement imposes tremendous loads upon all components including the supercharger, due to violent acceleration of the engine, upshifts and deceleration. The same goes for a chain and sprocket drive, which, even with an elongated timing chain presents a lubrication problem. Furthermore, an exposed chain is extremely dangerous in case of breakage. A gear or chain layout also has the disadvantage of sometimes being *too* positive. In other words, a certain amount of slippage between the engine and the supercharger can be a good thing because it certainly reduces by a considerable margin the stresses and strains imposed on the drive components. All of this reverts to a belt drive in one form or another. The main disadvantage here is that a rubberized flat or V-belt is quite limited in its power-transmission ability. Consequently, multiple belt installations become necessary, which are rarely successful in all respects due to the variance in belt circumference, even in so-called "matched sets." A single belt would seemingly be the best compromise but this requires a low amount of power to drive the supercharger.

When dealing with gasoline in a supercharged engine, the spark plugs and exhaust valves can be real troublemakers. The plugs and exhaust valves must work under a much wider heat range in a supercharged engine than in a normally-aspirated engine, especially if the engine is used on the street and highway. Under conditions of partial throttle and load, everything may be dandy, but when the pressure is cranked on and the combustion pressure and temperature rise, the plugs and exhaust valves are very apt to become sources of pre-ignition. It may be entirely necessary to carry two sets of plugs, one set for city driving and a "colder" set for use on the highway. Usually, with up to a 50 percent boost, a plug that is one step "colder" than for the stock engine is all that is required for general use. For hard and fast highway driving or a trip to the drag strip or straightaway course, a plug that is three steps "colder" than the stock plug should work quite well.

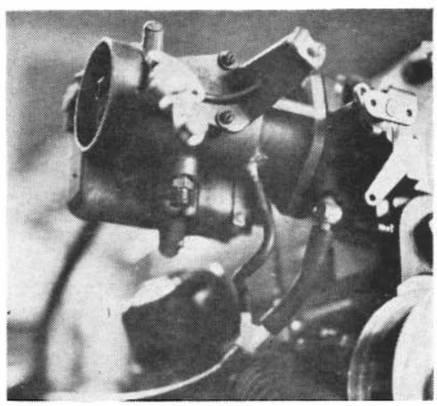
Unfortunately, we can't change exhaust valves as easily as the plugs can be changed. But we can make sure that the basic engine design has not overlooked or neglected exhaust valve cooling. For example, exhaust valve seat inserts are not desirable because they cause a valve head temperature increase of about 300 degrees F. Removable valve guides increase valve head temperatures by about 200 degrees F., as compared with integral valve guides. Also, it's a good idea to make sure that engine cooling water gets as close as possible to the valve seat and port. Furthermore, a large diameter exhaust valve is not compatible with low valve head temperatures or rapid heat dissipation. For this reason, exhaust valves should be kept at fairly small diameters and should not be lightened extensively. In most overhead valve engines, these conditions are pretty closely kept, but with a flathead, pre-ignition could quite easily develop with a 50 percent boost. In a supercharged competition alcohol burner, the spark plug and exhaust valve problem doesn't get critical until boost pressures of 15 psig or more are reached.

The foregoing was certainly not meant to frighten anyone away from the very real and practical benefits of supercharging. Instead, I wanted to show that supercharging is a rather complex science and that some serious consideration should and must be given to the important points before any supercharger installation can be considered complete and efficient.

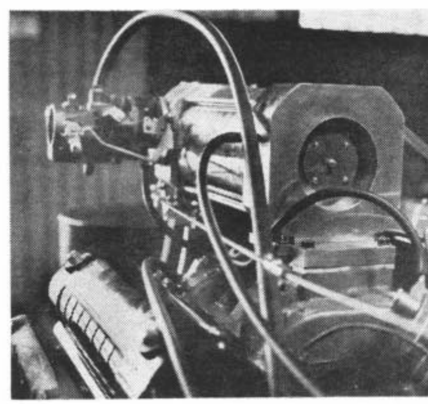
We're probably all familiar with the various types of superchargers now in use but it seems advisable to dig into their pressure characteristics and capacities. For example, the pressure output of a centrifugal supercharger varies as the square of the supercharger shaft speed, which obviously means that at low engine speeds, the pressure output is poor. Unless of course, the impeller speed is governed by a variable step-up arrangement in order to keep the



