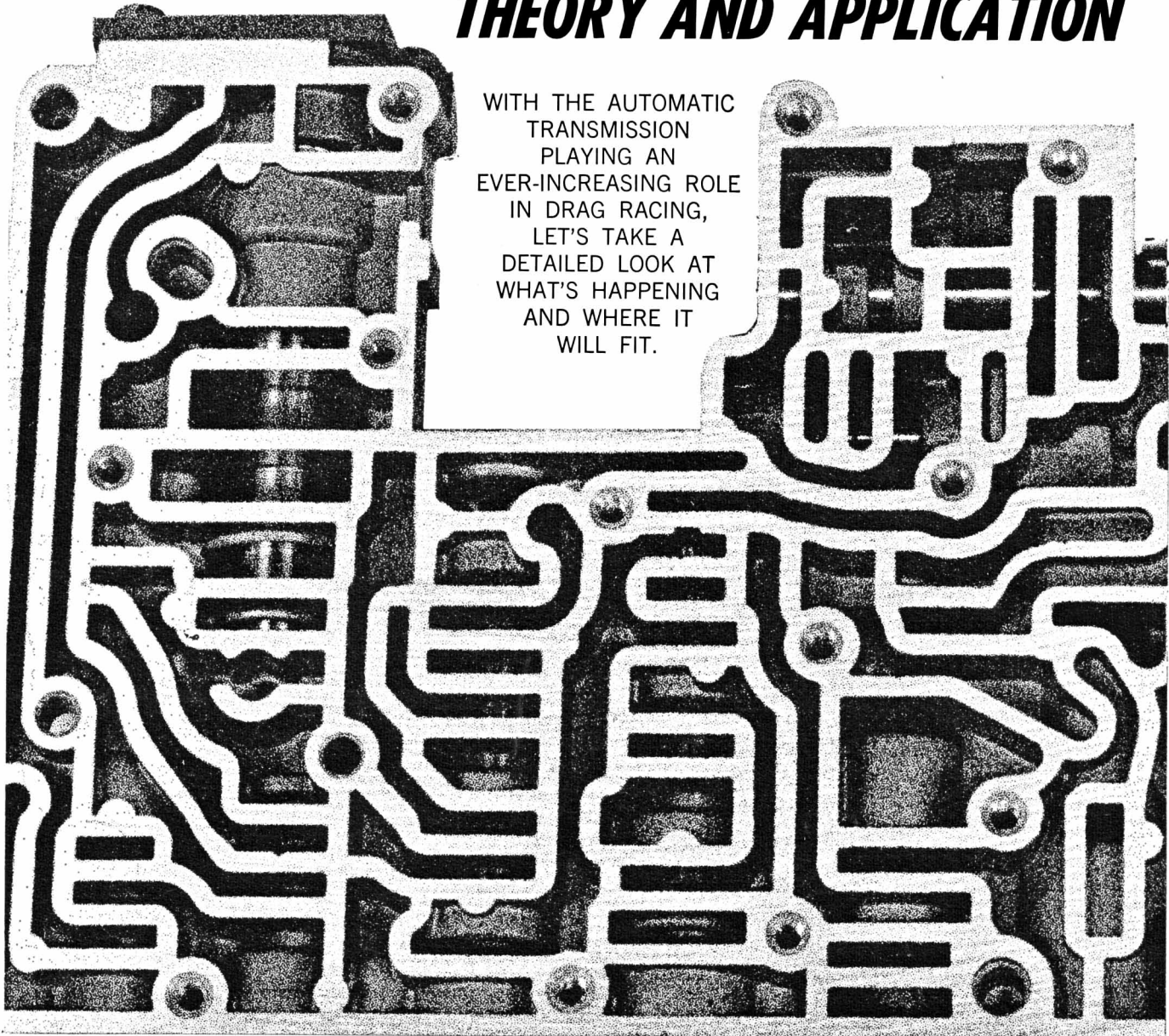


TORQUE CONVERTERS: THEORY AND APPLICATION



WITH THE AUTOMATIC TRANSMISSION PLAYING AN EVER-INCREASING ROLE IN DRAG RACING, LET'S TAKE A DETAILED LOOK AT WHAT'S HAPPENING AND WHERE IT WILL FIT.

