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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT VI, MAINTAINING MECHANICAL GOVERNORS--DETROIT DIESEL ENGINES.
HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO
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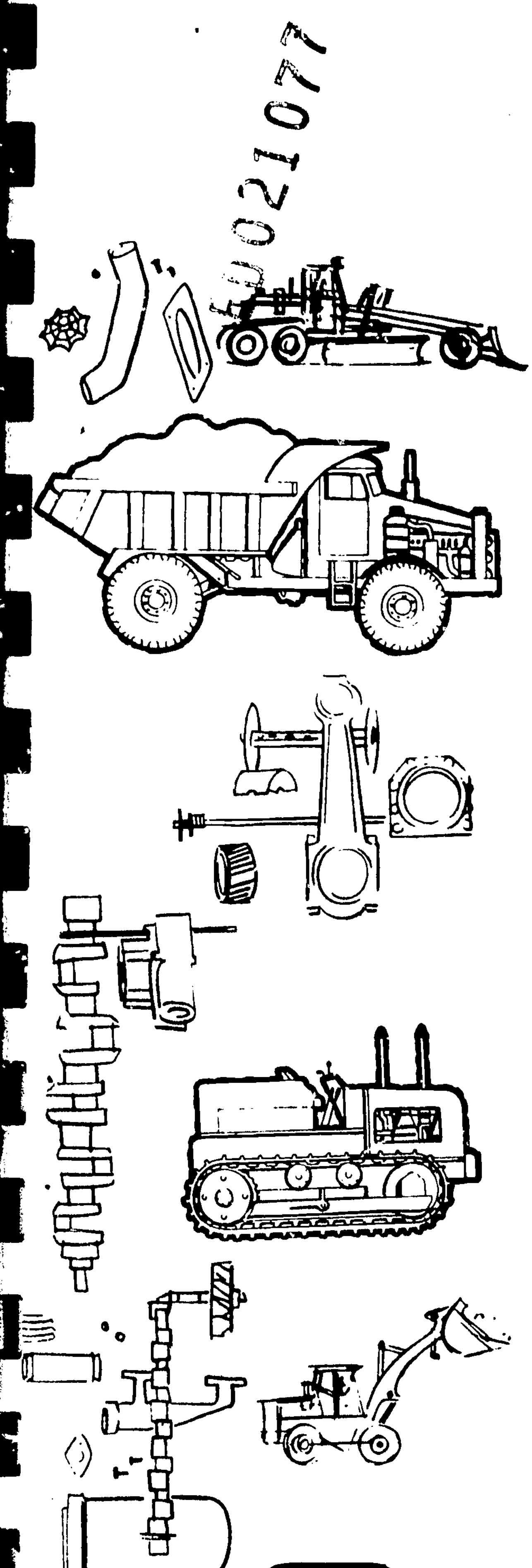
THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATION AND MAINTENANCE OF MECHANICAL GOVERNORS USED ON DIESEL ENGINES. TOPICS ARE (1) TYPES OF GOVERNORS AND ENGINE LOCATION, (2) GOVERNOR APPLICATIONS, (3) LIMITING SPEED MECHANICAL GOVERNOR, (4) VARIABLE SPEED MECHANICAL GOVERNOR, AND (5) CONSTANT SPEED MECHANICAL GOVERNOR. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "MECHANICAL PRINCIPLES OF GOVERNOR OPERATION" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

STUDY AND READING MATERIALS



AUTOMOTIVE DIESEL MAINTENANCE 1

MAINTAINING MECHANICAL GOVERNORS -- DETROIT DIESEL ENGINES

UNIT VI

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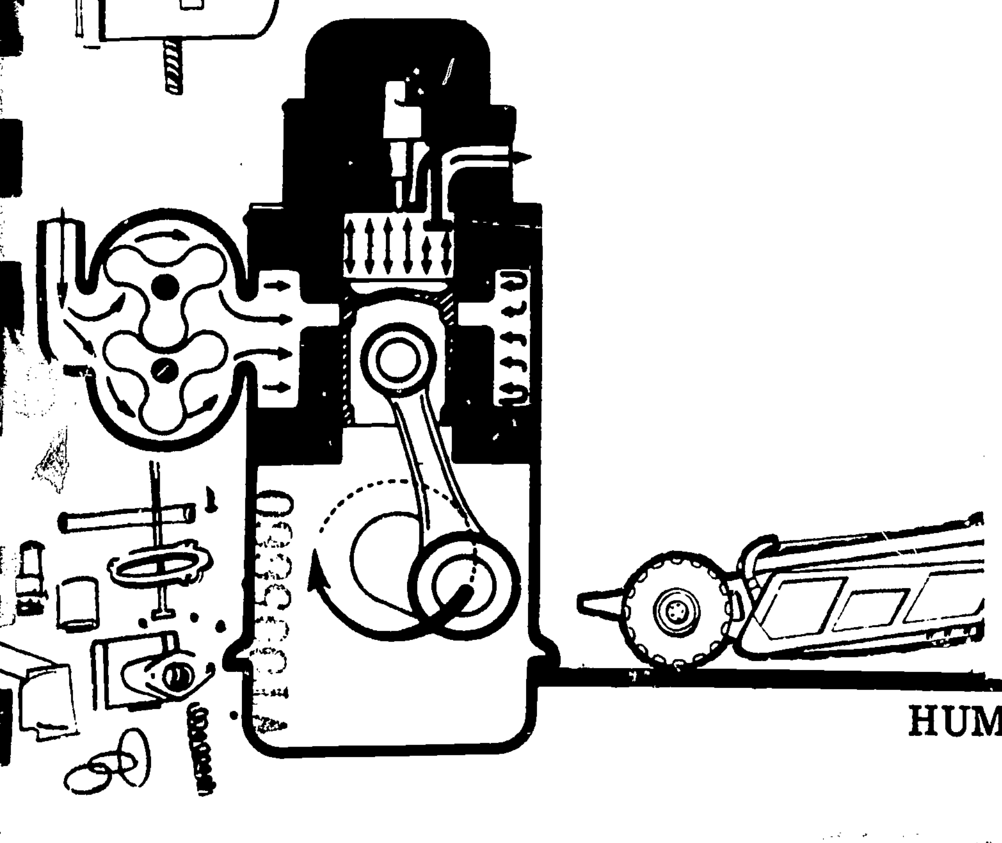

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SECTION A -- TYPES OF GOVERNORS AND ENGINE LOCATION

The power requirements on an engine may vary due to fluctuating loads; so there must be some way to control the amount of fuel required to hold the engine speed reasonably constant during load fluctuations. So we have a governor in the linkage between the throttle control and the fuel injectors.

Figures 1 and 2 represent a typical governor mounting on the In-line 71 and V-71 Series engines. Both governors are the mechanical limiting speed type.

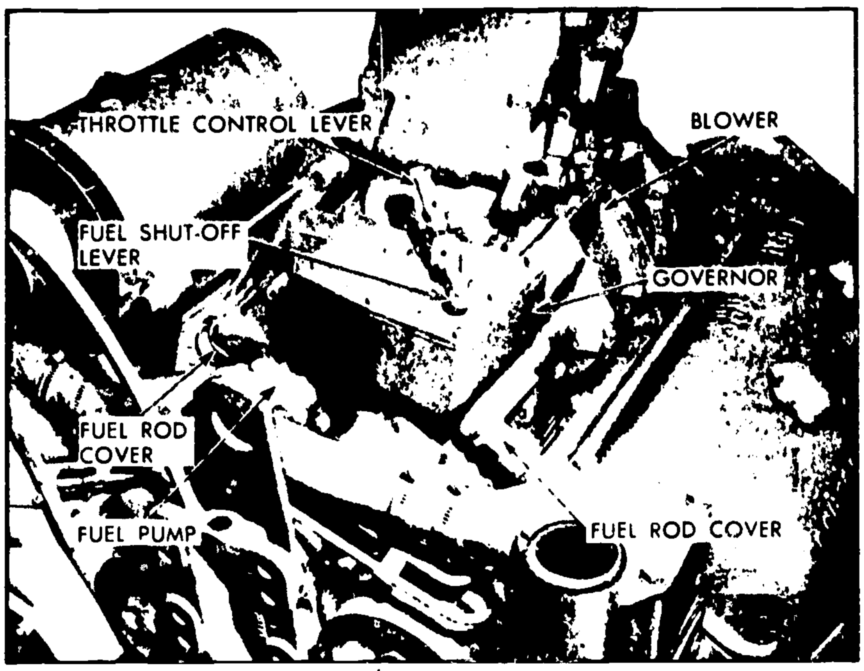


Fig. 1 Limiting speed mechanical governor mounting in V-71 Series.

There are three basic types of mechanical governors. They are:

1. Limiting speed mechanical governor.
2. Variable speed mechanical governor.
3. Constant speed mechanical governor.

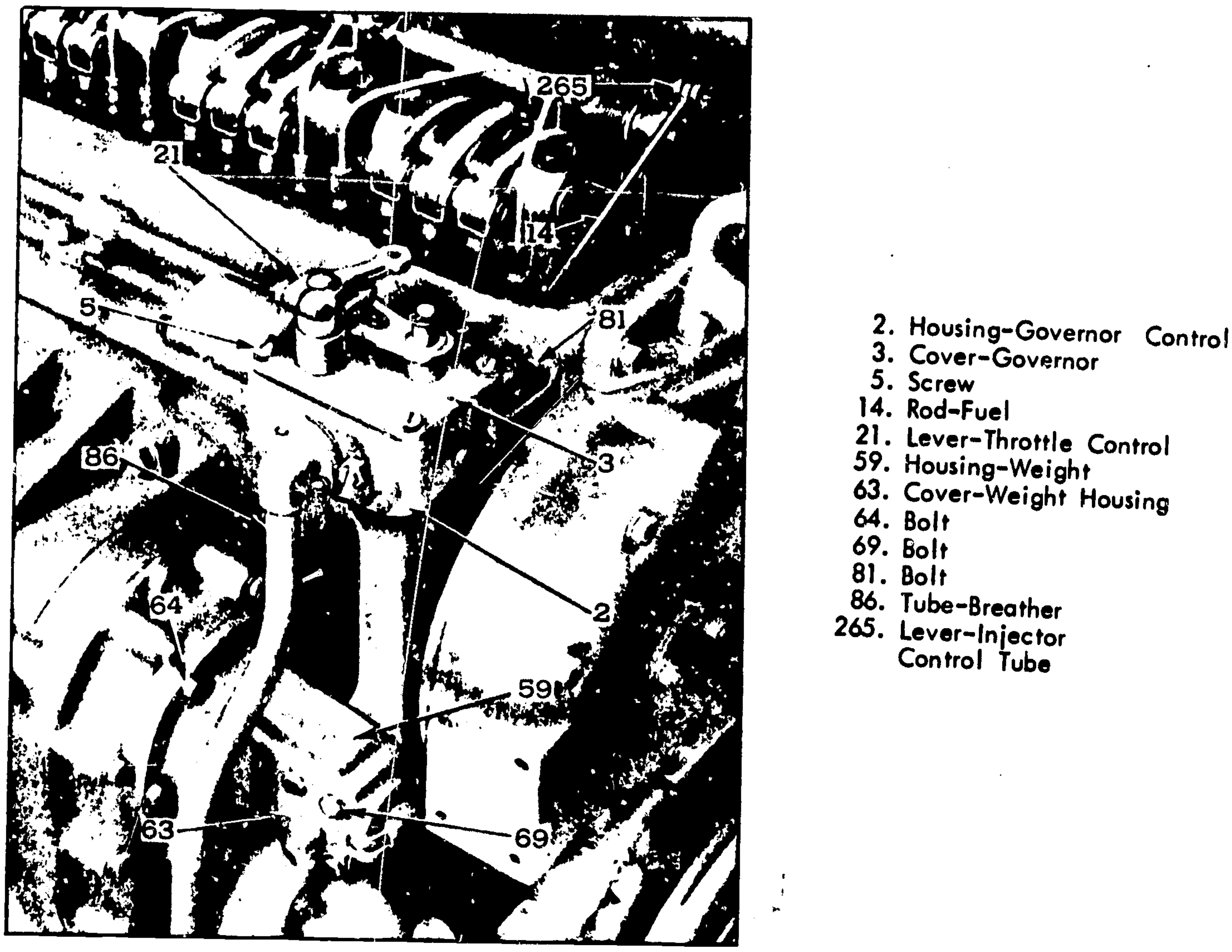


Fig. 2 - Typical Limiting Speed Governor Mounting
In-Line 71 Series

SECTION B -- GOVERNOR APPLICATIONS

In this unit we'll cover all three of these governors, but will concentrate on the limiting speed mechanical governor since it is the most widely used on off-highway mobile equipment.

An engine requiring minimum and maximum speed controls, together with manually controlled intermediate speeds, is equipped with a limiting speed mechanical governor. An example of this application would be a truck, or a rubber-tired dozer or loader.

An engine subjected to varying load conditions that require an automatic fuel compensation to maintain a near constant engine speed -- which may be changed manually by the operator -- is equipped with a variable speed mechanical governor. An example of this application would be a saw mill.

Constant speed mechanical governors are used on engines which require a constant speed of predetermined value. There is no intermediate or manually controlled range between high and low engine speeds. The only requirement is to control idling speed and to maintain a constant operating speed. An example of this application would be a generator set.

SECTION C -- LIMITING SPEED MECHANICAL GOVERNOR (IN-LINE AND V-71 SERIES)

In the V-71 series engines, the governor is mounted on the front end of the blower and is driven by a blower rotor. The governor assembly consists of two sub-assemblies:

1. Control housing cover.
2. Control and weight housing.

The limiting speed governors used on V-71 engines are double weight type. For certain applications, double weight, dual range governors are provided.