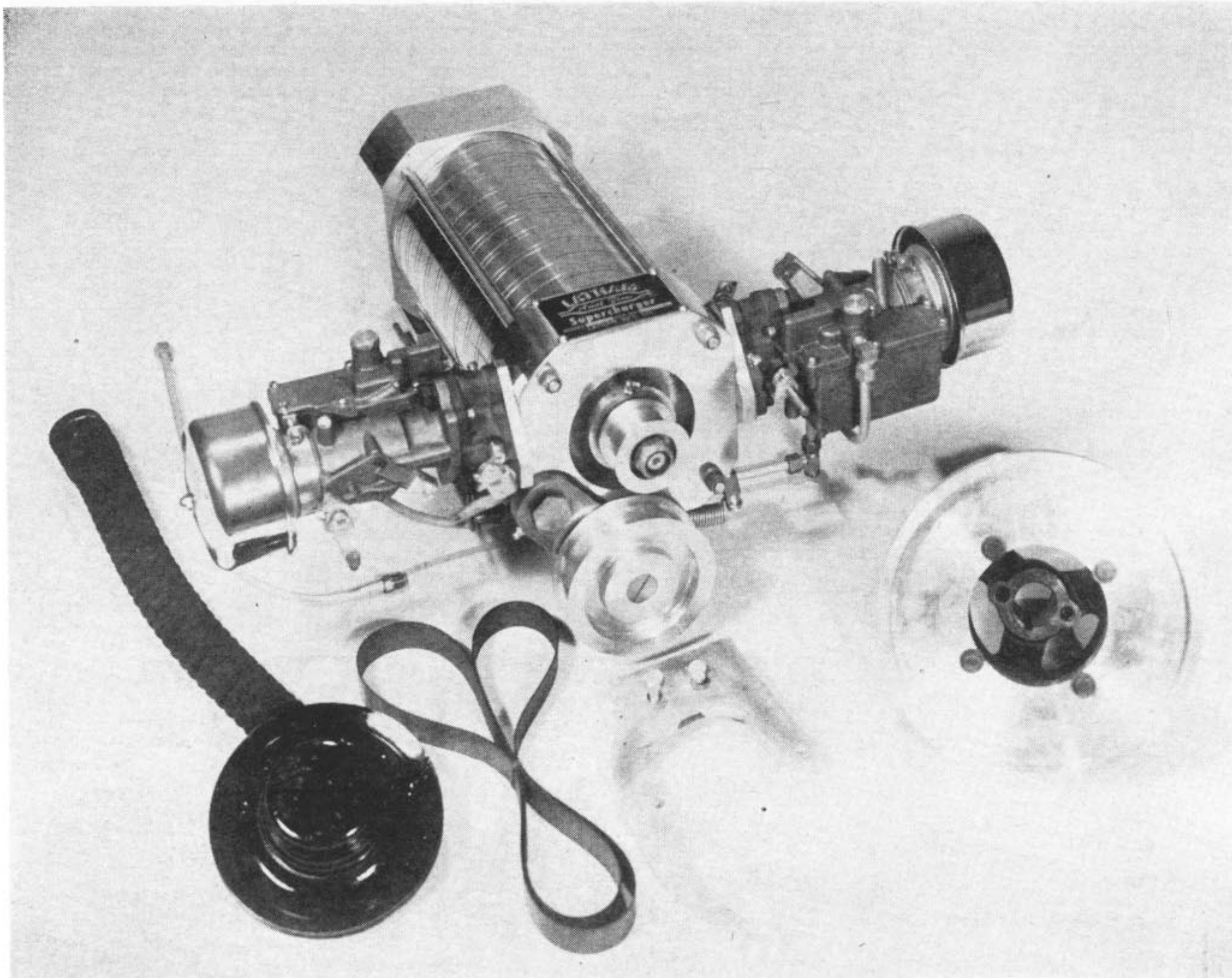
For 3rd test, center section, dividing bulkhead of Ford manifold were removed to increase area by 50%. Net gain—2 bhp.



