MECHANICAL STUDY GUIDE

Alco

LOCOMOTIVES WITH MODEL 244 ENGINES

ALCO DIESEL-ELECTRIC LOCOMOTIVE SCHOOL
INSTRUCTION SERIES

TYPES OF DIESEL-ELECTRIC LOCOMOTIVES

Diesel-electric locomotives may be divided into three general groups according to the type of service for which they are designed. The locomotives of one group may sometimes perform service for which those of another group are specifically designed, but in general they are not as well adapted to it. The three groups are yard switchers, road switchers and road locomotives.

The switching locomotive is designed to handle heavy loads at low speeds in yard, terminal and transfer service. Therefore, it is generally provided with less horsepower capacity in relation to its weight than road locomotives, which must operate at higher speeds. Since visibility in both forward and backward directions is of great importance, the operating controls are placed in a cab with windows on all sides. The power plant is enclosed in a narrower hood so that the crew can see past, and sometimes over it. Doors in the side of the hood give ready access to the power plant for servicing and maintenance of the power plant, while hatches in the top permit removal of parts such as cylinder heads and pistons from the engine. The entire hood may be removed and the diesel engine lifted from the locomotive frame for overhauling. The cab is located at the rear of the locomotive when only one engine is used, which is the most common practice. When two engines are used the cab is located in the center with a hood housing one engine at each end.

Switchers are sometimes used for short main line or branch line runs. For such service they may be equipped with multiple unit control.

The road switcher, designed for operation on main or branch lines in either freight or passenger service as well as in yard and terminal switching, is similar in general appearance to the yard switcher. Thus it has the high visibility in either direction and accessibility for maintenance of the switcher. Behind the cab, however, it carries a short hood in which a steam generator may be mounted to provide steam to heat and air condition passenger trains. It is also equipped with trucks better suited for high speed service than are those of the yard switcher. It is frequently equipped for multiple unit operation.

Road locomotives are of two types. Both are designed for through, main line service with little switching or backing. The control cab is located at the front end of a unit with windows in the front and sides only. It is raised above a rounded nose which houses miscellaneous auxiliary equipment. The high forward location of the control cab gives excellent visibility forward and to the sides. The contour of the control cab is carried on back to the rear of the locomotive to house the power plant and provide enclosed space around it for inspection and adjustments while the locomotive is in motion. These locomotives are equipped with high speed trucks and air brake equipment designed to give satisfactory control of both the longest and the fastest trains.

Road locomotives designed to handle freight trains and moderately fast passenger trains are equipped with four-wheel trucks. If intended for passenger service they are also equipped with steam generators. They are frequently used interchangeably in passenger and freight service.

It has been shown that train resistance becomes high at very high speeds and that the combination of high tractive effort requirements and high velocity results in a very high demand for horsepower. Consequently locomotives designed to pull high speed passenger trains exclusively are provided with power plants which produce higher horsepower than those provided for slow or medium speed service. These larger power plants make the locomotive units heavier and require six-wheel trucks to carry them without unduly heavy concentrated loads on the rails. The six-wheel trucks also provide better riding at high speeds. Since the power requirements rather than adhesive requirements determine the weight of such units, it is unnecessary to place motors on all axles. The center axle of each truck is usually an idler. The weight carried on the remaining four motored axles of each unit is sufficient to provide ample adhesion for starting and accelerating trains which can be hauled at the high speeds for which these locomotives are designed.

The high speed road passenger locomotives are always equipped with train heating steam generators. Steam from these boilers is also used to operate some types of air cooling equipment as well as to heat water for wash rooms in the coaches and kitchens in the dining cars.

In addition to the two-motored, three-axle trucks used on high speed passenger locomotives, some road switchers are equipped with shorter three-axle trucks. These are used where track structures require lighter loads per wheel than would be obtained with two-axle trucks. Some of these trucks are equipped with only two motors each, the center axles being idlers. However when maximum tractive effort is required all three axles are motored, so that the total weight of the locomotive is adhesive weight.

By using electric control of governor settings and motor connection switches, it is possible to connect the controls of several units to the operating station of one unit so that the several units will operate as one locomotive. Cables known as jumpers, with plugs on each end, are plugged into receptacles provided on the ends of the locomotive units to connect the control circuits. This is known as multiple unit control, commonly abbreviated MU. As many as four units may be thus controlled from one cab.

If switchers or road switchers are equipped for MU they may be coupled together with either end of any unit ahead, although they are usually arranged with the front ends of the end units of the combination pointed away from the other units.

Road locomotive units are constructed as "A" or "B" units. An "A" unit is complete in itself, having a control cab from which it or a combination of units may be operated in train service. The "B" unit has no control cab and is designed to be operated in train service only as part of a multiple unit locomotive controlled from an "A" unit. Some "B" units, however, have hostler's controls from which they may be operated independently for movement about locomotive having flat ends so that they present a relatively smooth contour when coupled together or behind an "A" unit.

When road units are coupled for multiple unit operation they have an "A" unit leading. This may be followed by from one to three "B" units. Such a combination, however, provides a control cab at one end only so that the locomotive must be turned around to pull a train in the opposite direction. Turning of the locomotive at terminals is often eliminated by using an "A" unit with its nose trailing as the last unit.

THE LOCOMOTIVE STRUCTURE

The locomotive structure may be divided roughly into three parts; trucks, frame and cabs, and hoods.

The locomotive trucks support the locomotive and carry the traction motors and brake rigging. Except for very small locomotives, whose use is largely restricted to the movement of a few cars at a time within an industrial plant, virtually all diesel-electric locomotive units are carried on either 8 or 12 wheels. These wheels, nearly always forged and rolled from steel and usually 40 inches in diameter ,and the gear by which the wheels are driven are pressed on the axles so that the assembly turns as a unit. The tread of the wheel is turned to a carefully designed contour with a flange on the side toward the center of the track. This tread contour and flange guides the wheel along the rail.

The ends of the axles are carefully machined to a very smooth finish to form the journals which turn in the bearings carrying the weight of the locomotive. On switchers these bearings are usually of brass similar to those used on freight cars. On road locomotives roller bearings are usually employed, in which case the inner race is pressed on the end of the axle.

The journal bearings are housed in boxes which, on the usual style of truck, are free to move vertically in guides known as pedestals which are part of the main frame on the truck. The main frame is a steel casting, roughly rectangular in shape, with pedestals on the sides near the corners. For a six wheel truck an additional pair of pedestals is provided at the centers of the sides. Plain bearing boxes are lubricated by wool waste or felt wicks soaking oil up from a reservoir in the bottom of the box. Roller bearings are lubricated by an oil bath through which the rollers travel as the axle rotates.

In the center of the truck and extending crosswise is the truck bolster. On switching locomotives this is commonly cast as an integral part of the main frame. On all locomotives designed for operation over the road at ordinary or high speeds, including road switchers, the bolster is hung to the frame by links so it is free to swing a limited distance from side to side. This cushions the lateral shocks which would otherwise be transmitted to the body of the locomotive and improves its riding qualities. The bolster is restrained by guides of the wheels and axles as the motors turn them or the brakes retard them is transmitted through the journal bearings, boxes, pedestals and main frame to the bolster, which in turn transmits the thrust to the locomotive frame.

The bolster is connected to the locomotive frame by center plates which allow it to turn or swivel under the locomotive so that it can negotiate curves. The center plate on the underside of the body frame protrudes into a circular depression in the truck center plate. This carries the weight of the locomotive body to the truck bolster and the mating of the protrusion on the body center plate with the rim of the truck center plate transmits the thrust of the truck to the body.

The weight of the locomotive body is carried through the bolster and truck frame to springs which cushion vertical shocks.

On rigid bolster trucks, usually used on switchers, the springs support the frame on equalizers, steel bars lying across the tops of the journal boxes, which distribute the load to the axles. On the truck approved by the American Association of Railroads as standard for diesel-electric switchers the springs on each side consist of a semi-eliptical leaf spring and two coil springs on each side of each truck. The leaf spring extends lengthwise of the locomotive, carrying the load of the truck frame at its center and supported by the equalizers at each end. The coil springs are located over each end of the leaf springs.

Swing bolster trucks usually have full eliptical leaf springs set crosswise at each end of the bolster. These rest on a spring plank, a steel plate or beam which is carried on the bottom ends of the swing links. The frame, in turn, is carried on the equalizers by coil springs. It is common practice to shape the equalizers so that they drop down low between the journal boxes so that the weight is applied to them below their points of support. These are known as drop equalizers.

Six-wheeled, or three-axled, trucks are constructed similarly to the four-wheeled trucks except that the bolster straddles the middle axle and is carried on four instead of two eliptical leaf springs. Instead of the two pairs of equalizers usually found on four-wheeled trucks, the six-wheeled trucks usually have four single equalizers. One of these spans from the center journal box on each side to one of the end boxes, so that two equalizers, one from each end, rest on each middle box. One coil spring rests on each equalizer. Six-wheeled trucks built to accommodate three traction motors are modified somewhat from the usual six-wheeled truck design to provide space for the center motor.

Each traction motor has a pinion mounted on one end of the armature shaft to drive the gear on the axle. On four or six-wheeled trucks to traction motors are suspended between the truck bolster and the axles with armature shafts parallel to axles. Each motor has on one side of its frame a pair of bronze bearings designed to support part of the weight of the motor and to resist the thrust of the gears against motor suspension journals machined on the driving axles. These motor suspension bearings are lubricated in a manner similar to the plain journal

The side of the motor next to the bolster is provided with a lug which fits between springs in a pocket in the bolster. Thus the suspension bearings on the axle furnish partial support for the motor and maintain proper meshing between the pinion and axle gear. The nose lug on the other side furnishes the rest of the support and keeps the motor from revolving itself around the axle instead of turning the axle.

Brake shoes are usually hung from the truck frame in front of and behind each wheel. They are forced against the wheels by a lever system which is actuated by air pressure acting on pistons in cylinders mounted on the truck frames. The air is conveyed to the brake cylinders from the air brake system on the locomotive body through flexible hose. Part of the brake shoes may be pulled up against the wheels by a hand operated mechanism mounted on the locomotive body and connected flexibly to the brake rigging on the truck. This mechanism multiplies the force of the hand many times, but is intended merely to hold the locomotive when it is standing.

Sanding pipes are also located on the trucks to guide sand from a supply carried in boxes in the locomotive body to the points of contact between wheels and rails to increase adhesion. This sand is conveyed from the boxes by gravity and a blast of compressed air.

The frame of the locomotive, as has been previously stated, is supported by the trucks through the center plates. It, in turn, supports the power plant, operating cabs, hoods or engine enclosures, and all auxiliary apparatus except that already described as being mounted directly on the trucks. In addition, as the motors drive the wheels, the frame transmits the pull or push of the trucks to the train through the coupler. A similar load is imposed on the frame when brakes are applied. If more than one unit is used, the frames of those units between the train and other units are required to carry the pull or push of the additional units.

In switching locomotives the frame is made in the form of a platform constructed of heavy steel beams and plates, usually welded into an integral structure. This frame then has cabs, hoods, power plant and auxiliaries set on it.

