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# METHOD OF MOUNTING CYLINDER BLOCKS OF IN-LINE ENGINES ON CUE CRANKCASES

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# METHOD OF MOUNTING CYLINDER BLOCKS OF IN-LINE ENGINES ON CUE CRANKCASES

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## SUMMARY

This report describes the installation of six-cylinder blocks from two in-line aircraft engines on CUE crankcases. The adaptation permits the separate operation of any cylinder as part of a single-cylinder test engine. The overhead camshaft is driven from one of the half-speed accessory drive shafts of the CUE crankcase through a chain drive. All the inlet and the exhaust valves of the multicylinder block are left in operation. The cylinder blocks and the valve mechanisms are unaltered and after use on the CUE crankcase they can be returned to multicylinder service.


## INTRODUCTION

The difficulty of reproducing in single-cylinder construction the coolant flow, the heat flow, and the stress conditions that exist in the multicylinder block of in-line, liquid-cooled engines makes it of appreciable advantage to test any cylinder from a multicylinder block on a single-cylinder crankcase without resorting to a simulated single-cylinder construction. The high rate of coolant flow passing through cylinder blocks normally results in a small temperature gradient from one end of the cylinder block to the other or between cylinders. This temperature gradient is somewhat less than that of the single-cylinder construction.

A further advantage of using multicylinder-engine blocks for single-cylinder tests lies in the greater availability of standard engine parts.

A single-cylinder CUE crankcase has been set up at the Aircraft Engine Research Laboratory for high-output fuel tests with the Allison V-1710 cylinder block. A CUE crankcase has been set up upon which a Rolls Royce V-1650 cylinder block is mounted. This report has been prepared as a result of requests for information concerning details of these installations. Copies of the shop drawings used for these installations can be obtained upon request from the NACA.

These projects were undertaken by the staff of the Fuels and Lubricants Division of the Aircraft Engine Research Laboratory of the NACA at Cleveland, Ohio, during 1943.

## MODIFICATIONS TO THE CUE CRANKCASE

The Waukesha CUE crankcases used for the installation of the Allison and the Rolls Royce cylinder blocks are of the standard type described in reference 1. In both installations the cylinder blocks are mounted with the cylinder-barrel skirts above the top plate of the engine. The installations require somewhat longer connecting rods than are standard for these respective aircraft engines. The CUE connecting rods for the Allison and the Rolls Royce blocks have a center-to-center length of $13\frac{15}{16}$ and $13\frac{3}{4}$ inches, respectively.

The position of the cylinder blocks necessitates machining a channel in the camshaft supporting plates as shown in figure 1. Furthermore, it is necessary to reduce the diameter of the flywheel to 18 inches to avoid interference when the cylinder block extends to the rear of the crankcase. Additional plates are installed on the flywheel hub to partly offset the loss of inertia caused by reducing the flywheel diameter.

## ADAPTATION OF ALLISON BLOCK TO THE CUE CRANKCASE

The Allison cylinder block is installed on the CUE crankcase complete with camshaft, camshaft cover, and all valves. Modifications to the block are not required. The block is attached to the engine by mounting it on a long heavy plate shown on top of the crankcase in figure 2. This mounting plate is bolted to the top of the crankcase. The cylinder block is bolted to this plate with any chosen cylinder in the firing position. The spacing between cylinder 3 and cylinder 4 on the Allison block is greater than the spacing between the other cylinders, which prevents a simple construction with six round holes in the mounting plate. Instead, one round hole is provided to accommodate the firing cylinder and the other five cylinder barrels extend into the irregularly shaped openings shown in figure 3. The spacing of the block hold-down studs also varies for different cylinders. The adjustment for varying stud spacing around the firing cylinder is accomplished by having the studs screw into four nuts that can be moved along inverted T-slots in the mounting plate. No adjustment is provided for the studs at the other cylinders and only when cylinder 6 is fired can all the block hold-down studs be used. When other cylinders are fired, a few pairs of studs along the block fit into the nonadjustable stud holes in the mounting plate and keep the block in position.