Right-hand carburetor is drilled for venturi and manifold vacuum for ignition advance. Fitting is for fuel overflow drain.



Rear of blower showing blower-to-manifold adaptor, volute and manifold fittings for pressure readings from both points.



Latham kit for ohv Mercury. Ohv Ford V8 kits contain modified steady-rest. Here it is, just bolt it on.

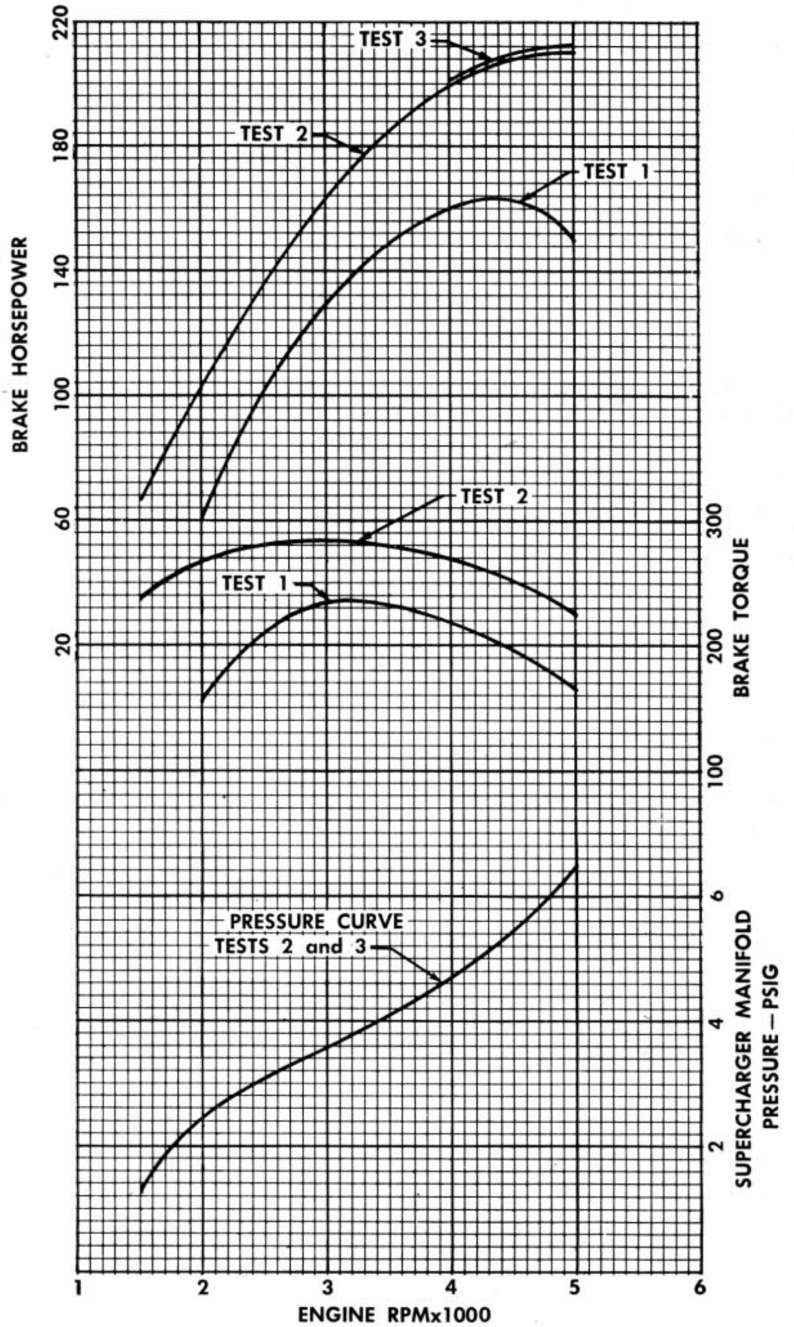
impeller speed higher in relation to engine speed. In this type, the tip speed of the impeller is vitally important, a peripheral speed of 1300 feet per second being considered maximum for efficient pressure delivery. Incidentally, the pressure build-up of this type is due to a conversion of the velocity of the fuel/air charge leaving the impeller tip. In highly specialized centrifugal units, a pressure output of 400 percent (60 psig) is possible. Even at this pressure, the power required to drive the unit is relatively low and the efficiency of the supercharger is quite good given correct design.

