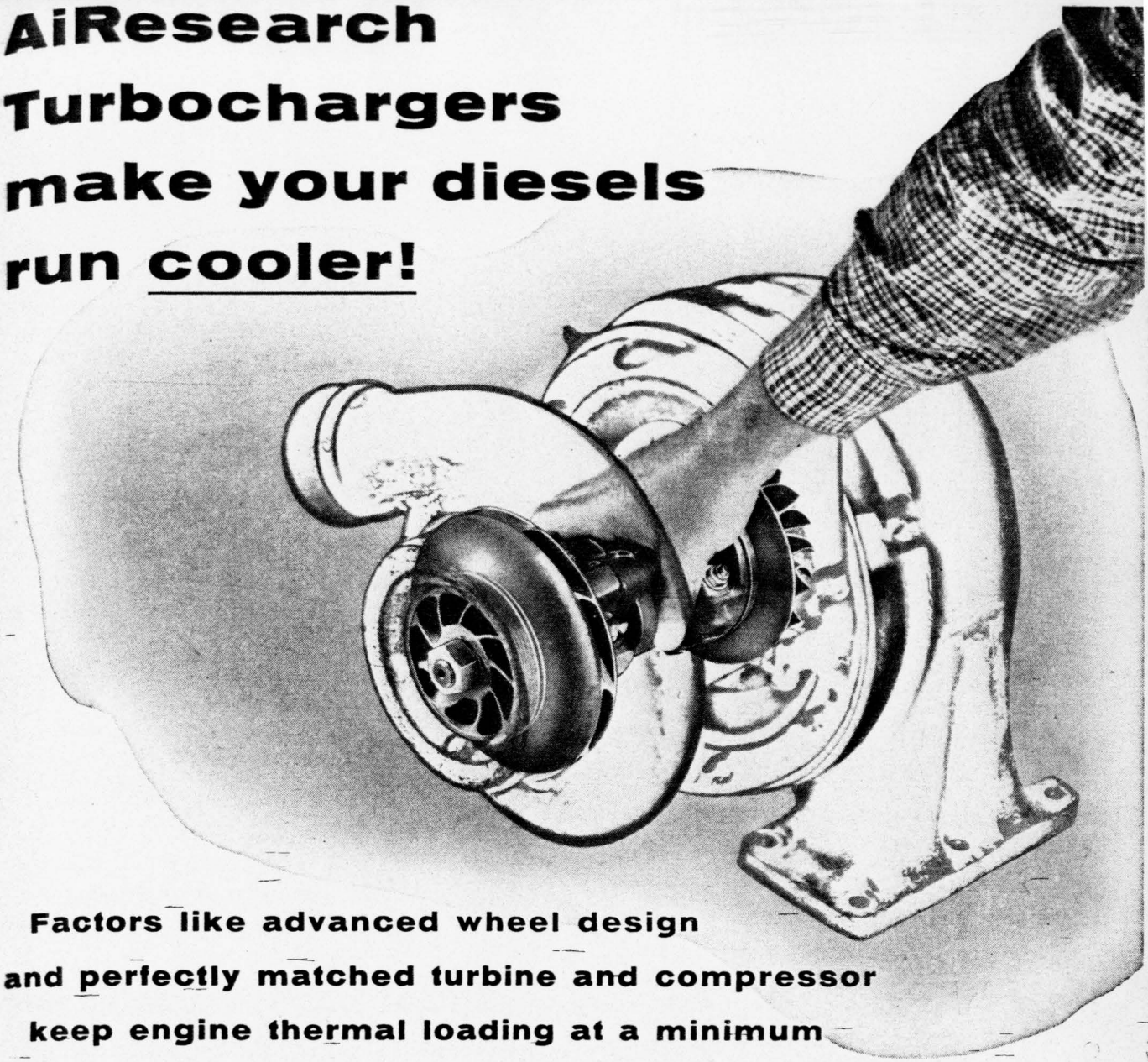
AiResearch Turbochargers make your diesels run cooler!