A flat steel plate 1/4 inch thick is inserted between the lower surface of the coolant jacket and the upper surface of the mounting plate in order that the edges of the long holes in the mounting plate, which are shown in figure 3, will not unevenly or excessively wear the bottom of the aluminum coolant jacket of the block. When different cylinders are moved into firing position, the 1/4-inch plate is moved along with the block. A standard Allison copper gasket is used between the coolant jacket and the 1/4-inch plate to provide a soft bearing surface for the aluminum coolant jacket. The long overhang of the plate at the front and at the rear of the engine is supported by two $1\frac{1}{2}$-inch angle-iron braces that bolt to the lower front of the crankcase or bed plate, as shown in figure 2.

The Allison cylinder block requires a coolant flow of 120 gallons per minute at an engine speed of 3000 rpm. This flow is supplied by a centrifugal pump driven by a 5-horsepower motor. The rate of flow is measured by an orifice and a manometer.

The separate intake and exhaust ports with similar bolt spacing of each cylinder of an Allison block makes it possible to use the same intake and exhaust pipe connections when changing from one cylinder to another.

## ADAPTATION OF ROLLS ROYCE BLOCK TO CUE CRANKCASE

The installation of a Rolls Royce block of six cylinders is patterned after the Allison setup with a few changes necessitated by the difference in blocks. Because the Rolls Royce block has equally spaced cylinders, the plate corresponding to the one shown in figure 3 has a round hole for each cylinder. The cylinder hold-down studs, however, do not have equal spacing and a sliding nut is used in the inverted T-slots for the studs around the firing cylinder. One principal difference between the Rolls Royce and the Allison adaptations is the method of sealing the shaft that extends through the camshaft cover. The Rolls Royce block has no opening in the end of the valve compartment, which makes it necessary to cut a hole in the valve-gear cover as shown in figure 4.

The Rolls Royce block has separate exhaust ports and the exhaust pipe can be bolted onto whatever cylinder is in firing position. All cylinders, however, have a common intake port, requiring separating baffles in the intake port between each two adjacent cylinders, as shown in figure 5.

## CAMSHAFT-DRIVE MECHANISM

The camshaft is driven from one of the engine half-speed accessory drive shafts, as shown in figure 2. In the design of this drive, consideration was given to the use of bevel gears and to the use of sprockets and chain. The chain drive was chosen only because of the facility of construction. The camshaft and the engine accessory drive shaft are each coupled to the chain drive through automobile drive shafts comprising two universal couplings with a splined joint, as shown in figure 2. This assembly allows for both radial and axial misalinement.

The upper drive shaft is connected to the camshaft through the combination adapter and flywheel shown in figures 2 and 6. This flywheel was found necessary for smoothing out the torsional vibrations of the camshaft. The circumference of this flywheel is graduated for use in timing the valves.

The method of sealing the camshaft drive at the cylinder blocks against oil leakage is shown in figures 4 and 6 for the Rolls Royce and the Allison, respectively.

The chain mechanism is enclosed in a box that is bolted to the end of the plate on which the cylinder block is mounted. The chain box has identical upper and lower sprockets mounted on shafts and ball bearings. The chain is a double strand, 5/8-inch pitch, roller type. Slack is eliminated from the chain by an idler sprocket located on the top side of the chain box approximately halfway between the main sprockets. The chain box is supplied with oil from a sight-feed drip valve on top of the box. Excess oil is carried off through a drain so located in the bottom of the box that the chain always dips into oil.

The camshaft timing is adjusted through the splined coupling and the chain and the sprocket. The splined coupling has 16 splines and each of the sprockets has 21 teeth. The timing is advanced $67.5^{\circ}$ when the splined shaft is advanced three splines; whereas the timing is retarded $68.6^{\circ}$ when the sprocket timing is retarded four teeth, thus producing a net retardation in camshaft timing of $1.1^{\circ}$.

During engine operation all the valves in the block function normally and receive a normal amount of oil from the camshaft. This fact causes small amounts of oil to run down the inside of the cylinders that are not firing. A drip pan is placed under each of the long holes in the plate to catch the leaking oil.

## OPERATION

The accuracy of the valve timing is checked during operation by observing the timing scale on the camshaft flywheel with a stroboscope. Variation in camshaft speed and twist in the drive system, which might be caused by flexibility in the drive mechanism, has been found to be negligible.

Satisfactory operation of the Allison block CUE installation has been obtained over a period of extensive testing, most of which was done at 3000 rpm. Tests have been conducted with indicated mean effective pressures up to 422 pounds per square inch.