The Roots type supercharger may be likened to a gear pump and it operates in the same way. The fuel and air passing through the supercharger is in excess of the piston displacement for each revolution, consequently a positive pressure is built up within the manifold and not within the supercharger itself. When a Roots type of proper displacement is used in a single-stage application, the maximum pressure will only very rarely exceed a 100 percent boost (15 psig). Due to a "slip loss" between the rotors and case, the volumetric efficiency (and the pressure output) of this type reaches a maximum (about 80 percent volumetric efficiency) at a supercharger shaft speed of about 4000 rpm and remains constant thereafter. At a shaft speed of about 2500 rpm, the volumetric efficiency of the supercharger is reduced to around 65 percent, which means good pressure output at relatively low engine speeds. A shaft speed of 10,000 to 12,000 rpm is considered maximum for this type. With a 100 percent boost, the horsepower required to drive the Roots varies from about 50 for the smaller units to 80 or 90 for the larger units, consequently a rugged, dependable drive is essential.

With the eccentric vane type, high maximum pressures of the order of 200 percent (30 psig) are obtainable in single stage applications and low speed pressure output is quite good. However, this is offset by the fact that the vanes must slide in the eccentric drum and they must either rub against the bore of the case or they must have "feet" to follow the contour of a cam. In either case, the internal friction plus the actual compression of the fuel/air charge within the unit generates heat, a very undesirable alien, which expands the fuel/air mixture and lubrication of the sliding and rubbing components, while not only desirable is quite difficult to achieve. Also, the eccentricity of the rotating drum and vane assembly, in relation to the bore of the case, causes an unbalanced condition at all speeds and to keep this factor within reasonable limits, the unit must be made rather large and rotated at relatively low speeds.

Our tests are concerned not only with a new brand name of supercharger but with a type that is new for automotive applications. It is the Latham axial flow supercharger. The axial flow principle has been in use for many years in turbines and fluid pumps, and more recently in gas turbine engines, aircraft and otherwise, in which the axial flow unit serves in the capacity of compressor or supercharger. As the term implies, the flow of air, gases or fluids is parallel to the axis of the rotor.

The Latham axial flow supercharger represents two distinct forward steps in the development of the type. First, the Latham unit is relatively small, light in weight and with a lower power requirement for the amount of boost, which makes it a very logical prospect for automotive applications. Second, and undoubtedly more important for the entire field of axial flow turbines, pumps and compressors, the Latham unit contains a patented method of construction consisting of pre-formed rotor and stator blades that are positively and accurately locked in place so that they cannot become dislodged due to centrifugal forces or heat. The latter point has been and still is an extremely difficult nut for designers to crack with the natural consequence that the cost of producing axial flow units is astronomical. The design of the Latham supercharger makes it possible to reduce manufacturing costs to the point where it is well within the realm of reason.



Horsepower, torque, manifold pressure curves for tests. Results were very encouraging.

Basically, the Latham unit consists of a stator (stationary) and case assembly and a rotor assembly. In the stator and case assembly there are 10 or more rows of stationary, inwardly pointing radial blades with uniform spaces between each row. Front and rear end-plates form the inlet and discharge volutes, respectively, and these are also machined to accept a pair of rotor bearings. The stator and case assembly is held together by four external fore-and-aft drawbolts. The rotor assembly also contains 10 or more rows of radial blades with uniform spaces between each row, but these blades point outward and upon assembly, fill the gap between the rows of stator blades. The rotor assembly is also held together by four drawbolts. A stub shaft, each carrying a mounting bearing extends from both ends of the rotor. The forward stub shaft also carries the supercharger drive pulley. The result is that there are alternate rows of rotor and stator blades with a small space between each.