Road locomotives, with their streamlined bodies, have frames built on the principles of truss bridges. The load carrying frame work extends to the roof and across the top, so that it actually forms the skeleton for the cab and body of the locomotive. This results in a very strong frame with a minimum of weight. Remember that the weight inherent in the power plant capable of producing the high horsepower needed for speed in a road locomotive results in ample adhesive weight for tractive effort, so that any unnecessary weight in the locomotive structure would only add to the load to be hauled.

Locomotives are equipped with lights to illuminate the engine room or hood interiors, equipment compartments and operating cab. When the locomotive is moving at night the general illumination of the operating cab may be turned off and only the gauges illuminated.

an oscillating searchlight which casts a moving beam into the sky to warn of its approach. If the train is stopped on double track by an accident which might obstruct the adjacent track, on which trains move in the opposite direction, this light may be quickly changed to red as a warning to approaching trains.

Frequently a small light is provided at the rear of "A" units or on the ends of "B" units for use in backing or moving about terminals.

All switchers and road switchers have headlights at both ends.

All locomotives are provided with lighted numbers so that they may be identified at night. Operation outside yards on nearly all railroads requires the provision of classification lights. These may be changed from white, to indicate an extra train, to green, to indicate a train which is followed by another operating on the same time table schedule, or turned off entirely if the train is a regularly scheduled one without a following section. If the locomotive is used at the rear of a train to push it, marker lights must be provided. These show red to the rear and either green or yellow to the sides and usually to the front also. They are carried on the rear of every train to indicate that it is a complete train.

The locomotive must also have a compressed air supply system. This consists of a compressor, usually driven directly by an extension of the engine crankshaft and usually two main reservoirs in which the air is stored under pressure. A pressure governor is provided to stop the compressor or to hold open its intake valves so it can not compress air even though it continues to revolve when the reservoir pressure reaches a predetermined value. This is usually 140 pounds per square inch. Radiators are inserted in the compressed air lines to cool the air after compression. The compressed air is used to operate the brakes on the locomotive and train, to blow the air horn, ring a warning bell, operate windshield wipers and radiator shutters, to operate the large power contactors which connect the motors in various combinations as described later, and to blow sand under the wheels to increase traction.

GENERAL QUESTIONS

1. Give four (4) advantages the diesel-electric locomotive has over the steam locomotive.

   a.______________________ c.______________________

   b.______________________ d.______________________

2. Name four (4) general types of diesel-electric locomotives.

   a.______________________ c.______________________

   b.______________________ d.______________________

3. List the different types of ALCO diesel-electric locomotives and their horsepower.

   a.______________________ e.______________________

   b.______________________ f.______________________

   c.______________________ g.______________________

   d.______________________

4. The switcher locomotive has all weight on ______________________.

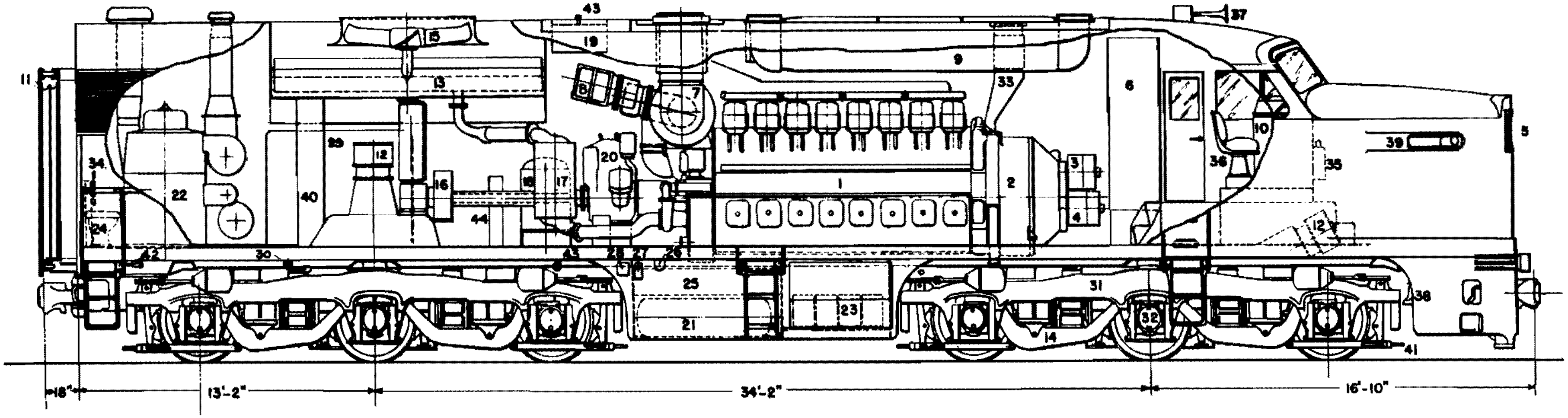
5. The construction of a road switcher locomotive provides space for a ____________ ____________ and/or ______________________.

6. The passenger locomotive has a two-motored three-axle truck that reduces the weight on drivers. Advantages derived from this type truck are:

   a.______________________ b.______________________

7. The "chain of power" in a diesel-electric locomotive consists of a ____________ turning a ______________________ that supplies electricity through cables and contactors to the ______________________, ____________.

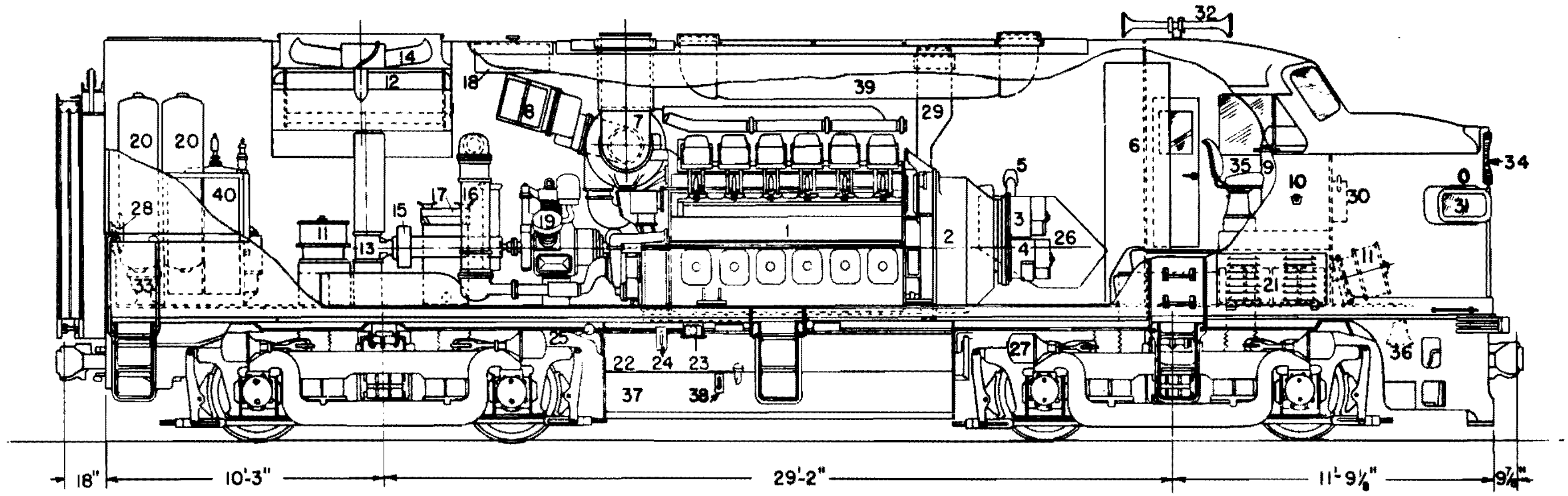
8. In all modern diesel-electric locomotives the engine is started by means of a ______________________.



2250 H.P. ALCO ROAD PASSENGER LOCOMOTIVE "A" UNIT

Identify the component parts of the road passenger locomotive by writing below the names that correspond to the numbers above.

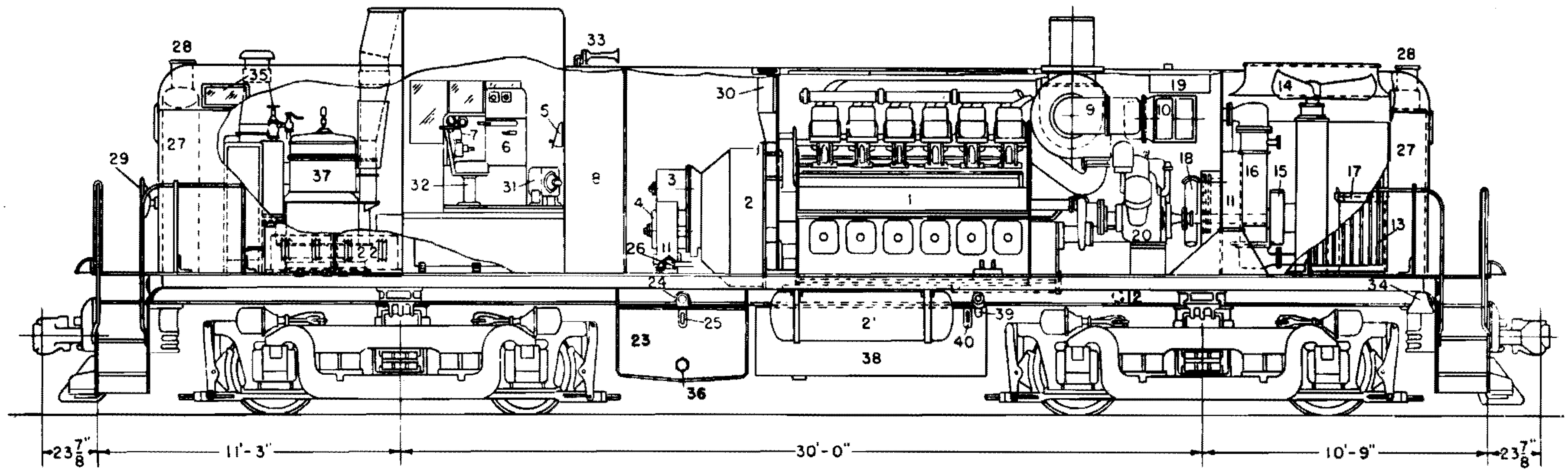
1. ____	12. ____	23. ____	34. ____
2. ____	13. ____	24. ____	35. ____
3. ____	14. ____	25. ____	36. ____
4. ____	15. ____	26. ____	37. ____
5. ____	16. ____	27. ____	38. ____
6. ____	17. ____	28. ____	39. ____
7. ____	18. ____	29. ____	40. ____
8. ____	19. ____	30. ____	41. ____
9. ____	20. ____	31. ____	42. ____
10. ____	21. ____	32. ____	43. ____
11. ____	22. ____	33. ____	44. ____



1600 H.P. ALCO ROAD FREIGHT-PASSENGER LOCOMOTIVE "A" UNIT

Identify the component parts of the road freight passenger locomotive by writing below the names that correspond to the numbers above.

