The Proof
of the
Super-Six

Hudson Motor Car Company
Detroit, Michigan, U. S. A.

THE A. A. A. tests of the Super-Six prove more than mere speed. They absolutely settle every question of design, endurance and reserve power. They demonstrate that the Super-Six is a better buy than average cars at much lower prices. Because lack of friction and perfect lubrication, insures long motor life. And long motor life means low running cost. The smoothness, flexibility and enormous reserve power of the Super-Six is just as valuable to the man who drives only twenty miles an hour as it is to the man who occasionally likes to jump to sixty miles

The Proof
of the
Super-Six

WHEN engineers wish to make a record of comparative facts in simple form they use charts and diagrams. These present more or less abstruse problems to the layman and therefore the engineers' diagrams showing by curves and plotted lines the result of their research work, are considered dry reading matter.

The Hudson Motor Car Company broke all precedents by publishing the horse power "curve" of the Super-Six motor in a daily newspaper advertisement.

This excited a great deal of comment for two reasons. The engineers who were able to understand it appreciated that it meant a wonderful performance. Those who could not understand it, asked questions about it.

And it devolved upon the Hudson dealer and salesman to answer those questions, although he, too, invariably felt more like asking than answering them.

We claimed that we obtain greater power from the Super-Six motor because we eliminate the crankshaft distortion and thereby permit of higher motor speed in an advantageous manner, and without the possibility of detriment or shortening the life of the motor.

We explained that our patented system of compensating for the forces which manifested themselves in the crankshaft eliminated a great deal of friction and vibration. All these facts were evidenced by the power curve of the Super-Six motor. Because no one could conceive how it was done, the question invariably asked was, "How do you get this great increase of power?"

All kinds of wild guesses were made as to the construction of this motor, and when we came out with the positive statement that it was a conventional motor in every sense, did not have aluminum pistons or extremely light and fragile reciprocating parts, the interest became still more tense.

Had we exhibited the crankshaft itself, the system of compensating generally would have been believed to be thoroughly understood by everyone who viewed it.

Upon seeing the shaft, ninety-nine percent of the observers will form an erroneous opinion as to what we have accomplished. This is because we have added weights to deal with mathematically computed forces. They *do not* "balance" anything tangible.

We had to combat the enormous momentum resulting from centrifugal force.

A crankshaft *must* revolve, and in order to obtain power, we must be able to revolve it at a comparatively high speed. Centrifugal force manifests itself the minute a crankshaft is revolved, and the faster it revolves, the greater the force. It does not increase in direct proportion to the speed, but it increases as the square of the speed.

For example, if the force is equal to 20 lbs. pull at 100 revolutions, it will not be 60 lbs. at 300 revolutions, but 3 times 3 times 20; or 9 times 20, which equals 180 lbs. At 400 revolutions it will be 4x4x20, equal to 320 lbs.

This is a mechanical law which cannot be discounted or eliminated. It has been understood by engineers and mechanics since Isaac Newton gave it to the world, and no human can discount it in the least. Therefore, when the inquirer asks, "How do you balance this crankshaft, or where do you get this power, or what is your patent?", we must first of all describe what happens to a crankshaft when it is revolved at high speed, due to centrifugal force.

We are undertaking to explain to the uninitiated a subject which has been a stumbling block to automobile engineers for many years—quite a task.

If you take hold of a brick weighing 7½ pounds and swing it around in a circle at arm's length, the pull on the shoulder joint is considerable. If you were physically able to revolve it fast enough, the brick would either pull the shoulder out of its socket, or fly out of the hand, due to the inability of the fingers to retain their grip.

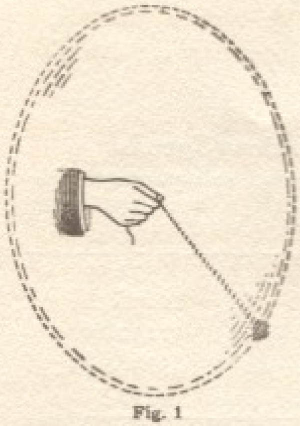


Fig. 1

A pebble on the end of a string exerts considerable pull when it is whizzed around fast enough. And the string will slip through the fingers unless held tighter.

This is exactly what we have to contend with in a crankshaft.

The throws, or cranks, represent a mass which is "off center," and it is a mass of considerable weight.