LUBRICATION -- On the V-71 engines oil sprayed from an orifice in the front blower end plate lubricates the governor. This orifice directs a stream of oil onto the revolving governor weights, and the weights in turn sling the oil to all moving parts within the governor. Surplus oil returns to the engine crankcase through connecting passages in the blower and cylinder block.

The limiting speed mechanical governor illustrated in Figure 1, performs two functions:

1. Controls the engine idle speed.
2. Limits the maximum operating speed of the engine.

The limiting speed mechanical governor which is used on the In-line 71 Series engines is also mounted on the front of the blower as illustrated in Figure 2.

The governor is driven by the upper blower rotor. The governor used on the In-line Series engines consists of three sub-assemblies:

1. Control housing cover.
2. Control housing.
3. Weights and housing.

Surplus oil from the cylinder head provides lubrication for the parts in the governor control housing, while oil picked up from a reservoir in the blower front end plate by a slinger attached to the lower rotor shaft, provides lubrication for the governor weights and weight carriers.

The governor illustrated in Figure 2, does three things:

1. Controls the engine idle speed.
2. Limits the maximum operating speed of the engine.
3. Regulates fuel input at part throttle.

The limiting speed governors used on the In-line 71 series engines may either be single weight or double weight type. Double weight dual range and fuel modulating type governors are provided for certain applications.

In both series, each governor has an identification plate located on the control housing, containing the governor assembly number, type, idle range rpm, and drive ratio.

The governor provides full fuel for starting when the control lever is in the idle position. Immediately after starting, the governor moves the injector racks to that position required for idling.

There are actually several types of mechanical limiting speed governors used on In-line 71 and V-71 series engine. The type of governor used on a particular engine is determined basically by the engine application -- its function or job.

Because the governors used on the In-line 71 and V-71 series engines are similar in operation and construction, we will combine both series, and point out the variations.

Let's take a look at how each of these governors works.

SINGLE WEIGHT GOVERNOR IN-LINE 71 -- The centrifugal force of the revolving governor weights (76), see Figure 3, is converted into linear motion which is transmitted through the riser (67) and operating shaft (26) to the operating shaft lever (27). One end of lever (27) operates against the high and low speed springs (48 and 46) through the spring cap (47), while the other end provides a moving fulcrum on which the differential lever (23) pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low speed spring (depending on the speed range), the governor stabilizes the engine speed for a given setting of the governor control lever.

In the low speed range, the centrifugal force transmitted operates against the low speed spring. As the engine speed is increased, the centrifugal force compresses the low speed spring (46) until spring cap (47) is tight against the high speed plunger (44). This removes the low speed spring from operation and the governor is then in the intermediate speed range. In this range, the centrifugal force is operating against the high speed spring and thus the engine speed is manually controlled.

As the engine speed is increased to a point where the centrifugal force overcomes the pre-load of the high speed spring, the governor will move the injector racks out to the position required for maximum no-load speed.

A fuel rod (14), connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The engine idle speed is determined by the centrifugal force required to

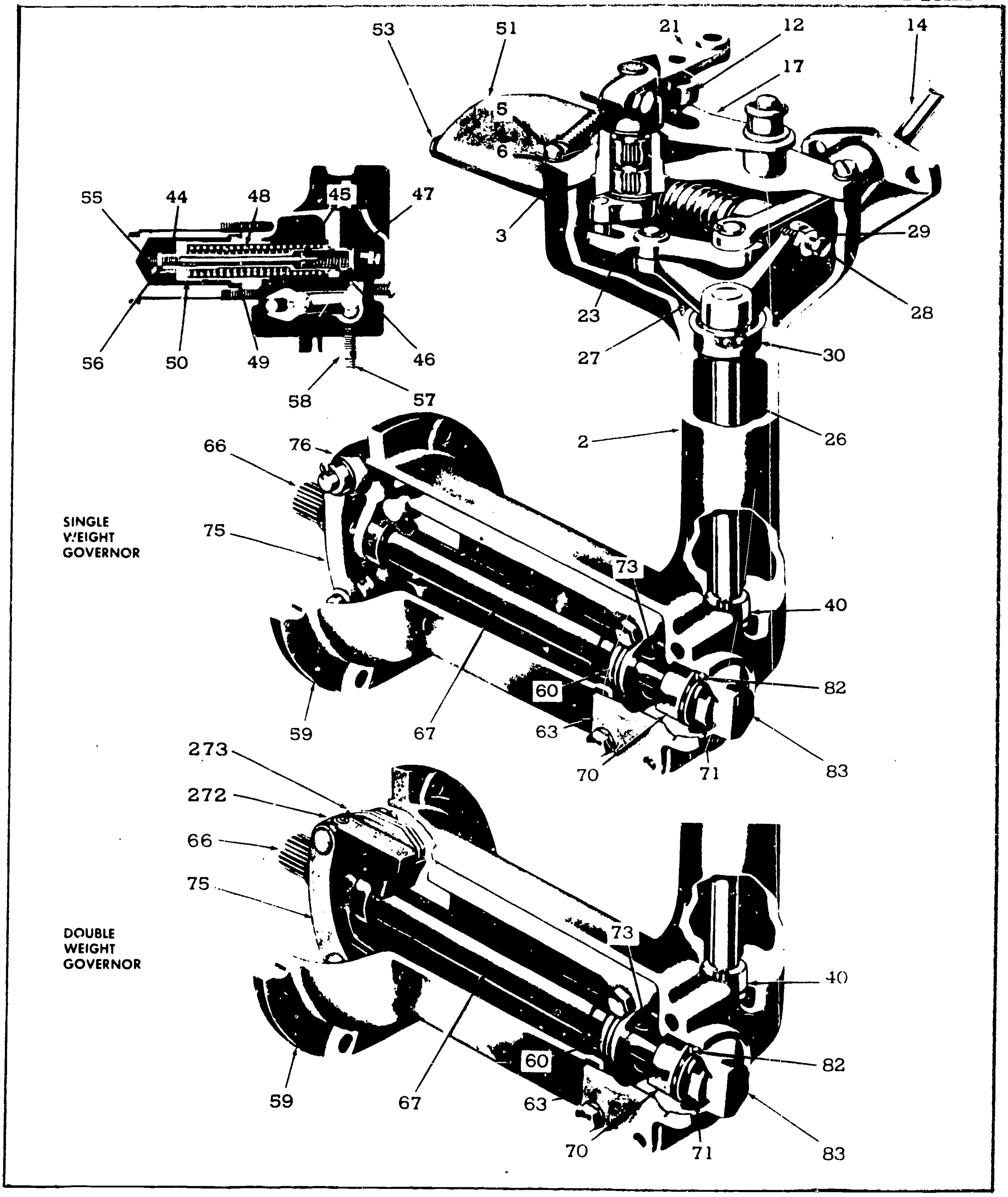


Fig. 3 Limiting speed mechanical governors (Series 71).

balance out tension on the low speed spring.

We adjust engine idle speed by changing the tension on the low speed spring, using the idle adjusting screw (55).

The maximum no-load speed is determined by the centrifugal force required to balance out the tension on the high speed spring.

Adjustment of the maximum no-load speed is done by the high speed spring retainer (50). Movement of the high-speed spring retainer nut will increase or decrease the tension on the high speed spring.

DOUBLE WEIGHT GOVERNOR -- IN-LINE 71 AND V-71 SERIES -- The centrifugal force of the revolving governor weights (272 and 273), see Figure 3, is converted into linear motion which is transmitted through the riser (67) and operating shaft (26) to the operating shaft lever (27). One end of lever (27) operates against the high and low-speed springs (48 and 46) through the spring cap (47), while the other end provides a moving fulcrum on which the differential lever (23) pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low speed spring (depending on the speed range), the governor stabilizes the engine speed for a given setting of the governor control lever.

In the low-speed range, the centrifugal force of the low-speed weights operates against the low-speed spring. As the engine speed increases, the centrifugal force of the low-speed weights compresses the low-speed spring until the weights are against their stops, thus limiting their travel, then the low-speed spring is fully compressed and the low-speed cap is against the high-speed plunger.

Throughout the intermediate speed range the operator has complete control of the engine because both the low-speed spring and the low-speed weights are against their stops, and the high-speed weights are not exerting enough force to overcome the high-speed spring.

As the speed continues to increase, the centrifugal force of the high-speed weights increases until this force can overcome the high-speed spring and the governor again takes control of the engine, limiting the maximum engine speed.

A fuel rod (14), connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The engine idle speed is determined by the centrifugal force of the low speed weights (272) required to balance out tension on the low-speed spring

Adjustment of the engine idle speed is done by changing the tension on the low-speed spring by means of the idle adjusting screw (55).

The maximum no-load speed is determined by the centrifugal force of the high-speed weights (273) required to balance out the tension on the high-speed spring.

Adjustment of the maximum no-load speed is done by the high-speed spring retainer (50). Movement of the high-speed spring retainer nut will increase or decrease the tension on the high-speed spring.

In the V-71 series there is a slight variation in that at the low-speed range, the centrifugal force of the low and high-speed weights together operate against the low-speed spring. As the engine speed increases, the centrifugal force of the low and high-speed weights together compresses the low-speed spring until the low-speed weights are against their stops, thus limiting their travel. At this time the low-speed spring is fully compressed and the low-speed spring cap is within .0015" of the high-speed plunger.

SECTION D -- VARIABLE SPEED MECHANICAL GOVERNORS (IN-LINE AND V-71 SERIES)

OPERATION -- The variable speed mechanical governor performs three functions:

1. Controls the engine idle speed.
2. Limits the maximum no-load speed.
3. Holds the engine at any constant speed, between idle and maximum, as desired by the operator.

The governor is mounted on the front of the blower, and is driven by a blower rotor on the V-71 engines and by the upper blower rotor on the In-line 71 engines.

Two manual controls are provided on the variable speed governor: a governor control lever for starting and stopping, and a speed control lever. For starting, the governor control lever is moved to the RUN position, which moves the injector control racks to the FULL FUEL position. Upon starting, the governor moves the injector racks out to that position required for idling. The engine speed is then controlled manually by movement of the speed control lever.

The centrifugal force of the revolving governor weights is converted into linear motion, which is transmitted through the riser and operating shaft to the operating shaft lever. One end of the operating shaft lever bears against the variable speed plunger, while the other end provides a changing fulcrum on which the differential lever pivots.

The centrifugal force of the governor weights is opposed by the variable speed spring. Load changes, or movement of the speed control lever, create an unbalanced force between the revolving governor weights and the tension on the variable speed spring. When the two forces are equal, the engine speed stabilizes for a setting of the speed control lever.

Fuel rods connected to the injector control tube levers and the control link operating lever assembly are operated by the differential lever, through the operating lever connecting link. This arrangement provides a means for the governor to change the fuel settings of the injector control racks.

The engine idle speed is determined by the centrifugal force required to balance out the tension on the variable speed spring in the low-speed range.

Adjustment of the engine idle speed is accomplished by changing the tension on the variable speed spring by means of the idle speed adjusting screw.

Adjustment of the maximum no-load speed is accomplished by varying the tension on the variable speed spring by the installation or removal of stops and shims, as required.

Lubrication for the variable speed governors is done exactly the same way as in the limiting speed governors.

SECTION E -- CONSTANT SPEED MECHANICAL GOVERNOR (IN-LINE 71)

OPERATION -- The constant speed governor has only one speed setting. Upon starting the unit, the engine will automatically attain a speed of approximately 1250 rpm.

This speed can be adjusted by the use of shims behind the governor spring. As the load is applied to the unit, the engine speed drops until at full load the speed is approximately 1200 rpm.

The governor is mounted at the front end of the blower and is driven by the upper blower rotor.

A spring on the top of the governor holds the governor control lever in the

"Run" position. A cable from the instrument panel, when pulled, overcomes the spring and draws the injector racks to the "no fuel" position (through the governor), thus stopping the unit.

The centrifugal force of the revolving flyweights is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever, one end of which is the spring seat, while the other end provides a changing fulcrum that the differential lever pivots on. A fuel rod, connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The centrifugal force of the governor weights is opposed by the governor spring. Load changes create an unbalanced force between the revolving governor weights and the tension of the spring. When the two forces are equal, the engine speed stabilizes. Whenever the centrifugal force of the revolving weights overcomes the tension of the spring, the injector racks will be moved toward the "no fuel" position. Also, whenever the centrifugal force of the weights allows the spring to expand, the injector racks will move toward the "full fuel" position.

Adjustment for the no load speed is made by varying the tension of the spring by the use of shims. The addition of shims behind the spring will raise the engine speed; likewise, the removal of the shims will lower the engine speed.

CHECKING GOVERNOR OPERATION -- Governor difficulties usually are indicated by speed variations of the engine. However, this doesn't mean that <u>all</u> such speed fluctuations are caused by the governor. Therefore, when improper speed variations appear, the unit should be checked as follows:

1. Make sure the speed changes are not the result of excessive load fluctuations.
2. Check the engine to be sure that all cylinders are firing properly.
3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and injector control tube.

With the fuel rod connected to the injector control tube lever, the mechanism should be free from bind throughout the entire travel of the injector rack(s). If friction exists in the mechanism, it may be located and corrected as follows:

1. If an injector rack sticks or moves too hard, it may be due to the injector hold-down clamp being too tight or improperly positioned.

   To correct this condition, loosen the injector clamp, reposition, and tighten to 20-25-ft-lb torque.