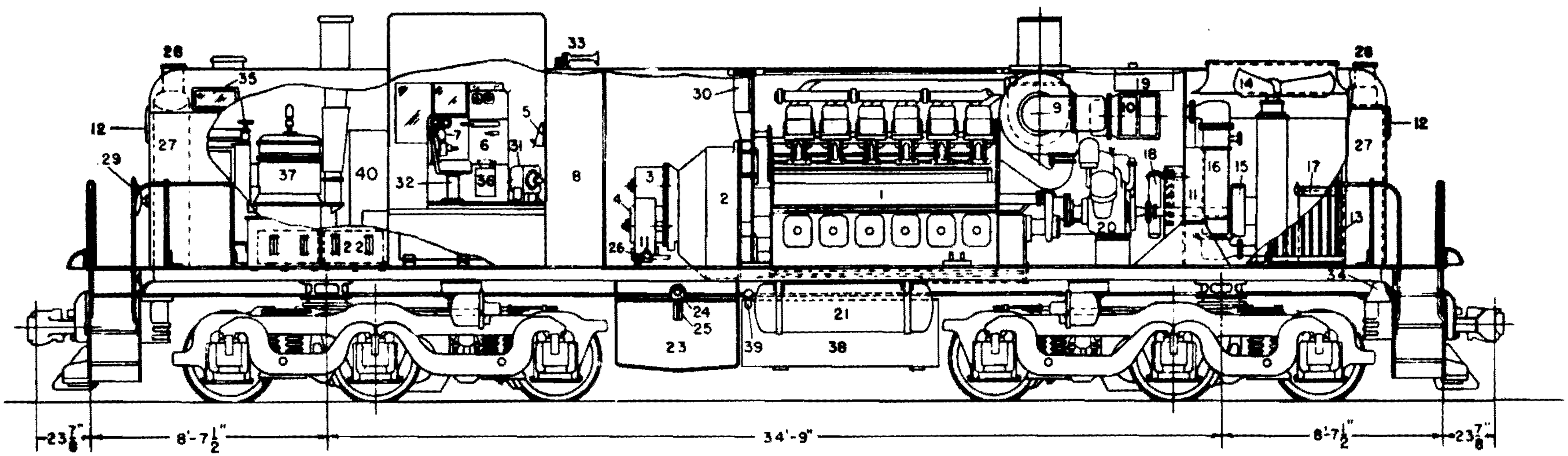
1. ____	11. ____	21. ____	31. ____
2. ____	12. ____	22. ____	32. ____
3. ____	13. ____	23. ____	33. ____
4. ____	14. ____	24. ____	34. ____
5. ____	15. ____	25. ____	35. ____
6. ____	16. ____	26. ____	36. ____
7. ____	17. ____	27. ____	37. ____
8. ____	18. ____	28. ____	38. ____
9. ____	19. ____	29. ____	39. ____



1600 H.P. ALCO ROAD SWITCHER LOCOMOTIVE - 4 TRACTION MOTORS

Identify the component parts of the road switcher locomotive by writing below the names that correspond to the numbers above.

1. ________	11. ________	21. ________	31. ________
2. ________	12. ________	22. ________	32. ________
3. ________	13. ________	23. ________	33. ________
4. ________	14. ________	24. ________	34. ________
5. ________	15. ________	25. ________	35. ________
6. ________	16. ________	26. ________	36. ________
7. ________	17. ________	27. ________	37. ________
8. ________	18. ________	28. ________	38. ________
9. ________	19. ________	29. ________	39. ________
10. ________	20. ________	30. ________	40. ________



1600 H.P. ALCO ROAD SWITCHER LOCOMOTIVE - 6 TRACTION MOTORS

Identify the component parts of the road switcher locomotive by writing below the names that correspond to the numbers above.

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________
7. ____________
8. ____________
9. ____________
10. ____________
11. ____________
12. ____________
13. ____________
14. ____________
15. ____________
16. ____________
17. ____________
18. ____________
19. ____________
20. ____________
21. ____________
22. ____________
23. ____________
24. ____________
25. ____________
26. ____________
27. ____________
28. ____________
29. ____________
30. ____________
31. ____________
32. ____________
33. ____________
34. ____________
35. ____________
36. ____________
37. ____________
38. ____________
39. ____________
40. ____________
41. ____________

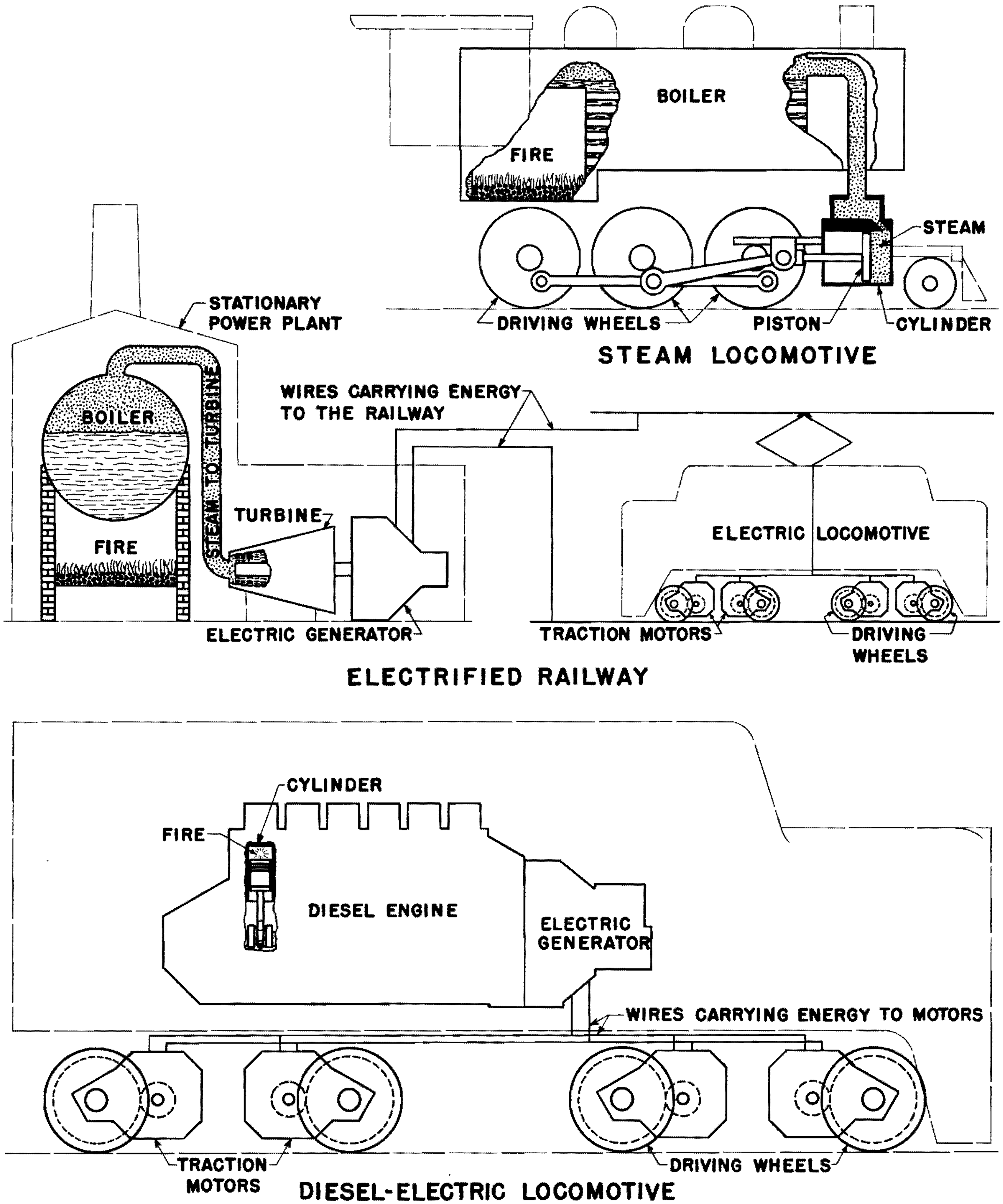

BOILER
FIRE
STEAM
DRIVING WHEELS
PISTON
CYLINDER
STEAM LOCOMOTIVE
STATIONARY POWER PLANT
WIRES CARRYING ENERGY TO THE RAILWAY
BOILER
STEAM TO TURBINE
TURBINE
FIRE
ELECTRIC LOCOMOTIVE
ELECTRIC GENERATOR
TRACTION MOTORS
DRIVING WHEELS
ELECTRIFIED RAILWAY
CYLINDER
FIRE
DIESEL ENGINE
ELECTRIC GENERATOR
WIRES CARRYING ENERGY TO MOTORS
TRACTION MOTORS
DRIVING WHEELS
DIESEL-ELECTRIC LOCOMOTIVE

FIG. I

FUNDAMENTALS OF DIESEL ENGINES

Any locomotive requires a source of energy to operate it. With the exception of a few electric locomotives using electricity generated by waterpower or battery, locomotives obtain their energy from the combustion of fuel. Whatever the fuel used, oil, coal, wood or some other fuel, its combustion generates heat energy. This heat energy must then be converted to mechanical energy to propel the locomotive.

In steam locomotives the fuel is burned in a boiler, and the heat energy converts the water to steam. The steam is transmitted through pipes to the cylinders, which are directly connected to the driving wheels through pistons, crossheads, connecting rods and crank pins. The pressure of the steam pushes the pistons in and out of the cylinders to generate mechanical energy to propel the locomotive.

On electrified railroads the fuel is burned in the boilers of stationary power plants to generate steam which is used to turn electric generators. The energy thus derived is transmitted as electric current through wires to the locomotives along the railroad. In the locomotive, traction motors convert this electrical energy to mechanical energy to propel the locomotive.

The diesel-electric locomotive, like the steam locomotive, obtains its energy from fuel burned within the locomotive. It differs, though, in that it burns the fuel in the engine cylinders instead of in a separate firebox. It is the pressure of the gases heated by the burning fuel, instead of steam, which pushes the pistons to produce the mechanical energy. The intermediate substance, steam, and its attendant apparatus, boiler, firebox and steam pipes, are eliminated.

It is impractical to connect the pistons of the diesel engine directly to the locomotive driving wheels because the diesel engine cannot start under load nor operate effectively at extremely low speeds. Therefore, the engine drives a generator which generates electrical energy. This energy turns traction motors that are geared to the driving axles as in the locomotives of electrified railroads. (Fig. 1) Thus the engine may turn at high speeds while the locomotive is running very slowly.

INTERNAL COMBUSTION ENGINES COMPARED

The diesel engine is one form of internal combustion engine. Another form which may be more familiar to many readers is the gasoline engine. Consequently, an examination of the principal similarities and differences between these engines will prove helpful.

Either a gasoline or diesel engine must do the following five things in order to produce a power impulse:

1. Fill the cylinder with air.

2. Compress the air in the space between the piston and cylinder head.

3. Introduce fuel into the cylinder and mix it thoroughly with the air.

4. Ignite and burn the fuel.

5. Discharge from the cylinder the gases resulting from combustion.

This cycle of operations may be performed in four strokes of the piston (two inward and two outward) or in only two (one in and one out). If four strokes are used to complete the cycle it is known as a four-stroke-cycle. If only two strokes are used it is a two-stroke-cycle. Most gasoline engines and ALCO diesel engines for locomotive service operate on four-stroke-cycles. Consequently this discussion will be confined to the four-stroke-cycles.