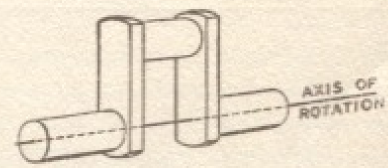


Fig. 2

In a sturdily constructed automobile engine of 40-50 H.P. it will run at least 7½ pounds and will be about 2½ inches from the center. Thus we have a weight of 7½ pounds being spun around in a circle 5 inches in diameter.

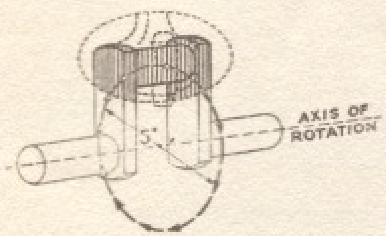


Fig. 3

It is clear that such a weight exerts considerable pull at the rotating axis or center line of the crankshaft. The weight being tied to the shaft by the cheeks of the crank, it pulls upon the center line in the direction shown by the arrow in the diagram, (fig. 4) just the same as the brick would pull one's arm out of its socket if one could revolve it fast enough. The pull increases in proportion as the square of the velocity.

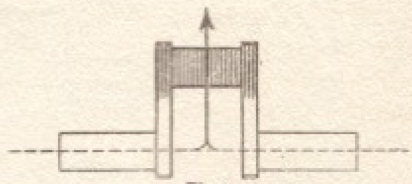


Fig. 4

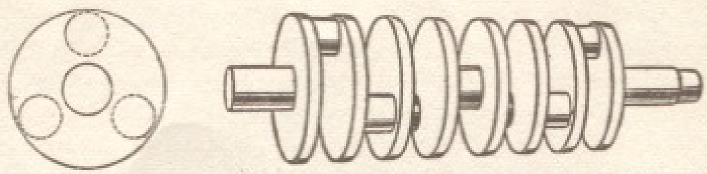
We have computed the following table of figures to show the pull exerted on the rotating axis by a 7½ pound weight at

2½ inches from the center line. It will be noticed that, as is the case of an automobile shaft, when high speeds become desirable, these forces become formidable.

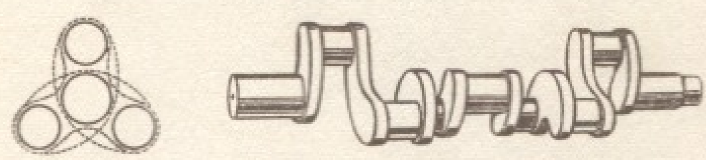
Momentum at One Crank for Various Speeds

R. P. M.	Centrifugal Force in Lbs.	R. P. M.	Centrifugal Force in Lbs.
100	5.325	1000	532.59
200	21.303	1500	1198.326
300	47.934	2000	2130.36
400	85.212	2500	3328.689
500	133.125	3000	4793.31

Now, in a six-cylinder crankshaft, or, in fact, in any crankshaft which has the cranks or throws disposed around a circle in such a manner that they do not come opposite one another, we have a compounding of this tendency to pull outward from the rotating axis.



PERFECTLY BALANCED - SYMMETRICAL IN EVERY WAY



CONVENTIONAL SYMMETRICAL SHAFT

Because a six-cylinder shaft has two sets of three throws which are exactly alike, we must regard each set of three separately. For that reason, the explanation which follows applies to three throws of a six-cylinder shaft.

Such a shaft may be *perfectly symmetrical* in form so that it is perfectly balanced as long as it retains its shape.

We are going to show that such a shaft cannot possibly retain its shape when it is doing work at high speed. All so-called balancing is therefore of no avail, as a friction eliminating factor, if the shaft is distorted from its symmetrical form.

For the same reason it must be apparent that the heavier the shaft, the greater the weights we have to control with. And the greater the weight, the greater the pull from the center line and the tendency to distort at high speed.

If, however, we make the shaft very light, we cannot obtain sufficient section of material to insure the necessary rigidity and make the shaft resist bending under the power load.

Remember too, that even a perfectly symmetrical shaft, machined all over and with absolutely no tendency to have excessive weight off-set from the center at any point, is out of balance when the shaft becomes bent or distorted from its true center line in the slightest degree.

Before entering into further explanation of the distortional effects in a six-cylinder crankshaft, we must resort to another simile to make clear the points which follow.

Imagine a rope held by two people a few rods apart. They begin to revolve this rope, as you would a skipping rope, for instance. It will naturally fly outward from the center as shown in the upper diagram, and the pull at the hands of the parties holding the rope will be noticeably increased as they increase the speed of the rope.