Factors like advanced wheel design and perfectly matched turbine and compressor keep engine thermal loading at a minimum

So effective is the AiResearch turbocharger that it provides power gains while actually lowering the heat level of the engine.

Ambient air is compressed with an efficiency as high as 82%, feeding a maximum weight of air into the cylinders at the lowest possible temperature.

Results: maximum power gain at minimum fuel cost; complete combustion with elimination of objectionable smoking; low engine thermal loading insuring long, trouble-free operation.

All AiResearch turbochargers are air cooled, placing no added burden on the diesel cooling system and requiring no complicated plumbing. The rotating assembly is removable as a unit, simplifying in-the-field maintenance. This advanced design evolved from the most extensive experience in the field of small turbomachinery in America.

Your inquiries are invited.

BASIC SPECIFICATIONS FOR AIRESEARCH TURBOCHARGERS

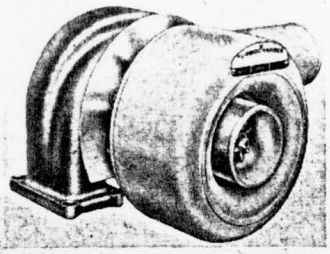
MODEL	F-51	C-60	A-60	E-100	B-100
Diameter — in. nom.	9	11.5	15.25	15.25	16
Length — in.	9	14.12	16.75	17.25	21.75
Weight — lb.	40	95	125	135	195
Output — lb/min. (Standard Conditions)	25-40	35-65	35-65	70-95	115-175

THE GARRETT CORPORATION

AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS



Schwitzer's new 4-in. air-cooled model turbocharger can have turbine and compressor inlet and outlet flanges set in any position for convenient mounting.

Field experience and continuous engineering development have resulted in Schwitzer's . . . .

New Turbocharger Models

TURBOCHARGING is a cheap way to get power. Investment cost per horsepower added by a turbocharger is about ¼ to 1/3 the cost per horsepower of the basic engine. Secondly, turbocharged engines deliver more horsepower per fuel dollar than unsupercharged engines. Small wonder then, that boosting output by turbocharging both field engines and new ones is so attractive.

Actually the savings don't end here—especially for new equipment. Vehicles cost less since a lighter chassis can be used. Greater pay loads at higher speeds are possible on trucks and earthmoving equipment.

Compact, light-weight turbochargers such as those made by the Schwitzer Corp., among others, permit simplified mounting, usually directly on the exhaust manifold within existing space limitations. This organization, for example, makes many models based on four sizes of turbochargers which are adaptable, in single or multiple units, to engines from 50 to 1400 hp.

Turbine and compressor inlet and outlet flanges on these units may be set to any one of several positions permitting mounting in the most compact manner. Unlike mechanically-driven superchargers, no costly gear trains, couplings and special mountings are required.

The charging pressure of these units is from 2-3 atmospheres and the weights and air capacities of the four wheel diameters are as follows:

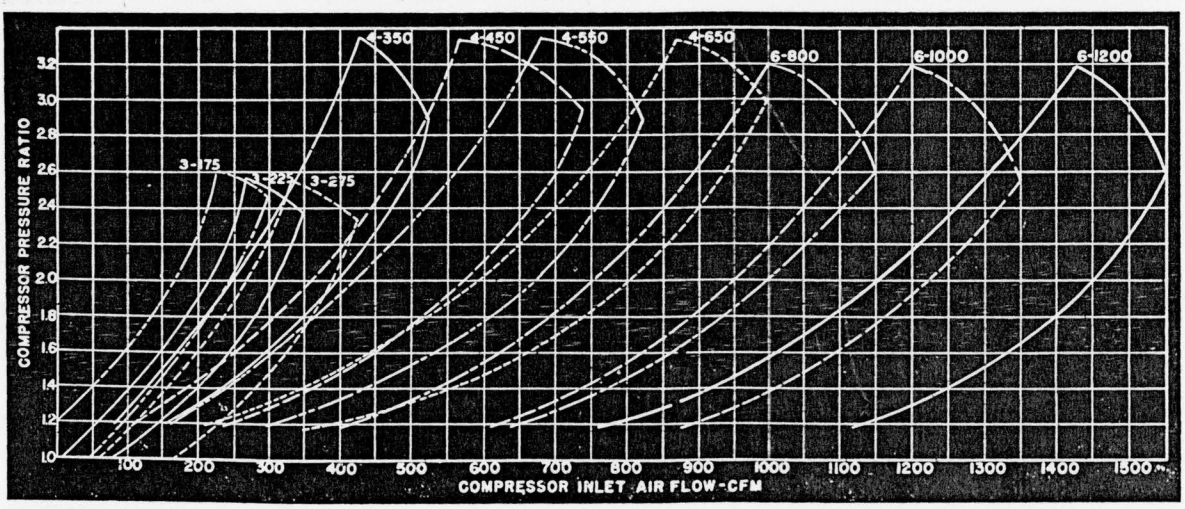
Turbine Wheel Size	*Approx. Air Delivery*	*Weight*
3-in.	150-300 cu ft	20 lb
4-in.	300-500 cu ft	28 lb
5-in.	250-500 cu ft	40 lb
6-in.	600-1200 cu ft	55 lb