The cycles of operation of gasoline and diesel engines, even though both use four strokes, differ in respect to:

1. The time at which fuel is introduced into the cylinder.

2. The method of ignition.

3 The manner in which the fuel burns.

To show these differences clearly it will be convenient to use diagrams, called indicator diagrams or indicator cards, which picture what happens inside a cylinder of an engine. On these diagrams (Figs. 2 and 3) the horizontal dimension represents the volume of space between the cylinder head and the crown of the piston. This may be thought of as being represented by the distance from the cylinder head to the piston. This is exactly true for that part of the diagram representing the stroke of the piston and in most diesel engines it is approximately true for that part representing the clearance space. The clearance space or clearance volume is the volume remaining between piston and cylinder head when the piston is as close to the head as it gets in its stroke.

The vertical dimension represents the pressure of air and combustion gases in the cylinder. Thus on Fig. 2 at point "A" we find that when the piston is 3 inches from the top dead center on one of its strokes the pressure in the cylinder is slightly over 100 pounds per square inch. At "B" we find that when it is 2 inches from top dead center on another stroke the pressure is 50 pounds per square inch. Similarly any other point on the diagram represents a particular position of the piston on a particular stroke and the corresponding pressure existing in the cylinder.

THE OTTO CYCLE

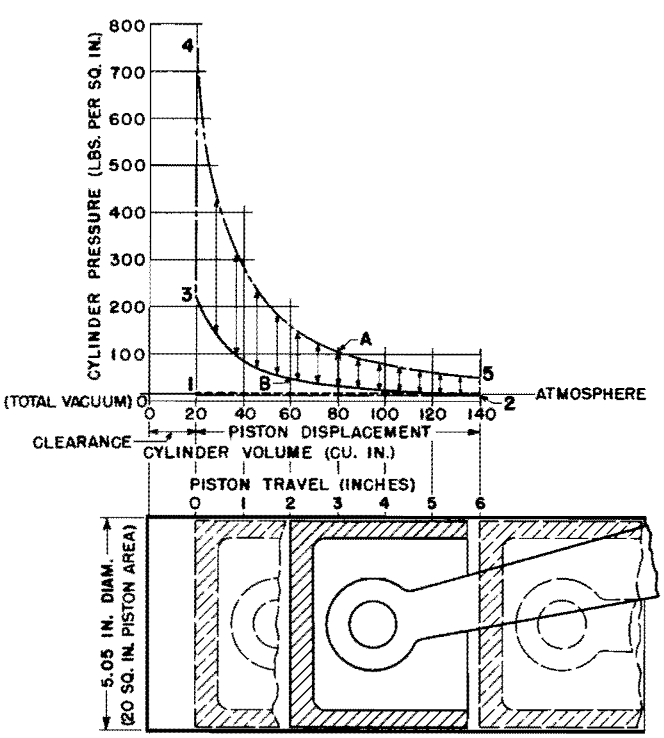
The theoretical cycle of operation of the common gasoline engine, named the

Otto cycle after the maker of the first engine to operate on this cycle, is pictured in Fig. 2. The pressure scale at the left of the diagram shows pressures in pounds per square inch absolute, i.e. above the pressure of an absolute vacuum. The pressure of the atmosphere outside the cylinder is represented by the thin horizontal line at 14.7 psi (pounds per square inch) on the scale.

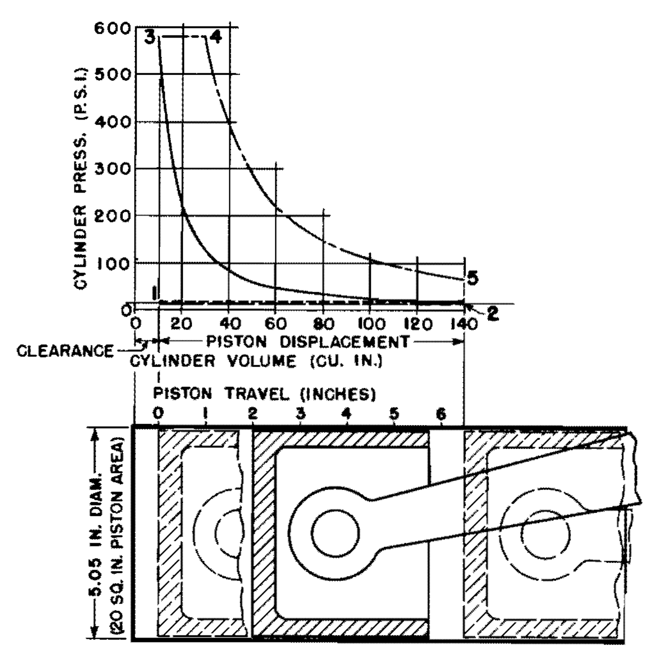
The line from point 1 to point 2, drawn like this — — — —, represents the suction or intake stroke of the piston. The piston is moving outward drawing in a mixture of air and fuel. Theoretically the pressure in the cylinder during this stroke would be that of the atmosphere outside, and should be thus shown on a theoretical diagram. This is also true of the exhaust stroke. But if the lines representing both of these strokes are shown at atmospheric pressure they appear as one. Actually there is some resistance to the flow of the air or exhaust gases through the valves, so the pressure within the cylinder is lower than that of the atmosphere during the intake stroke and higher during the exhaust stroke. In order to show the two strokes distinctly this actual difference in pressure has been shown on Figs. 2 and 3, although the remainder of these diagrams represent theoretical conditions only.

The solid line from point 2 to point 3 represents the compression stroke, during which the piston moves inward and compresses the air-fuel mixture in the cylinder.

At about the time the piston reaches the end of the compression stroke the fuel is ignited by an electric spark, and it burns almost instantaneously. The



OTTO CYCLE
FIG. 2



DIESEL CYCLE
FIG. 3

fuel in this cycle burns so rapidly that the piston moves very little during the period of combustion. It is said to burn at constant volume.

When a fuel burns and heats the surrounding gases they must either expand or undergo a rise in pressure. Since in the Otto cycle there is no opportunity for the gases to expand during combustion their pressure increases greatly as shown by the line (—·—·—·—) from 3 to 4. By the time combustion is completed the piston starts on its second outward stroke, now under the high pressure of the heated gases. This is the power stroke. As the gases expand, their pressure decreases so that the mean, or average, pressure acting on the piston through its stroke is much less than the maximum pressure resulting from combustion at the stroke's beginning. The end of this stroke is at 5. The sudden drop in pressure here is due to the opening of the exhaust valve and consequent passage of the gases from the cylinder to the atmosphere.

The total pressure acting against the crown of the piston is not all effective in producing power. Some must be used to store energy in the flywheel to force the piston back and forth on the other three strokes. On those strokes movement of the piston is opposed by the differences between the pressures existing in the cylinder and atmospheric pressure. The difference between the average pressure pushing the piston outward on the power stroke and the sum of those opposing its movement on the other three strokes is called the <u>mean effective pressure</u>, abbreviated m.e.p. Since the pressures opposing piston movement on the exhaust and intake strokes are very small, the m.e.p. is only slightly less than the average difference between the pressures on the power and compression strokes, shown by the double-ended arrows on Fig. 2.

The exhaust stroke is represented by the line (-------------) from 5 to 1. At 1 the cycle begins again with another intake stroke.

THE THEORETICAL DIESEL CYCLE

The true theoretical diesel cycle, named for Dr. Rudolph Diesel, its inventor, is shown in Fig. 3. The various operations in this cycle are represented by the same numbers and line symbols used in Fig. 2 for the corresponding operations in the Otto cycle. The pressures shown in these diagrams are typical of the cycles represented, but do not represent any particular engines.

As air is compressed its temperature tends to rise. This accounts for the heating of the cylinder of the hand tire pump when one pumps up a tire by the roadside. The principle of heating air by compression was used by some aboriginal tribes to light fires. They placed a bit of tinder in the bottom of a hollow tube and drove a closely fitting plunger into the tube by a sharp blow of the hand. The air which was trapped and compressed by the plunger was heated. The temperature inside the tube rose so high that the tinder was ignited.

Similar action takes place inside the internal combustion engine cylinder. As air is compressed by the piston its temperature rises. This fact limits the allowable compression pressures in Otto cycle engines. The fuel is already present in the cylinder during compression and would be ignited before the piston reached dead center if compression raised the temperature high enough.

The diesel engine does not introduce fuel into the cylinder until compression is completed, or nearly so. Consequently, it is practicable to compress the air so highly that its temperature rises above that required to ignite the fuel. In fact, that is the best-known characteristic of the diesel engine. It ignites fuel by the heat of compression without a spark or other external source of heat. The Otto cycle engine requires an electric spark for ignition.

The difference in typical compression pressures is clearly shown by comparison of the positions of point 3 on Figs. 2 and 3.

Fuel is always burned in the Otto cycle very rapidly while the piston is virtually stationary at the end of its stroke, so the cylinder volume does not change during combustion and the pressure rises tremendously (Fig. 2). In the true Diesel cycle the fuel is injected at a controlled rate so that it burns more slowly. The piston moves outward, increasing cylinder volume, during combustion. If the time combustion started and its rate were properly controlled, the expansion of the gases behind the piston would just compensate for the rise in temperature and the pressure would neither rise nor fall during combustion. Fig. 3 shows constant pressure combustion between points 3 and 4.

COMPRESSION RATIO

One of the early types of internal combustion engines sucked air and fuel into the cylinder during the first part of the outward stroke of the piston and then ignited and burned the fuel at about midstroke. There was no compression of air before ignition. This engine was so inefficient that it was not used long. Both theory and practical experience show that high compression ratios contribute to high efficiency. The compression ratio is the displacement volume (area of piston x stroke) plus the clearance volume (volume remaining between piston and cylinder head at the inmost end of the stroke) divided by the clearance volume. If we represent the displacement volume by the symbol V and the clearance volume by v, the compression ratio = $\frac{V + v}{v}$

The higher the compression ratio of the cylinder, the more the pressure will be raised during the compression stroke. Note that the clearance space in the diesel engine (Fig. 3) is much smaller than that of the otto engine (Fig. 2) having a cylinder of the same size. It is for this reason that the compression pressure (Point 3) is so much higher in the diesel engine than it is in the otto engine. It is this high compression ratio, which may only be used when the fuel is not present during compression, that gives the diesel engine its high efficiency.

ACTUAL CYCLE OF DIESEL ENGINES

Before discussing the cycle actually used in nearly all modern diesel engines, two more terms will be explained. Up to this point the piston has been referred to as moving inward and outward in the piston. Most diesel engines, however, have their cylinders set more or less vertically with the open ends down. Consequently the outward strokes of their pistons are downward and the inward strokes are upward. Through the rest of this discussion the directions up or down instead of in or out will therefore be used. When top of the cylinders is mentioned it will mean the closed end.

In order to convert the reciprocating motion of the piston to rotating motion to turn generators and other machinery the pistons are connected by rods to the cranks of a crankshaft (Fig. 4, a). When the center of the crank to which a given piston is connected lies exactly in line with the crankshaft bearing centers and the piston pin centers as seen from the end of the engine (Fig. 4, b and c) no amount of thrust on the piston will turn the shaft. Consequently the piston is said to be on dead center at these positions.

As the piston approaches dead center its motion slows to a stop and at the moment the crank passes the dead center position the piston is stationary. Then, as the crank continues its rotation, the piston begins its stroke in the opposite direction.