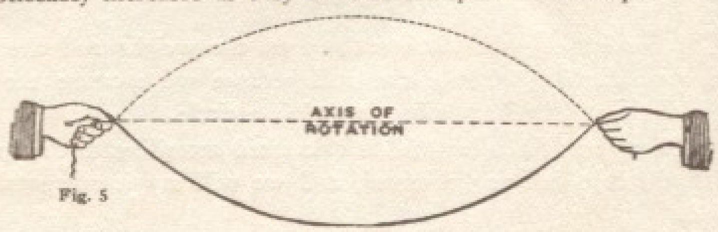


Fig. 5

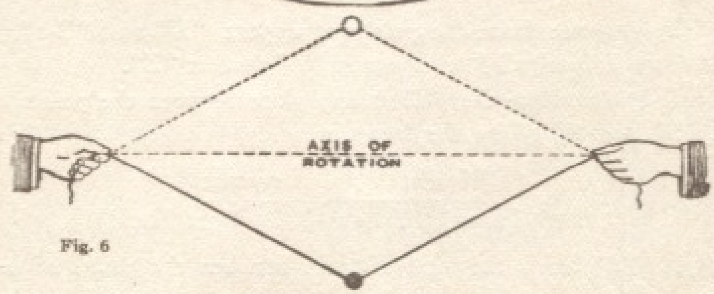


Fig. 6

Now, if we tie a weight to the center of the rope, it will assume the shape shown in the lower diagram. The pull at the center line or axis of rotation will be greatest at the point directly opposite the weight. At other points along the center line, the pull will be proportional to the Weight times the Leverage, divided by the total Distance between the points of support.

In Fig. 7 we have moved the weight to one end of the rope, and it will now assume the shape shown.

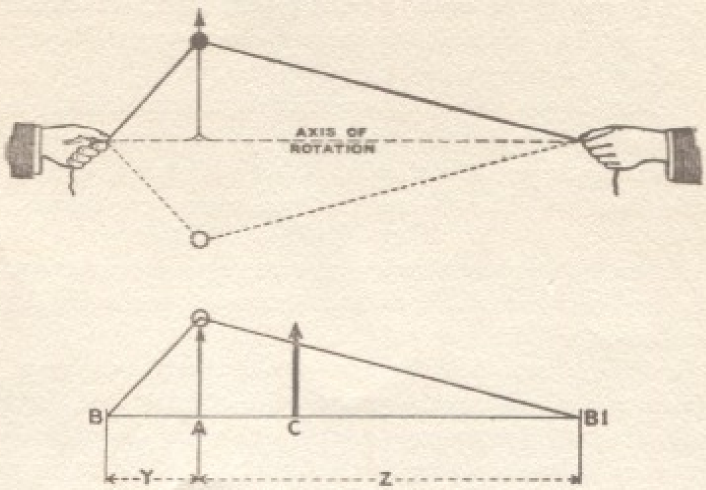


Fig. 7

If we increase the distance between the weight and the center line, we naturally increase the pull because we increase the speed at which the weight is traveling around in a circle.

The pull at the point "A" is calculated according to the speed at which the rope is being revolved, and we will say it amounts to 30 pounds.

The distance from the points of upport, "B" and "B-1", to the point of maximum pull "A" is less at "Y" than at "Z".

We can compute the pull at any place between the points of support "B" and "B-1" by the formula

$$\frac{\text{Weight} \times \text{Leverage}}{\text{(Left Hand)}\ \ Y \ \text{ or } \ Z\ \ \text{(Right Hand)}}$$

"Y" plus "Z" being the total distance between the points of support.

Assuming that the distance between the points of support is 10", "Y" being 2" and "Z" being 8", we wish to find the pull exerted by the 30 pound weight at the point "C" which is 6" from the point of support "B-1".

$$\frac{W \times 6}{Z} = \text{Pull in Pounds.}$$

This works out as follows:

$$\frac{30 \times 6}{8} = \frac{180}{8} = 22\tfrac{1}{2} \text{ pounds.}$$

This shows that the numerous crank throws disposed along a length of shaft exert a pull away from the center line proportional to their distance from the points of support, which, in the case of an automobile crankshaft, would be the main bearings.

Diagram No. 8 represents the half of a six-cylinder crankshaft.