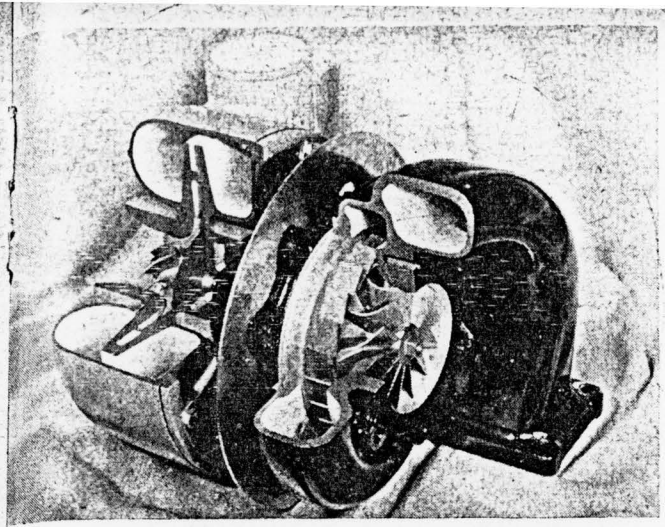
The water-cooled 5-in. unit is Schwitzer's old work horse. But after years of reliable service it is still going strong. The 3-, 4-, and 6-in. turbos are new units. These air-cooled units round out Schwitzer's line of turbochargers. The air-cooled design eliminates all cooling water connections from the engine and gives greater simplicity, a most desirable feature. The only piping to the engine now consists of two oil lines for lubrication of the bearing and shaft assembly.

These turbochargers can be adapted to a wide variety of engines without change in basic design. Interchangeable stainless steel turbine nozzle rings are available to match operating conditions of each specific application.

Divided housings and nozzles are designed so that the turbine can operate as a blow-down or a steady-flow type. Generally, better results are obtained with the blow-down principle. This involves dividing the exhaust manifold so that there is no overlap of the cylinder exhaust processes discharging into any one branch of the manifold. The divided manifold and turbine housing makes better use of the exhaust gas energy. Lower average exhaust manifold pressures and better cylinder scavenging result.

Curves show compressor inlet air flow cfm at different pressure ratios for 3-, 4-, and 6-in. model air-cooled turbos.





Radiation shield between turbocharger at right and compressor at left helps to keep heat from air-cooled turbo away from air in compressor.

