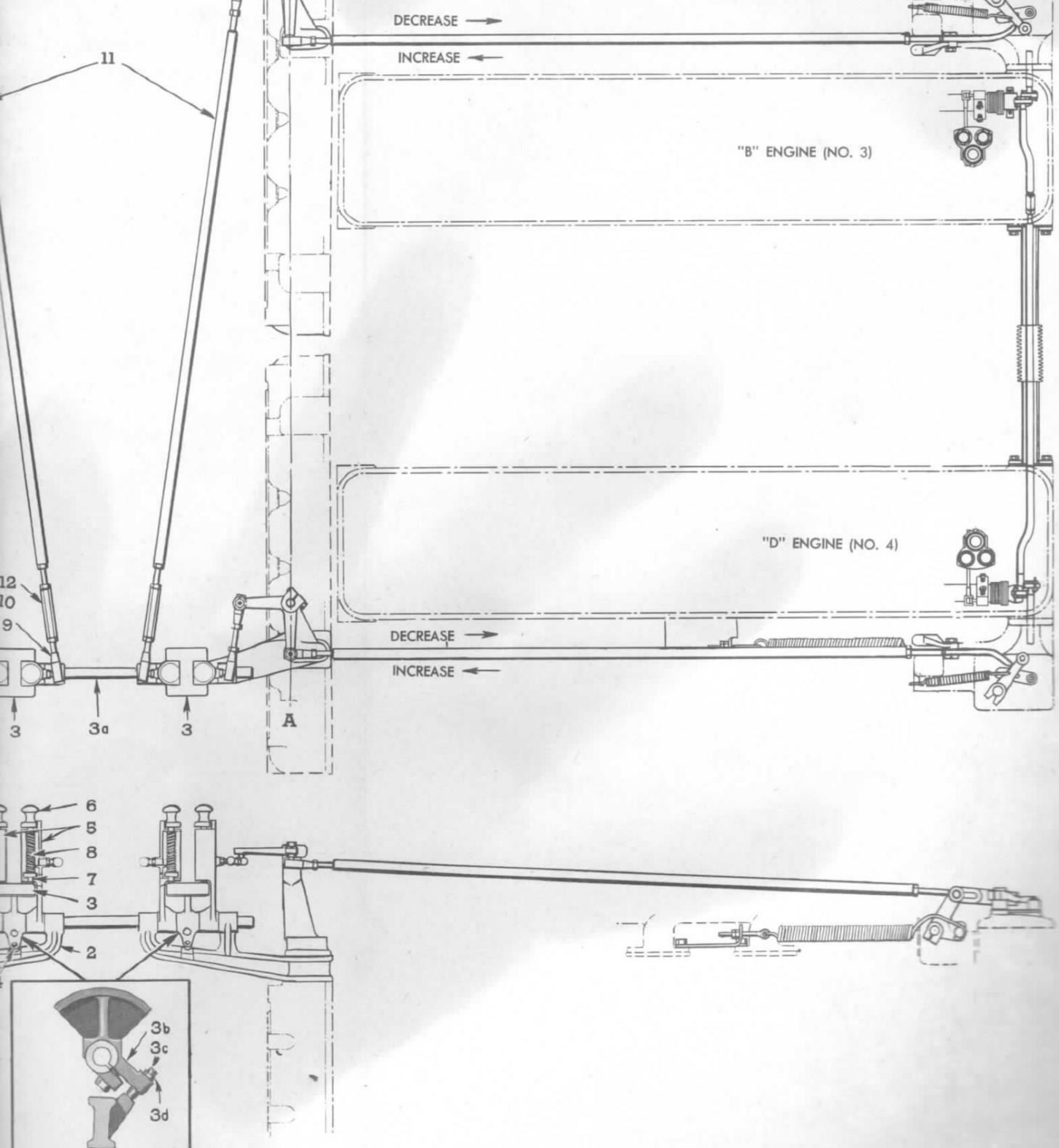
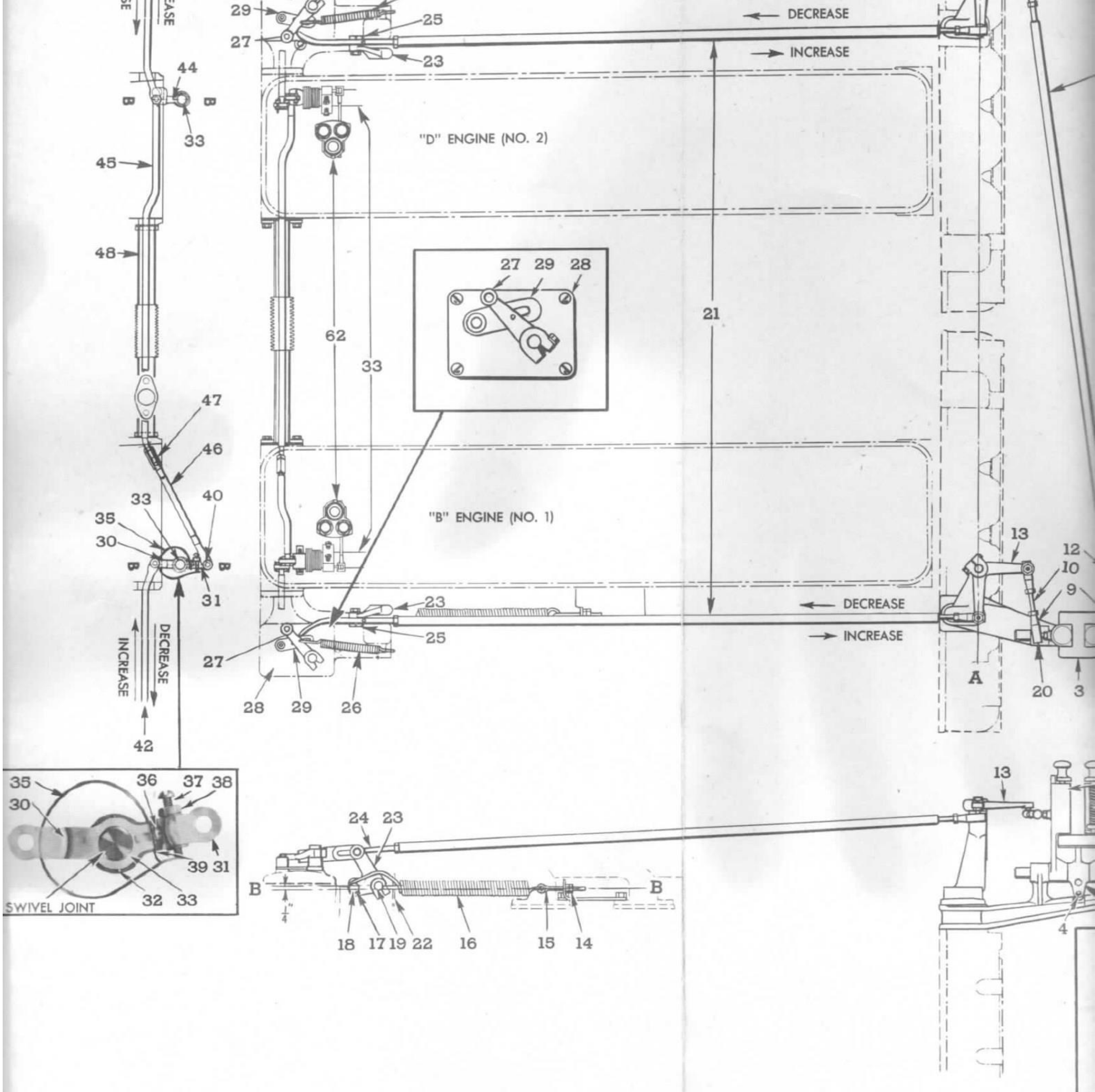
Fig. 37—Throttle Control Adjustment Diagram for Twin and Quad Marine units using variable Speed Mechanical Governor