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## REFERENCE

1. Pope, A. W., Jr.: The C.U.E. Cooperative Universal Engine for Aviation Single-Cylinder Research. SAE Jour., vol. 48, no. 1, Jan. 1941, pp. 33-40.

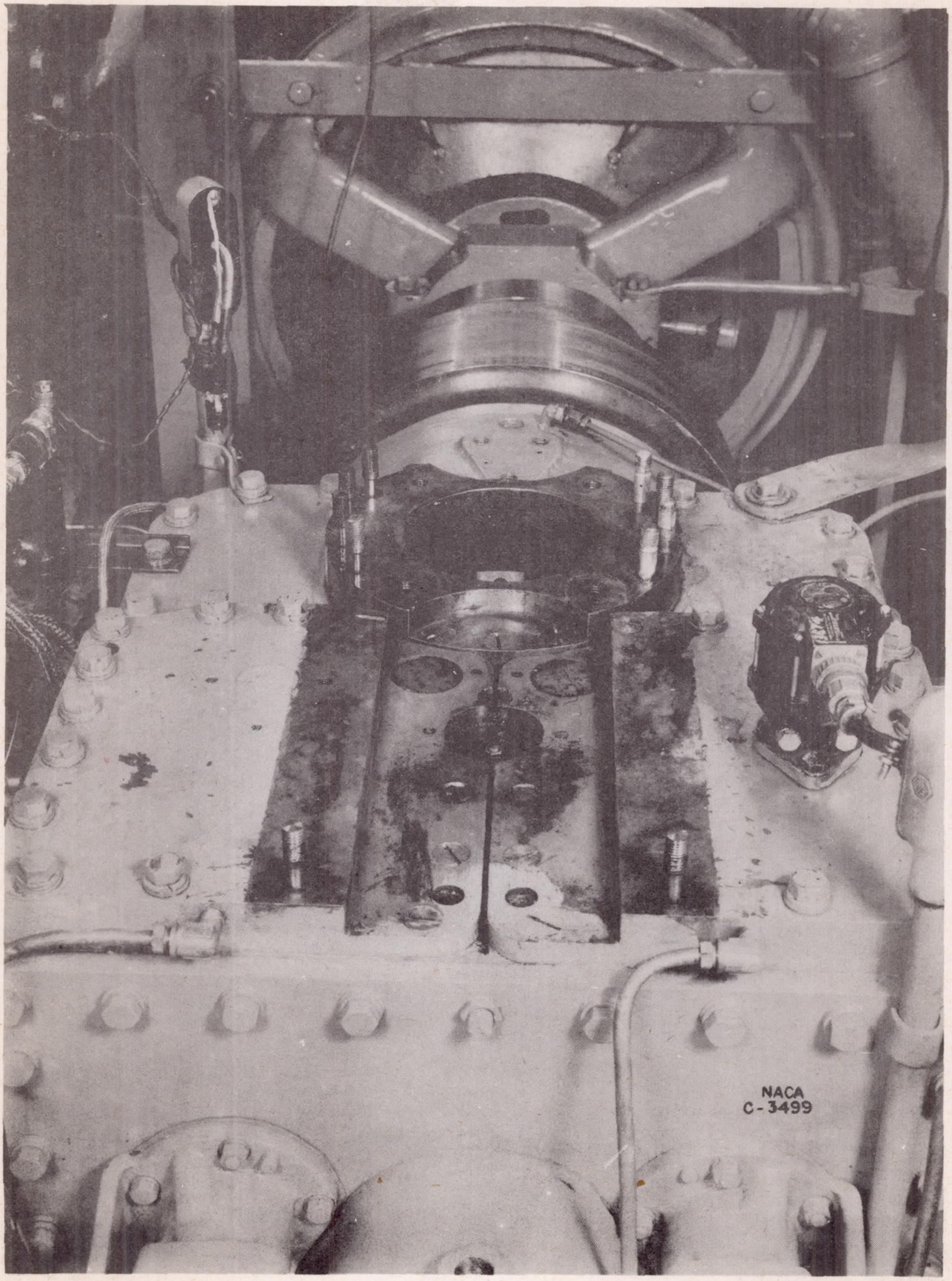


Figure 1. - CUE crankcase showing alterations to top plate.