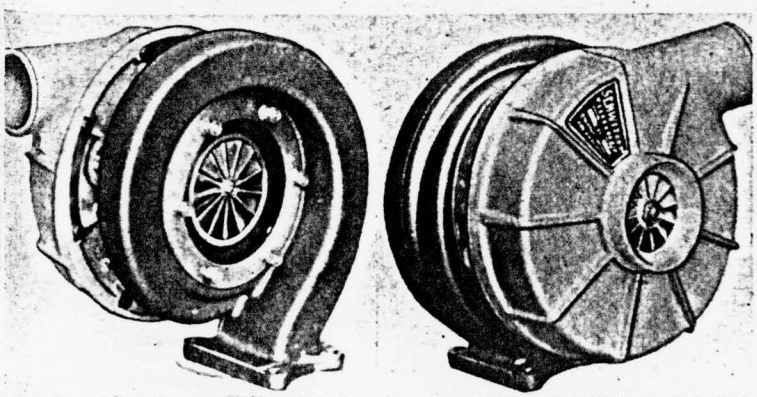
Efficiences are constantly being raised and turbine speeds are being increased beyond those believed practical only a short time ago. Also, significant results are being obtained with after coolers which reduce air temperature leaving the turbocharger and permit better performance over a wider range. Use of the after cooler is encouraged wherever possible.

The turbine housing is a Ni-Resist casting capable of withstanding high temperatures without scaling or stress failures. The bearing housing is grey cast iron while the compressor housing and cover are aluminum. Present recommended exhaust gas temperature limit is 1500°F.

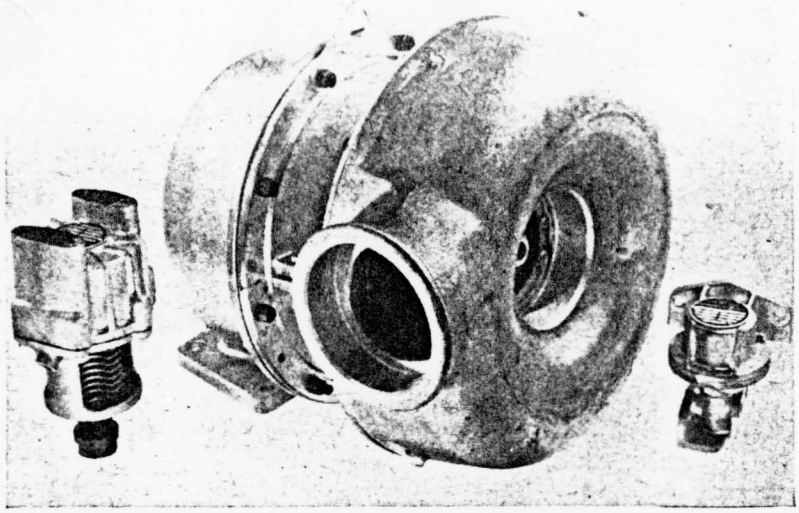
The bearing is of the sleeve-type, lubricated by engine oil. A double piston ring-type oil seal at each end of the shaft is pressurized by an air bleed from the compressor to seal leakage. End thrust at the compressor end of the shaft is relatively light. The compressor and turbine wheels are designed so that the thrust between them is balanced.

Design configuration of the cobalt-base alloy turbine wheel combined with the aluminum compressor wheel results in low inertia and low stress. Only a fraction of a second is required for the turbo to reach approximate full speed when a load is suddenly applied to the engines.

Advantages incorporated in their light weight result in ease of installation and quick acceleration. These units are designed for long reliable service and require only the normal maintenance given other parts of the engine.



Water connections for Schwitzer's older model 5-in. water-cooled turbocharger can be seen between the turbo and compressor on either view of this unit.



AiResearch turbocharger is shown with units making up pressure-ratio control system. Exhaust by-pass valve is at left of turbocharger. Pressure-ratio sensor is seen at right of turbocharger.

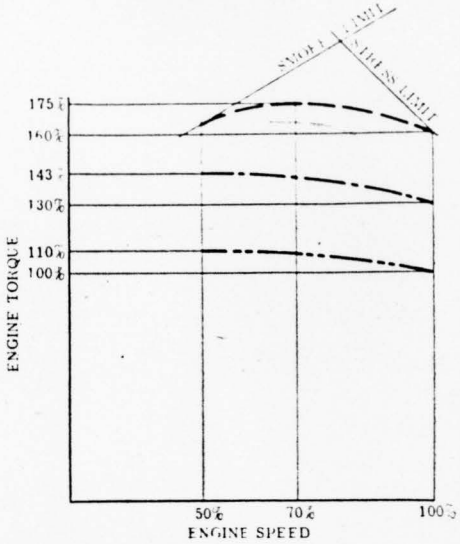


Fig 1. Typical torque curves for (bottom) naturally-aspirated engine; (center) mechanically supercharged engine and (top) conventionally turbocharged engine. Shape of top curve is a compromise governed by operating limits, here shown as the typical smoke and stress limit lines.

