SECTION VI

CAMSHAFT GEAR TRAIN, CAMSHAFT ASSEMBLIES, TIMING AND OVERSPEED TRIP

A. DESCRIPTION

1. Camshaft Drive Gear Train

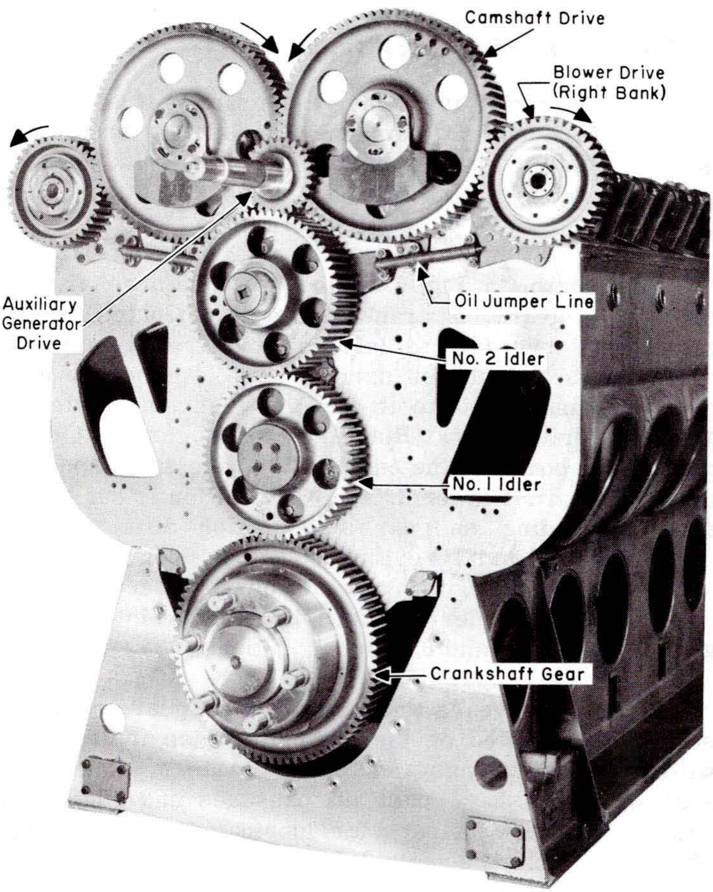
Power necessary to drive the camshaft and engine blowers is supplied from the crankshaft through the gear train at the rear of the engine. Fig. 6-1 shows the gear arrangement and Fig. 6-2 a cross-section of the gear train.

As shown in Fig. 6-1, the gear train consists of spur tooth gears, a crankshaft gear mounted on the crankshaft, two idlers, left and right bank camshaft drive gears and blower drive gears. The second idler gear has increased tooth length to accommodate the auxiliary drive gear. Rotation of the camshaft drive gears is inboard of the engine and at the same speed as the crankshaft. Blower drive gear rotation is out-board, speed depending on gear size, which differs, being smaller on 8 and 16 cylinder engines, compared to 6 and 12 cylinder engines. Hence, blower speed is faster on 8 and 16 cylinder engine. Only one blower drive gear is used on 6 and 8 cylinder engines.

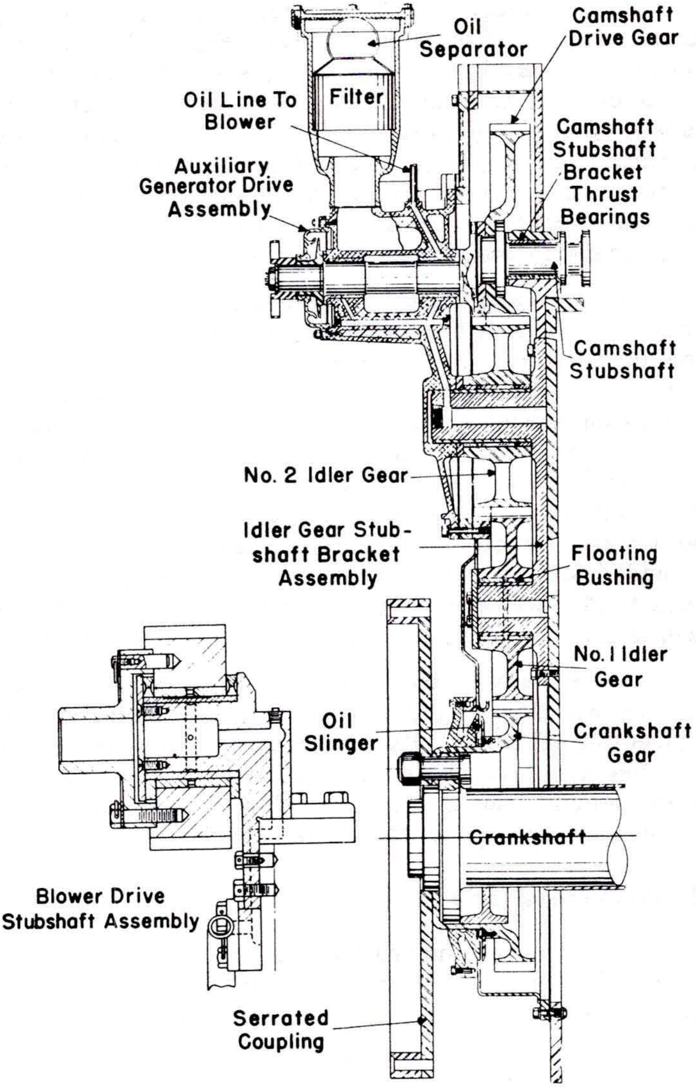
The idler gears and blower drive gears rotate on stubshafts mounted on the end plate which are equipped with floating bushings and thrust bearings. The stub-shaft brackets have cast oil passages and connecting cast oil passage jumpers for lubrication and camshaft oil supply from the main lube oil manifold. The cam-shaft drive housing enclosing the gear train is wider on 6 and 12 cylinder engines than on 8 and 16 cylinder due to blower drive gear size.