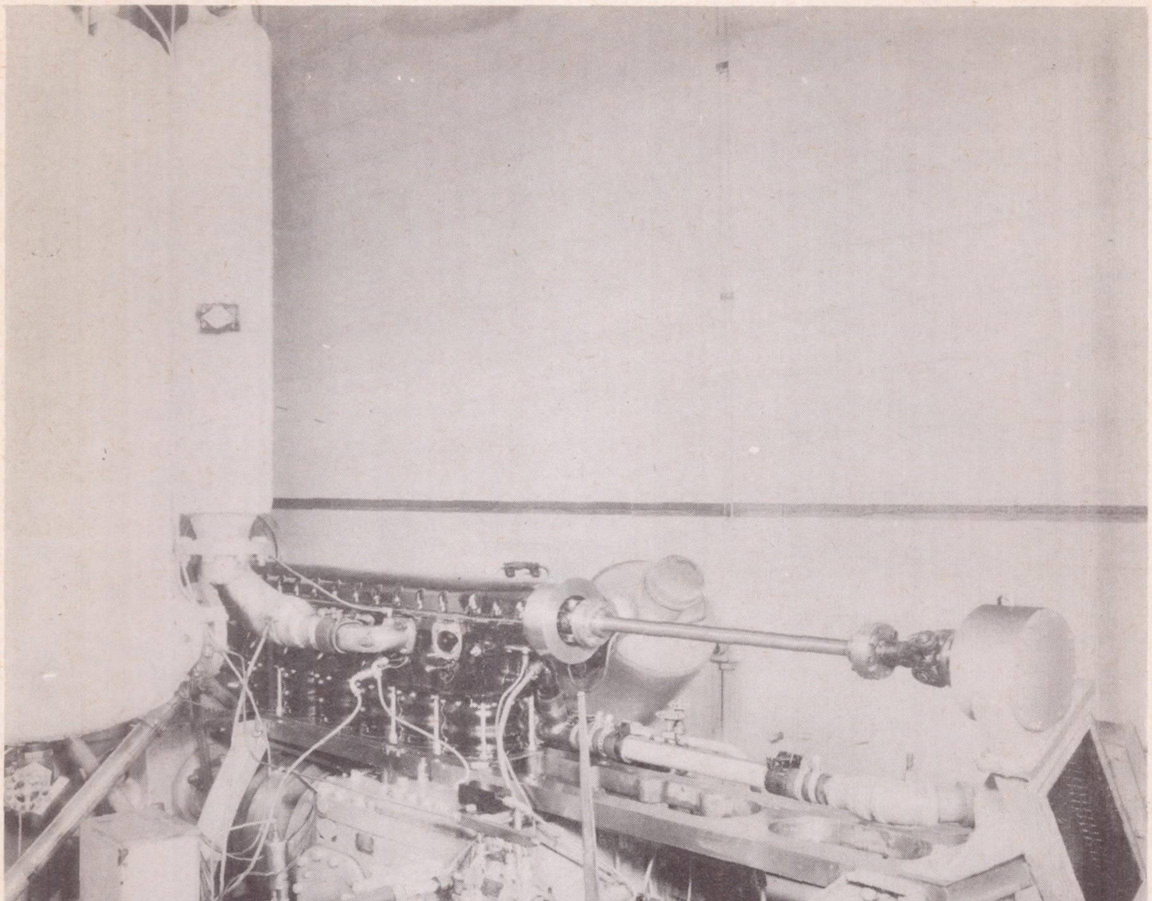


Figure 2. - CUE crankcase with Allison V-1710 block.