One of the outgrowths of efforts to produce the best possible transmission is the hydraulic torque converter. Now that the torque converter has proven itself in competition, many of the mysterious and misleading concepts that had been previously circulated about the function and operation of this unit have grown and multiplied to a level that makes it difficult to separate fiction from fact.

One of the pioneers in the use of automatic transmissions for high performance applications is B & M Automotive of Van Nuys, Calif. We contacted Bob and Don Spar, the guiding hands of B&M, for a detailed explanation of just what torque converters were all about.

To begin, it must be understood that the torque converter should always be

matched to the performance characteristics of the vehicle in which it is installed. Indeed, any time a change is made to modify or alter vehicle performance, a proportionate change should be made to the converter.

The torque converter, when properly matched to the performance characteristics of a given vehicle, can improve "seat of the pants" feeling of acceleration more than any other single piece of speed equipment. In fact, a torque converter properly chosen or modified for the correct stall speed can cut 2 to 5 tenths of a second off your Elapsed Time over a stock converter.

A modified torque converter physically replaces the stock unit; it can be installed in less than an hour and is approved by

all associations as legal for stock classes.

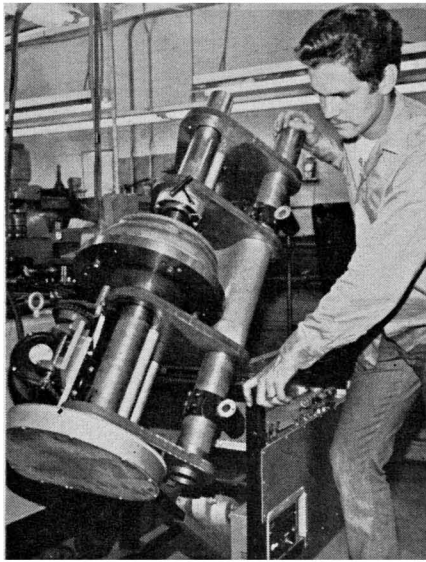
CHOOSING A CONVERTER

The single most important factor determining the correct torque converter for your application is *Stall Speed*.

The exact stall speed of any torque converter is dependent upon the particular combination of a large number of major and minor factors, though basically it is a result of engine torque at low RPM plus torque capacity of the converter, combined with the holding ability of the brakes. For example, the torque capacity built into a converter by the original manufacturer is in direct proportion to the amount of low RPM engine torque to give an average stall speed for stock torque converters of 1400 RPM.

(continued on following page)

TORQUE CONVERTERS:



Precision machining and reworking of the converter parts and pieces are extremely vital in setting a unit up for performance applications such as drag racing. After the converter has been modified, the flex plate mounting lugs are then double-checked for any face run-out before the unit is tapped for biggest bolts.



Anyone can very closely determine the amount of available stall speed in a torque converter with the help of a good set of brakes and a tachometer.

Stall speed is the amount of engine RPM that can be attained at full throttle with brakes locked and transmission in gear before the car moves. It must be remembered, however, that stall speed is variable. Identical torque converters placed in two different cars can deliver varying stall speeds due to dissimilar characteristics of the two cars. For instance, high speed brake linings that have a lower static capacity (holding ability) can cause a loss of 400 to 600 RPM of stall speed, with no other changes! In addition, an extremely high RPM camshaft that reduces the available low RPM engine torque would cause a similar or further loss of stall speed. The latter condition is the most meaningful, for we know that to increase high speed engine performance we will lose something at low RPM, so in our test to find the stall speed, we now discover that the engine won't reach as high an RPM before it either moves the car or stalls.

By comparing the resulting stall speed level with what was formerly adequate and determining the requirements of our performance improvements, we can very closely estimate the correct stall speed for our needs.

Now all we need to know is how high we can go and how to achieve it.

As we know, stock torque converters have an average stall speed of 1400 RPM. A stock converter can be modified to increase the stall speed a maximum of approximately 500 RPM without substantially harming efficiency at high RPM. Any additional modification presents a problem of diminishing returns. A converter so modified would lose too much performance at the top end, offsetting or even overpowering any gains achieved at the bottom due to the higher stall speed.