2. A binding injector may result from internal dirt accumulation, defective plunger and bushing, or a bent injector rack.

   The injector must then be removed, reconditioned, and tested.

3. An injector rack may bind as the result of an improperly positioned control rack lever.

   Loosen control rack adjusting the screws. If this relieves the bind, relocate the lever on the control tube and position the rack.

4. The injector control tube may bind in its support brackets, thus preventing free movement of the injector racks to their "no-fuel" position due to tension of the return spring.

   This condition may be corrected by loosening and realigning the control tube supporting brackets.

   If the control tube support brackets were loosened, realigned and tightened, the injector racks must be repositioned.

5. A bent control tube return spring may cause friction in the operation of the injector control tube.

   If a control tube return spring has been bent or otherwise distorted, install a new spring.

6. Check for bind in the pin which connects the fuel rod to the injector control tube lever and replace the pin if necessary.

If, after making the preceding checks, the governor fails to control the engine properly, the governor should be removed and reconditioned.

CLEANING AND INSPECTING THE GOVERNOR -- Before removing any parts from the governor, wash the entire unit in clean fuel oil, dry it with compressed air, and inspect for worn or damaged parts that you can repair or replace without complete disassembly.

Once the governor has been disassembled, dip all governor parts in a suitable cleaning fluid to loosen and remove all accumulations of foreign material. Use a stiff brush and compressed air, as necessary, to assure absolute cleanliness of all parts.

The function of the governor is to control the fuel injection by means of a linkage within the governor plus inter-connecting linkage between governor and the injector. It is extremely important that all moving parts be absolutely free, and that no binding exists under any condition of operation.

Inspect all the bearings to be sure that they are absolutely free of corroded or pitted surfaces, and that they are otherwise staisfactory for further use.

Revolve operating shaft bearing and the governor weight shaft bearing slowly by hand; replace the bearings if rough or tight spots are detected.

Inspect the spring seats, plungers, adjusting screws, lock nuts, and other parts of the control housing for defects that might affect the governor operation.

Inspect the operating shaft and the shaft bushing for excessive wear. If excessive wear is noted, a new bushing and shaft must be installed.

Examine the riser thrust bearing for excessive wear, flat spots or corrosion. If any of these conditions exist, a new thrust bearing assembly must be installed.

Inspect the roller bearings and the throttle shaft for excessive wear or flat spots. If one or both conditions exist, new bearings and throttle shaft must be installed.

If new bearings are installed in the governor cover, the lower bearing should be flush with the lower end of the bearing boss. The upper bearing must be pressed in approximately 1/8" below the top surface of the upper bearing boss.

Examine the weight carrier pins and bearings for excessive wear and flat spots. If either of these conditions exist, new parts must be installed.

Weights should be assembled and checked for free movement.

In conclusion, remember that dirt is the primary factor which tends to prevent successful governor operation. The governor cannot be expected to control the engine speed unless the governor drive, and the linkage between the governor and the fuel injection system are free of dirt.

Also, if the governor and linkage are not properly aligned, binding will cause excessive friction and hunting will result When installing or adjusting the governor, never force the parts into place as this may bend the parts and cause malfunction of the controls.

DIDACTOR PLATES for AUTOMOTIVE DIESEL MAINTENANCE

Plate I - Simple Flyweight Governor

1. drive shaft from engine
2. drive-shaft gear
3. flyweight
4. speeder spring
5. ball arm
6. pivot for ball arm
7. ball head
8. ball-arm toe
9. support bearing
10. speeder rod
11. axis of rotation

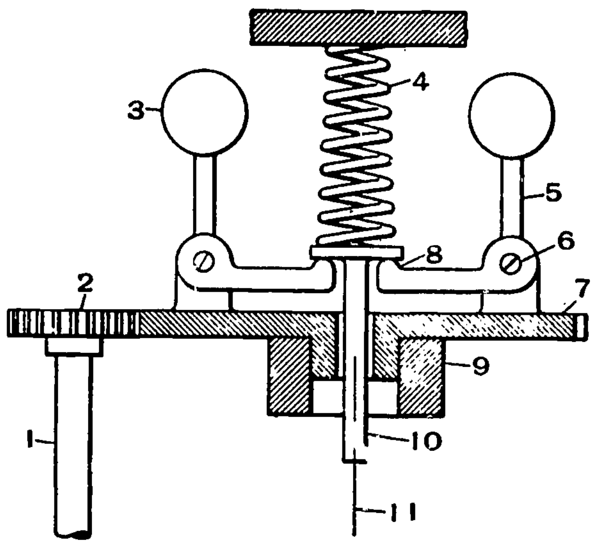


Plate II - Governor at Normal Speed

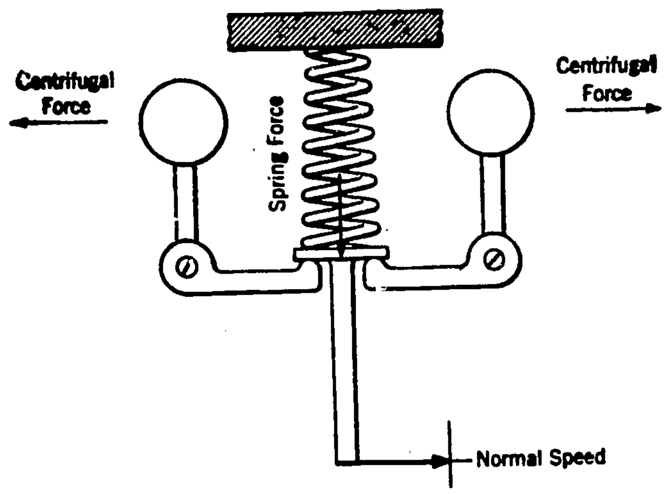


Plate III - Engine at Higher RPM

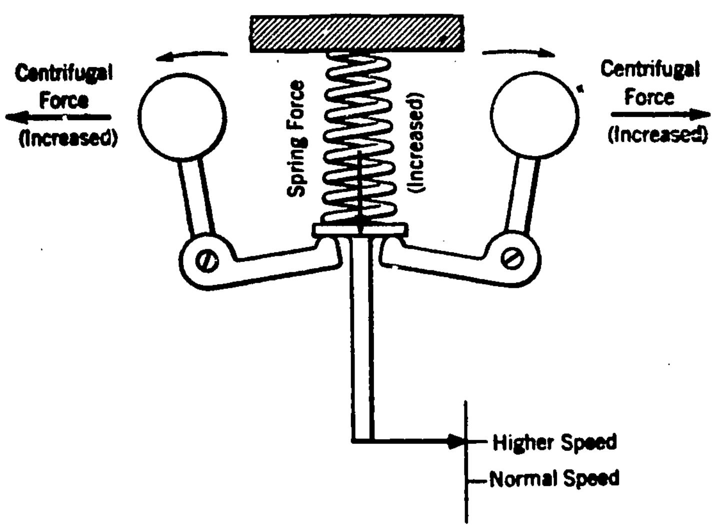


Plate IV - Engine at Lower RPM

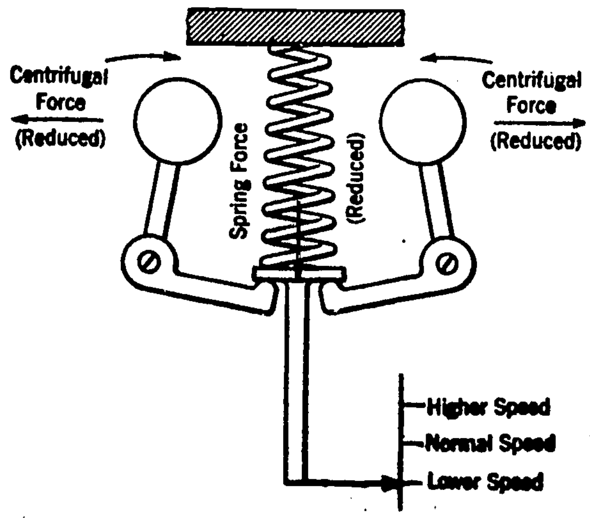
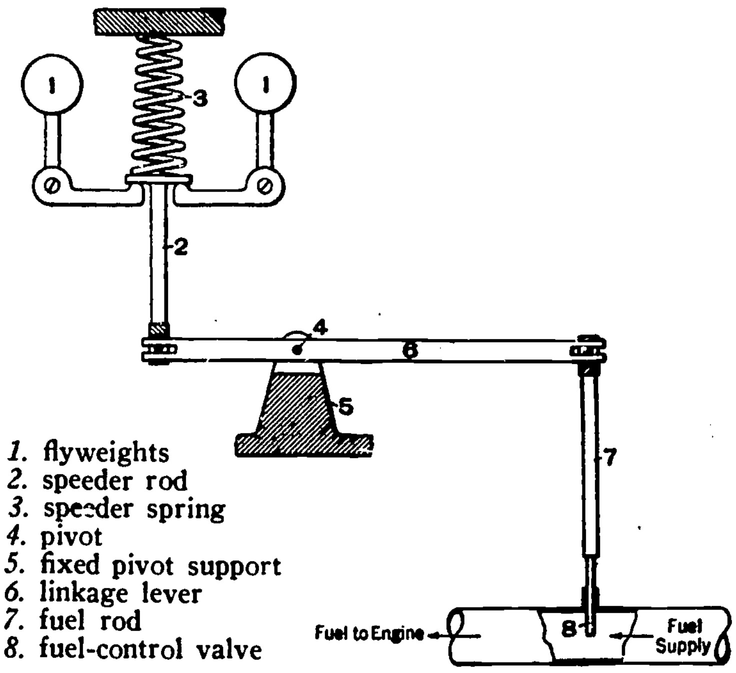


Plate V - Governor Control Linkage



1. flyweights
2. speeder rod
3. speeder spring
4. pivot
5. fixed pivot support
6. linkage lever
7. fuel rod
8. fuel-control valve