2. Camshafts

Camshaft assemblies consist of flanged segments, end stubshafts, and on 12 and 16 cylinder engine camshafts a spacer is used between the center segments. Each segment spans several cylinders, 3 on 6 and 12,



Camshaft Gear Train
Fig. 6-1



Cross-Section of 567C at Camshaft Drive End
Fig. 6-2

and 4 on 8-567CR and 16 cylinder engines; 8-567C engines use only short segments, Fig. 6-3. Segment flanges are marked as shown in Figs. 6-5 and 6-6 to aid in correct assembly. Current "polydyne" long segments having improved exhaust cams for better valve operation, replace prior used long segments. At each cylinder there are two exhaust cams, one injector cam and two bearing journals supported in bearing blocks equipped with lead base babbitt steel backed inserts.

Flanged stubshafts mounted at each end of the camshaft, in stubshaft bearing brackets, provide support for the drive gears and counterweight assemblies. One piece, thin steel backed bronze bearing inserts are now used. Consequently, the stubshaft bearing bore is smaller than the replaced brackets used with the thick bronze multiple bearings, so they are not interchangeable. The camshaft drive gears and counterweight assembly are bolted and doweled to the rear stubshafts, which are provided with thrust bearings. Counterweights are also bolted and doweled to the front stubshafts. The overspeed trip is incorporated in the right front counterweight.

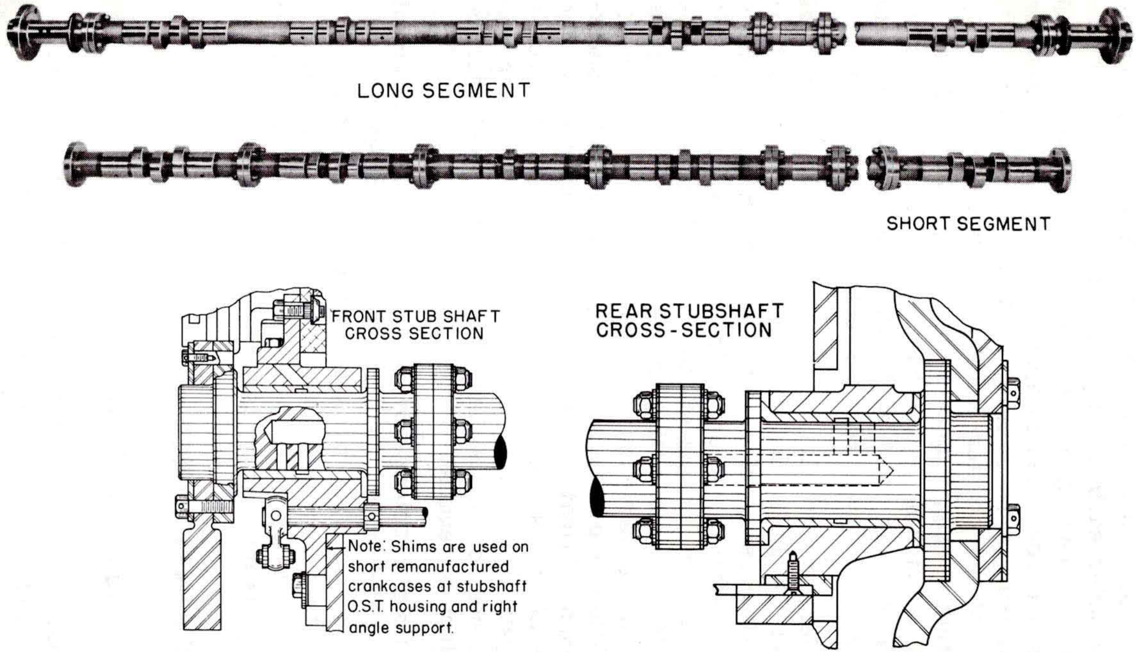
Oil is supplied the hollow camshaft from the main lube oil manifold to the rear stubshaft bearings through connecting oil lines. Each camshaft segment bearing is supplied oil from the camshaft center bore. One segment bearing cap at each cylinder location is flanged for an oil line to the rocker arm shaft.