The pre-formed rotor blades form a pitch angle in relation to the rotor axis and the stator blades do likewise. The pitch angle of both rotor and stator blades diminish from front to back, which means that the rear blades get more of a "bite" than those in the front rows. The purpose of the rotor blades is, of course, to force the fuel/air charge into the intake manifold, while the stator blades help maintain the direction of flow substantially parallel to the rotor axis. For this reason, the stator blades face in the direction opposite the rotor blades. Also, the rows of rotor and stator blades are staggered, in relation to each other, to prevent "surges" and "pulsations" in the so-called critical speed ranges.

The supercharger inlet volute is at the front and for normal passenger car installations, mounts a Carter YH sidedraft carburetor on each side of the volute. The carburetor venturi is 1$\frac{5}{16}$ inches in diameter and the throat size is 1$\frac{1}{2}$ inches in diameter. These are similar to those used on six cylinder Chevrolet Corvettes and Nash-Healeys. The carburetor throttles work in unison with the interconnecting linkage passing beneath the stator case. The discharge volute of the supercharger assembly bolts to either a two- or four-barrel stock intake manifold by means of an adaptor. (For flathead Ford or Mercury V8 engines, a special manifold is supplied in the installation kit.) The supercharger is supported at the front by a special bracket.

The method of driving the supercharger is as simple as it is effective. A special pulley of fairly large diameter (depending upon the final drive ratio desired) is bolted to a slightly modified crankshaft pulley and/or vibration damper. This pulley lines up vertically with the supercharger drive pulley, which is quite small in diameter. The belt connecting the two pulleys is a Gilmer flat belt 1$\frac{1}{8}$ inches wide, which is made up of very fine braided steel wire cables that are surrounded and bonded to a neoprene strip. This strip, in turn, is bonded to a textured nylon friction surface that contacts the drive and driven pulleys. A spring-loaded idler pulley is interposed between the drive and driven pulleys to maintain proper belt tension. Most of the people who witnessed the tests at first laughed at the flat belt idea. As the tests progressed, the yaks were on them. This type of flat belt will not stretch perceptibly due to the steel cables and the nylon friction surface should, with proper installation, last indefinitely and this material gets an excellent "bite" on the pulleys. Another advantage is that this type of belt is very flexible, being only about .070 of an inch thick, and this permits a good degree of "wrap" around the small diameter supercharger pulley, which in turn, reduces the amount of slippage at this source. A similar arrangement but with V-belts would require a crankshaft pulley diameter of about two feet in order to maintain the same drive ratio. Factory tests have indicated the belt life to be in excess of 30,000 miles when installed on a passenger car and at steady speeds, slippage is of the order of from one to two percent, a very nominal figure. Our tests merely confirmed these findings. The use of this belt also indicates that the power required to drive the supercharger is indeed low (about 10 horsepower) for the amount of boost.

In operation, the supercharger rotor assembly is the only moving part and does not contact any other part, aside from the pair of durable precision Norma-Hoffman ball bearings. A grease fitting is provided at each bearing for occasional lubrication. Another interesting fact is that with the exception of the bearings, the entire supercharger—pulleys, stator and case assembly, rotor assembly, shafts, drawbolts, nuts and washers—is constructed from prime aircraft grade wrought aluminum alloy. This not only affects light weight but also causes thermal expansion of the various parts to be as nearly equal as possible.

This supercharger is a product of its inventor, Norman R. Latham, owner of the Latham Manufacturing Company of West Palm Beach, Florida, and has been the subject of several applications for design and manufacturing patents. The supercharger is indeed a work of art in design, construction, simplicity and workmanship and reflects an attention to detail that is compatible with products of only the highest precision.

