lem—and these new ones take very heavy equipment, such as skin mills, spar mills, and stretch presses that we didn't even have in World War II. And all that equipment takes money. The largest hydropress in our aircraft industry — an 8,000 ton machine to form tougher metals—is being bedded down in our plant now. It cost $750,000 and it's just one of the hundreds upon hundreds of items we've had to buy to build these new airplanes."

Of course, Mr. Gross was referring primarily to modern airframes, because that is his business. Just about the same arguments apply to the new art of mass producing jet engines. Their builders have had to start from scratch and design new tools and conceive new methods. For instance, the production of gas turbine blades for axial flow engines is the most difficult and slowest phase in the construction of jet engines in great numbers. Engine manufacturing firms all over the world are burning the candle at both ends tyring to work out ways and means of turning out these precision blades in great numbers with great speed.

Canadian Solution: Avro Canada and Modern Tool Works Ltd., Toronto, put their heads together on this problem, and came up with the 14 Spindle Duplicator machine (Fig. 1), a number of which are now producing blades for Orendas. Indications are that the Duplicator will cut blade manufacturing time to a quarter. As its name implies, the basic principle of this machine is that of duplicating or tracing the contours of a master blade form simultaneously on to 14 work pieces. This is done through a hydraulic tracer system. The head, carrying the tracer stylus and 14 spindles, pivots on bearings at either end through the action of a hydraulic cylinder. The spindles themselves are driven from a common shift by 90 degrees skew bevel gears and each spindle can be removed for servicing.

The master blade and blade blanks are held by a special fixture on the work table which moves on precision bearings under the spindle head. As the spindle head pivots downwards towards the work, the stylus engages the master blade and while the spindle head continues its arc of travel the work table is actuated to and from the end mills under the exacting control of the hydraulic tracer, thus generating the desired form.

After each cutting stroke the spindle head raises clear of the work and the table automatically indexes longitudinally at the pre-selected feed rate in readiness for the next cutting stroke. An electro hydraulic control system makes the complete machining cycle automatic. The accuracy and fine finish produced by this machine reduces further finishing operations to a minimum.

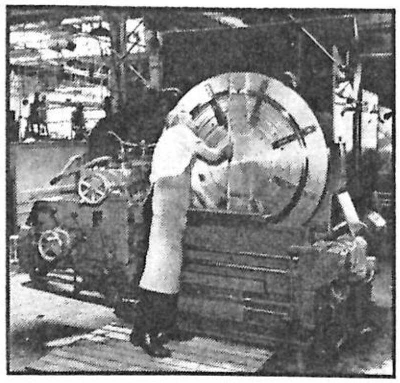

FIG. FOUR

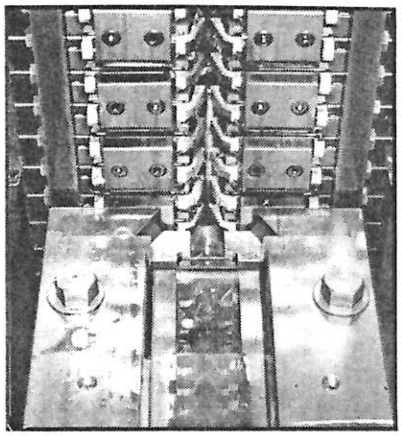

FIG. FIVE

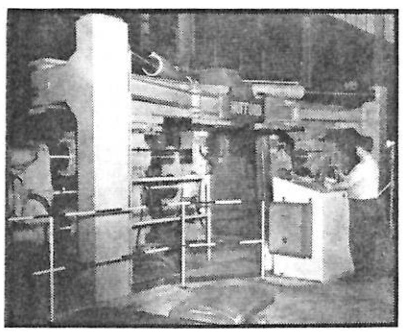

FIG. SIX

A RELATED problem is the broaching of the fir tree roots of turbine blades. Pratt & Whitney Aircraft has taken several steps forward in broaching practice in revising the procedure for broaching these roots. One of these steps is in forming both sides of the blade-root at one pass, another is in the introduction of individual teeth in the broach, rather than using multi-tooth sections. Both serve to increase the rate of production and at the same time increase the life of the cutting tools.

Previous method of machining these roots was to mill the "limbs" on one side of the "tree", then index the part and mill the limbs on the other side, using the same cutter, a method that was neither accurate nor fast enough. Now Pratt & Whitney uses a broaching-and-grinding operation that gives the necessary accuracy and is also cheaper.

Broaching of both sides of the root at one pass is now carried out on a Lapointe 15-ton 90-inch vertical broach (Fig. 5). Setup differs from the usual broaching practice in that each individual tooth in the body is separate rather than having a number of teeth in one section.

Because of the character of the metal used for these particular blades, the roots are broached .005 inch oversize, the remaining stock being removed on a surface grinder, whose wheel is dressed with a Diaform Dresser, at a 10-to-1 ratio, or on a two-wheel Excello or J & L grinder designed for this operation.

Large Rings: Again at Pratt & Whitney, a difficult problem was posed by the machining of thin-walled stainless steel rings of very large diameter for turbojet nozzle vane rings, blade shrouds, and tailpipes. The diameters to be handled — running up to 48 inches — required a large lathe, capable of a 60-inch swing, a size which is normally built only for heavy duty work. But the jet engine rings are shallow and of thin wall-section and the cuts to be made are relatively light and precise, and so the large horsepower of the conventional heavy duty lathe was not actually needed. What was really wanted was the range of a large carwheel lathe with the sensitivity of a tool-room lathe.

The result was an entirely new lathe by Lodge & Shipley: a right-angle chucking lathe with a T-shaped bed (Fig. 4). That is, the section on which the carriage is mounted is at right angles to the center line of the lathe. The carriage a cross-slide which can move either parallel to the center line or at any angle to it. Hence, the new lathe can handle facing, straight or taper turning, or boring, and can be purchased with a contouring attachment.

This new Lodge & Shipley lathe uses