3. Overspeed Trip

An overspeed mechanism is provided as a safety feature to stop the injection of fuel into the cylinders should the engine speed become excessive.

If the engine speed should increase to approximately 900 RPM, the overspeed mechanism will shut down the engine. Fig. 6-4 shows the overspeed mechanism in both the normal latched and the tripped position.

A trip shaft extending the length of the engine banks under each camshaft is provided at each cylinder



Camshaft Assemblies
Fig. 6-3

with a cam, which when rotated contacts a spring loaded catch pawl mounted on each cylinder head, located directly under each injector rocker arm. In the overspeed trip housing on the front of the engine, the trip shafts are connected to spring operated links and lever mechanism. A reset lever on a spring lever arm shaft when rotated counter-clockwise puts a tension on an actuating spring; tension being held by a trip lever engaging a notch in the reset lever arm shaft. This is the normal running position, in which the cams on the trip shaft are held away from the rocker arm catch pawls.

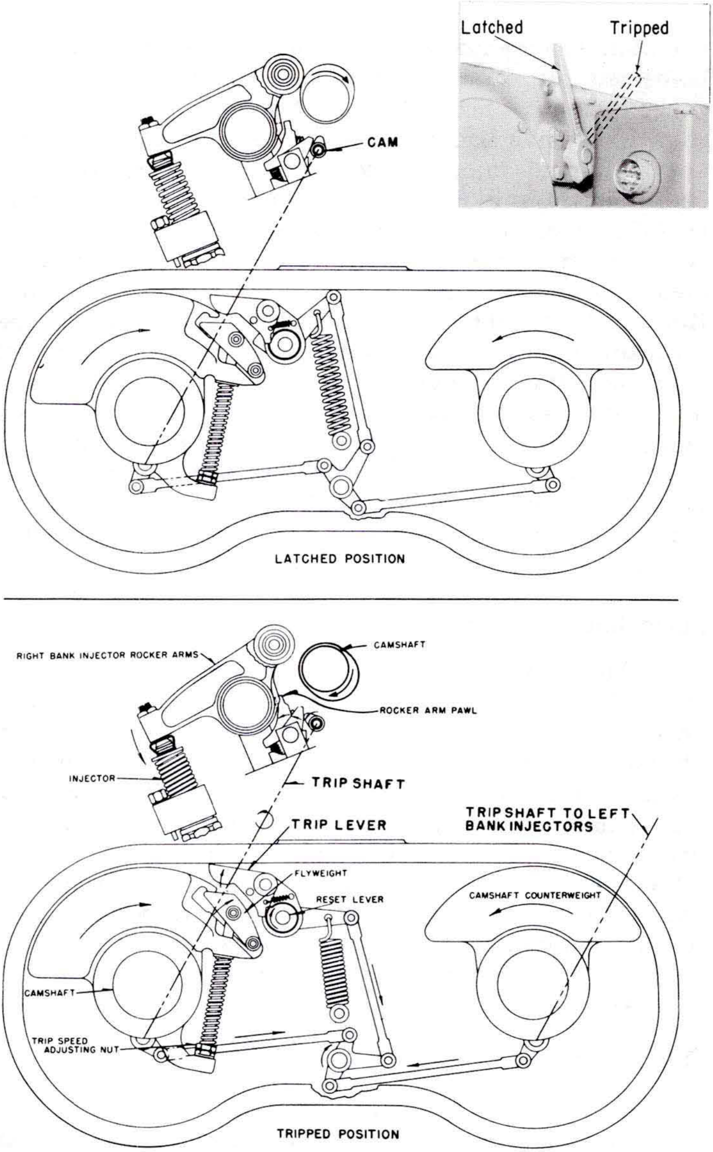
Incorporated in the right bank front camshaft counter-weight is the overspeed trip release mechanism. It consists of a flyweight held by an adjustable tension spring. When engine speed exceeds the safe limit, the set tension of the spring is overcome by the centrifugal force acting on the flyweight, causing the flyweight to move outward to contact the trip lever. This allows the actuating spring acting through connecting links to rotate the trip shafts. Consequently, the trip shaft cams contact and raise the injector rocker arm pawls preventing full effective injector rocker arm roller contact on its cam. This prevents fuel injection and stops the engine.

Upon resetting, by counter-clockwise movement of the reset lever, the trip shaft cams release the injector rocker arm catches. Rotation of the camshafts on starting the engine lift the rocker arms slightly allowing the catch pawls to resume unlatched position, releasing the injector rocker arm for normal operation.