Only in engines which inject the fuel oil into the cylinder with a blast of highly compressed air can the true diesel cycle, with its combustion at constant pressure, be approximately carried out. As such engines, known as air injection engines, have been constructed up to the present, they can operate at low speeds only and are necessarily large and heavy. In order to obtain the necessary power in the available space for a locomotive diesel, the engine must run at higher speed. In such engines the fuel must be injected alone, without an air blast. This is known as solid injection.

Solid injection engines actually operate on a mixed cycle in which most of the combustion takes place at constant volume, as in the otto cycle, and only a small portion of the combustion takes place at constant pressure. The actual cycle of operations of a typical four-stroke-cycle, solid injection engine is shown in Fig. 5.

It will be noticed that in Fig. 5 the sharp corners and points of the

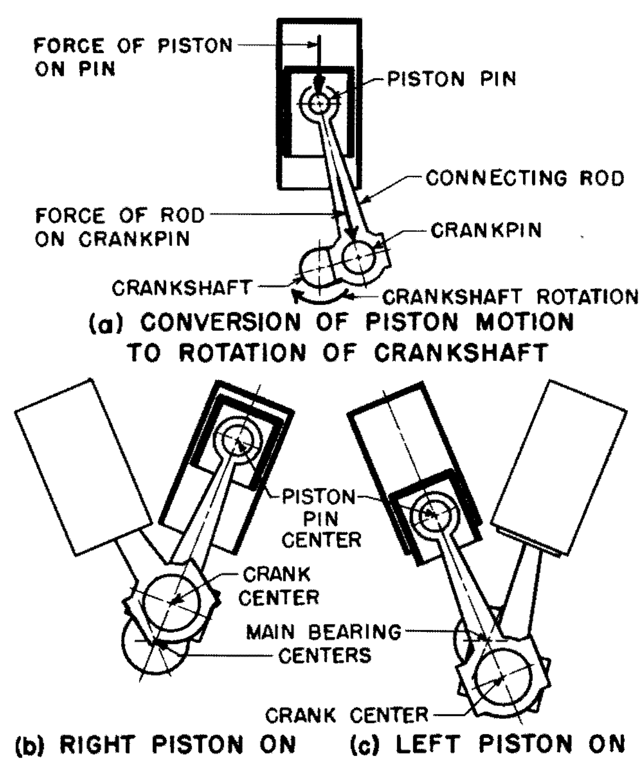


FIG. 4

previous diagrams have disappeared. These were shown in the previous diagrams because they pictured theoretical conditions. The physical limitations of actual engines produce more gradual changes from one operation to another, so that on the diagram the sharp demarcations between operations are not present. The time required for valves to open and shut, for combustion to get under way and for air and gases to start or stop motion are among the physical limitations causing the rounding of these corners.

Figure 5 represents a much larger cylinder than those represented by Figs. 2 and 3, and the horizontal dimension (cylinder volume) is drawn to a different scale. However, the pressures are shown on the same scale in all three diagrams. Notice that the sharp rise in pressure during combustion which was characteristic of the otto cycle is here added to the high compression pressure which was characteristic of the true diesel cycle. The result is a much higher firing pressure in the mixed cycle than was found in either of the others.

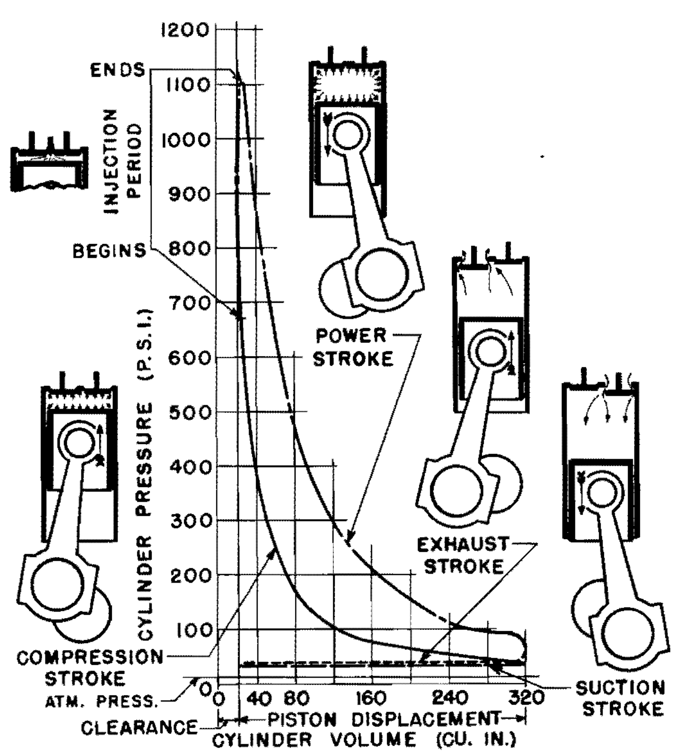
FUEL INJECTION

As the piston approaches top dead center on the compression stroke, fuel oil must be forced into the highly compressed air in the cylinder. In the engine whose operation is pictured in Fig. 5, injection begins when the piston is about 0.1" from the end of its compression stroke. Injection ends at about the same point on the power stroke. While the piston only moves a total of 0.2", or about one one-hundredth of its total travel for a revolution, during this injection period, the time consumed is about 1/8 of the time for a revolution of the crankshaft.

Since combustion is dependent on the uniting of air with the fuel, the fuel must be broken up into a very fine mist and thoroughly mixed with the air. This is accomplished by forcing the oil through tiny holes in a nozzle which projects slightly through the cylinder head into the clearance space above the piston.

The pressure with which the oil is forced through the tiny holes of the nozzle must be much higher than that within the cylinder.

The duration of the combustion period is controlled by the rate at which oil is injected into the cylinder. It burns as it enters.



ACTUAL CYCLE
SOLID INJECTION ENGINE
FIG. 5

The force with which the piston is pushed down, and hence the speed and power of the engine, is determined by the amount of fuel injected for each power stroke. The fuel injection pump meters the fuel as it pumps it, injecting just the amount called for by the governor.

If, when the cycle pictured in Fig. 5 was performed, less fuel had been injected and burned, the pressure would not have been raised so high. Consequently, the space between the compression and expansion lines (m.e.p., approximately) would have been less. If the speed of the engine had not changed, the power developed would therefore have been less. The relationship between speed, m.e.p., cylinder dimensions and power output is simple. The speed of the engine, the mean effective pressure on the piston, the length of the piston stroke, and the area of the piston all increase the power output of the cylinder as they increase. If the m.e.p. in pounds per square inch, the length of the stroke in feet, the piston area in square inches, and the number of power strokes per minute (counting all cylinders in the engine) are multiplied together and the product divided by 33,000, the result is the power developed in the engine. The actual output is reduced somewhat by friction in the moving parts.

Mathematically this is expressed in the easily remembered formula,

$$HP = \frac{PLAN}{33000}$$

From the above it may be seen that when the bore and stroke of an engine cylinder have been fixed there are still two ways in which its power output may be varied. One is to vary the amount of fuel burned per stroke (change m.e.p.). The other is to vary its speed. If the load on the engine is increased without a corresponding increase in the fuel injected per stroke, the engine speed will be decreased. If load is decreased the speed will increase. It is the function of the governor to regulate the fuel supply to maintain constant speed as the load varies.

SUPERCHARGING

It is well known that air is required to support combustion. For each pound of fuel oil burned in a four-stroke-cycle solid injection diesel engine about 25 pounds of air is necessary. At atmospheric pressure this air occupies about 324 cubic feet of space. If the pressure on this air is doubled (raised to 14.7 psi above atmospheric pressure), without changing its temperature, twice as many pounds of air will be contained in the same volume. In other words, when compressed to 14.7 psi gauge pressure, a given volume of air will support the combustion of twice as much fuel as will the same volume of air at the pressure of the natural atmosphere.

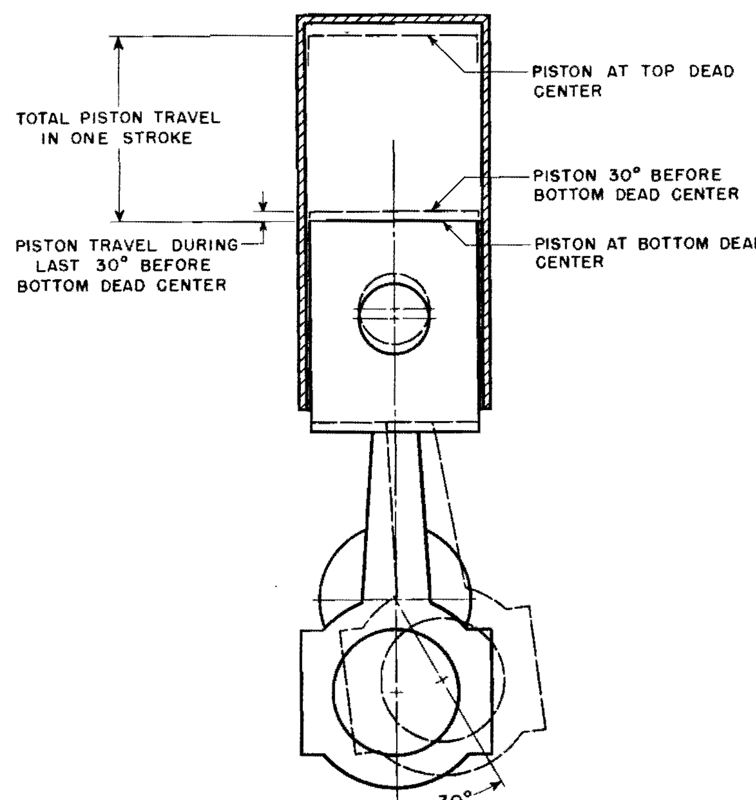
By raising the pressure of the air flowing into the cylinders (supercharging) more air is packed in on each intake stroke. This permits the burning of more fuel on each power stroke. The result is more power per cylinder from a superof the same piston stroke, cylinder bore and speed.

The cycle of operation illustrated in Fig. 5 is that of a super-charged engine. For this reason the cylinder pressure during the intake stroke is approximately 20 psi above that of the atmosphere, as is shown by examination of the diagram.

VALVES

Poppet valves in the head of the cylinder are opened by rocker arms actuated from the camshaft through push rods. These valves admit air and let out exhaust gases at the proper times. Since large volumes of gases must be handled quickly, two valves are provided for air and two for exhaust in each cylinder.

The piston moves but little and could not produce much power during the last few degrees of revolution of the crankshaft at the end of the power stroke (Fig. 6). Consequently, the exhaust valve is opened slightly before the end of this stroke, Fig. 5, to allow more time for combustion products to be completely cleared out before the cylinder is again filled with air. To further insure complete removal of combustion gases the air valve is opened somewhat before and the exhaust valve left open a few moments after the beginning of the intake stroke. Thus the incoming air is able to push out exhaust gases remaining in the clearance space. The removal of exhaust gases from the cylinder is known as scavenging, and the exhaust stroke is sometimes called the scavenging stroke.



PISTON TRAVEL DURING BOTTOM 30° OF STROKE
FIG. 6

Again at the end of the intake stroke and beginning of the compression stroke the crankshaft rotates several degrees with little movement of the piston. In order to take advantage of this time for the admission of air to the cylinder the air valves remain open until the crankshaft has rotated a few degrees beyond dead center and the piston has started on the compression stroke. (See Fig. 5).