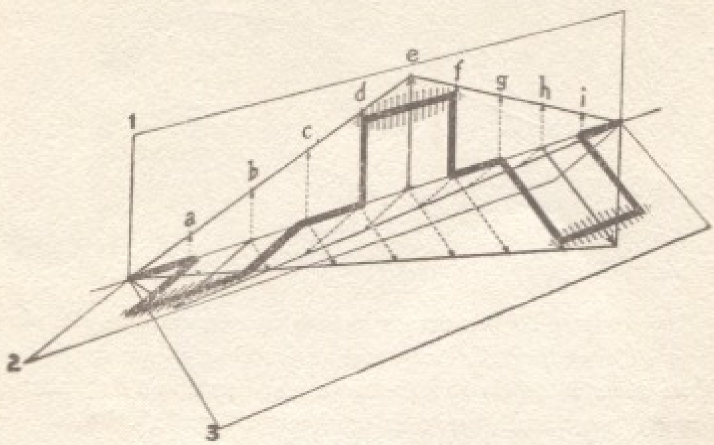


Fig. 8

It will be seen that the "throws" or crank pins lie in three planes or surfaces which we have marked 1, 2 and 3.

The pull resulting from the mass of the crank at "e" in plane "1" is graphically represented by the lines drawn from the top of the arrow to the points of support, or main bearings. The small arrows within this enclosure indicate roughly the magnitude of the forces at various points between centers. Notice that this diagram is very much like the illustration of the skipping rope.

In plane 2 we have a different condition due to the throw of the shaft (or mass) being nearer one end of the shaft as in the second skipping rope diagram.

In plane "3" we have the same condition, but at the other end of the rotating axis.

Now we may calculate the exact pull on the center line of the crankshaft at any point by taking the three forces into consideration.

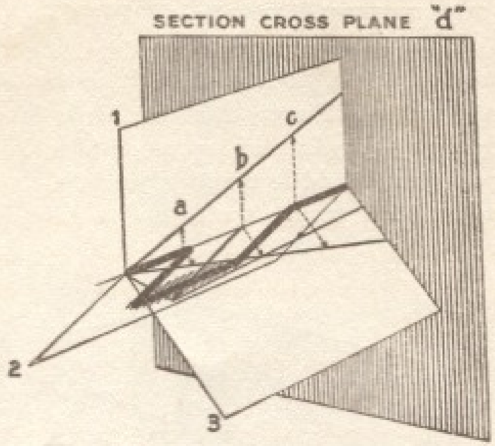


Fig. 9

For instance, if we take a section of the shaft in the plane "d", Fig. 9, we find that the forces are disposed as shown in Fig. 10. At "2" we have a force of fairly large magnitude; at "1" not so great, and at "3" very much less than at either "1" or "2".

For comparison, assume that the pull at "1" is equal to 50 pounds; the pull at "2" equal to 70 pounds, and the pull at "3" equal to 30 pounds. It is very much like a three-cornered tug-of-war affair with three ropes tied together in the center and three teams pulling in the direction of the arrows of the diagram in Fig. 10. The strongest teams are "1" and "2", and they will tend to pull the center (where the ropes meet) in the direction of "4".

This is what is known as a resultant load and is found by computing the forces at "1", "2", and "3", and their paths of action.

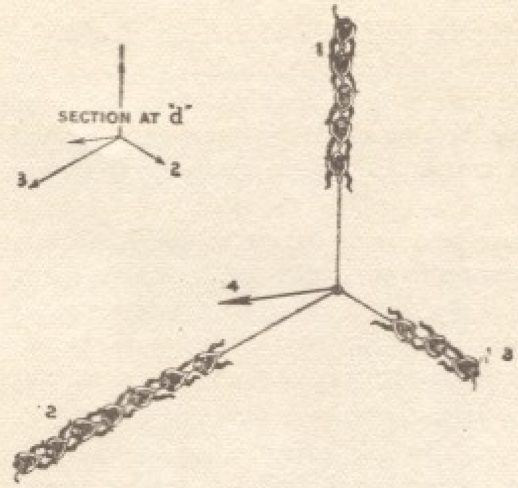


Fig. 10

It is therefore obvious that there IS a tendency to pull the center line of the crankshaft in a direction which can be determined by mathematics, and that this tendency is lesser or greater as the speed decreases or increases.

Turn back for a moment to the table of forces acting on the crankshaft at different speeds.

Is it not immediately apparent that such enormous loads must distort a shaft from its true center line or axis of rotation?

It is a recognized fact that a crankshaft bends when it is speeded up sufficiently.