B. MAINTENANCE

1. Camshaft Gear Train

Gear teeth should be inspected for fatigue indications, cracks, pits, or other evidence of failure. Whereever possible, inspection by Magnaflux methods are recommended. For Magnaflux inspection of engine gears,



Overspeed Trip
Fig. 6-4

see Maintenance Instruction **1754.** Gears should also be inspected for excessive backlash by inserting a feeler gauge the entire length between teeth, or by other methods. Excessive backlash will result in improper valve operation and injection periods as well as poor gear operation. Limiting backlash clearance is given under specifications at the end of this section. Clearances between gear stubshaft and gear bushings and thrust clearances must also be maintained within specified limits. It should be noted that blower thrust washer (bronze) 8069139 is used "outboard," while washer (cast iron) 8166495 is used "inboard" on blower drive gear stubshaft. All production 8 and 16 cylinder 567C engines have 30 tooth blower drive gears except a few pilot models which used 31 tooth gears similar to earlier 567 series engines of the same size. The blower drive gears for 6 and 12 cylinder 567C engines have 41 teeth, the same as used on earlier 567 series engines of the same size. Export 6 and 12 cylinder 567C engines however use a 40 tooth blower drive gear.

Although no wear should occur at the oil slinger, the .100" plus or minus .010" dimensions between crankshaft gear oil slinger and housing cover should be checked on assembly. This measurement is obtained by laying a straight edge across the camshaft drive housing flange, with crankshaft positioned toward the generator and measuring the distance to face of oil slinger. Then determine the protrusion of slinger mating surface on lower housing cover from its flange. The difference between these measurements equals the clearance. If required add or remove shims to obtain proper clearance.

2. Camshafts

Camshaft assemblies installed in an engine must conform to segment sequence and location for left and right bank as shown in Figs. 6-5, 6-6 and 6-7 on respective engines. (Figures 6-5, 6-6 and 6-7 show short camshaft segments part numbers in addition to the long segment numbers and location on the 567C engine to provide association of these parts for customers having earlier 567 series engines.)

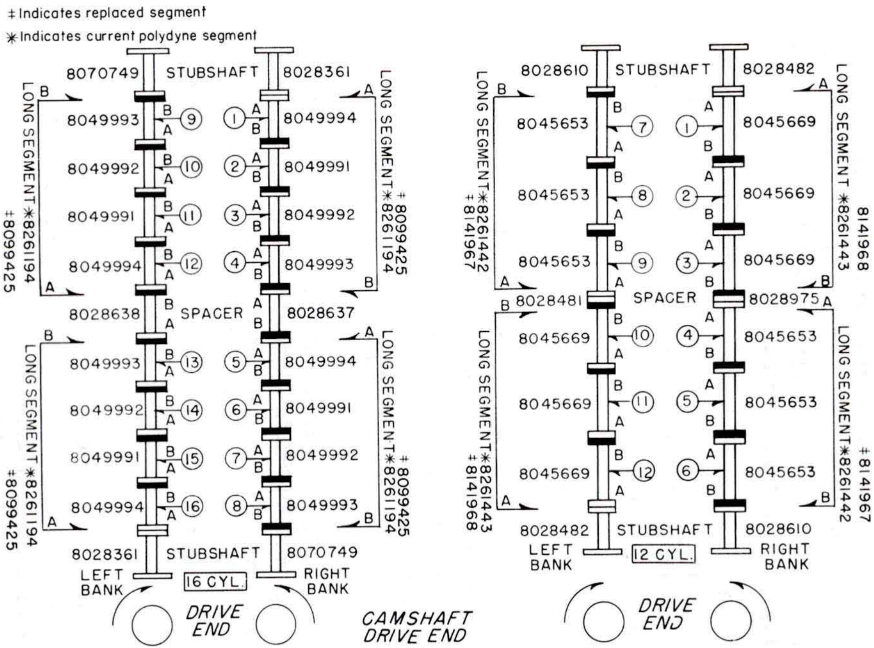
One dowel bolt hole in each segment flange is smaller than the others to assure correct segment angular position. On right bank camshafts, the "A" marking on each flange is toward the front of the engine. On left bank camshafts, the "B" marking on the flange must be toward the front of the engine (except the 8-567C engine and Fig. 6-7 arrangement).

Check segment journal to bearing clearance and thrust clearance at rear stubshafts. Limits are given at end of section. Clearance measurement can be obtained with feeler gauges.