Since a slight period of time elapses between the beginning of fuel injection and the actual ignition of the first particles of fuel, injection is started slightly before the piston reaches the end of the compression stroke. This causes ignition to begin at the desired point in the cycle. The rate at which fuel is injected is regulated so that it is burning during an appreciable length of time while the piston is passing the end of its stroke and commencing the power stroke. The result is that most of the combustion takes place at constant volume while the piston is practically stationary at the end of its stroke. During this portion of the combustion period pressure rises rapidly. The remainder of the combustion period occurs with the piston moving downward, increasing the volume occupied by the gases. This increasing volume allows the gases to expand as they are heated by the burning fuel and the rate of combustion is so controlled that the pressure remains approximately constant during this period. After combustion ceases the gases expand as the piston moves outward and the pressure consequently decreases, since no heat is now being furnished to maintain the pressure.

TURBOSUPERCHARGER

The exhaust gases leaving the cylinder still contain heat energy which cannot be extracted in the cylinder. Some of this is used to further expand the gases in a gas turbine which forms part of the turbosupercharger. The turbine consists of a number of vanes which direct the hot gases against blades mounted on the outer edge of a disk. These vanes are so shaped that the gases expanding through them gain very high velocities. When they hit the rotor blades at these high velocities they push against them, causing them to turn. The impeller of a centrifugal air compressor is mounted on the other end of the shaft on which the turbine rotor is mounted. As it turns, this impeller draws air in from the atmosphere and forces it into an air manifold under pressure. From the manifold the air rushes into each cylinder as its air valves are opened.

The exhaust stroke is found in Fig. 5 at slightly more than 20 psi above atmospheric pressure. This is due to the resistance of the supercharger turbine to the passage of the exhaust gases from the cylinder. The power taken from the cylinder by this back pressure represents but a small portion of the total required to drive the supercharger. The remainder is obtained from heat in the exhaust gases which would otherwise be lost.

CAMSHAFTS

In order to make the 12 and 16 cylinder engines compact and to avoid extremely long crankshafts the cylinders are arranged in two banks in the form of a 45° "vee". The air and exhaust valves and fuel injection pumps of each bank are operated by a camshaft. Each opening of a valve or stroke of a fuel injection pump occurs only once in four strokes of the piston. Each piston makes two strokes (one up and one down) in each revolution of the crankshaft. Consequently the camshaft must make exactly one revolution for every two made by the crankshaft. This relationship is accomplished by gearing the camshaft to the crankshaft with twice as many teeth on each camshaft gear as on the crankshaft gear.

Since the distance from crankshaft to camshaft would necessitate unduly large gears for direct meshing, an idler gear is inserted between each camshaft gear and the crankshaft gear. These idler gears have no effect on the gear ratio.

The camshaft rotation and, hence, the valve and fuel pump operation are rigidly associated with the rotation of the crankshaft. In fact the crankshaft is a major link connecting valve and injection pump operation to piston position. Consequently the crankshaft position is used as a measurement of the time when each valve or pump operation (known as an event) should occur. The timing of valve and injector events is always determined in degrees of crankshaft rotation from top or bottom dead center position of the associated piston.

COOLING

Since a great deal of heat is generated in the cylinders by the burning of the fuel they would become overheated and would soon be destroyed if some arrangement were not made for cooling them. They are cooled by circulating large amounts of water through space surrounding the cylinder walls and through passages in the cylinder heads. This water is circulated by a centrifugal pump geared to the crankshaft. The water is cooled by circulation through air cooled radiators.

LUBRICATION

All moving parts must be protected from friction by a film of oil. In order to insure this protection, lubricating oil is pumped to all bearings by a circulating pump which is also geared to the crankshaft. This oil carries away heat from the bearings, cylinders walls, and particularly from the pistons, as well as lubricating them.

It is very important to exclude dirt from the closely fitted parts and small orifices of the diesel engine. Consequently, air, fuel and lubricating oil are filtered before entering the engine.

* * * * * * * * * *

The end of the engine connected to the generator is called the generator end. The opposite end is called the free end. The free end is considered the front of the engine, even though it may be placed to the rear in a locomotive. The right side of the engine is the side of the engine on the right as one stands at the generator end and faces toward the free end. The opposite side is, of course, the left side. Cylinders are numbered from the free end.

Since the construction of the first commercially practical diesel engine in 1897, the economy of diesel engines has led engineers to strive to adapt them to more and more applications. The early diesels were too heavy and bulky to be used in other than stationary and marine applications. However, the advent of improved materials made possible the construction of engines of less weight able to withstand the high pressures inherent in diesel operation, and the development of equipment for solid injection of the fuel made high speed diesel engines possible. These high speed engines of relatively light weight are capable applications. Today the diesel engine, with such wide applicability, with rugged construction, and with the capacity to burn low cost fuel with high efficiency, reigns supreme in the field of compact, heavy-duty power plants.

MECHANICAL QUESTIONS

1. A diesel engine is an internal combustion engine utilizing ________________ ________________ ignition.

2. The four events taking place in the diesel cycle are, in the order of their occurrence:

   a. ________________ b. ________________ c. ________________ d. ____________

3. The diesel engine has a higher ______________ ______________ than a gasoline engine.

4. In a gasoline engine, combustion is caused by a spark igniting the mixture of gasoline and air. In the diesel engine combustion is caused by increasing pressure in the cylinder and raising the __________________________ of the air so that when fuel is injected into the cylinder it ignites.

5. In a four cycle engine it is necessary for the crankshaft to make ___________ revolutions to complete one cycle.

6. Supercharging means putting air into the cylinder under _______________ .

7. The turbosupercharger is driven by exhaust gases, the exhaust then: (Check one)

   ____a. is mixed in the air intake manifold.
   ____b. passes out the stack to the atmosphere.
   ____c. carried thru a pipe to heat the engine.

8. The air discharge of the turbosupercharger is connected to the _____________ ____________________.

9. When the turbosupercharger pressure is lower than normal, it is an indication that the engine is not developing ____________________________ __________________.

10. In the identification of an engine the term - 9" x 10-1/2" - indicates one of the following dimensions. (Check one)

    _____a. Bore and stroke.
    _____b. Distance between cylinders.
    _____c. Horsepower rating.

11. The ALCO 12 cylinder engine develops _____ horsepower, available for traction; the 16 cylinder engine develops ________ horsepower.

12. Idling speed of the 244 engine is ________ RPM.
    Full speed of the 244 engine is _________ RPM.
    Overspeed setting is ____________ RPM. to _______________ RPM.

13. The engine overspeed reset switch is located on the ____________ bank, ____________ end of engine.

14. The engine water pump; lube oil pump, ______________________________ and ____________________ are mounted to the free end. The cylinders are numbered from the __________________________ ________________________ of the engine.

15. The main base is fabricated to make it stiffer. True ____________________. False _______________.

16. The main purpose of the __________________ __________________ is to create a vacuum in the crankcase and to exhaust crankcase _____________________ to the atmosphere.

17. Write below the two principal purposes of the main base.

a. _________________ ________________ b. _______________ _______________

18. Give two functions of the base screens.

a. ____

b. ____

19. The main bearing shells are composed of three different metals. They are:

a. _______________ b. ________________________ c. __________________

20. Main bearings should be fitted to shaft by using a scraper.

True _________________. False _________________.

21. The main bearing caps are non-interchangeable. True ______. False ______.

22. It is important that an elongation gauge, (stretch gauge) be used in order to have the main bearing and connecting rod bolts tightened properly. What is the recommended bolt stretch? Main bearings ____________________ connecting rod bearings _____________________________.

23. The purpose of the two idler gears is to _______________. __________________.

24. The vibration damper minimizes the detrimental effect of __________________ ____________________________.

25. Bolted to the end of the lower gear casing are the water and lube oil pumps both of which are driven by gearing from the _________________________.

26. At both ends of the engine oil leakage around the crankshaft is prevented by

27. The engine can be barred over by the following method (check one).

_______ a. Holes in a flywheel.
_______ b. Timing gear and worm gear.
_______ c. Batteries.

28. The lube oil pump is a gear type pump having a capacity of _______________ gallons per minute.

29. Check the correct term below which describes the purpose of the lube oil regulating valve.

_______ a. By-pass a definite amount of oil all the time.
_______ b. Keep a definite oil pressure in the bearing header regardless of pump output.
_______ c. Clean the oil.

30. The lube oil filter tank contains _____ cartridges of the ___________ type.

31. The lube oil strainer strains all the oil going to the moving parts of the engine.

True ________. False _______.

32. Lube oil is cooled by the following method (check one).

_______ a. Jacket water in a heat exchanger.
_______ b. Passing through radiators.
_______ c. Passing through pipes in the expansion tank.

33. The main generator is connected to the engine by means of:

_______ a. Flexible coupling.
_______ b. Armature flange bolted directly to crankshaft.
_______ c. A clutch arrangement.

34. The generator adapter must be held in close alignment to the ____________ _____. This will allow the ________________ to be installed with no alignment problem.

35. It is necessary to check crankshaft deflection after mounting Main generator to the Engine.

True _______. False _______.

36. Pistons are made of (check one).

_______ a. Cast steel

37. Over sized pistons may be used in the diesel engine.

True________. False________.

38. The piston has______compression rings and __________oil control rings. All rings are made of______________ ________________.

39. To prevent the piston pin from touching the cylinder wall the piston is designed for:

______a. A drive fit in piston and connecting rod.
______b. Lock rings in piston.
______c. Aluminum plugs fitted to the piston pin holes in the piston.

40. On oil-cooled pistons the lube oil goes through the connecting rod to the hollow center of the____________ __________, then to the crown of the piston to furnish oil for ____________________________.

41. To give a longer life to cylinder liners they are ___________________________.

42. The water for cooling the cylinder liner circulates between the liner and the _____________ ______________.

43. The cylinder block is always full of water for cooling.

True________. False___________.

44. The water pump is an impeller type pump having a capacity of _____________ gallons per minute.

45. When water or oil is leaking out of the tell-tale hole immediate action should be taken to plug this hole.

True ________. False___________.

46. The cooling water fan is driven from a magnetic type clutch and is not mechanically driven by the engine.

True__________. False ____________.

47. The two purposes of the camshaft are to cause ______________ action and ______________________injection.

48. The speed of the camshaft is the same as the speed of the crankshaft.

True _________. False___________.

49. The cylinder head contains two valves for ____________ and two valves for

50. The cylinder heads are made of__________ ______________and (are) (are not) interchangeable.

51. A copper gasket is used between the cylinder liner and the cylinder head.

True__________. False __________.

52. The purpose of the valve lever assembly is to transmit cam action to the ____________________.

53. One valve lever opens two valves through the use of a ________________ arrangement.

54. Before adjusting valve clearances set the piston near top center between the compression and power strokes to insure both valve levers being in position to allow all valves to be closed. The clearance at each valve should be ______________________________ inches.

55. Lube oil is fed to the valve levers by way of the push rods.

True___________. False__________.

56. Great care should be exercised when working on injection equipment, as the smallest piece of foreign matter will impair the operation of the pump or nozzle.

True__________. False__________.

57. The amount of fuel is controlled by rotation of the plunger in the pump so that a _____________cut in the side of the plunger cuts off fuel at just the proper time.