For our tests we selected a 3$\frac{3}{4}$ inch bore, 3.3 inch stroke, 292 cubic inch 1956 Ford overhead valve V8 engine, which by virtue of its relatively low compression ratio of 8 to 1, was considered almost "ideal" for our purpose. The engine was new and totally and completely stock except that the cylinder

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SUPERCHARGE FOR POWER

bores had been increased to permit a piston skirt-to-cylinder wall clearance of .005 of an inch. Nothing else was touched. In stock form, it was equipped with a stock Holley four-barrel carburetor. For our tests, it was run without a fan, generator, air cleaner and fuel pump. For the first test, standard 18 millimeter Champion 870 spark plugs gapped to .035 of an inch were used and the initial spark advance was set at 10 crankshaft degrees before top center giving a total advance of 35 degrees before top center. The premium pump grade gasoline used was a brand available anywhere in the country. The fuel/air mixture ratio was corrected to produce maximum power. SAE 30 Valvoline lubricating oil was used for all tests. Cooling water temperature was maintained at 160 degrees F. Stock exhaust manifolds were used, which discharged gases into two large diameter collectors. The tests were conducted at the Edelbrock Equipment Company of Los Angeles, who graciously loaned us the use of their 300 brake horsepower Clayton engine dyno and facilities.

For the first test, the engine was run in its stock condition to give us basic figures from which we could later plot power and torque curves with and without the supercharger. Our runs started at 2000 rpm, progressing in 500 rpm increments until 5000 rpm was reached, which was past peak power with the stock engine. In any event, the valves floated at 5200 rpm which negated running beyond 5000 rpm. To eliminate the possibility of errors from creeping in, we made at least two runs at each rpm.

The first test showed a maximum of 163 brake horsepower for the stock engine, which was developed at 4400 rpm. Maximum torque was 235 pounds-feet at 3200 rpm. At 2000 rpm, the brake horsepower was 60, the torque was 158 pounds-feet. At 3000 rpm, the brake horsepower was 130, torque was 234 pounds-feet. At 4000 rpm, the brake horsepower was 160, torque was 220 pounds-feet. At 5000 rpm, the brake horsepower was 150, torque was 162 pounds-feet.

For the second test, all the pieces for the Latham supercharger kit were installed on the engine. The kit included the supercharger assembly with the idler pulley, carburetors and throttle linkage assembled into one unit, a slightly modified crankshaft pulley, the supercharger drive pulley, the Gilmer drive belt, a modified fan and water pump pulley, supercharger front support plate, carburetor choke cables, throttle rod extension, a pair of Hellings dry-mesh air cleaners, fuel line extensions, a length of flexible radiator hose, supercharger-to-intake manifold adaptors, lengths of 3/16 inch and 1/4 inch vacuum hose and all the necessary nuts, bolts, washers, gaskets, etc., to make the installation in a passenger car. The choke cables and air cleaners were not used. The right hand carburetor was fitted with a "Y" vacuum take-off, one branch of which was connected to the carburetor venturi, the other connected to the carburetor body just above the throttle valve. The other end of the "Y" take-off was hooked up to the primary ignition advance diaphragm case. The left hand carburetor contained a fitting below the throttle valve that registered inlet volute vacuum. This was hooked up to the secondary vacuum diaphragm case on the Ford ignition. Another fitting in the right side of the inlet volute was for a line to the vacuum booster pump of the Ford fuel and vacuum pump assembly for proper windshield and power brake operation. This was not used, so the hole was plugged. Installing and adjusting the supercharger for the first time took about three hours, which was simply a case of removing the stock carburetor and installing the kit according to the very explicit instructions. All the parts went together as was intended. No surgery, torch work or modification of any kind was necessary. To check the supercharger pressure output, a pressure line was led from the aforementioned drilled and tapped hole in the number six cylinder intake manifold branch to a very sensitive manifold pressure gauge that was calibrated in inches of mercury absolute. Another line was hooked up from the discharge volute to a similar gauge. This permitted a close check between the discharge volute pressure and the actual manifold pressure. The only other change to the engine was to replace the Champion 870 spark plugs with a set of 860's gapped to .028 of an inch. These were one step "colder". The engine-to-supercharger drive ratio was 5.17 to 1, meaning that at an engine speed of 5000 rpm, the supercharger rotor would be turning at 25,850 rpm.

Before any serious runs were made, the fuel/air mixture was very closely observed under full load conditions and was found to be 13.8 with the standard Carter metering rods and jets. For the purpose of our full throttle, full load dyno runs, I considered this too lean and I didn't want to "cook" anything, although it might have been satisfactory for street operation with short periods of full load. Accordingly, the metering jets were removed and bored from .089 of an inch to .096 of an inch. This brought the fuel/air mixture to 12.9. A mixture ratio of one pound of gasoline for 13 pounds of air is considered correct for maximum power in most cases. For the best fuel economy, a better plan would have been to reduce the diameter of the power step on the metering rods by .007 of an inch. This would have assured a good economy mixture ratio for "cruise" conditions and would have enriched the mixture sufficiently for maximum power upon demand. But we were concerned with output, not economy, so the jets were bored instead.