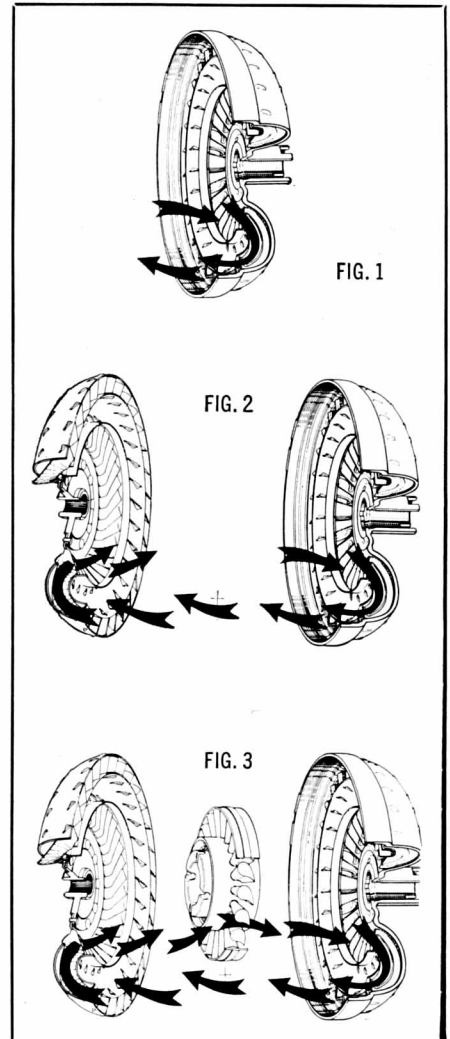
This fact is directly related to one of the basic principles of torque converter operation and that is that any unit which transfers power through fluid flow cannot transmit torque, or power, unless there is circulation of fluid in the unit. The fact is, all torque converters transmit torque by means of high velocity fluids which are

directed at a driven member (turbine) by a driving member (pump). These members have absolutely no mechanical connection. Since one part depends on the fluid force delivered by the other to make it react, we can see that there will always be "slippage"; that is, the driving member will always be turning faster than the driven member.

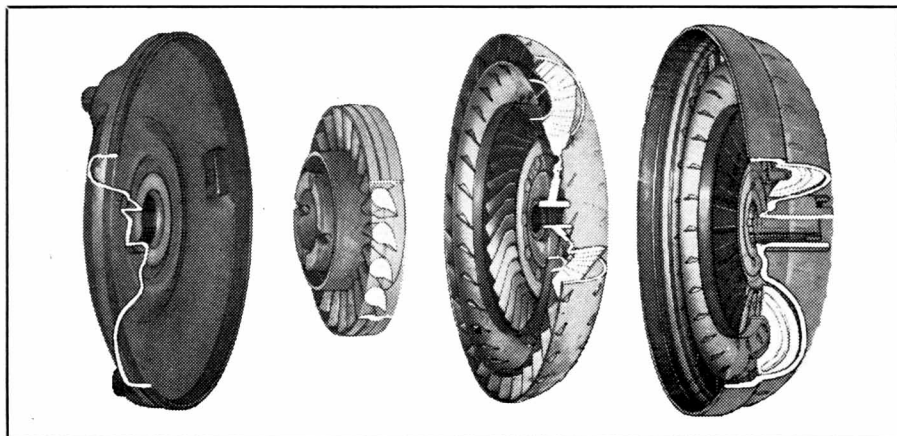
Don't be misled though, by that word "slippage," as it does not reflect a direct horsepower loss. It is, however, a factor to be compensated for and can be offset easily, but this is a subject we will cover further on.

Actually, the amount of "slippage" built into any torque converter is the factor that determines the mechanical stall speed of the unit. Herein is where many individual concepts of torque converter capability stray from reality.

With a certain amount of "slippage" to begin with, we now want to increase the figure even more to gain stall speed. Therefore, we must also be ready to ac-



There is no mechanical connection of any kind in a torque converter transmission. Oil is only means of transferring the power. Curved vanes absorb energy from the oil as it is discharged from center of turbine in a direction opposite to the rotation of the turbine (Fig. 2). Unused energy helps drive oil pump (Fig. 3).



cept increased slippage at the top end. Now, as we've said, the torque converter can be modified a certain amount to gain low RPM "slippage" (or stall speed) before loss of overall efficiency becomes unjustifiable. A torque converter in stock form can be up to 98% efficient, which means there is only a 2% power loss at high speed; a very negligible factor — and quite comparable to any form of power transmission known today.