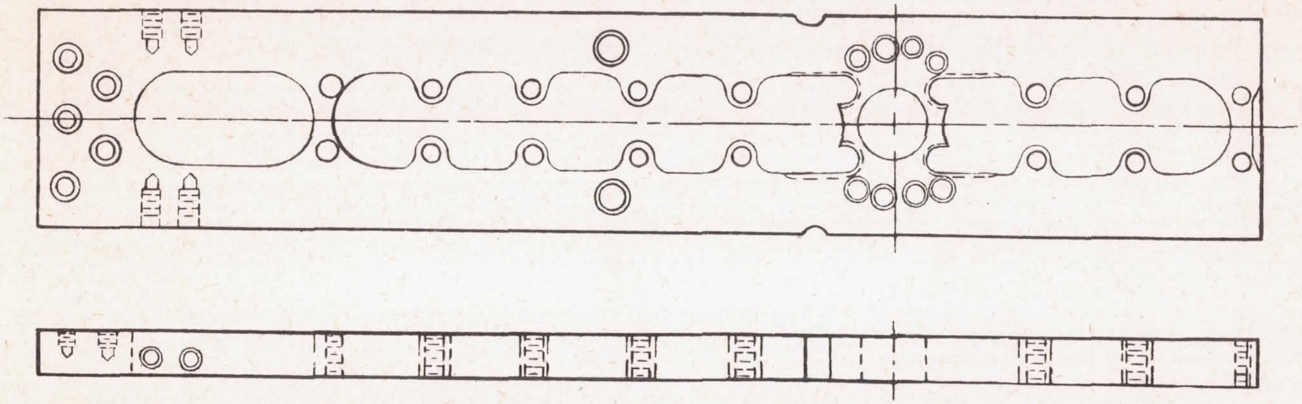

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*Figure 3. - Mounting plate for Allison V-1710 block.*