58. Opening pressure of the fuel injection nozzle is__________pounds per square inch.

59. It is important that a__________ __________be employed when reassembling the fuel injection nozzle to the holder.

60. Nozzle tip assemblies used on the 244 engine have_________________holes with a diameter of______________________ mm.

61. Fuel pump rack reading is_____________mm idle, ________mm full load.

62. In the fuel system of the locomotive the fuel oil passes through a _________ filter before reaching the booster pump.

63. On the discharge side of the pump the fuel passes through a ______________ filter before reaching the engine.

64. After the engine has been supplied with fuel oil a regulating valve controls the pressure at ____________________ psi.

65. Fuel pump timing is ____________ degrees before top dead center.

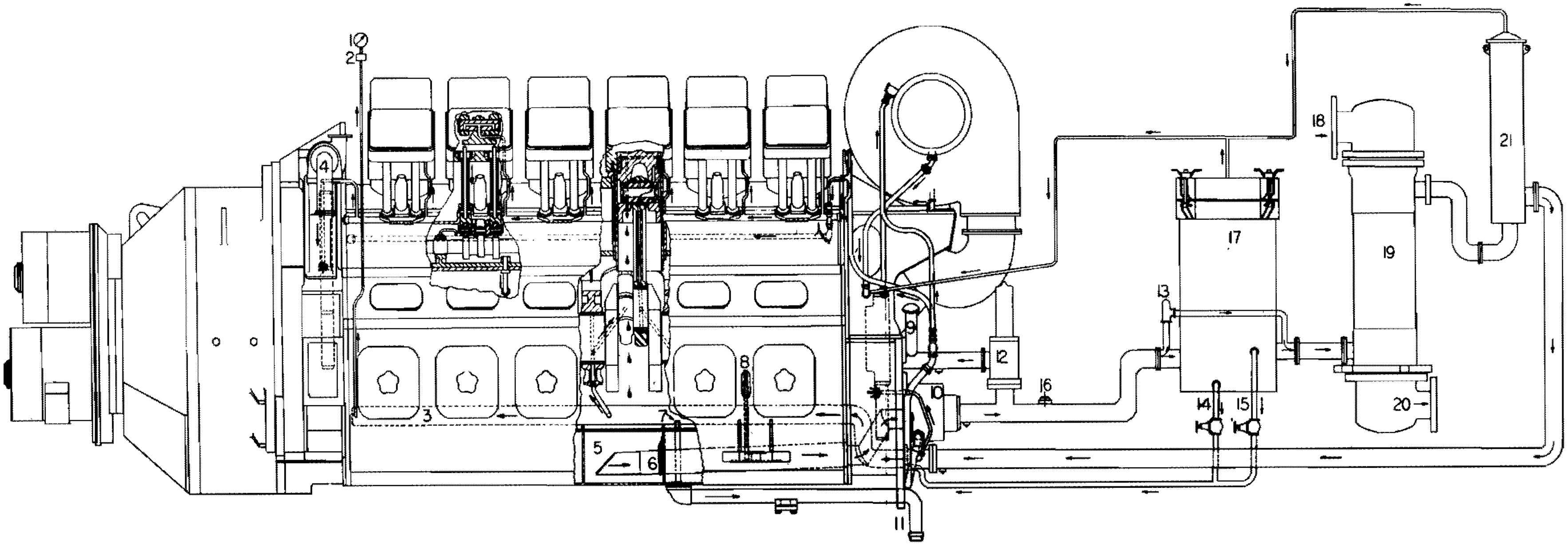
66. The air compressor is directly connected to the engine crankshaft and therefore turns whenever the engine turns but air is compressed only when needed through the use of a ____________________.

67. The air compressor has its own ________________ system, and should be checked when engine lube oil is checked.

68. The steam generator is a completely automatic, oil fired, down draft, water tube boiler.

True ____________. False ____________.

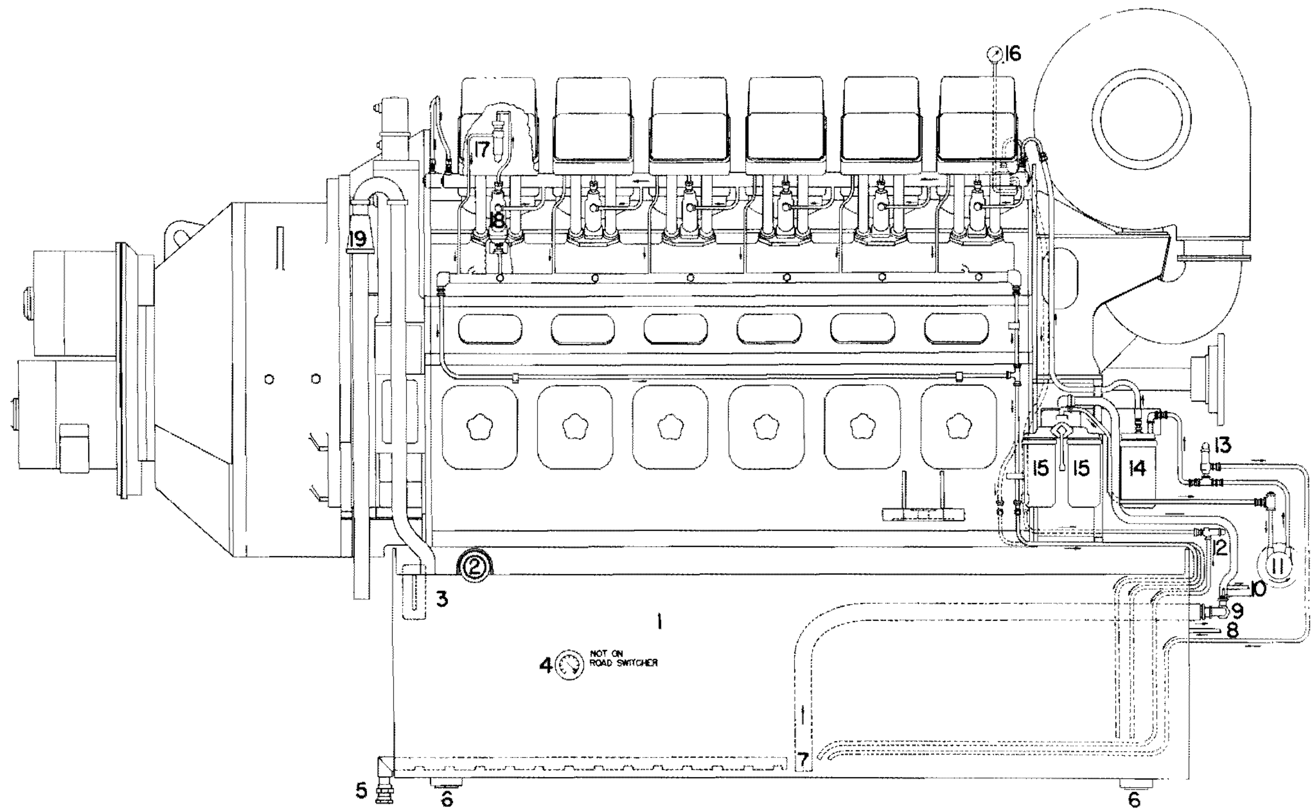
69. In the steam generator the volume of water flowing through the servo control, controls the volume of ________________ and ____________________.



LUBRICATING OIL SYSTEM

Identify the component parts of the lubricating oil system by writing below the names that correspond to the numbers above. With a green pencil trace the flow of oil through the system.

1. ______	6. ______	11. ______	16. ______
2. ______	7. ______	12. ______	17. ______
3. ______	8. ______	13. ______	18. ______
4. ______	9. ______	14. ______	19. ______
5. ______	10. ______	15. ______	20. ______



FUEL OIL SYSTEM

Identify the component parts of the fuel oil system by writing below the names that correspond to the numbers above. With a red pencil trace the flow of oil through the system.