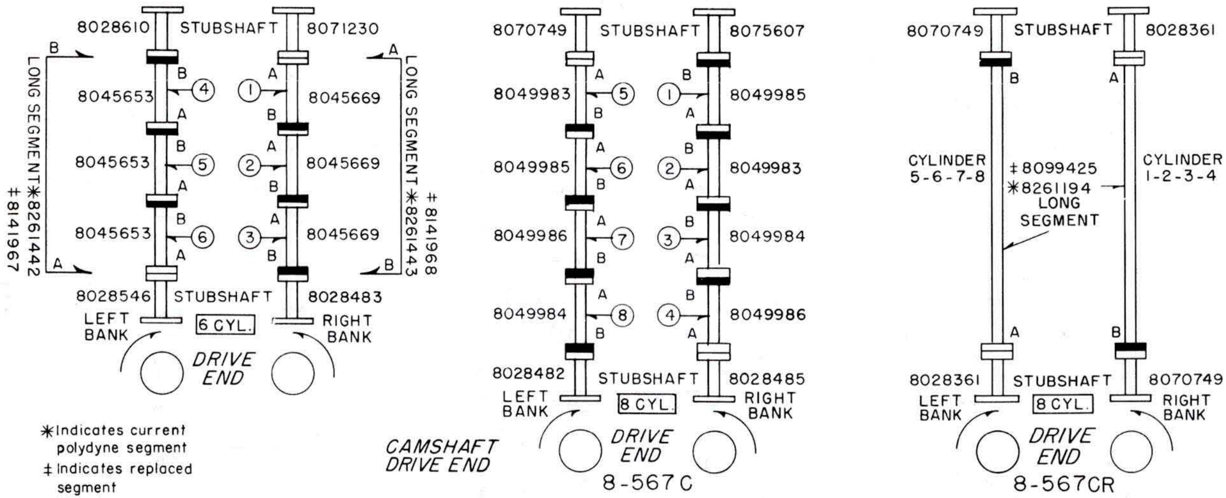
Camshaft Removal

The camshaft may be removed without disturbing the stubshafts by removing the dowel bolts connecting the segment flange and stubshaft flange, removing oil lines from segment bearing blocks to rocker arms and removing rocker arms. Remove segment bearing block caps to allow camshaft removal. If the camshaft is removed for other reasons than bearing replacement an attempt should be made to retain relative position of the bearing bushings on re-installation of the camshaft. This may be accomplished by immediately replacing caps after camshaft removal, or if the entire block is removed, re-insert block bolts and wire the free ends of the bolts.

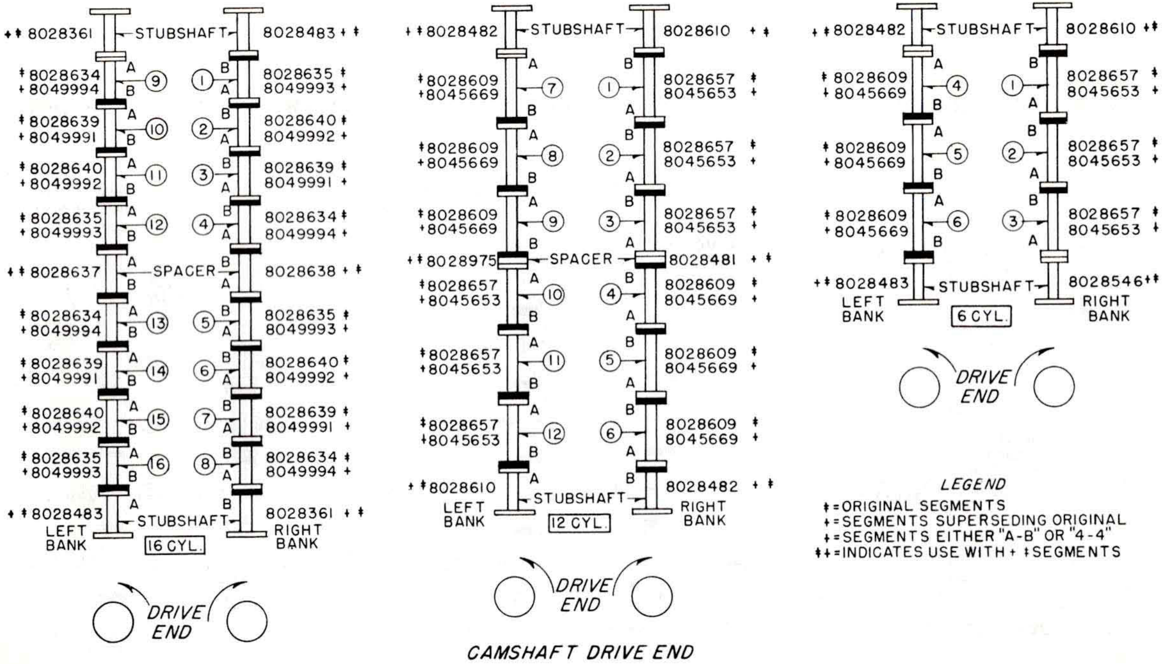
Upon installation or replacement of the camshaft, lubricate freely all moving parts, place the assembly in proper aligned position after replacing blocks and bearings as removed. Rotate camshaft to check for binding. Apply flange dowel bolts and reassemble rocker arms and associated parts. Check valve timing of at least one cylinder to check segment positioning and then make other adjustments such as exhaust valve setting and injector timing.