The second test showed a maximum of 210 brake horsepower at 5000 rpm and 282 pounds-feet of torque at 3000 rpm. At 2000 rpm, the power was 103, torque was 267 pounds-feet. At 3000 rpm, power and torque were 163 and 282 pounds-feet, respectively. At 4000 rpm, the power was 200, torque was 267 pounds-feet. At 5000 rpm, the power was 210, torque was 223 pounds-feet. This means a gain of 60 brake horsepower or 40 percent at 5000 rpm and an increase of 48 pounds-feet of torque or 20.5 percent at 3000 rpm due to the Latham supercharger. Also, the speed at which maximum power was developed was raised 600 rpm or 13.6 percent. A couple of runs were made at 1500 rpm, a speed that is well below the stall speed of most automatic transmissions. At this point, the engine produced 67 brake horsepower and 239 pounds-feet of torque, a most creditable performance.

The manifold pressure output at the various check points was as follows: At 1500 rpm—1.25 psi; 2000 rpm—2.5 psi; 3000 rpm—3.6 psi; 4000 rpm—4.7 psi; 5000 rpm—6.5 psi. Thus the pressure curve of the Latham unit, as can be seen on the accompanying chart, resembles the pressure curve of a centrifugal supercharger quite closely. At 5000 rpm, a positive manifold pressure of 6½ psi is equivalent to a 43.3 percent boost. At 2000 rpm, the brake horsepower power increase was a whopping 72 percent; at 3000 and 4000 rpm, the gain dropped off to 25 percent, and again increased steadily after 4300 rpm. The torque output of the supercharged engine represents a gigantic jump of 72 percent over the stock engine at 2000 rpm. From 3000 to 5000 rpm the torque curve with the supercharger is substantially the same shape as the stock engine, but 20½ percent higher at 3000 rpm to 37.6 percent higher at 5000 rpm. In terms of car performance, this means excellent acceleration with a very considerable gain in top speed. The pressure output at the discharge volute was as follows: At 1500 rpm—1.7 psi; 2000 rpm—4 psi; 3000 rpm—5 psi; 4000 rpm—8 psi; 5000 rpm—11.5 psi.

For the third test, the intake manifold was removed and the center section of the supercharger adaptor and manifold were cut out, as shown in an accompanying photo. This was done strictly on speculation to see if any actual flow restriction existed at this point. A blast on the dyno revealed a very slight gain; at 4000 rpm, a one brake horsepower increase, at 5000 rpm, a two brake horsepower increase, otherwise no gain. It was hardly worth the effort and there's a good chance that the flow characteristics were upset at partial throttle openings.

Excessive heat, being the prime enemy of a successfully supercharged engine, is best gotten rid of by the most convenient and expedient means. During our tests however, no attempts were made to reduce the heat incurred during engine operation. If the exhaust riser in the intake manifold had been blocked off, about a two percent gain in power would have been realized. By the same token, a well-designed set of "scavenge" type exhaust headers would probably show a 10 percent increase. And most certainly, a good reground camshaft would be responsible for at least another 12 percent, as well as adding about 700 rpm to the peaking speed. With the "full race" treatment, but without disturbing the bore, stroke or compression ratio, it is most reasonable to assume that this engine with the Latham supercharger could produce an honest, sustained 280 brake horsepower on gasoline.

During the warm-up runs for the third test, a head gasket was blown which is another rather critical point with a supercharged engine. A pair of new gaskets were installed after they were sprayed on both sides with silver enamel, which was allowed to become "tacky". The heads were tightened to 80 pounds-feet. This cured the gasket problem for good.