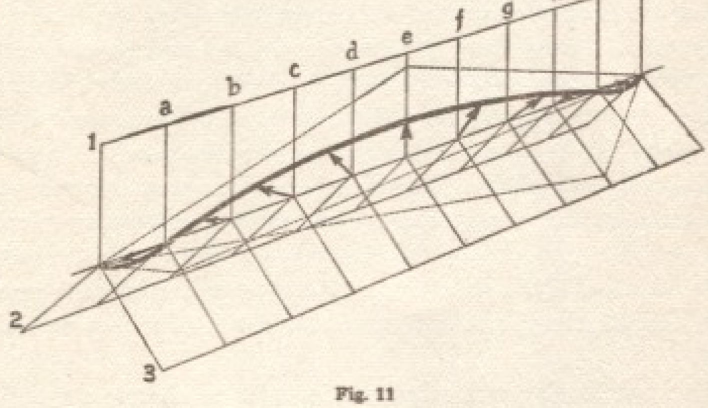


Fig. 11

But the Hudson engineers also found that by computing the momentum or load at numerous intervals between the point of support, the tendency was not only to bend the shaft, but to give it a spiral twist. This can be appreciated by connecting the load diagrams in Fig. 11, which are plotted for ten spaces along the entire length of the shaft.

It must now be clear to the reader that such distortion increases the bearing pressures in the motor and upsets the harmony and equidistant spacing of the pistons and their connecting rods. This means that power is used up in excessive friction at the bearings, and force-feed oiling systems must be resorted to if they are to be kept cool.

There must be power losses at these points.

It also shows that the power strokes of the motor cannot be harmonized, or, to speak technically, in perfect synchronism if the shaft be twisted. This makes for a rough sounding motor and cuts down its power.

It is not vibration which causes the noise and power loss at high speed in the six-cylinder motor, but those conditions which we have just outlined.

The Hudson Motor Car Company has patented its system of compensating these forces because its engineers were apparently the first to discover their existence and find a means to counteract them.

From the foregoing it can be easily understood that masses of the correct size and weight, attached at the correct points, will counteract the pull on the axis of rotation at any point along the shaft.

This is what Hudson engineers have done. By placing weights on the cheeks of the cranks in such a manner as to counteract any tendency to pull away from the true center line or axis of rotation, the weights naturally *keep* the center line true; and the faster the shaft runs, the stiffer it becomes and the truer its axis of rotation.

We have made some interesting tests with so-called perfectly "statically" balanced shafts. We found that the most accurate shaft we could make could not be speeded up more than 2000 revolutions without the distortion due to the centrifugal action manifesting itself.

We witnessed a test in which a shaft was spun in a crank case by an electric motor, the pistons and connecting rods having been previously removed.

The front bearing was taken out in order to observe the rigidity of the shaft as it revolved and it was noticed that at 1500 revolutions the front end of the shaft became slightly blurred; at 1900 revolutions it was distinctly blurred and at 2200 no out lines were visible. It was apparently running out 1/16″. Above this speed the shaft was distorted to such an extent that the lubrication of the bearings became impossible.

Upon removing the shaft from the crank-case after this test, it was found it had taken a permanent set of 1/8″. Now this bending of a heavy crank shaft could only have been accomplished by a formidable force; and that force must have acted in a direct manner from the center line outward or it would not have bent the shaft.

Bear in mind that this was not a shaft out of a cheap motor, but one of the finest that can be made.

In making the same test with a Super-Six Hudson shaft, it was found that it could be speeded up to over 3000 revolutions without the slightest possible distortion or blurring of the front end being visible.

For this reason we say that there is no limit to the speed of the Super-Six crankshaft.

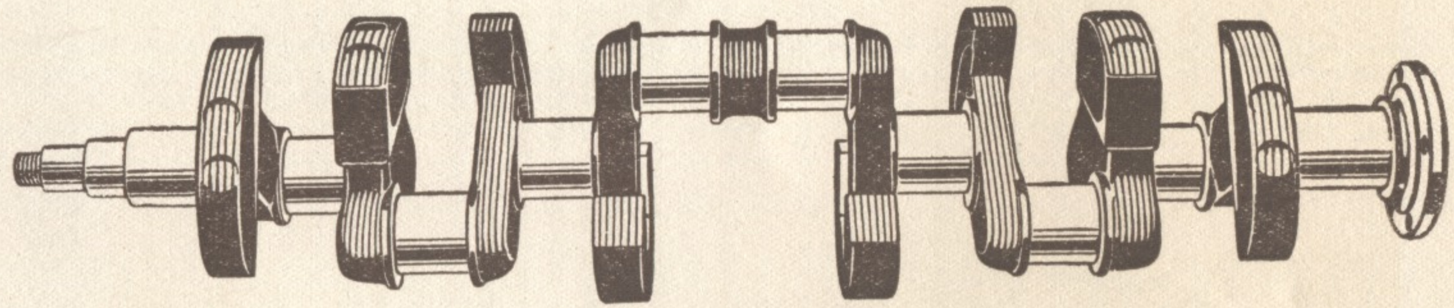
Now, the proof of the theory has been demonstrated by our records at Sheepshead Bay.