Long And Short Camshaft Assemblies — 12, 16 Cylinder 567A, B And C Engines
Fig. 6-5



Long And Short Camshaft Assemblies — 6, 8 Cylinder 567A, B, C Engines And 8-567CR Engines
Fig. 6-6



Camshaft Assemblies — Early 567 Cast And Fabricated Top Deck Engines

Fig. 6-7

Camshaft Segment Removal

Individual segments comprise the entire camshaft on 6 cylinder engines, and are removed as previously given. It is also necessary to remove the entire camshaft to remove a segment of 12-cylinder engine camshafts due to center segment flange and spacer arrangement. The bolt heads held in the spacer and covered by adjacent segment flange prevent removal. Individual segments however may be removed from the 8 and 16 cylinder camshafts by removal of flange connecting dowel bolts.

Camshaft Inspection

After removal of camshaft, dismantle, wash and remove all dirt from oil passages. Visually inspect stubshafts and segments paying particular attention to cam lobes and journals for pitting, chipping, excessive scoring and heat discoloration. Journals and cams with light pit marks, minute flat spots and light score marks may be reused after blending and removal of sharp edges by hand polishing. Check inside of dowel bolt holes for burrs and remove.

Camshaft segments and stubshafts that show heat discoloration should be Magnaflux inspected and hardness tested. See Maintenance Instruction 1754 for this information. Discoloration on the unfinished portion of the camshaft should be disregarded as it results from production process as may be seen on a new camshaft.

After assembly of camshaft and stubshaft check for concentricity between journals. Concentricity should be within .002" T.I.R. Support the camshaft on precision rollers at journals 1, 7, 10 and 16 on 16 cylinder; 1, 6, 7 and 12 on 12 cylinder; 2 and 7 on 8 cylinder and 2 and 5 on 6 cylinder. For further limits see specifications.

3. Firing Order and Top Dead Center

Column A - Firing Order

Column B - Position of flywheel in degrees when piston is at top dead center.

6 Cylinder		8 Cylinder		12 Cylinder		16 Cylinder	
A	B	A	B	A	B	A	B
		*8-567CR					
1	0 deg.	1	0 deg.	1	0 deg.	1	0 deg.
4	45	5	45	12	19	8	22-1/2
3	120	3	90	7	45	9	45
6	165	7	135	4	94	16	67-1/2
2	240	4	180	3	120	3	90
5	285	8	225	10	139	6	112-1/2
		2	270	9	165	11	135
		6	315	5	214	14	157-1/2
				2	240	4	180
				11	259	5	202-1/2
				8	285	12	225
				6	334	13	247-1/2
						2	270
						7	292-1/2
						10	315
						15	337-1/2

8-567C	
1	0 deg.
5	45
3	90
7	135
2	180
6	225
4	270
8	315

*NOTE: 8-567CR and 8-567C crankshafts are not interchangeable.

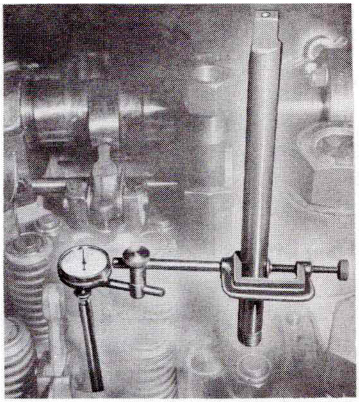
4. Locating Top Dead Center

If it should become necessary to check the position of the flywheel or the flywheel pointer for top dead center, proceed as follows:

a. Remove injector from No. 1 cylinder.
b. Turn crankshaft in normal direction of rotation until piston is just before top center.
c. Insert threaded rod 8051833 through injector hole and screw into piston puller hole in crown of piston.

d. Attach dial indicator 8039138 to a bolt screwed into threaded lifter hole in cylinder head, Fig. 6-8. Place indicator as shown, and depress a few thousandths of an inch.

e. Set indicator at zero and mark flywheel at pointer. Turn crankshaft in normal direction until piston moves up to and past top dead center and indicator returns to zero.

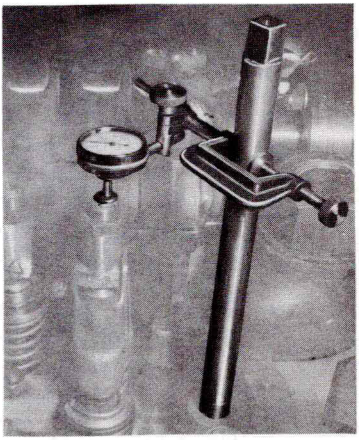


Locating Top Dead Center
Fig. 6-8

NOTE: The distance the piston travels after the indicator is attached should be within the range of the indicator.

f. Continue turning crankshaft until piston moves approximately .010" past zero, then turn crankshaft in opposite direction until indicator returns to zero. This will compensate for clearance in bearings and piston assembly.

g. Mark flywheel again at pointer. Divide distance between the two marks. This point will be top dead center for No. 1 piston.