The one element of the Ford engine that was not compatible with the supercharger was the spark advance curve, and with the supercharger, the engine was quite sensitive to spark advance. Even if the advance curve had been "tailored" to the unblown engine, it would have been completely out of reason with the supercharger. For all runs, the spark was manually adjusted to produce maximum power, with the result that it was possible to lay out an optimum spark advance curve, which is included here. It's entirely possible to reproduce this curve with the stock Ford ignition, although a centrifugally advanced, dual coil, dual point ignition would be much superior. After holding the engine in the 4000 to 5000 rpm range under full load for the better part of a minute, the spark plugs appeared in good shape, but a bit on the "hot" side. For sustained full load operation, a plug that is one step "colder" should do the job, but the Champion 860's are about right for general use.

Aside from the head gasket incident, operation of the supercharged engine was always very smooth. It had a nice, crisp, sharp sound to it and it was instantly responsive to the throttle. Above 2000 rpm, the supercharger was completely silent, except when the engine was accelerated rapidly, which was accompanied by a high-pitched whistle for a couple of seconds. The front of the supercharger case, even around the front bearing, was always cold to the touch. At the back, the case was only slightly warm due to the internal compression of the fuel/air charge within the supercharger and the transfer of heat from the exhaust heated intake manifold. Incidentally, the heat rise in any supercharger is directly proportional to the supercharger efficiency. There was never, at any time, any indications of detonation or pre-ignition at any speed or under any load condition and this point alone is worth its weight in uranium with a supercharged engine. It's a certainty that the 363 rotor and stator blades thrashed the fuel/air mixture to a fare-thee-well, which is all to the good in maintaining a homogenous mixture. For this reason, and others described earlier, fuel economy with the Latham supercharger should be quite good, a point that doesn't seem to exist with other supercharger installations. This thrashing action takes place even without the drive belt, in which case, the engine operates as a normally-aspirated unit. After the tests, each component of the supercharger was closely examined in a fault-finding campaign. The only criticism that arose was that the Carter carburetors are a bit short of venturi area for maximum top end power with the 292 cubic inch Ford engine. This was pointed out by the fact that at 5000 rpm at full load, there was a vacuum of four inches of mercury at the carburetor base. This is not really a disadvantage in view of the better engine flexibility, low and mid-range performance and fuel economy obtainable with the smaller venturi area. I feel sure that if the supercharger drive ratio had been increased to about 5½ to 1, or the engine speed increased to about 5500 rpm, we could have ended up with a genuine 50 percent boost with a power increase to match. However, a 40 percent power gain in the hand is worth a 50 percent gain or more all over the ground. And I for one would be perfectly willing to sacrifice 10 percent in boost pressure any day for complete dependability in operation and performance.

The Latham unit is amazingly flexible because stages can be added or subtracted to suit the pressure requirements and piston displacement of any standard or special installation. Also, these superchargers have been rotated in excess of 40,000 rpm, which, for a high pressure competition installation, suggests a final drive ratio of between 6½ and 7 to 1. Additional carburetion is no problem either because the existing side drafts can be replaced with carburetors of larger venturi area and one or more downdrafts may be added to the top of the inlet volute as well. There seems no end of possibilities with this unit.

The Latham supercharger is available for the following cars as a complete installation kit. The prices shown are F.O.B. West Palm Beach, Florida. Flathead Ford V8 and Mercurys—$479.50 (includes a special intake manifold); Ford V8, 1954 through 1956—$469.50; Mercury V8, 1954 through 1956—$459.50; Chevrolet V8, 1955 through 1956—$465; Cadillac V8, 1955 through 1956—$512. With any of the above kits, there is no interference with the hood or any other component. The supercharger assembly with two carburetors, idler pulley, throttle and choke linkage costs $395. Installation charges, made only at the factory, vary from $12.50 to $25. Ford Thunderbird and Chevrolet V8 Corvette kits are now in the works, but prices have not yet been established. Anyone desiring to furnish his own carburetors may deduct between $40 and $50.

Yeah, I know, it's still a lot of loot. But the joy of the Latham supercharger is that a practically guaranteed 40 percent power increase can simply be bolted on an engine without any internal disturbances. How simple can it get? To end it all, there's a natural moral to this tale. To wit: "For more GO, try an axial flow!" It works.