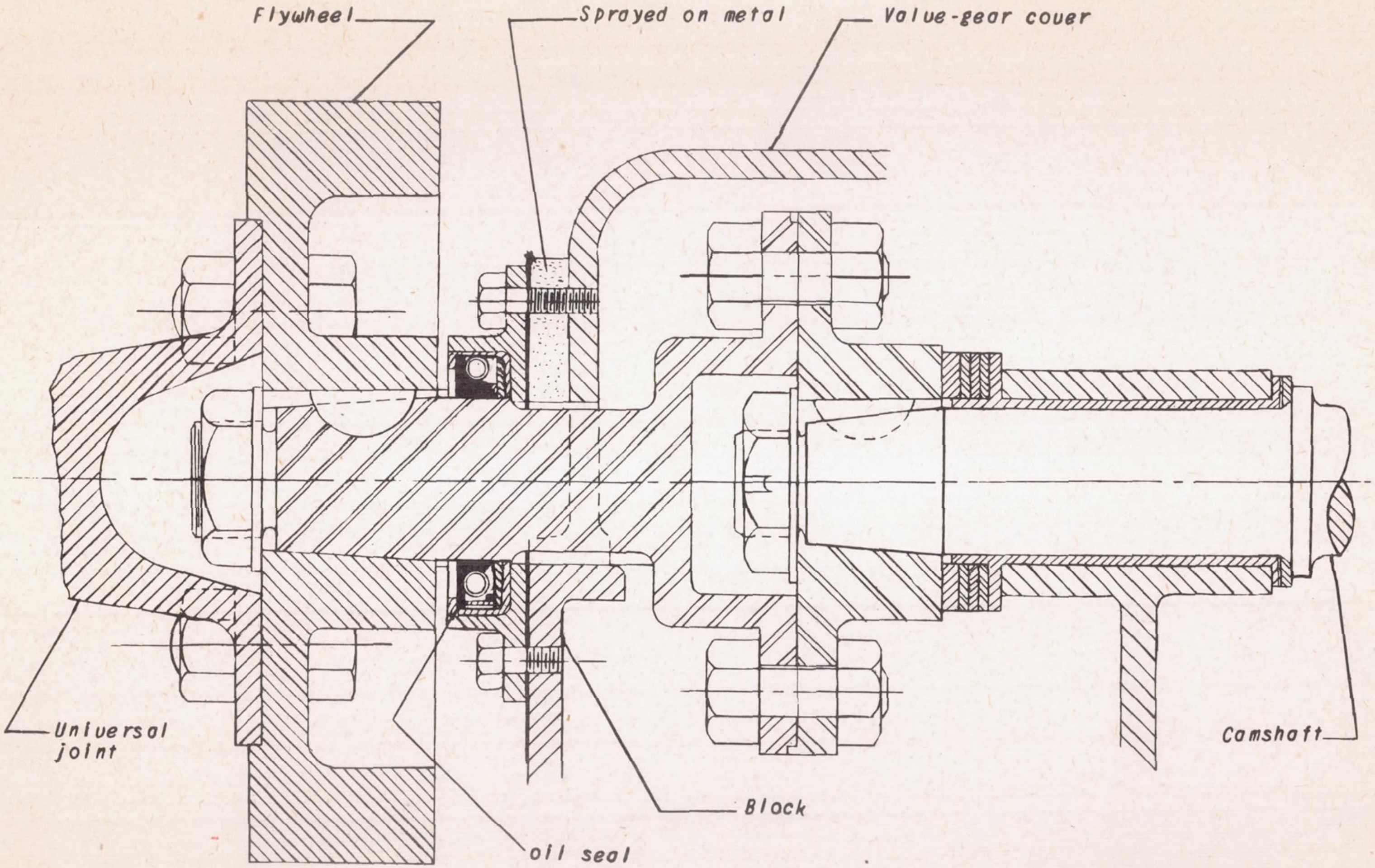


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Figure 4. - Camshaft oil seal for Rolls Royce V-1650 block.

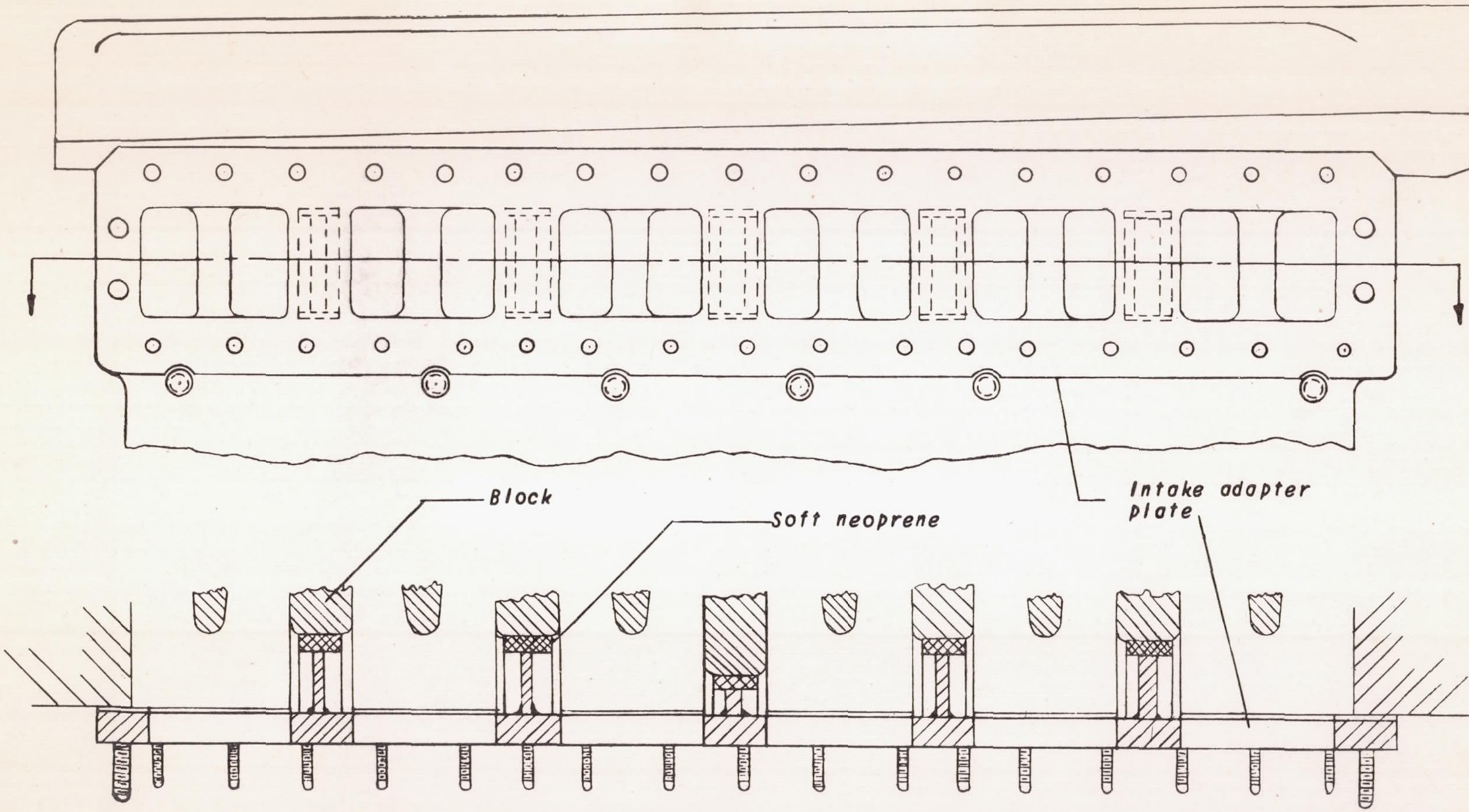


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Figure 5. - Intake baffles for Rolls Royce V-1650 block.