Plate VI - Fuel Increasing

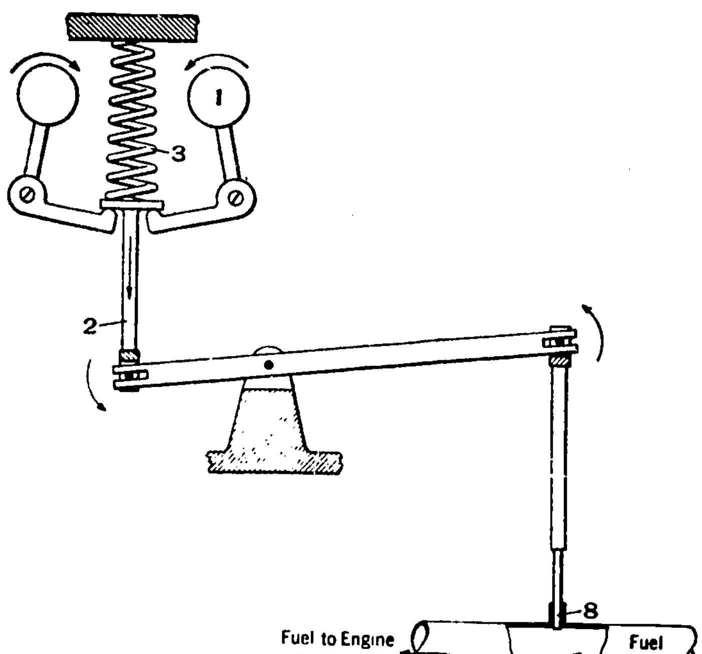


Plate VII - Reduced Engine Speed

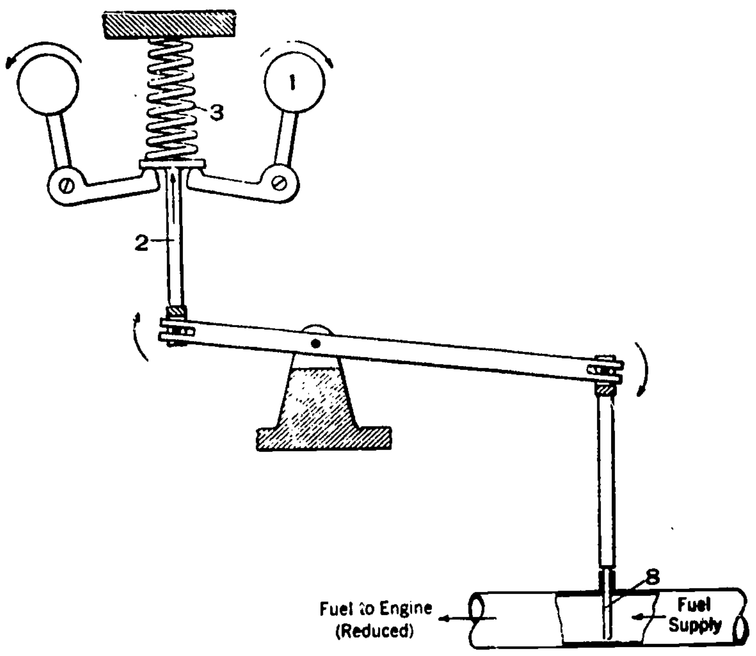


Plate VIII

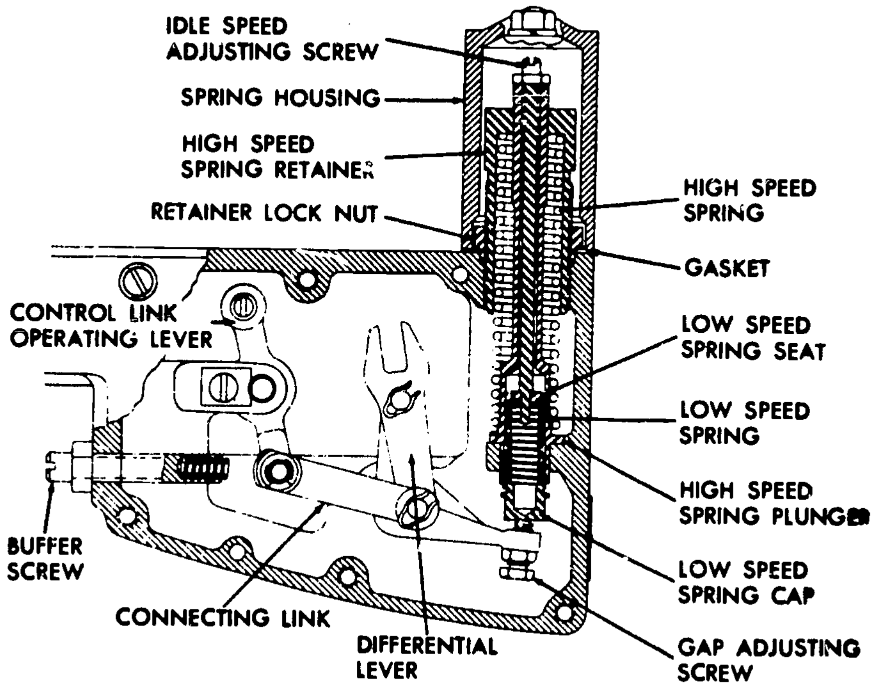
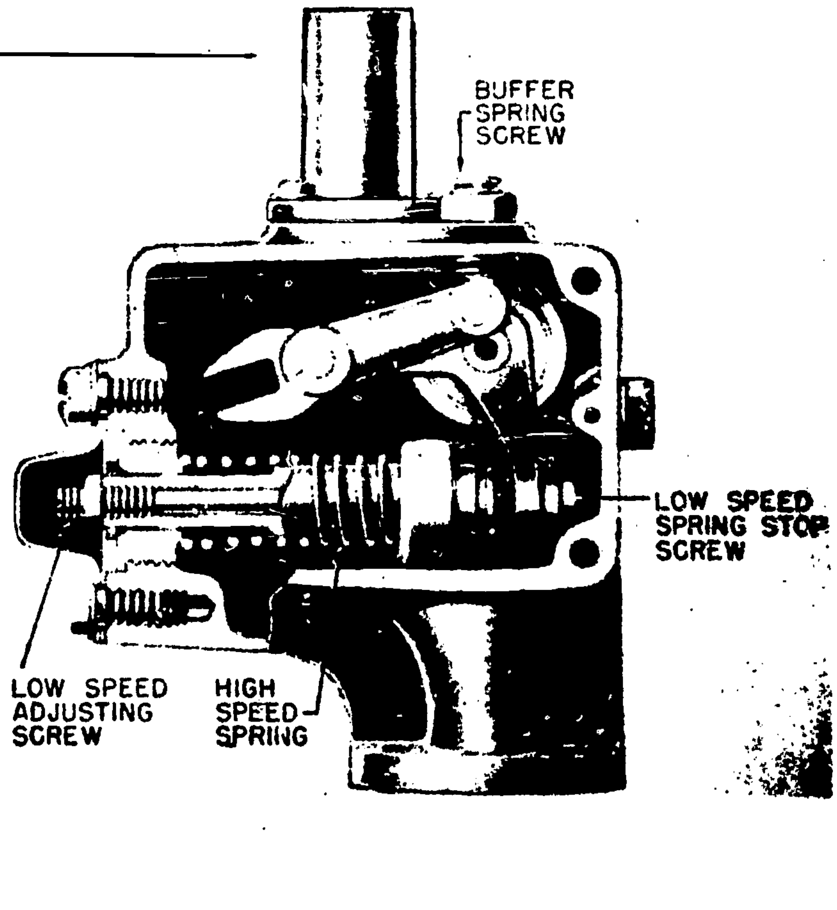


Plate IX



DIDACTOR

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MECHANICAL PRINCIPLES OF GOVERNOR OPERATION

Human Engineering Institute

Press A —1 Check to see that timer is OFF

1

In this lesson, we will review why governors are a necessity on diesel engines, what some of the basic principles are that allow this mechanism to operate, some definitions of terms you should know to understand governor operation, and a few troubleshooting tips to look for when the governor fails.

Press A — 2

1

2

The speed of a diesel engine may be roughly controlled by using a tachometer to indicate the engine speed, and by changing the fuel supply manually to correct for changes in speed. If the engine speeds up, reduce the fuel supply. If the engine slows down, increase the fuel supply. This system would require constant attention, and would depend solely on the quick reaction of the operator--in other words, it would be inadequate for diesel application. The answer then is automatic control through governing.

Press A — 3

1

3

A regulating governor performs the following:

(1) It measures changes in engine speed.
(2) It adjusts the fuel supply to correct for the change in engine speed.

The result of the governor operation allows the engine to run at a constant speed under varying loads. There are two essential parts to every regulating governor, namely, the speed measuring mechansim and the fuel changing mechanism. First let's see how the governor measures speed.

Press A 4

1

4

In order for the governor mechanism to measure the speed of an engine, it would have to be connected to ______________.

6 A. The flywheel gear teeth.
5 B. The crankshaft.
7 C. The blower drive gear.

1

5

No. This would give speed of the engine: however, on the GM the governor is linked to the blower drive gear. Let's move on.

Press A 7

1

6

No. The governor could not be connected to the gear teeth on the flywheel. The outer perimeter of the flywheel turns two or three times faster than the engine speed. The correct answer is blower drive gear. Let's move on.

Press A 7

1

7

Correct. On the GM engine the governor's rotating mechanism is driven by the turning of the blower rotors. This is true for both the in-line and the Vee series engines.

Since the engine speed is increased and decreased by measuring the amount of ____________ the governor would have to be part of the ____________. Choose the A, B or C pair below that best fits the two blanks.

9 A. air, blower system.
8 B. fuel, fuel pump
10 C. fuel, throttle control linkage.

1

8

You are partially right, the amount of fuel is regulated to increase or decrease the speed. However, the governor does the controlling of the fuel and it could not be part of the fuel pump as the pump rotates in direct relation to engine speed.

Press A 10

1

9

No. As you have learned in the first five units of this course, supply of air is constant in the pistons and does not affect speed. Fuel is the medium that is regulated. The correct answer was C: fuel, throttle control linkage.

Press A 10

1

10

Correct. The exact amount of fuel is measured by the injector control rack, which is controlled by the governor, which is part of the throttle control linkage. Plate I shows a simple flyweight governor which operates on the principle of revolving weights (3) and centrifugal force and spring (4) tension.

Press A 11

1

11

Look at it this way, the governor control has two forces working against each other. See Plate I. One is the spring tension (4) constantly expanding and contracting through movement of a manual throttle, and pushing against the ball arm toe (8). The other force is the movement of the ball arm toe (8), which is forced up and down by rotating force of the flyweights (3) (produced by the engine) and pushing against the spring (4). The motion in and out of the flyweights is produced by centrifugal force.

Press A 12

1

12

The scientific definition of CENTRIFUGAL FORCE is "the force which tends to throw a thing(s) out from the center of rotation." The faster the flyweights rotate, the farther out they move; the slower they rotate the closer to the middle they remain. Plate II shows the position of the flyweights at normal engine speed. At normal speed the tension of the spring is equal to the force of the flyweights against the spring.

Press A 13

1

13

Plate III illustrates the position of the flyweights when the engine is at a ____________ speed. Notice the weights are farther from the axis (center).

This would indicate that the ________ is ____________. Choose the correct set of words that best fit the 3 blanks above:

14 A. lower, spring, more compressed.
15 B. higher, engine, turning over faster.
14 C. lower, engine, running slower.

1

14

No. Remember we said when the engine speeds up the centrifugal force throws out the flyweights. The correct answer is: the engine is at a higher speed, meaning it is turning over faster.

Let's move on.

Press A 15

1

15

Correct. The faster the blower turns, the faster the flyweights revolve indicating that the engine is running at a faster rate. Plate IV shows the flyweights closer to the center of the axis, this would indicate that the ___________ has been _________. Choose the correct set of words that best fit the blanks.

16 A. spring, compressed
17 B. spring, expanded
16 C. engine, set at full throttle

1

16

No. Remember we said when the flyweights were in, the engine is running slower; this would expand the spring, not compress it. The correct answer is: the spring has been expanded.

Press A 17

1

17

Correct. You have done well in answering the questions in this part of the material. Now you have an option.

If you feel you know this material well enough and want to move on--PRESS B. 19

If you wish to review the material to learn it better--PRESS A. 2

XC – 18

1

18

You have answered one or more of the questions incorrectly in this sequence of material. Since it is important that you have the basic principles of how a governor operates, before moving on to new material, let's repeat what's been said. Read carefully.

Press A 2

1

19

OK. Plate V shows how the governor is connected into the linkage controlling the fuel supply. On the GM two cycle engine, the fuel rod linkage is connected to the injector control rod which measures the amount of fuel.

Press A 20

2

20

Plate VI shows the reaction when the flyweights move in: fuel is increased to the engine. This would indicate that a __________ may have been placed on the __________.

Choose the correct two words:

22 A. force; spring
22 B. load; engine
21 C. force; flyweights

2

21

No. If a centrifugal force had been placed on the flyweights they would move out, right. The picture shows they are close to the center. The answer is given in the next frame. Let's move on.

Press A 22

2

22

Correct. Both A and B are right. When loads are imposed on the engine, the governor calls for more fuel. Remember: when the flyweights move in, the spring is expanded, calling for more fuel. Also if a force is imposed on the spring, there is more tension against the flyweights, causing them to move in; result: more fuel.

Press A 23

2

23

Plate VII shows the flyweights have moved out, indicating that the engine has increased in speed whereas the fuel is reduced to the engine.

An increase of speed could be caused by one of three things: (1) the operator, (2) the load decreased, and (3) engine and vehicle moving downgrade.

Press A 24

2

24

Now that we understand the basic principles of how a mechanical governor works, let's get a couple of definitions and concepts straight to see why it works. First, as the flyweights are moving in a circular motion we can say that they have ENERGY, or the ability to do work. This energy is transmitted in the form of FORCE exerted on the ball arms. The ball arms, by means of a FULCRUM, exert PRESSURE on the spring.

Press A 25 2

25

Look at it this way. A FULCRUM (sometimes called a PIVOT) as we saw in the previous illustrations, is the same principle as a teeter-totter. We know that a heavier person sitting close to the pivot can be lifted by a smaller person sitting far away from the pivot. We can say the smaller weight, located farther out from the fulcrum, has a MECHANICAL ADVANTAGE. The same holds true in the governor principle. We can see now that not just any spring can be used in the governor; it must be matched to the governor.

Press A 26 2

26

How, then, is this revolving motion transferred to the injector fuel rods? Let's take another look at a previous picture, Plate V, and see.

Here we see three pivot points, one at (4), the other two below the weights (1).

As the downward force is applied from the weights moving out, pressure is applied to the spring. This action moves (2) which moves (6) and (7). We call this converting revolving motion into linear motion.

Press A 27 2

27

See Plate V. Point (4) is placed closer to (2) than to (7) because ______________________.

28 A. the governor needs a mechanical advantage.
30 B. the fuel rod needs the mechanical advantage.
29 C. (2) has to make a longer stroke than (7).

2

28

No. In this arrangement the fuel rod has the mechanical advantage. Remember -- we said the point farthest away from the pivot has the mechanical advantage.

Let's move on.

Press A 30

2

29

No. The governor stroke is shorter because of the location of the pivot. The correct answer is that the fuel rod has the mechanical advantage over the governor in this arrangement.

Press A 30

2

30

Correct. The pivot, being closer to the governor, permits the other end to have the mechanical advantage. This means it takes a lot less force to move the governor from the fuel rod than it does from the opposite side of the pivot or fulcrum.

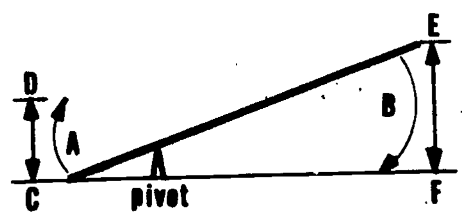
Another advantage in placing the pivot here is ______________________.

33 A. the governor stroke is shorter.
31 B. the fuel rod stroke is shorter.
31 C. that both strokes are the same.

2

31

No. Look at this illustration. Point A moves a much shorter distance from C to D, than B moves from E to F. Which one has the mechanical advantage?



A. A has the advantage.
32 B. B has the advantage.
(Wrong answer will not advance film).

2

32

Correct: B has the advantage. Now you're getting the idea. Think of this idea like a pair of pliers: the more you squeeze the handles, the more pressure the jaws can produce.

Press A 33

2

33

OK. You have done well in this material. Remember in your study of machines--these terms and definitions will keep popping up over and over. If you feel you have a good understanding of them and want to move on--PRESS B. 35

If you would like to review them again--PRESS A. 19

XC → 34

2

34

You have answered one or more of the questions incorrectly in this sequence of material. In your study of the diesel, and all things mechanical, the terms and definitions just covered will be important to you. Therefore, go over this information one more time. Read carefully--and think before you answer.

Press A 19

2

35

Before going to troubleshooting tips, let's talk about other terms that are common to engine language. The term POWER is defined as the RATE at which work is done. It takes more power to do work rapidly than to do work slowly. Engines are rated in terms of the amount of work they can do per minute. The work capacity of an engine is measured in HORSEPOWER (HP). HP is the theoretical measure of the amount of work one horse can do in one minute.