So, what we have is a torque converter that began with 1400 RPM stall speed and can be modified to attain 1900 RPM before stall — with a minimal loss of top end efficiency.

If the former method is not sufficient for your application, the next step upward to higher stall speeds is to the smaller diameter torque converters.

In our search for higher stall speeds while still maintaining acceptable overall efficiency, the most effective method is to reduce converter diameter. These smaller units, known as the "Hemi" for TorqueFlites, "Semi-Hemi" for Turbo-Hydros, and "Falcon" for Ford C-4 and C-6 units, are worth 1000 RPM over the larger stock converter, before modification.

What makes this method so ideal is that we have reduced the circumferential speed, thereby lowering the fluid pressure and circulation rate, which means we have a unit with lower torque capacity and therefore more stall speed, with a minimal loss of high speed efficiency! These units can also be modified to gain approximately 500 RPM over their stock form, which would take us from 2400 RPM before modification to 2900 RPM stall speed.

By careful "tuning" of all factors having an effect on stall speed, these units can attain 3000 RPM stall speed.

The highest stall speed presently available with an acceptable amount of overall efficiency is 3000-3200 RPM. These units, approximately 96% efficient, are slightly over 11" in diameter and modified for the maximum stall speed.

There are presently no converters available with more than 3000-3200 RPM stall speed that have a high speed efficiency of 95% or over, the minimum acceptable level. B & M is presently experimenting with several units of a higher stall-speed design, but so far they are not economically practical.

If still higher stall speeds are required, try a "Clutch-Flite," which eliminates the stall speed problem entirely, as well as maintaining maximum efficiency at high revolutions.

B & M recommends lower stall speeds for street use, as high stall speeds will maintain a high amount of slippage at low cruising speeds, inducing heat build-up and causing discomfort under continuous start-stop conditions.

DRIVING WITH A TORQUE CONVERTER

STARTING LINE TIPS: The best and proven technique for driving a car

equipped with a torque converter is to accelerate from an idle or slightly above. In competition, the method is to stage at idle, then bang the throttle full open "at the green." This system takes advantage of the turbulence created from the sudden power surge and simulates a cavitation point (a pocket of turbulence) which reduces the torque capacity instantaneously and increases the stall speed momentarily, promoting increased acceleration. (If this technique doesn't work effectively for you, it indicates inadequate low RPM engine torque and the need for a higher stall speed converter.)

Sitting on the starting line at maximum stall speed with high engine RPM will generally result in inferior acceleration and worse E.T.'s, and often causes ballooning and severe damage to the con-

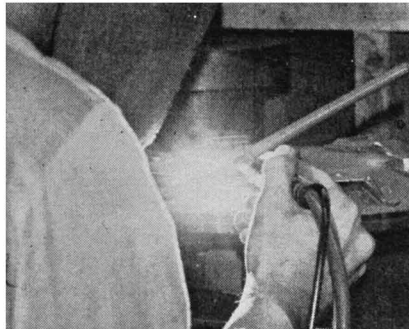
verter due to extreme pressure build-up.

Another possible cause of converter damage is excessive RPM. Engine speed should be limited to 8000 RPM if at all possible when using one.

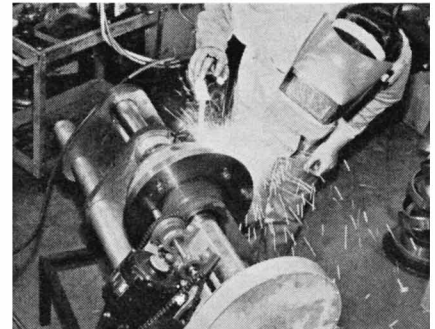
If you have just recently changed to a torque converter-transmission from some other form of power transmission, or are driving for the first time, here is one more aspect of torque converter function you should be aware of:

As stated earlier, a certain amount of "slippage" is built into every converter. As we explained, this "slippage" is a product of the relationship of input speed (driving member) to output speed (driven member). This situation is defined as the "speed ratio" and does not reflect a direct power loss, but it will show up on