2. Bracket—Throttle Control Shaft.
3. [redacted]-Quadrant.
3a. Quadrant—- Shaft.
3b. Stop Boss—Quadrant.
3c. Screw—Quadrant Stop.
3d. Locknut—Quadrant Stop Screw.
4. Bolt—Latch Quadrant Clamp.
5. Lever—Throttle Control.
6. Knob—Throttle Control Lever.
7. Pin—Throttle Control Lever Locking.
8. Spring—Throttle Lever.
9. Ball Joint.
10. Rod—Throttle Lever to Bell Crank Control (Short).
11. Rod—Throttle Lever to Bell Crank Control (Long).
12. Turnbuckle—Governor Control Rod.
13. Bell Crank.
14. Nut—Booster Spring Eye Bolt.
15. Eye Bolt.
16. Spring Booster.
17. Nut—Booster Spring Fulcrum Pin.
18. Pin—Booster Spring Fulcrum.
19. Shaft—Speed Lever Control.
20. Cotter Pin—Ball Joint.
21. Rod—Throttle Control.
22. Clip—Speed Control Lever Retracting Spring.
23. Lever—Speed Control.
24. Link—Throttle Control to Governor.
25. Bolt—Link to Speed Control Lever.
26. Spring—Stop Lever Retracting.
27. Lever—Governor Shutdown (Control).
28. Governor.
29. Control Cam.
30. Lever—Injector Control Tube.
31. Lever—Equalizer Link.
32. Pin—Injector Control Tube Lever to Control Tube.
33. Tube—Injector Rack Control.
35. Spring—Equalizer.
36. Screw—Equalizer Spring to Lever.
37. Screw—Equalizer Spring Adjusting.
38. Lock Nut—Equalizer Spring Adjusting Screw.
39. Stop—Equalizer Spring.
40. Pin—Equalizer Link to Lever.
42. Link—Governor Control (for "B" engine).
43. Link—Governor Control (for "D" engine).
44. Lever—Equalizer Link and Control Tube (for "D" engine.)
45. Link—Equalizer (Long).
46. Link—Equalizer (Short).
47. Turnbuckle—Equalizer Links.
48. Cover Tube—Equalizer Link.
62. Injector.