Press A 36

3

36

According to the definition of horsepower, the average horse can lift a weight of 200 lbs a distance of 165 feet in 1 minute. The amount of work involved here is 33,000 foot-pounds (165 times 200). If it took two minutes to do this work the foot-pounds involved would be__________and the HP would be______________.

36½ A. 66,000; 3 HP

36½ B. 16,500; 1 HP

37 C. 33,000; 1/2 HP

3

36½

No. If it took two minutes to do the same amount of work or twice as much time--then the answer would be 33,000 foot-pounds or 1/2 HP.

We would still be doing 33,000 foot-pounds of work; but at the rate of 16,500 foot-pounds per minute, thus requiring only half as much HP to do the job.

Press A 37

3

37

Correct. So we have a formula for figuring HP as follows:

$$HP = \frac{\text{ft. lb. per. min.}}{33,000} = \frac{L \times W}{33,000} \times t$$

where

L = length, in feet, through which W is moved.

W = force, in pounds, that is exerted through distance L.

t = time, in minutes, required to move W through L.

Press A 38

3

38

Another common term is friction. FRICTION is defined as the resistance to motion between two objects in contact with each other.

A good example of friction is when a sled will not slide on bare pavement. It slides well on ice because of reduced resistance to the runners.

This also holds true for the journal type bearings which support the crankshaft--the oil film reduces the resistance to sliding motion.

Also, if we did not have a film of oil, the metal would soon melt due to the heat produced by friction of bare metals rubbing together.

Press A 39

3

39

On the other hand, friction is exactly what we need for brakes and clutches.

Correct TIMING in an engine is very important for maximum power output and engine efficiency. Valve timing refers to the exact turns in the GM engine cycle at which the valves trap the ________ and then allow the ________ to escape.

40 A. mixture, incoming air
41 B. fuel, exhaust gases
42 C. mixture, exhaust gases

3

40

No. "Trapping the mixture" is correct but "allowing the incoming air to escape" is wrong. The answer was: allowing the exhaust gases to escape after the power stroke.

Let's move on.

Press A 42

3

41

No. But you are partially correct. Fuel alone cannot be trapped in the piston; it must be compressed air and fuel. The correct answer was: mixture and exhaust gases.

Let's move on.

Press A 42

3

42

Correct. The valves must close at an exact time--when scavenging is complete, and prior to compression of the fresh air. The valves must open and close in step with the piston movement of the cylinder which they control. The valve timing is accomplished by the rotation of the ________ ________ and the piston timing is accomplished by the rotation of the ________.

Select the correct words.

44 A. balance shaft, camshaft.
43 B. throttle linkage, crankshaft.
45 C. camshaft rod, crankshaft.

3

43

No. The throttle linkage operates the fuel injector racks, not the valves. The crankshaft does function with the pistons however, so you were half right. The answer was: camshaft, crankshaft.

Press A 45

3

44

No. The balance shaft has no cams, it is a plain rod that maintains engines balance on the in-line engines. Also the crankshaft does not function with the valves, it functions with the pistons. The answer was: camshaft, crankshaft.

Let's move on.

Press A 45

3

45

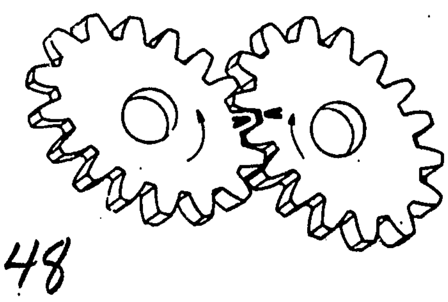
OK. Camshaft and crankshaft is correct. Correct valve and piston timing is accomplished by ________ the ________ on the gears at rear of engine.

46 A. increasing, balance weights.
48 B. matching, timing marks.
47 C. adding, spacer washers.

3

46

No. Balance weights are not adjustable. These are fixed by the manufacturer and are statically balanced at the factory. The correct answer was: matching the timing marks on the gears at the rear of the engine. The timing marks look like this.

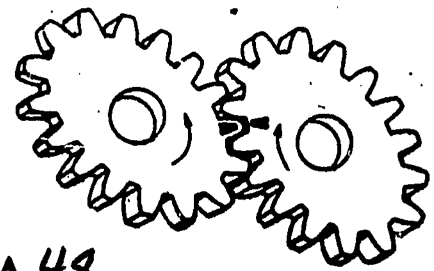


Press A 48

3

47

No. Adding spacer washers is wrong. The answer you should have picked was matching the timing marks on the gears. Each gear has timing marks that match the same marks on the other gears.



Press A 48

3

48

OK. Let's come back to governors now and discuss some possible troubles that may occur with the GM type limiting speed mechanical governor. Remember--we learned earlier that a basic governor has flyweights and a spring. In the GM type there are two sets of flyweights and two springs. There is a large set of flyweights, and a small set of flyweights. Also there is a large spring and a small spring.

Press A 49

4

49

In the idling speed range, control is effected by the centrifugal force of both sets of flyweights, acting against the small or low speed spring.

Maximum speed control is achieved by action of the small, or high-speed, flyweights acting against the heavy, or high-speed, spring.

Press A 50

4

50

Suppose we have a stripped spline on the governor drive shaft, causing a high-speed engine operation and excessive noise. This would mean that both ________ have been ___________.

52 A. springs, compressed.
53 B. flyweights, stopped.
51 C. flyweights, extended.

4

51

No. Since the drive shaft rotating the flyweights has been stopped due to a stripped spline, how could the flyweights be out? If the shaft stopped, the flyweights would stop, the springs would extend and would force the flyweights in. This would call for _________ fuel.

A. More — 53
B. Less

Press the correct one to go on. (Wrong answer will not advance film).

4

52

No. Remember we said when the flyweights are extended fully, the spring would be compressed. Since the flyweights have stopped the spring would be extended--calling for more fuel.

The correct answer was that both flyweights have stopped.

Press A 53

4

53

OK. You are getting the idea of the governor now -- remember weights out equals less fuel, spring extended equals more fuel.

Now let's see what could cause a stripped spline. The two most probable causes are:

(1) Improper assembly of the governor to the engine.
(2) Poor condition of the shaft bearing.

Let's talk about (1) first.

Press A 54

4

54

When assembling the governor to the engine, the weight housing could be cocked improperly by tightening the cap screws unevenly or by forcing the housing into position. Good common sense and following the correct procedure can eliminate this situation.

Another cause for spline strippage is assembly with dirty parts.

Press A 55

4

55

As we know, dirt causes drag and binding. This causes more force to be applied to splines--force that may result in breakage. Before disassembly of the weight housing, it should be flushed thoroughly with clean fuel oil, and washed thoroughly again before reassembly. In addition, the splines should be coated with grease before engaging them in the hollow blower shaft. This will tend to cushion the shock loads to which the splines are subjected.

Press A 56

4

56

Stripped splines could be caused by ____________.

57 A. too much grease on the spline.
57 B. an excess coating of fuel oil.
58 C. improper assembly to the engine.

Choose the correct answer.

4

57

No. You chose the wrong answer. Let's move back a few frames and read this again. Read carefully.

Press A 53

4

58

Correct. Another cause for a stripped spline could be that the operating yoke (forked lever) was placed between the thrust washer and balls of the bearing. This arrangement will quickly ruin the thrust bearing, and may cause the shaft to bind; this will place pressure on the shaft. Remember -- always follow the correct assembly procedures, no matter what assembly it is.

Press A 59

4

59

The other major cause of stripped splines is that the shaft bearing may be in poor condition. Freezing of the shaft bearing imposes high loads on the splines and may cause them to fracture. Any poor condition of the bearing that increases the friction also increases the load on the spline.

In conclusion, if you are repairing a stripped spline, renew the drive shaft, and check all other governor parts for burring, scoring, bending, or breakage. It may also be necessary to renew the hollow blower shaft if the internal splines are damaged.

Press B 60

4

60

In review, one of the most probable causes of a stripped spline is that ____________. (Pick one):

62 A. too much pressure is being applied to the yoke.
63 B. there has been an improper mounting of the governor to the engine.
61 C. the low speed weights are binding in the housing.

4

61

No. It is possible that this condition could exist, but not probable. The answer we wanted was B: There has been an improper mounting of the governor to the engine.

Let's go back and review this data again. Read carefully.

Press A 53

4

62

No. Remember we said there were chiefly two causes of stripped splines, one was improper mounting of the governor to the engine, the other was poor condition of the shaft bearing.

Let's move back a few frames and read this part again. Read carefully.

Press A 53

4

63

Correct. Another thing that can go wrong with the governor, which would cause erratic engine operation is binding in the governor or linkage. This trouble is recognized by "hunting" of the engine. When binding is suspected, the linkage and governor parts should be moved by hand. Linkage and fuel racks should work easily.

Binding can be caused by distorted parts, resulting from someone having forced them together.

Press A 64

4

64

Proper alignment of the fuel control rod is very important, especially where the tube is supported at the ends where the brackets and bearings are located. Bad bearings in this area can cause friction, which will cause slow responses to the governor controls.

As we learned in the fuel text, the injector hold-down clamp must be properly positioned, and not overtightened.

Press A 64½

4

64½

In conclusion, to prevent binding in the linkage, the following precautions should be taken:

(1) The governor and linkage should be cleaned frequently and watched for obstructions.

(2) Injectors should be free working at all times, especially the control racks.

(3) The clevis and pin joints must be smooth working. Should they be worn DO NOT FILE to make smooth, this will cause sloppy linkage movement. Replace the parts.

Press A 65

4

65

In review--when "hunting" of an engine occurs, it could be that the ______________.

67 A. plunger in one or more injectors is binding.
68 B. fuel rack in one or more injectors is binding.
66 C. there is an obstruction under the linkage, preventing movement.

5

66

No. If there was an obstruction under the linkage preventing movement, there would be no hunting in the engine. The answer we wanted was B: fuel rack in one or more injectors is binding.

Press A 68

5

67

No. The plungers in the injectors have nothing to do with the linkage. Remember, we learned they are actuated by the camshaft and push rods. The answer we wanted here was B: fuel rack in one or more of the injectors is binding.

Press A 68

5

68

OK. Let's go on to other troubles. Suppose you have an engine that idles either too fast or too slow. You have checked the linkage, the governor is working OK etc. What could be causing this? Earlier in this lesson, we learned that this may be caused by the

______________.

69 A. low speed weights not rotating.
70 B. linkage is not adjusted to no-fuel position.
71 C. low speed spring is improperly adjusted.

5

69

No. If the low speed weights were not rotating, neither would the high speed weights. Besides, the engine would be running at a high speed, an indication that the spline might be stripped. The answer we wanted here was that the low speed spring is improperly adjusted.

Let's move on.

Press A 71

5

70

No. This fact alone would not be causing a high or low idling speed. The answer we wanted was: low speed spring is improperly adjusted.

Press A 71

5

71

OK. Let's have another problem. An engine that stalls at idling speed indicates that the low speed spring tension is _______________.

72 A. too low
73 B. too high
73 C. completely bottomed.

5

72

No. If the spring adjustment was too loose or the tension was at a minimum the flyweights could not move in and the spring would be calling for fuel.

Let's move on.

Press A 73

5

73

OK. "Too high" and "completely bottomed" are the same thing. Look at Plate VIII. When the idle speed adjusting screw is bottomed, the spring (low speed) is compressed to the maximum. This would allow the flyweights to move in--result no fuel, and stalling at idle.

Press A 74

5

74

The opposite would be true if the spring was too loose.

Now, suppose you readjusted the low-speed spring by backing out the screw, but the engine still stalled out. You noticed this time, though, that the low-speed spring seat separated from the spring. It might be that the

____________________.

76 A. high-speed spring is too loose.
77 B. low-speed spring has lost its spring force.
75 C. threads are stripped on the adjusting screw.

5

75

No. If the threads were stripped on the screw, it would not have backed off the low-speed spring seat. The answer we wanted here was: low-speed spring has lost its spring force. This may happen to both springs after extended use.

Press A 77

5

76

No. Remember the high-speed spring adjustment affects the engine at full throttle. The answer we were after here was: low-speed spring has lost its spring force. This may happen to both springs after extended use.

Press A 77

5

77

Correct. You have done well in answering the questions. If you feel confident in knowing the material we just covered and want to move on--PRESS B. 79

If you would like to go over this material again to make sure you have it--PRESS A. 65

XC → 78

5

78

You have answered one or more of the questions wrong in this last sequence of material. Let's move back a few frames now and repeat the information. Read carefully and think before you answer.

Press A 65

5

79

Just as the low-speed spring can cause problems in the engine, so can the high-speed spring--as indicated by lower or higher speeds than rated speed at full throttle.

However, inability to reach rated speed, sometimes referred to as loss of power, is quite frequently caused by malfunction of engine parts other than the governor.

So DO NOT add shims to increase the high-speed spring tension when full power cannot be reached before checking other parts of the engine.

Press A 80

6

80

If the shims are added to obtain a greater speed, and then at some time later the real cause is fixed, it is quite possible that the engine will overspeed. We know that an overspeeding diesel is dangerous because of the heavy parts involved. There have been many cases of overspeeding where engines have come completely apart because of this situation.

Press A 81

6

81

Another possible trouble that can cause flat spots in governor control is improper gap clearance. A flat spot means simply that at a certain speed, as indicated on the tachometer, a change in the position of the throttle will not result in a noticeable change in engine speed. Adjusting the gap is real tricky.

DO NOT deviate from the maintenance instruction manual when performing this task, as there is danger of overspeeding when adjusting the gap with the engine running.