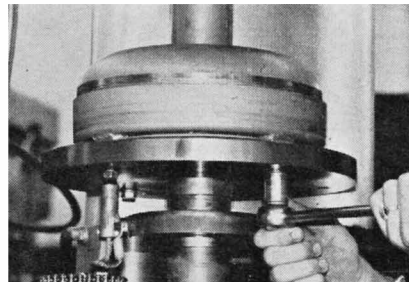
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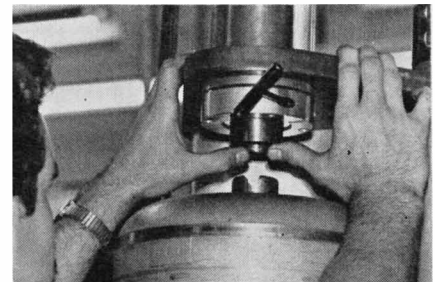
Heliarc welder is used to reseat all units for maximum possible transmission strength.



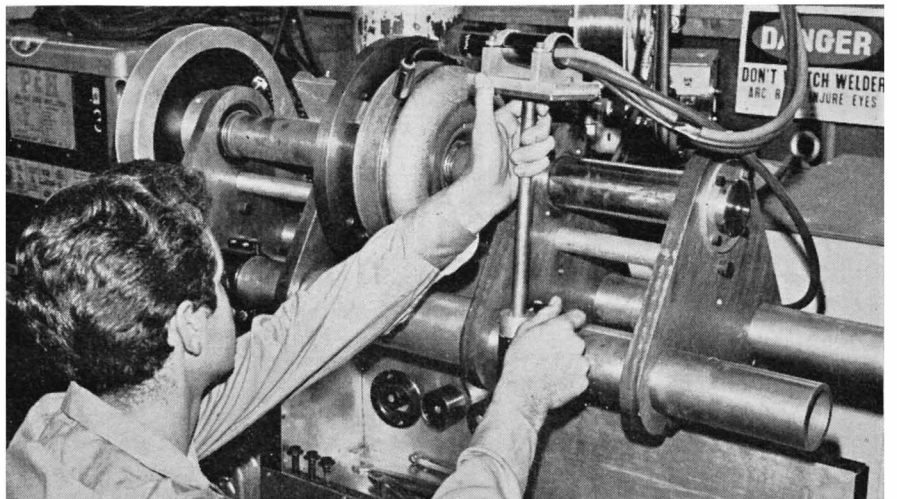
All converters are completely furnace brazed for peak strength and durability.



Precise alignment of the unit is required throughout the entire rebuilding process.



Poor alignment during rebuilding is the major cause of torque converter failure.



In order to gain the required alignment, B&M designed and built their own machine to hold the mandatory .006 eccentricity. Quality control is absolute necessity here.

**Straight
Talk
from
Bill
Jenkins**

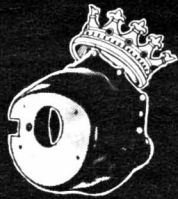


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TORQUE CONVERTERS

(continued from page 53)

your tachometer as a variation of RPM at a given speed. The speed ratio can be compensated for by a gear ratio change, just as you would in any similar situation, to select the desired RPM for maximum power. The speed ratio is proportionate to stall speed. High stall speeds have lower speed ratios (more slippage), further pointing out the need to limit stall speed level. The higher the slippage, the harder it is to compensate.

TORQUE CONVERTER DURABILITY

THE IMPORTANCE OF QUALITY CONTROL: Torque converter tolerances are very critical. The maximum allowable eccentricity (deviation from the centerline) in any converter is six thousandths (.006). MORE TRANSMISSION FAILURES CAN BE DIRECTLY ATTRIBUTED TO CONVERTERS MODIFIED WITH POOR QUALITY CONTROL THAN ANY OTHER SINGLE CAUSE. Extensive equipment and tooling are necessary to produce a quality torque converter that maintains the concentricity tolerances necessary for proper transmission operation. In fact, after an extensive and thorough search through the industry for adequate methods and equipment, B & M has found it desirable to design and build their own fixture for holding a torque converter to a degree of alignment acceptable to their standards while it is welded by integrated head, adjustable-tip, heliarc welders. A bad converter can cause premature front pump bushing wear, resulting in a spun bushing and the ultimate destruction of the entire pump. Less immediate but more costly damage to the transmission can be due to pump rotor wear, also a direct result of converter eccentricity. A front pump worn to excessive clearances from wobbling, due to an off-center pump drive, can continuously wear out clutches and bands, not to mention possibly destroying the converter itself; all due to converter eccentricity.