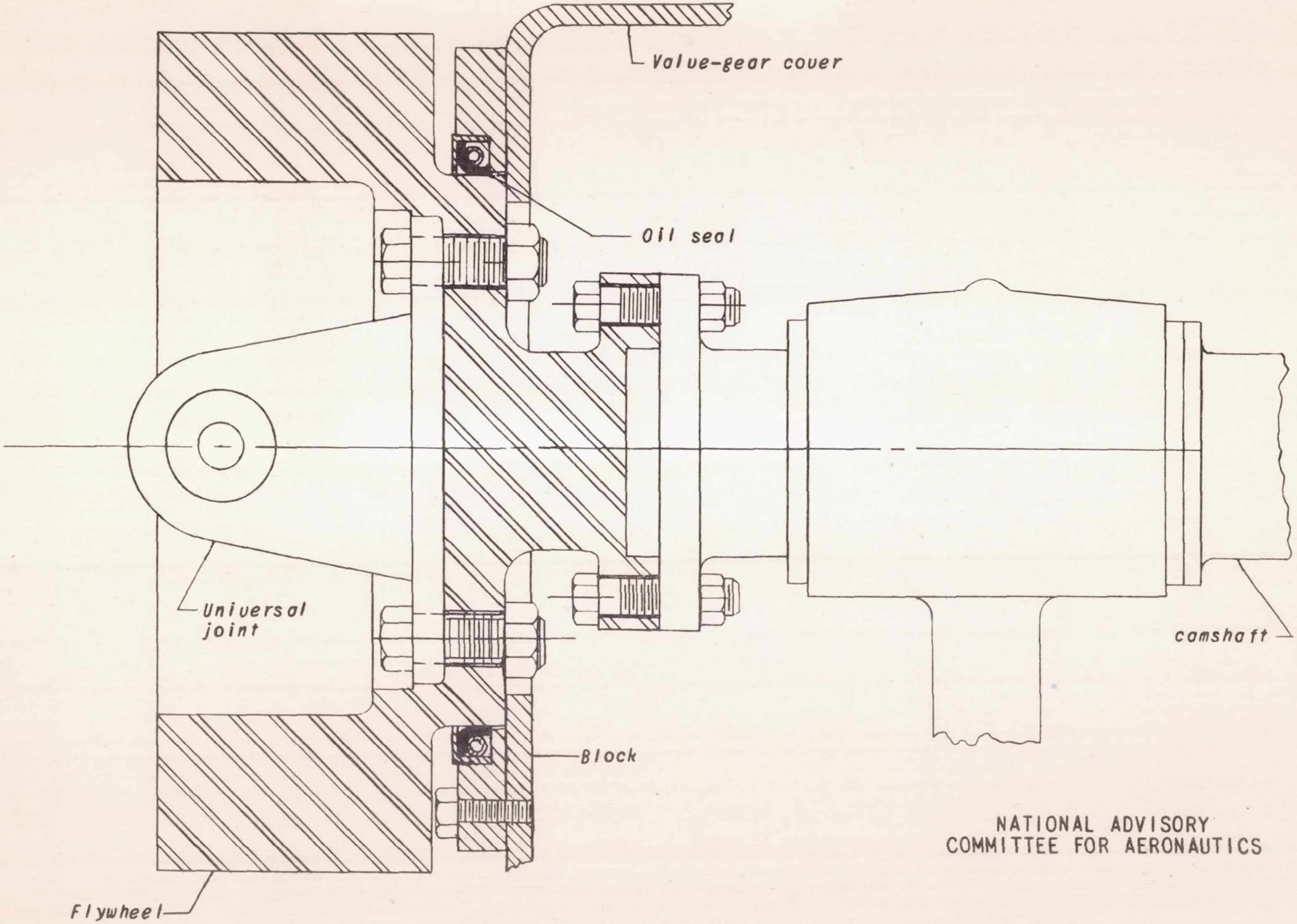


Figure 6. - Camshaft oil seal for Allison V-1710 block.