Press A 82

6

82

In review, the important thing to remember when adjusting the high-speed spring or the governor gap is ____________.

83 A. to check the gap before adjusting the spring.
85 B. not to overspeed the engine.
84 C. to first remove all shims from behind the spring.

6

83

No. Order of sequence has nothing to do with it. The answer you should have picked was: not to over-speed the engine. This is true when doing either of the two tasks.

Press A 85

6

84

No. There may not be any shims behind the spring. Let's review the past couple of frames so you can read this part again.

Press A 79

6

85

OK. A good rule-of-thumb is that if the flat spot occurs at about 1200 rpm, it is likely that the gap clearance is too wide.

If the flat spot occurs at about 800 rpm, it is likely the gap clearance is too narrow.

Press A ~~87~~ 86

6

DIDACTOR **FILM NO.** AM 1-6D

86

Another trouble that may occur is a rolling variation in engine speed when it is idling. This could be an improperly adjusted buffer screw. The buffer spring, see Plate IX, has the function of dampening oscillations of the differential lever.

Here, as in adjustment for other components on the engine, consult your maintenance manual.

Remember whenever the idling speed is adjusted, it will be necessary to readjust the buffer screw.

6

Press A ~~[illegible]~~ 87

87

Also it is important that the buffer screw is to be screwed in only far enough to prevent rolling. If the buffer screw is screwed in too far, it may be impossible to shut down the engine.

This completes the discussion on governors and troubles, now let's have a few review questions.

Press A 88

6

88

Flat spots indicated by lag in engine performance at certain rpm's can be caused by the __________ being out of adjustment.

90 A. high-speed spring
89 B. buffer screw
91 C. governor gap
90 D. low-speed spring

6

89

No. Remember we said the buffer screw dampens the oscillations of the differential lever. The correct answer was: governor gap.

Press A 91

6

90

No. The low-speed spring controls the idling range of the engine, and the high-speed spring controls maximum speed. The correct answer was: governor gap.

Press A 91

6

91

OK. When the engine is unable to reach maximum rpm at full throttle, and if it isn't a misfiring cylinder or some other component in the engine, it may be the __________.

92 A. low-speed spring.
93 B. governor gap.
94 C. high-speed spring.

6

92

No. Remember the low-speed spring controls the idling range. The answer we wanted was: high-speed spring.

Press A 94

6

93

No. Remember the governor gap controls the flat spots. The answer we wanted was: high-speed spring.

Press A 94

6

DIDACTOR

FILM NO. AM 1-6D

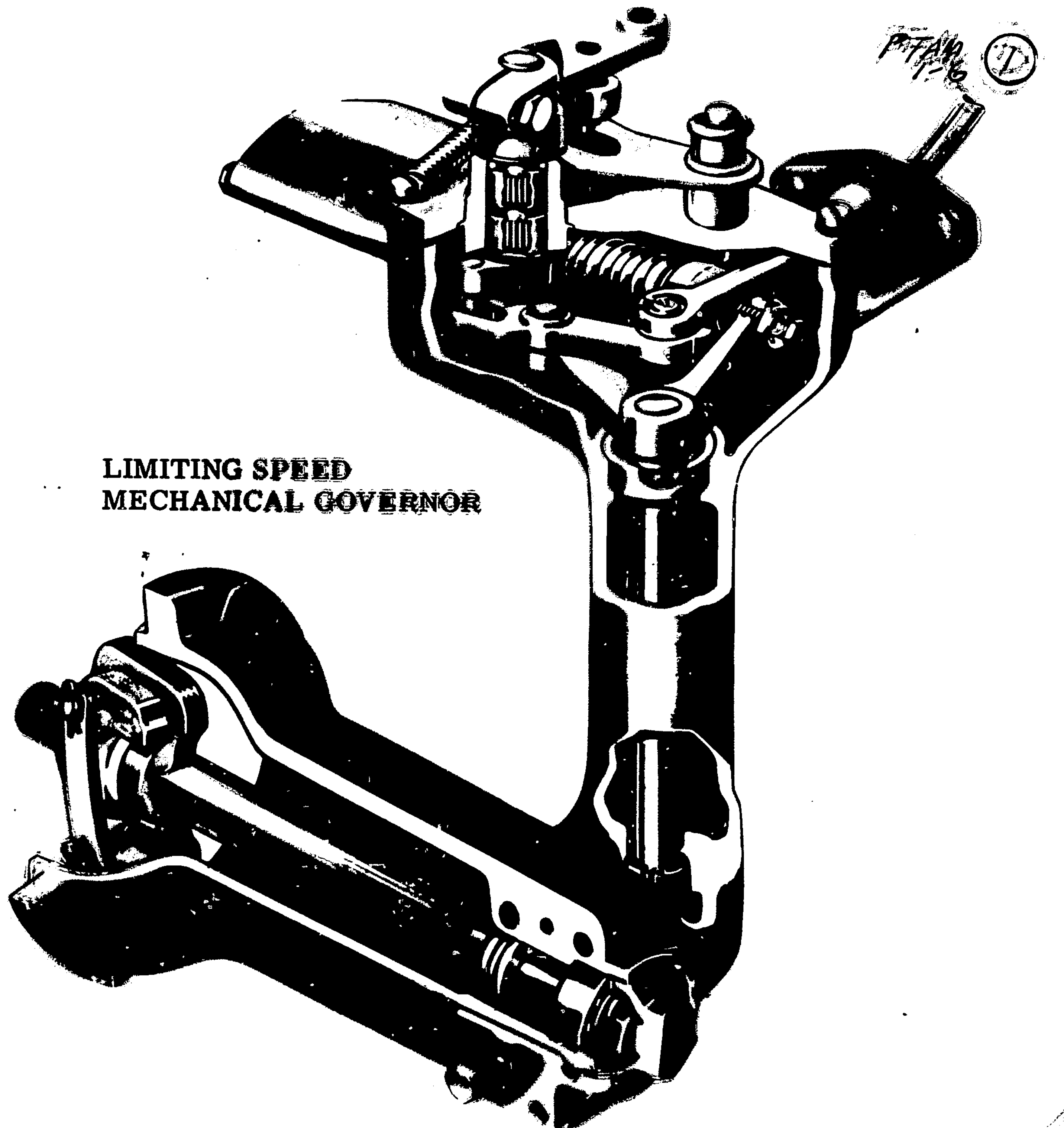
94

Correct. You have done well in answering the questions throughout the tape. This completes the lesson and we hope you have learned more about governors.

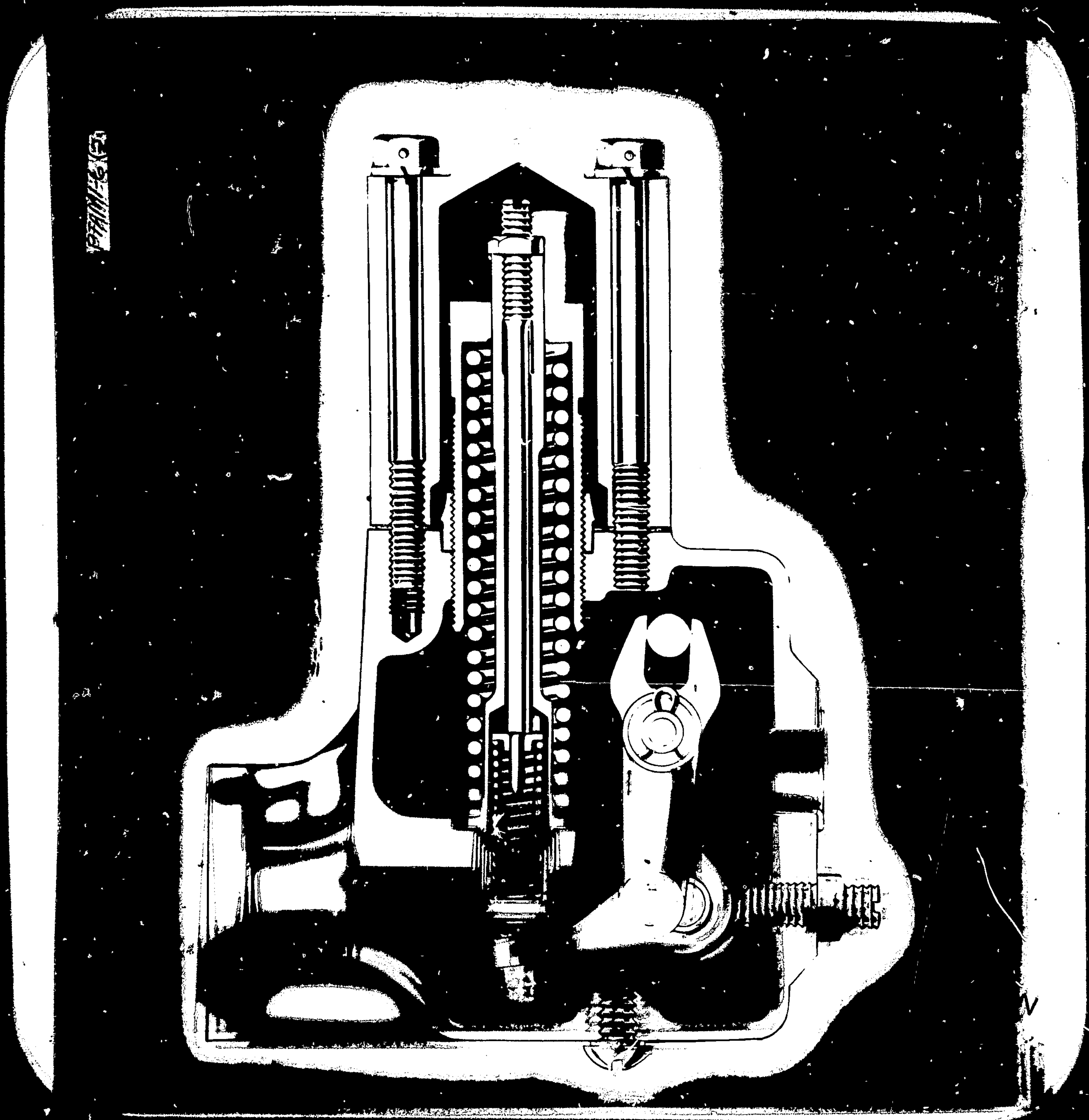
PRESS REWIND

Rewind

6



LIMITING SPEED
MECHANICAL GOVERNOR



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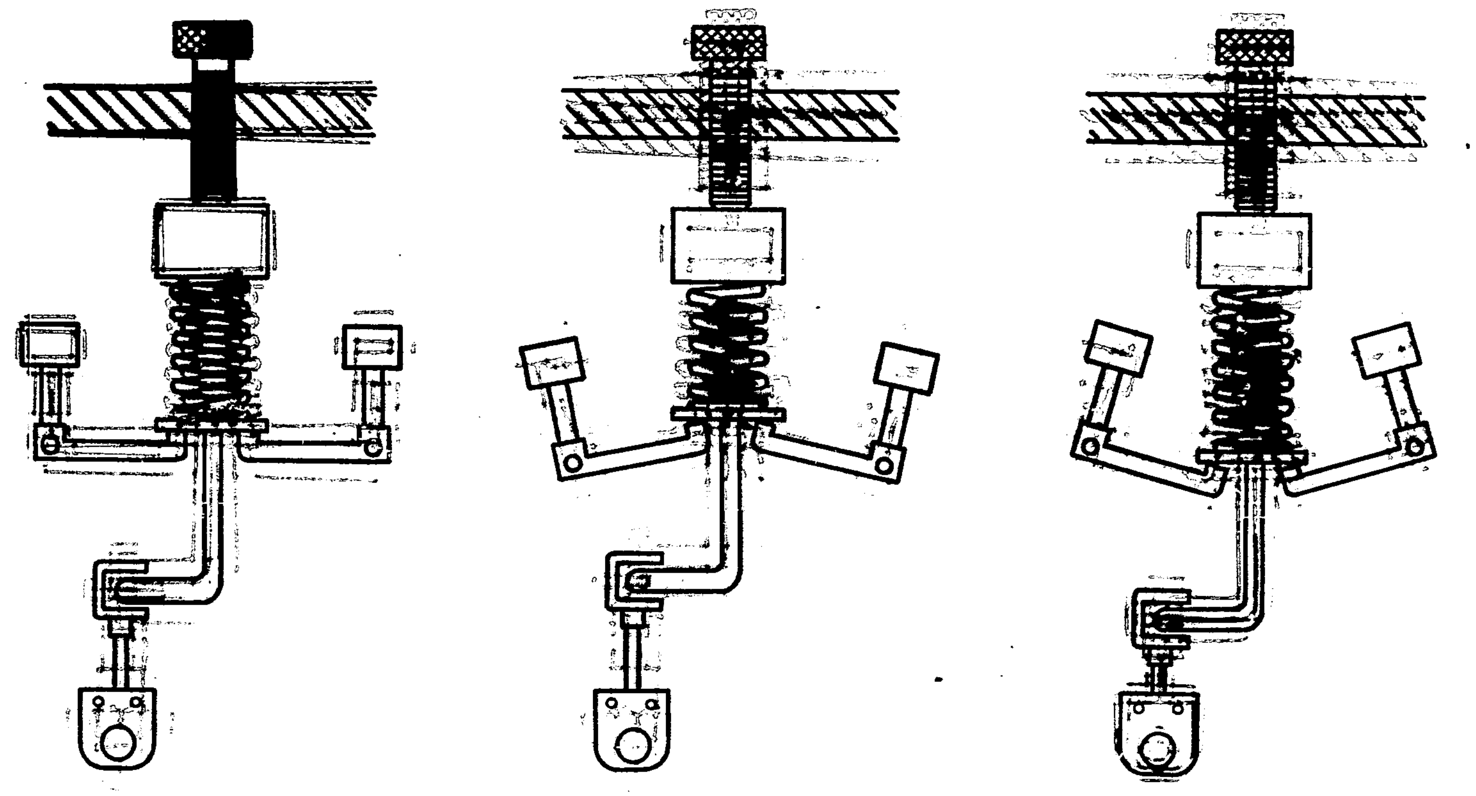