A few extreme cases of poor quality rebuilding techniques have even resulted in the separation of the converter halves and destruction of the entire trans.

MODIFICATION TECHNIQUES: All torque converters to be used for competition should be completely furnace brazed for maximum strength and durability. All Chrysler Corporation converters are furnace brazed in stock form, but General Motors and Ford units must be furnace brazed before they can be safely modified for higher stall speeds. Furnace brazing insures against the possibility of the fins "laying over" under higher pressure.

B & M thoroughly inspects and cleans all converters as soon as they are disassembled, and again before they are reassembled to insure maximum cleanliness in each unit. We cannot stress enough the importance of having a "fresh" con-

(continued on page 74)

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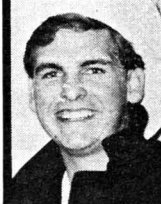


Pete "Super Shaker" Seaton:

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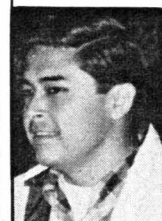
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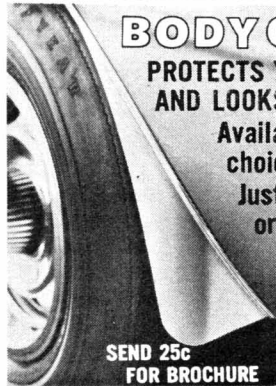
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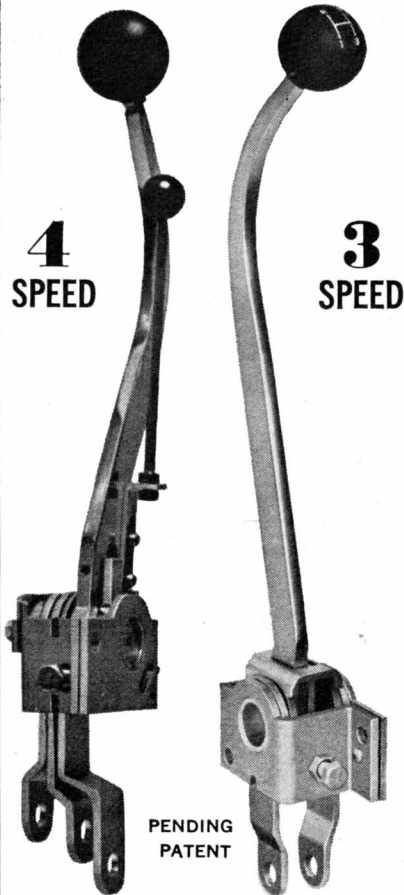
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TORQUE CONVERTERS

(continued from page 73)

verter, and especially so when installing a new or rebuilt transmission.

A sealed converter cannot be adequately cleaned from outside if there is any sediment or foreign material lodged in inaccessible corners of the unit. Any remaining particles could then be dislodged by the high-pressure, high-velocity oil that circulates within the converter, be transmitted to the transmission pressure regulator and cause the ultimate destruction of the entire transmission.

In addition to maintaining minute tolerances and high standards of cleanliness, B & M insures the safety and durability of your torque converter by using the same modern heliarc welding equipment that reseals all units to strengthen the flex plate mounting lugs, which are then double-checked for any face run-out and tapped for the largest bolt possible.

PRINCIPLES OF OPERATION

To complete our basic understanding of the function and effects of the torque converter, we can profitably devote the remaining space in this section to a brief description of the primary parts and the method by which power is transmitted and multiplied.

To gain a sufficient understanding of what a torque converter does, we must start with the fundamentals. Hydraulic torque conversion means multiplying engine torque by converting fluid velocity into power.

The torque converter serves two primary functions. First, it acts as a fluid coupling to smoothly connect engine power through oil to the transmission gear train. Second, it multiplies the torque or twisting effort from the engine when additional performance is desired.

The torque converter consists of three basic elements: the pump (driving member), the turbine (driven or output member), and the stator (reaction member). The converter cover is welded to the pump to seal all three members in an oil-filled housing. The converter cover is bolted to the engine flex-plate, which is bolted directly to the engine crankshaft. The converter pump is therefore mechanically connected to the engine and turns at engine speed whenever the engine is operating.