Timing Exhaust Valves
Fig. 6-9

5. Checking Exhaust Valve Timing

To check timing, place a dial indicator on the rocker arm adjusting screw as shown in Fig. 6-9. Valve end of rocker arm must be in its highest position, so that the exhaust valves are closed. Press indicator down approximately .100" and set dial to zero.

Turn crankshaft in normal direction of rotation until flywheel is at 106° A.T.D.C. of cylinder being checked. If timing is correct, the valve bridge will have moved down .014". Timing must not be later than 110° or earlier than 104° A.T.D.C. of cylinder being checked.

6. Timing Exhaust Valves

When blowers, oil separator, camshaft drive housing covers are removed for replacement of camshaft assembly, stubshafts or gears, the exhaust valves are timed as follows:

a. Remove or loosen all rocker arms except the one on which the dial indicator is resting, as shown in Fig. 6-9. Each camshaft must be timed to the crankshaft. Checking timing of any one cylinder is sufficient.

b. Locate top dead center for the cylinder to be checked (see page 613). Remove the dowels and bolts from the camshaft drive gear and remove gear. The camshaft can be rotated by placing a socket and wrench on flange bolt nuts.

c. Rotate the camshaft in its normal direction of rotation until the valve bridge on which the dial indicator is resting, moves down .014".

d. Turn the crankshaft in the normal rotation until flywheel pointer reads 104° after top dead center of the cylinder being checked. If a new gear train has been installed, the timing may be as early as 104° but not later than 106°. Unless a new gear train has been installed, it is preferable to set timing as nearly to the 106° mark as possible. With flywheel at 104° A.T.D.C. of the cylinder being checked, the dowel holes in the camshaft drive gear applied and dowel holes in the camshaft stubshaft should be in line or approximately in line with each other. If by turning the crankshaft from 104° to 106° A.T.D.C., the dowel holes can be made to line up, then the bolts should be tightened. If the dowel holes do not line up within this tolerance remove the camshaft gear from its stubshaft. Turn the gear 180° and replace on stubshaft or move the gear one tooth and replace on the stubshaft. The dowel holes should then line up.

e. If it is not possible to line up the dowel holes perfectly, they may be reamed oversize and oversize dowels installed. This will eliminate the necessity of redrilling the gear and stubshaft. Secure gear to its stubshaft.

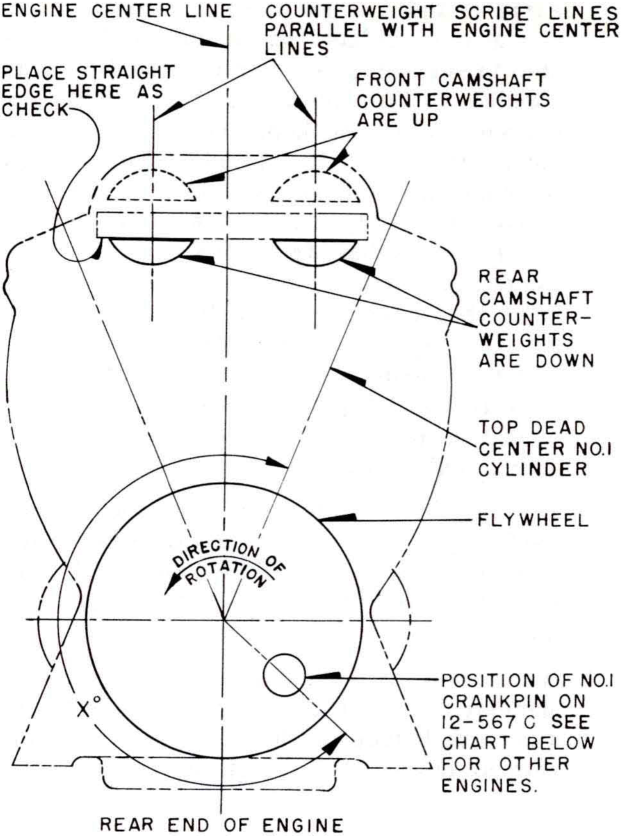
f. The crankshaft should now be rotated in its normal direction and the timing checked so that the valve bridge of the valve being checked has moved down .014", when the flywheel timing pointer is at 104°-106° A.T.D.C.

7. Counterweights

Counterweight replacement is rarely necessary. When applying counter-weights be sure they are installed in proper position as indicated in Fig. 6-10.