LOAD AND SPEED CONSTANT

LOAD DECREASING SPEED INCREASES

LOAD INCREASING SPEED DECREASES

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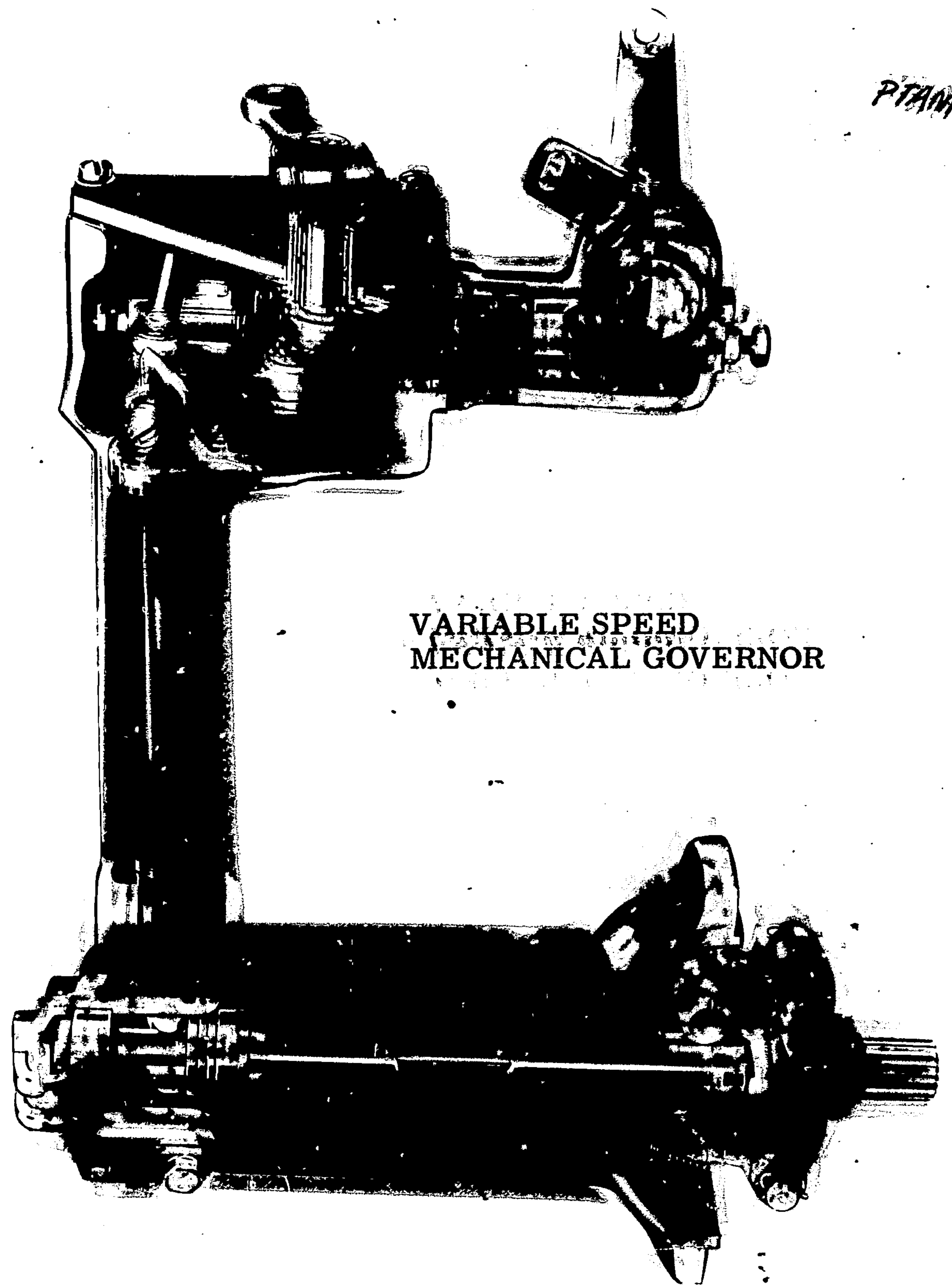
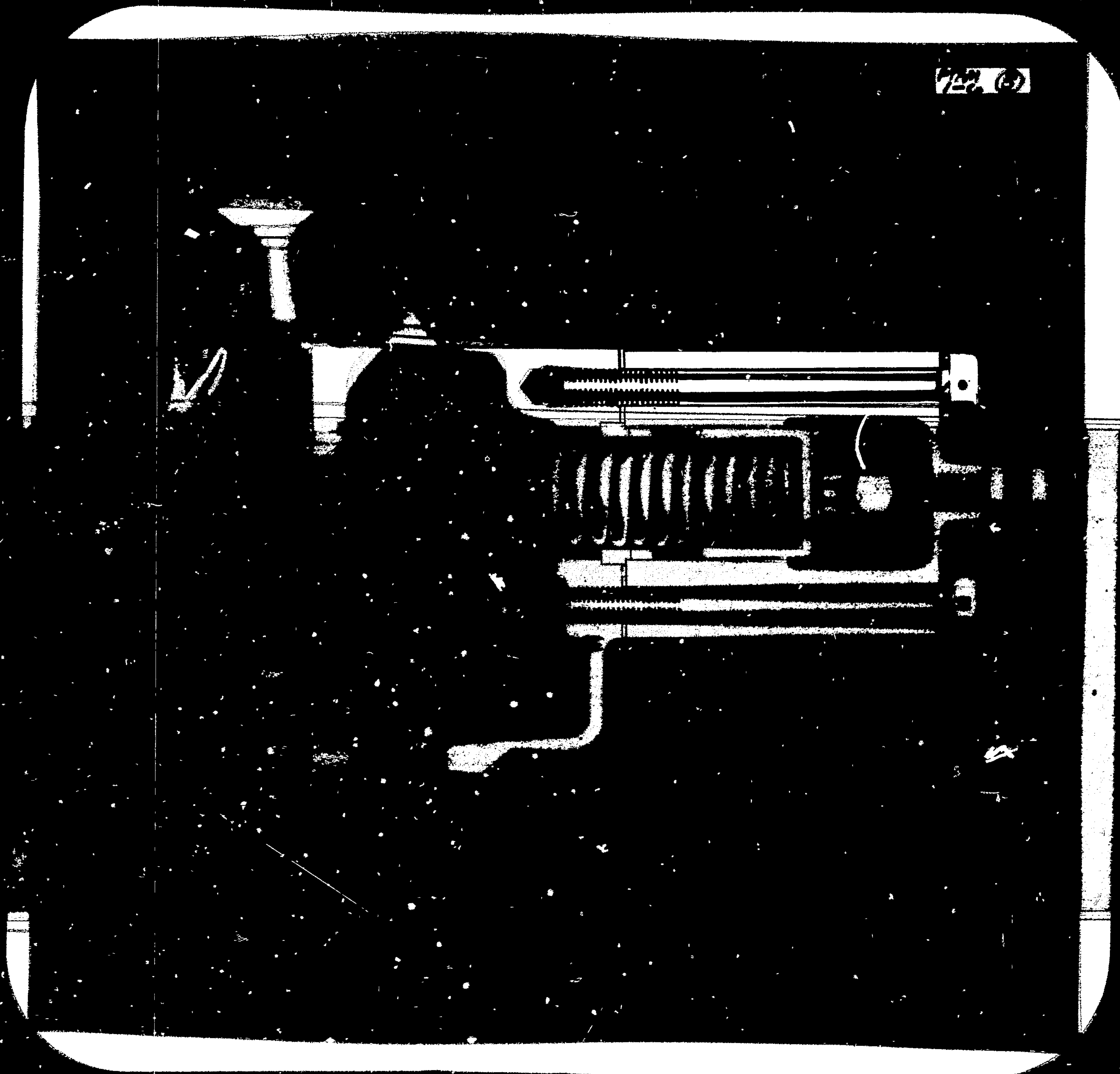


VARIABLE SPEED
MECHANICAL GOVERNOR



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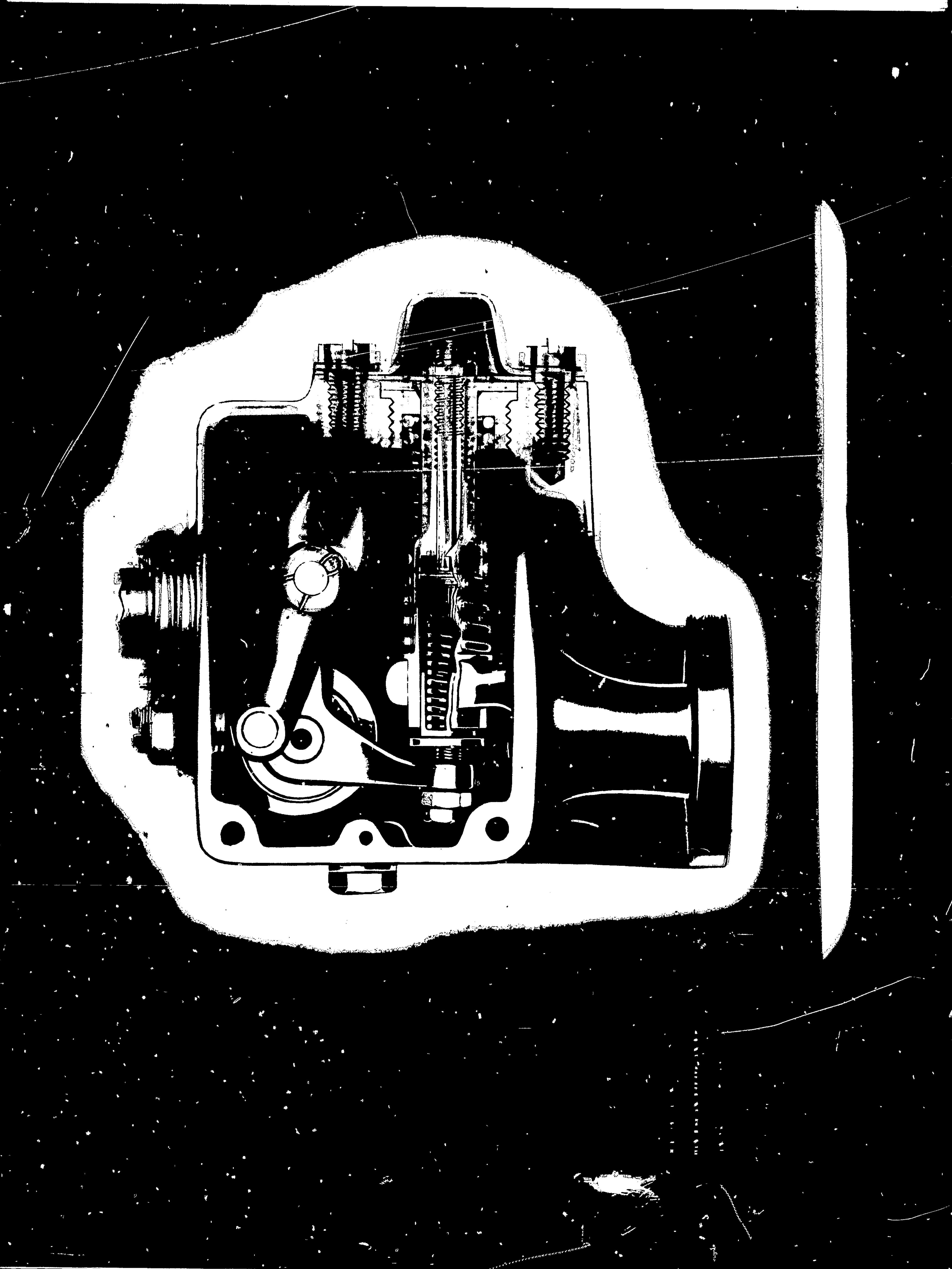