Controlled Turbocharging Improves Performance

Garrett Corporation's AiResearch Industrial Division has developed and put into production components of a new pressure boost control system for their entire turbocharger line. Faster turbo acceleration and improved engine torque characteristics are major results. Here's how it was done and what it means in performance.

TODAY's turbocharged engine offers high output and efficiency. Naturally-aspirated engines offer flexibility. Combine these characteristics and you'd have the current ultimate in diesel working power.

This combination of power advantages has now become a practical reality with a turbocharging system that is boost pressure controlled. Components of the system are now in production at The Garrett Corporation's AiResearch Industrial Division, Los Angeles. Units have already acquired extensive operational experience and are standard production items on some Caterpillar Tractor Company equipment.

Developed for use with the entire family of AiResearch turbochargers, the boost pressure control system provides two basic types of improvement over previous turbocharging methods. Improvements are accomplished by controlling speed and acceleration of the turbocharger.

First, improved turbo acceleration provides better engine response or snap and reduces exhaust smoke when under heavy load. Second, improved torque characteristics provide greater peak horsepower, greater engine lugging ability for heavy work with minimum gear shifts, together with reduced engine stress levels.

Why "Controlled Turbocharging"?

We can best understand the gains realized from this new development called "controlled turbocharging" by briefly tracing progress of the supercharged diesel.

Power developed by the naturally-aspirated diesel (lowest torque curve on Fig. 1) is limited by the amount of air it can breathe for combustion. This type of engine develops increased torque with decrease in engine speed under load. It is this "torque rise" that gives the diesel its lugging power, so valuable for heavy work.

When diesels were supercharged by mechanically-driven blowers (middle curve on Fig. 1) more air was made available for combustion and thus more power was developed. Since this type of supercharger is a positive pump like the engine, shape of the torque curve was unchanged. Crankshaft power, however, was required to drive the blower and this fact increased fuel consumption and limited available engine power.

The modern turbocharged diesel utilizes a more efficient supercharging unit driven with exhaust gas energy which was formerly wasted. This device made possible both increased power and decreased fuel consumption. However, under variable speed and load conditions and when supercharged with conventional, free-floating (uncontrolled) turbochargers, engines face two operating limits which influence their behavior.

At low rpm, engine torque is limited by the decreas-

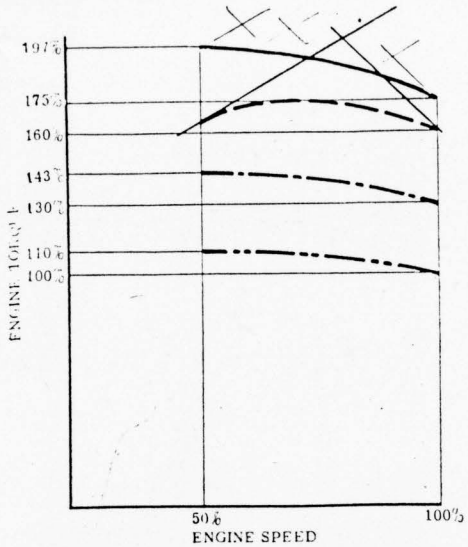


Fig 2. Same three torque curves with addition of a torque curve (top) made possible by controlled turbocharging. By control of the turbocharger speed, smoke and stress limitations are removed. The most desirable turbocharger speed is maintained over a wide range of engine speeds.