The car was a stock car in every respect *and used a splash feed oiling system.* It is obvious that the Super-Six motor could not have maintained a 76 horse power load at an average speed of 2650 engine revolutions for one hour and twenty minutes with an ordinary splash feed oiling system unless the bearing pressures of the crank shaft were comparatively nil. It has never been accomplished before and a few months ago would have been considered impossible.

It is the elimination of complicated oiling systems, the elimination of extra cylinders, and the elimination of light, fragile reciprocating parts in a high speed, high powered motor, which prove our patented system of counteracting the crank shaft distortion a revolutionary step in the automobile industry.

Hudson Super-Six Crank Shaft

Patented Dec. 28, 1915



Patent Number 1165861

All Other Cars Outrivaled

A 7-passenger Super-Six makes fastest time for touring cars up to 100 miles, in official tests, under A. A. A. supervision.

100 miles in 80 min., 21.4 sec. averaging 74.67 miles per hour, with driver and passenger.

The best previous stock car time was made by a car with more cylinders, more cylinder capacity and driver only.

75.69 miles in one hour with driver and passenger.

Some laps were made at 76.75 miles per hour.

70.74 miles in one hour, carrying 5 passengers, with top and windshield up.

The best previous time for stock cars similarly equipped was made by a car with more cylinders, more cylinder capacity, and with two passengers only.

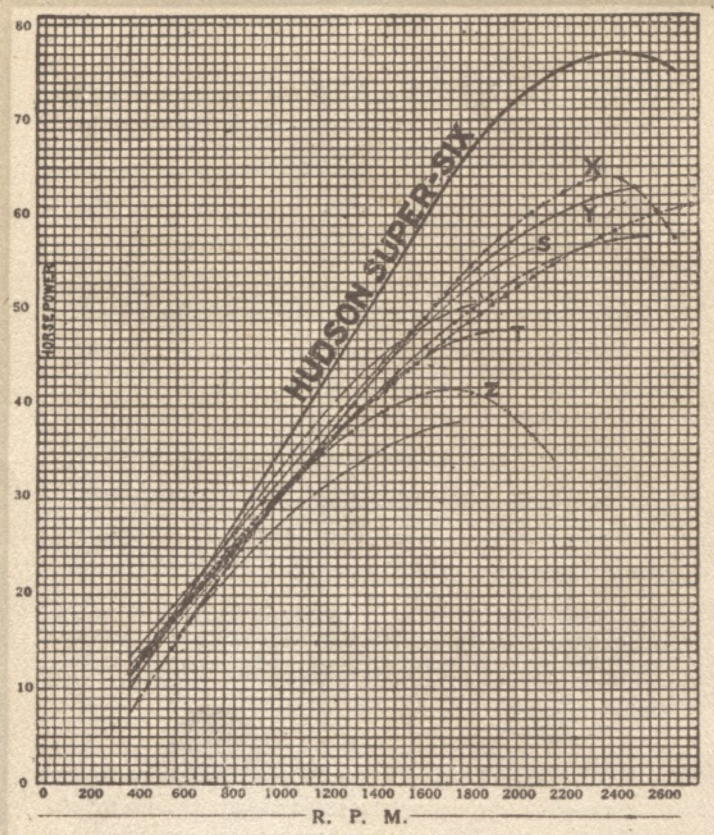
Standing start to 50 miles an hour in 16.2 sec.

All these Hudson records were made with the same stock car, using the same motor, at Sheepshead Bay Speedway in November, under supervision of the American Automobile Association.

During these tests the car was driven 1,350 miles, at top capacity, at speed exceeding 70 miles per hour, without discoverable wear on any part.

An endurance feat seemingly impossible.

Proving the most powerful motor per cubic inch displacement that the world has ever known.



Power curves of Hudson Super-Six compared with certain other motors reduced to the unit of size of the Hudson Super-Six—288.7 cubic inches

X—Indicates the power curves of a well-known eight-cylinder motor.
Y—Is that of famous Twelve.
Z—Is a smaller sized Eight, also well known.
S—Is that of a leading larger sized Six.