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

11. ____________________

12. ____________________

13. ____________________

14. ____________________

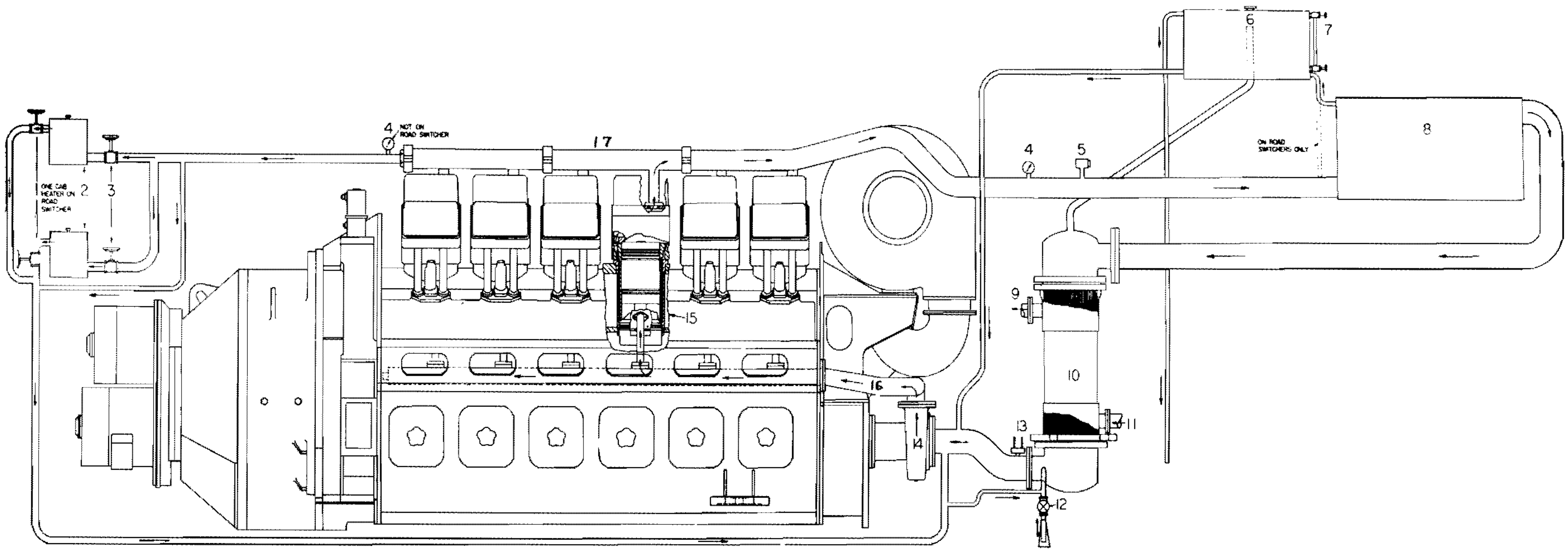
15. ____________________

16. ____________________

17. ____________________

18. ____________________

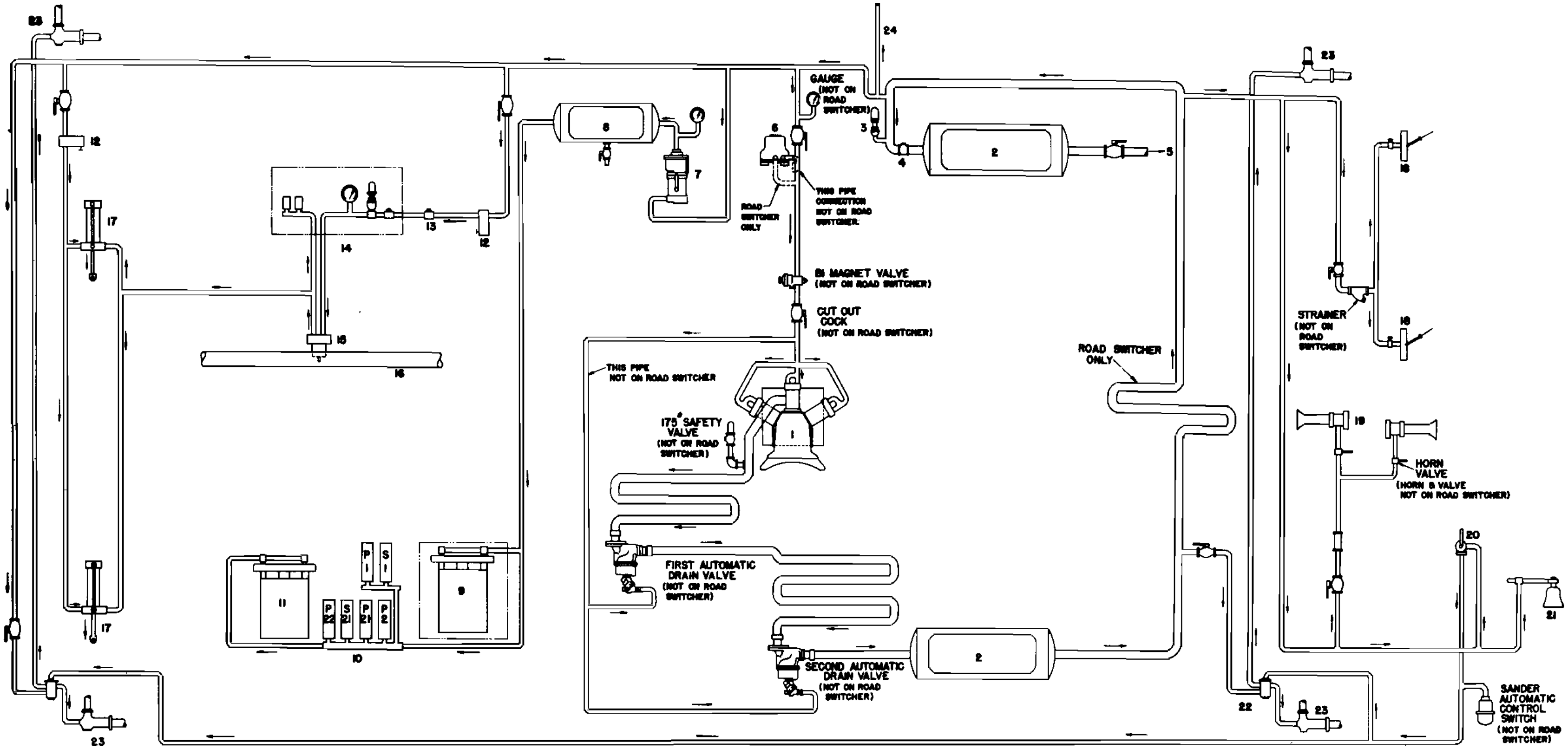
19. ____________________



COOLING WATER SYSTEM

Identify the component parts of the cooling water system by writing below the names that correspond to the numbers above. With a blue pencil trace the flow of water through the system.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________
12. ____________________
13. ____________________
14. ____________________
15. ____________________
16. ____________________
17. ____________________



AIR SYSTEM

Identify the component parts of the air system by writing below the names that correspond to the numbers above. With colored pencils trace flow of air through the system and indicate pressure levels.

1. ______	7. ______	13. ______	19. ______
2. ______	8. ______	14. ______	20. ______
3. ______	9. ______	15. ______	21. ______
4. ______	10. ______	16. ______	22. ______
5. ______	11. ______	17. ______	23. ______
6. ______	12. ______	18. ______	24. ______

ANSWERS FOR QUESTIONS
MECHANICAL STUDY GUIDE, IS-900

GENERAL

1. a. high availability
   b. flexibility
   c. low operating cost
   d. fuel economy

2. a. switcher
   b. road switcher
   c. road freight passenger
   d. road passenger

3. a. 660 HP switcher
   b. 1000 HP switcher
   c. 1000 HP road switcher
   d. 1600 HP road switcher
   e. 1600 HP 4 motor road switcher
   f. 1600 HP road freight passenger
   g. 2250 HP road passenger

4. drivers

5. steam generator
   dynamic braking grids

6. a. better riding
   b. lighter axle loading

7. a. diesel engine
   generator
   traction motors

8. battery

LOCATION OF APPARATUS

2250 HP ALCO Road Passenger Locomotive "A" Unit

1. diesel engine
2. main generator
3. exciter
4. aux. generators
5. headlight
6. contactor comp't.
7. turbosupercharger
8. turbo air filters
9. dynamic brake grids
10. control stand
11. vestibule
12. traction mtr. blowers
13. radiators
14. equalizer
15. radiator fan
16. eddy current clutch
17. lube oil cooler
18. lube oil filter
19. expansion tank
20. air compressor
21. main reservoir
22. steam generator
23. battery
24. toilet
25. fuel tank
26. fuel oil fill
27. fuel sight gauge
28. emer. fuel cutoff
29. boiler water tank
30. boiler water fill
31. truck frame
32. axle generator
33. gen. air duct
34. hand brake
35. cab heaters
36. engineer's seat
37. horn
38. bell
39. number box
40. tool compartment
41. slack adjuster
42. sanitary water fill
43. engine water fill
44. lube oil strainer

1600 HP ALCO Road Freight-Passenger Locomotive "A" Unit

1. diesel engine
2. main generator
3. exciter
4. aux. generator
5. sand filler pipe
6. contactor compt.
7. turbosupercharger
8. turbo inlet filters
9. control stand
10. marker bracket
11. trac. mtr. blowers
12. radiators
13. fan gear box
14. radiator fan
15. eddy current clutch
16. lube oil cooler
17. lube filter tank
18. expansion tank
19. air compressor
20. main reservoirs
21. batteries
22. fuel tank
23. fuel oil fill
24. fuel sight gauge
25. emerg. C.O. valve
26. sand box
27. brake cylinder
28. hand brake
29. gen. air duct
30. cab heaters
31. number box
32. horns
33. toilet
34. headlight
35. engineer's seat
36. bell
37. water tank
38. water sight glass
39. dynamic brake grids
40. steam generator

1600 HP ALCO Road Switcher Locomotive - 4 Traction Motors

1. diesel engine
2. main generator
3. exciter
4. aux. generator
5. gauge panel
6. control stand
7. brake valves
8. contactor comp't.
9. turbosupercharger
10. turbo inlet filter
11. tract. mtr. blower
12. engine water fill
13. radiator shutters
14. radiator fan
15. eddy current clutch
16. lube oil cooler
17. lube oil filters
18. lube oil strainer
19. expansion tank
20. air compressor
21. main reservoirs
22. batteries
23. fuel tank
24. filler connection
25. fuel sight glass
26. emerg. C.O. valve
27. sand boxes
28. sand box cover
29. hand brake
30. gen. air duct
31. cab heater
32. cab seat
33. horn
34. bell
35. number box
36. fuel tank drain
37. steam generator
38. water tank
39. water tank fill
40. water sight glass

1600 HP ALCO Switcher Locomotive - 6 Traction Motors

1. diesel engine
2. main generator
3. exciter
4. aux. generator
5. gauge panel
6. control stand
7. brake valves
8. contactor comp't.
9. turbosupercharger
10. turbo inlet filters
11. tract. mtr. blower
12. headlight
13. radiator shutters
14. radiator fan
15. eddy current clutch
16. lube oil cooler
17. lube oil filters
18. lube oil strainer
19. water expansion tank
20. air compressor
21. main reservoirs
22. batteries
23. fuel tank
24. fuel tank fill
25. fuel sight glass
26. emerg. C.O. valve
27. sand boxes
28. sand box covers
29. hand brake
30. gen. air duct
31. cab heater
32. cab seat
33. horn
34. bell
35. number box
36. hump controller
37. steam generator
38. water tank
39. water tank fill
40. aux. control comp't.

MECHANICAL

1. compression
2. a. intake
   b. compression
   c. power
   d. exhaust
3. compression ratio
4. temperature
5. two
6. pressure
7. b.
8. air manifold
9. full horsepower
10. a.
11. 1600, 2250
12. 350, 1000, 1100-1120
13. left, generator
14. turbocharger
    governor
    free end
15. true
16. crankcase exhauster vapors
17. support engine, oil sump
18. protect oil pump from foreign materials
    indicate bearing failure when making crankcase inspection
19. steel, copper lead, babbitt
20. false
21. true
22. .019," .015"
23. rotate camshaft gears
24. torsional vibration
25. crankshaft
26. oil slinger
27. b.
28. 267
29. b
30. 5, waste packed
31. true
32. a.
33. b.
34. crankshaft, generator
35. true
36. c.
37. false
38. 3, 3. cast iron
39. c.
40. piston pin, cooling
41. chrome plated
42. water jacket
43. false
44. 650·
45. false
46. true
47. valve, fuel
48. false
49. air, exhaust
50. cast iron, (are)
51. false
52. valves
53. bridge
54. .012
55. false
56. true
57. helix
58. 3600
59. centering sleeve
60. 9 .375
61. 11.5, 24.5
62. waste
63. micron
64. 35-40
65. 18°
66. governor
67. lubricating
68. true
69. fuel, air

SYSTEMS

Lubricating Oil System

1. pressure gauge
2. oil pressure switch
3. main lube oil header
4. crankcase exhauster
5. oil sump
6. suction pipe
7. sump drain plug
8. bayonet gauge
9. filler pipe
10. lube oil pump
11. sump drain pipe
12. regulating valve
13. filter by-pass valve
14. lower filter drain
15. upper filter drain
16. priming plug
17. lube oil filter
18. water inlet
19. lube oil cooler
20. water outlet
21. lube oil strainer

Fuel Oil System

1. tank
2. fill connection
3. sight glass
4. level indicator
5. drain valve
6. washout plug
7. suction pipe
8. St. Gen. return
9. emerg. cutoff valve
10. St. Gen. supply
11. fuel pump
12. regulating valve
13. relief valve
14. press. filter
15. suction filter
16. press. gauge
17. injection nozzle
18. injection pump
19. spark arrestor

Cooling Water System

1. heater outlet valve
2. cab heaters
3. heater inlet valve
4. water temp. gauge
5. high temp. switch
6. expansion tank
7. sight glass
8. radiators
9. lube oil outlet
10. lube oil cooler
11. lube oil inlet
12. water drain valve
13. temp. control thermostat
14. water pump
15. water jacket
16. water inlet header
17. water outlet header

Air System

1. compressor
2. main reservoir
3. safety valve
4. check valve
5. air brake line
6. air comp. gov.
7. control air reducing valve
8. control air reservoir
9. dyn. brake switch
10. power contactors
11. reverser
12. filter
13. reducing valve
14. temp. control panel
15. eng. temp. thermostat
16. water header
17. shutter Grad-U-Mt.
18. window wipers
19. horns
20. sand cont. valve
21. bell
22. sander auto. valve
23. sandtrap reservoir
24. main train line

Alco

AMERICAN LOCOMOTIVE COMPANY
Schenectady, N. Y.

Printed in U. S. A.

December 1953