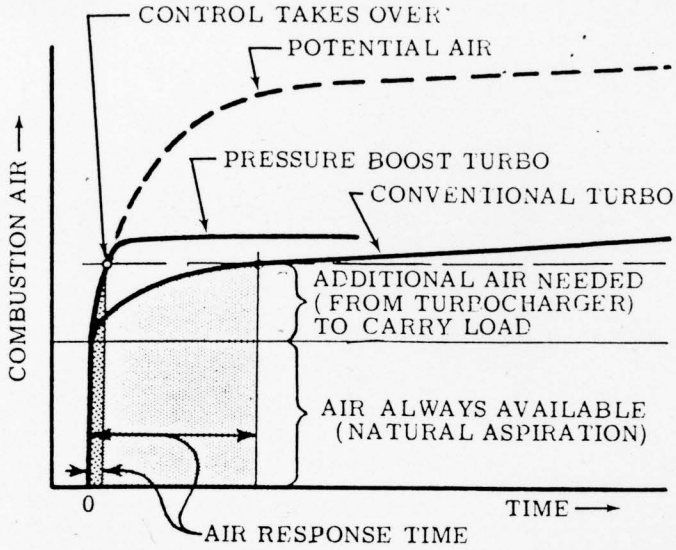


Fig 3. With pressure boost control, the turbo's nozzle ring can be selected for quick response and maximum torque at the lowest engine speed desired. Turbo speed limitation (stress limit) is no longer a factor in nozzle ring selection as excess exhaust gas, tending to drive the turbine faster, is bypassed. This action is shown by the line labeled "Pressure Boost Turbo".

ing combustion air available as turbocharger speed drops. This is the smoke limit example shown at the top of Fig. 1. At high engine speeds, torque is limited by the stress limit line shown. This line, a typical limit for a well-matched turbocharger and engine, represents either turbocharger speed stress or engine pressure stress. Other limit lines may be selected.

Torque curves of turbocharged engines have been worked out by compromise under these two limits. Conventional turbocharger application reduces relative lugging ability of the engine by increasing the speed at which maximum engine torque is obtained. This is also shown in Fig. 1.

The boost pressure controlled turbocharger removes these limitations on the turbocharged engine. Action of the control is to maintain the most desirable turbocharger speed over a wide range of engine speeds, as shown in Fig. 2. This removes need for a compromise of torque curve.

With this control, the engine operator can have his cake in the form of peak power and eat it as well in the form of engine lugging ability surpassing that of the naturally-aspirated engine. Thus, the controlled turbocharger combines high power and efficiency peak of the turbocharged engine with torque flexibility of the naturally-aspirated type.

How It Works

The AiResearch controlled turbocharger system operates by a simple principle. The turbocharger is matched to the engine with a turbine nozzle of a precisely selected size to drive the turbo unit fast enough for quick response and maximum torque at the lowest engine speed desired. This directly results in optimized torque characteristics and greatly improved response.

As engine speed increases, the boost pressure control system acts to maintain desired turbocharger speed by conducting excess exhaust gas around, rather than through, the turbine.

Rapid turbocharger response to engine load changes has become increasingly important as power levels increase. The boost pressure control system provides the highest response rates yet achieved, as shown in Fig. 3. In response to an increase in engine load, a controlled turbocharger, heading toward a high potential equilibrium speed, accelerates much more rapidly than an uncontrolled turbocharger.

As the desired turbocharger equilibrium speed is reached the pressure control takes over and maintains this speed. Thus, the time required to develop the desired amount of combustion air is greatly decreased.