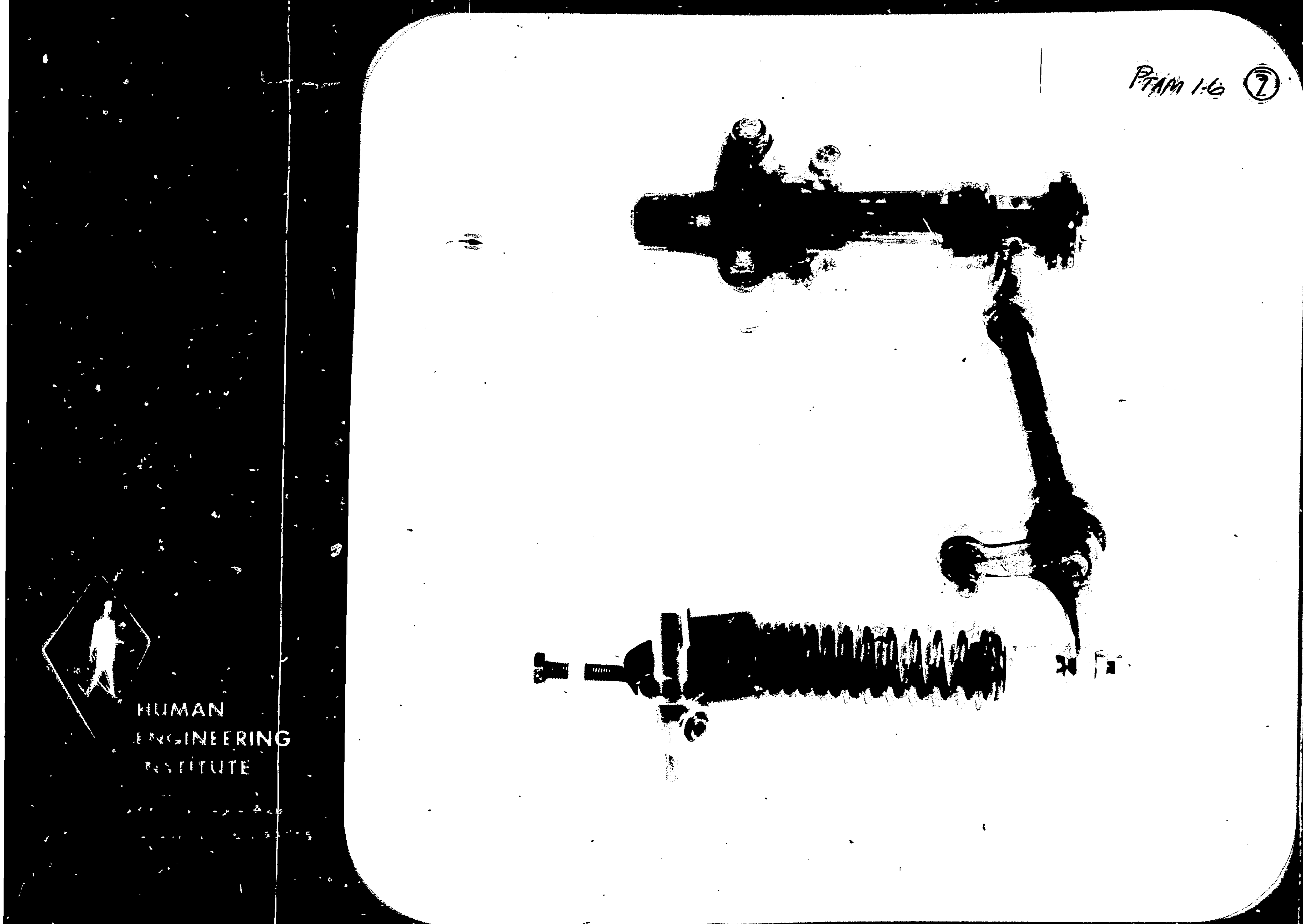
PTAM 1-6 (7)
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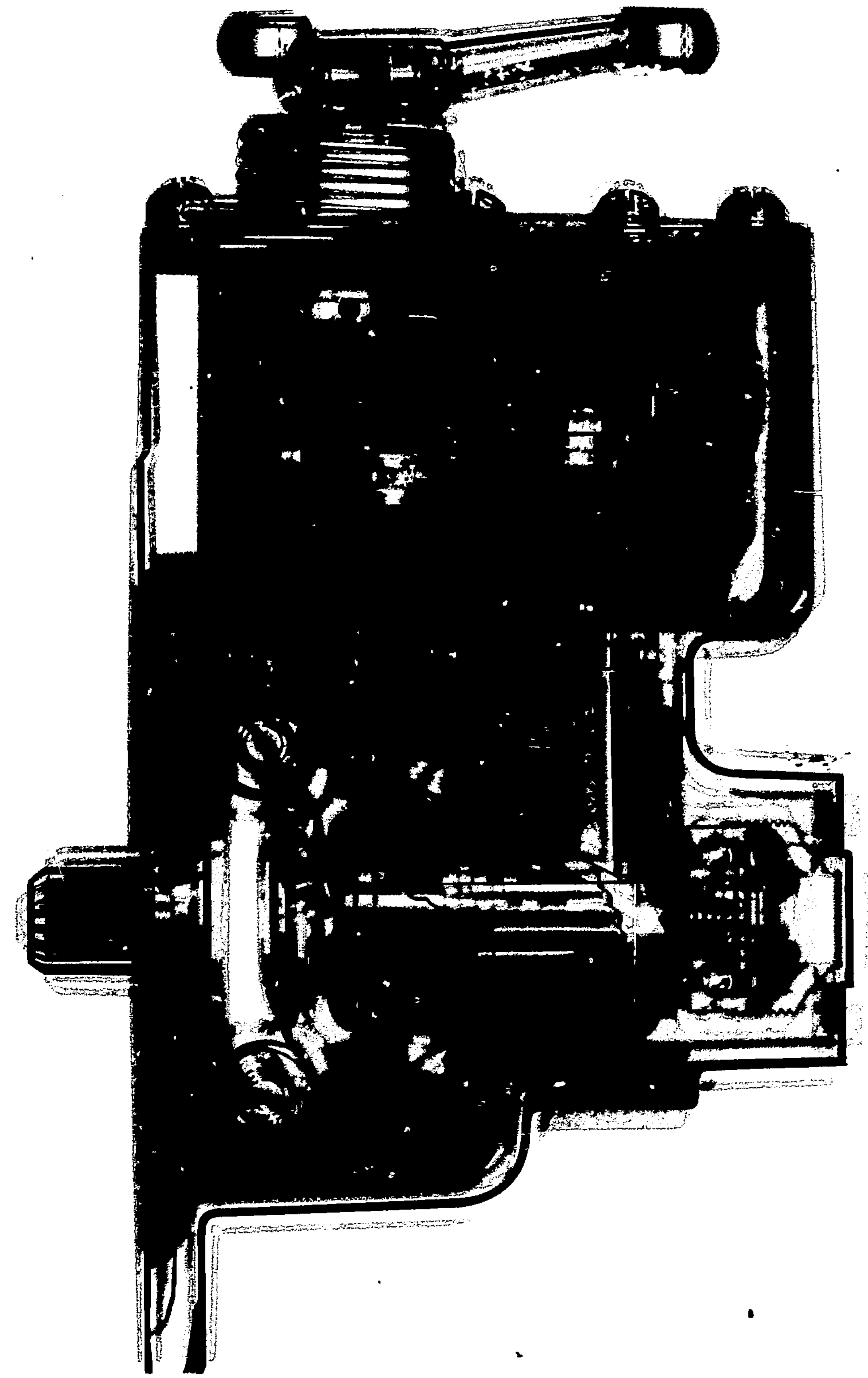

PTAM 1-6 (8)

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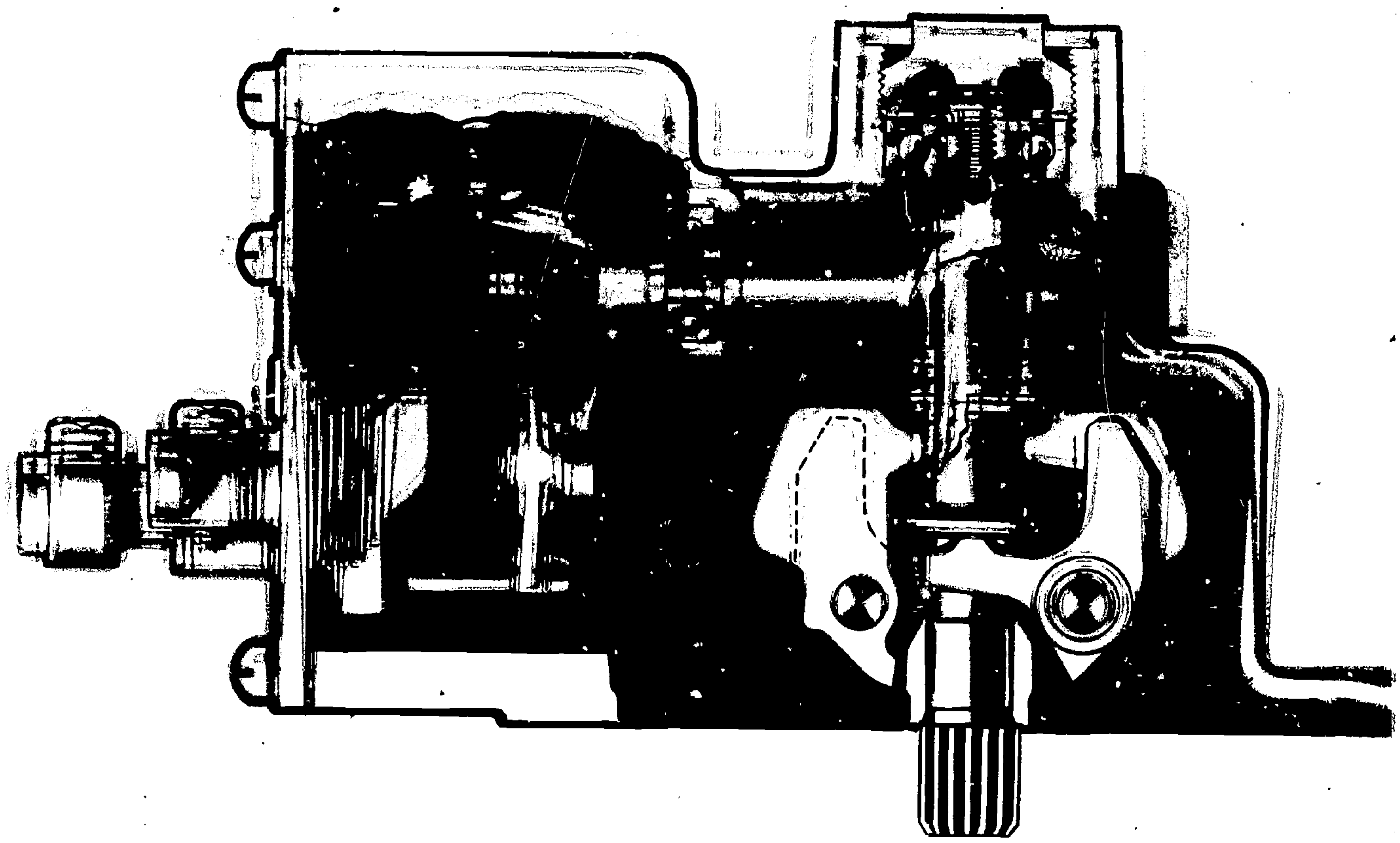

INSTRUCTOR'S GUIDE

Title of Unit: Maintaining Mechanical Governors -- Detroit Diesel Engines

Code: PTAM 1-6

10/4/65

FIRST: Be sure that each student's questions on the previous tape have been answered.

OBJECTIVES: By the end of the class each student should know:

1. Why diesel engines need governors.
   a. Explain a run-away engine.
   b. Explain why a diesel will not idle without a governor.
2. What the three types of governors used on the off-the-highway equipment are.
   a. How the above types are used for different applications.
   b. Other types of governors (optional for instructor).
3. Operations of a limiting speed mechanical governor.
   a. How this governor is mounted on the In-line 71 and V-71.
   b. How it is lubricated.
   c. What happens to the weights when the engine speeds up -- when the engine slows down.
4. What relationship the governor has to the fuel system.
   a. How is the governor controlled by the operator (throttle linkage) and how does the linkage eventually control the fuel.
   b. What actually happens in an injector when a governor makes an adjustment.
5. How a single weight governor compares to a double weight governor.
   a. Explain the high speed spring and the low speed spring.
6. What should be checked when governor malfunction is suspected.
7. How governors should be cleaned -- student should know steps to follow.
8. Briefly discuss:
   a. Purpose and operation of a mechanical variable speed governor.
   b. Purpose and operation of a mechanical constant speed governor.
9. What is meant by no-load speed in governor language.
10. What is meant by governor hunting.

LEARNING AIDS suggested:

Bring in a limiting speed mechanical governor for disassembly in class. A cutaway model would be helpful, if available.

Vue Cells:
- PTAM 1-6 (1) (Limiting Speed Mechanical -- Cutaway)
- PTAM 1-6 (2) (Limiting Speed Mechanical -- Top View)
- PTAM 1-6 (3) (Weight principle)
- PTAM 1-6 (4) (Variable Speed Mechanical -- Cutaway)
- PTAM 1-6 (5) (Variable Speed Mechanical -- Top View)
- PTAM 1-6 (6) (Constant Speed Mechanical)

Learning Aids cont'd.

PTAM 1-6 (7) (Governor assembly)
PTAM 1-6 (8) (Single Weight -- Cutaway)
PTAM 1-6 (9) (Double Weight -- Cutaway)

Film Strips: 71 In-Line Engines with Limiting Speed Governor (25SE26)
V-71 Engine with Limiting Speed Governor (25SE23)

QUESTIONS:

1. Why does a diesel engine need a governor?
2. What is a runaway engine?
3. Will a diesel idle without a governor? Why?
4. What are three types of governors mentioned?
5. What is a limiting speed mechanical governor?
6. What are the three governors major components?
7. How are they mounted on the In-line and V-series?
8. What happens to the weights when the engine speeds up?
9. What happens to the weights when the engine slows down?
10. How do the weights affect the fuel injector racks?
11. Why do the weights come back in?
12. What is the droop factor in a governor?
13. Explain high speed spring -- low speed spring.
14. What might be wrong when erratic "hunting" of the governor is occurring?
15. What items have to be removed before the governor assembly can be removed from the engine?
16. What three conditions should be checked when improper speed variations are detected in the engine?

Discuss the six conditions which can hinder the travel of the injector fuel rack(s):

a. The hold down clamp may be too tight.
b. An injector may be binding or bent.
c. An injector control rack level may be improperly positioned.
d. The injector control tube may be binding in its support brackets.
e. There may be a bent control tube return spring.
f. There could be a bind in the pin which connects the fuel rod to the injector control tube level.

How can these conditions be remedied?