8. Adjusting Overspeed Trip

To adjust the overspeed trip, shut engine down, remove the cover from right side of overspeed trip housing and turn adjusting nut to increase or decrease spring



X = DEGREES AFTER T.D.C. OF NO.1 CYLINDER. TO GET THE CRANKSHAFT IN THIS POSITION, TURN THE FLYWHEEL UNTIL THIS NUMBER IS AT THE POINTER.

ENGINE MODEL	X EQUALS
6 - 567 C	172½°
8 - 567 C	247½°
8 - 567 CR	184°
12 - 567 C	249½°
16 - 567 C	105°

Counterweight Timing
Fig. 6-10

tension as required. To increase engine speed at which overspeed trip operates, increase spring tension.

After the adjusting nut has been moved, the locknut must be tightened and the engine run to test speed at which trip operates. The speed rise of the engine from idle to trip should be made in 20 to 30 seconds. Several adjustments may be required before final setting of 900-915 RPM tripping speed is reached.

When setting the overspeed trip, engine speed should not exceed 930 RPM, to limit centrifugal force on the generator commutator. More stabilized overspeed trip operation is obtained by using recently improved cupped spring washer and cylindrical end spring guide in the overspeed trip.

See Scheduled Maintenance Program for frequency of checking the overspeed trip.

C. SPECIFICATIONS

Gear Ratio to Crankshaft

Gear	No. of Teeth	Ratio to Crankshaft RPM
Crankshaft	79	1:1
Idlers	58	1.362:1
Camshaft Drive	79	1:1
Blower (6 and 12)	41	1.925:1
Blower (12 Cylinder Export)	40	1.975:1
Blower (8 and 16)	30	2.633:1
Aux. Gen. Drive	26	3.037:1

Gear Backlash

Crankshaft gear to 1st idler	New .007" - .014"
1st idler to 2nd idler	New .007" - .014"
2nd idler to camshaft drive	New .007" - .016"

Camshaft drive to camshaft drive	New .007" - .022"
Camshaft drive to blower drive	New .007" - .016"
Aux. drive to 2nd idler	New .007" - .016"
Limit (all gears)	.030"

Camshaft Drive Gear Clearances		Limit
Idler gears (bushing to stubshaft)	New .005" - .008"	.016"
Bushing to gear	New .008" - .010"	.018"
Thrust Clearance No. 1 idler	New .009" - .017"	.025"
Thrust Clearance No. 2 idler	New .050" - .068"	.080"
Blower drive gears - diametric clearance-bushing to stubshaft	New .003" - .005"	.016"
Bushing to gear	New .007" - .009"	.018"
Thrust Clearance	New .009" - .017"	.025"
Floating bushing minimum length - No. 1 idler gear		3-27/32"
No. 2 idler gear		4-27/32"
Blower drive		2-19/32"

Auxiliary Generator Drive

Housing		
Pilot diameter	New	4.002" - 4.003"
	Limit	4.0045"
Bearing diameter	New	2.5025"- 2.5035"
	Limit	2.506"
Thrust dimension	New	10.0647"-10.0601"
	Limit	10.051"
Drive shaft		
Bearing diameter	New	2.499" - 2.500"
	Limit	2.4985"
Thrust dimension	New	10.077" -10.080"
	Limit	10.084"
Clearance		
Shaft to bushing	New	.0025"- .0045"
	Limit	.0075"
Thrust	New	.0123"- .0199"
	Limit	.033"

Camshaft and Stubshaft

			Limit
Camshaft journal diameter	New	2.496"-2.498"	2.495"
Diametric clearance - segment journal to bushing	New	.002"- .006"	.010"
Taper length of journal			.001"
Runout (journal) T.I.R.			.002"
Runout (base circle relative to journal)			.003"
Mounting flange (not convex) flat within*			.0005"
Mounting flange square with longitudinal center line within, T.I.R.*			.001"
*(Correct by grinding faces)			
Stubshaft journal diameter	New	2.497"-2.498"	2.495"
Diametric clearance-journal to bushing	New	.0035"-.0075"	.010"
Stubshaft thrust clearance	New	.010"- .018"	.025"
Dimension between thrust faces			Max. 4.195"

Camshaft Timing

Ideal Timing Setting.............. 106 deg. A.T.D.C. valve open .014"

Timing of new gear train not earlier than.................... 2 deg. Max. (or 104 deg. A.T.D.C. at .014" valve open)

Limit of lag - camshaft behind crankshaft - due to worn gears...................... 4 deg. Max. (or 110 deg. A.T.D.C. at .014" lift.

Flywheel Pointer setting....... 0 deg. T.D.C. of No. 1 Cyl.

Overspeed Trip

Clearance-trip latch to flyweight............................ .010" Min.

Trip setting....................... 900 - 915 R.P.M.

D. EQUIPMENT LIST

	Part No.
Rod for locating top dead center	8051833
Dial Indicator	8039138
Feeler Gauge Set	8067337