Some Results

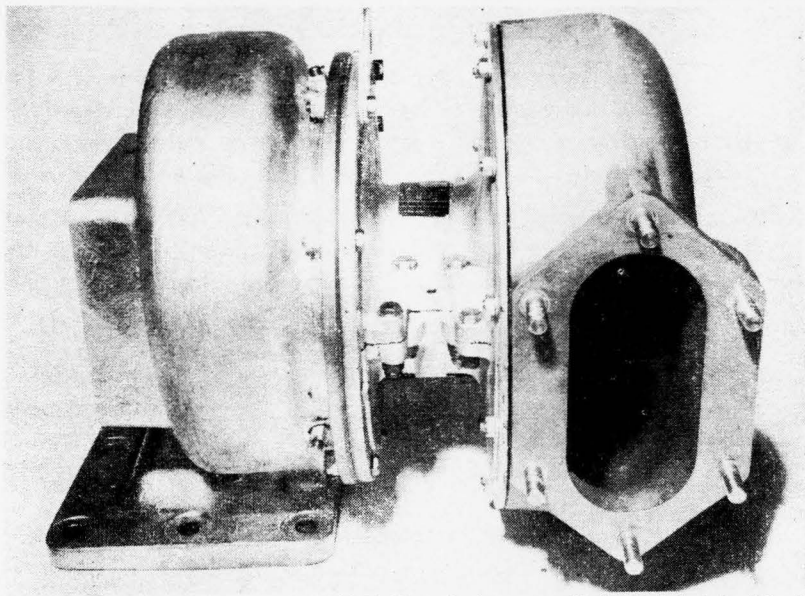
Caterpillar DW 20 and DW21 wheel tractors are equipped with the AiResearch boost pressure controlled turbocharging system. The system provides equal rimpull for these tractors at up to 10% higher travel speeds. In addition to more than double torque rise, improved lugging and acceleration characteristics, other benefits experienced include decreased specific fuel consumption, and reduced smoking.

Extensive tests with retrofitted installations on over-the-road truck operations have been conducted by AiResearch. Results show an average 5% increase in fuel mileage over normally-turbocharged diesels. This margin is 10% over non-turbocharged models and in individual cases as high as 21%.

It appears that this highly refined method of turbocharging will provide a substantial boon to operators of diesel engine equipment, significantly increasing the already notable accomplishments in the area of turbocharged diesel working power.

Union Pacific Turbocharging Program

Three year test proves advantages of multiple turbocharger installations



Four of these AirResearch model T3006-01 turbochargers will be installed in 25 of Union Pacific's GP-9 diesel locomotives.

DURING the past three years the Union Pacific Railroad has been conducting extensive tests with three prototype diesel locomotive units in freight service equipped with multiple turbochargers. This turbocharging system was developed by the AirResearch Industrial Division of the Garrett Corporation. It would now appear that these tests have proven successful.

AirResearch has announced a contract to equip 25 Union Pacific GP-9 diesel locomotives each with four T3006-01 turbochargers. The turbocharged engines are rated at more than 2000 hp. They are able to maintain this output at the highest operating altitudes of the Union Pacific's track system.

In addition to this advantage, specific fuel consumption has been reduced and combustion improved to a degree which will permit smoke-free burning of lower-grade fuels.

These converted units will operate mainly in Union Pacific's high altitude regions where the advantages of the turbocharging system in maintaining full power are most pronounced.

It has also been announced by Union Pacific that an order has been placed by the Railroad for 75 new turbocharged diesel-electric locomotives from the Electro-Motive Division of General Motors Corporation. Total cost of the purchase will run over $19 million.

U.P. points out that the chief advantage of these turbocharged units will be the economy resulting from use of low-grade fuel. The new units, which will generate 2400-hp, will burn a residual-type fuel instead of the more expensive diesel fuel now in use on the line.

MULTIPLE-TURBOCHARGING UNION PACIFIC DIESELS

AIRESEARCH

is now turbocharging Union Pacific's heavy duty, 2-cycle GP9 diesel with four T3006-01 turbochargers. This application of multiple turbocharger systems on this type of locomotive has already accumulated more than 1.5 million turbocharged miles. Its important advantages are:

- Smaller turbochargers easily installed for retrofit
- Substantially increased engine horsepower at all altitudes
- Lower engine fuel consumption
- Higher air flow through the engine, allowing the use of heavier grade, cheaper fuel
- Cooler engine exhaust
- Engine exhaust free of smoke and sparks
- Turbochargers easier and less costly to maintain

AiResearch is a world leader in the development and production of air-cooled turbochargers and turbocharger controls for all major diesel engine applications. More than 35,000 AiResearch turbochargers now deliver close to 9 million turbocharged horsepower. Your inquiries are invited.

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