The torque converter is supplied with oil under pressure to prevent cavitation and provide for circulation and cooling. This oil is the only means of transferring power to the wheels; there is no mechanical connection of any kind in a torque converter transmission.

In order to understand the function of a converter, let's follow the oil as it goes through its cycle.

In the torque converter the vanes are curved in order to get the desired amount of power from the pump and turbine. The pump blades are curved in an opposite

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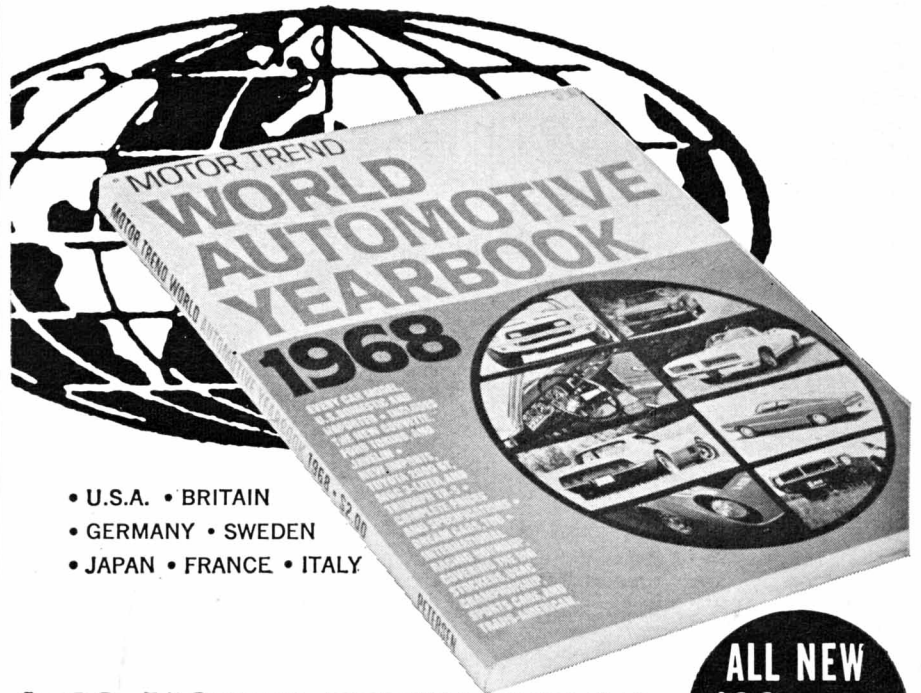
direction from the direction of rotation, which gives added acceleration to the oil as it leaves the pump rim (Fig. 1). The vanes in the turbine are also curved to absorb the required amount of energy from the oil as it passes through the turbine. To be able to do this the vanes are curved in a manner that causes the oil to be discharged from the center of the turbine in a direction opposite to rotation of the turbine (Fig. 2). As the oil leaves the turbine blades at the center it still has a lot of kinetic energy left. Due to the curvature of the turbine blades, it would exert this energy against the blades of the pump and hinder its operation unless some means were provided for turning the flow to assist the pump. This is accomplished by interposing a stator between the pump and turbine with vanes so curved that they will change the direction of the oil discharged from the turbine and cause it to flow in the same direction as the rotation of the pump. Now, instead of oil bucking the pump and interfering with it, the unexpended energy in the oil is actually helping the pump do its job (Fig. 3). The stator performs the same function in the hydraulic circuit as the fulcrum does in a lever system; thus it becomes a reactionary member assisting the function of the pump giving torque conversion. Through this assistance, it takes less engine power to drive the pump, the engine is able to deliver more power to the turbine, and torque multiplication of 2.5 to 1 can be obtained as power to drive the rear wheels.

As the rotational speed of the turbine increases, the direction of the oil flow from the turbine exit changes so that it exerts a force on the back of the stator vanes. This condition would cause turbulence resulting in increased friction and power loss. Therefore, the stator is mounted on a freewheeling clutch which locks in a direction opposite to that of the pump and turbine rotation. As the turbine speed approaches pump speed creating a "coupling condition," the stator freewheels and is carried along with the rotating oil mass. Once this coupling point is reached and the stator starts rotating, there is no longer any multiplication, strictly a fluid coupling.

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