DECREASE
INCREASE
"B" ENGINE (NO. 3)
"D" ENGINE (NO. 4)
DECREASE
INCREASE
11
12
10
9
3
3a
3
A
6
5
8
7
3
2
3b
3c
3d


DECREASE
INCREASE
"D" ENGINE (NO. 2)
"B" ENGINE (NO. 1)
SWIVEL JOINT
A
B
21
62
33

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XI. SET GOVERNOR SPEED CONTROL LEVER BOOSTER SPRING (ENGINES RUNNING—EQUALIZER CROSS LINK DISCONNECTED)

1. With engine running, set the governor speed control lever (23), Fig. 37, in the IDLE position.
2. Adjust spring fulcrum pin (18) ¼" below a line "BB" drawn through the center of the eye bolt hole (15) and the center of the speed lever control shaft (19) as shown in Fig. 37.
3. Remove nut from the link to speed lever control bolt (25) and separate link (24) from bolt (25).
4. Tighten eye bolt nut (14) until the speed control lever (23) will return to the idle position with a sluggish motion when pushed to the full throttle position by hand. A sluggish return is when the speed control lever does not return promptly to the idle position but returns only after the engine has practically attained its top speed.
5. Having obtained the sluggish return of speed control lever mentioned in "4" above, now back off on the eye bolt nut (14) until the lever (23) returns rapidly from the top speed to the idle position as soon as the hand is removed. Tighten eye bolt lock nut.
6. Reconnect link (24) to lever (23) with bolt (25).

THROTTLE CONTROL—TWIN MARINE ENGINES WITH VARIABLE SPEED GOVERNORS

DESCRIPTION—Fig. 37 illustrates the throttle control arrangement used on the six-cylinder, twin or quad Marine units using variable speed governors.

A variable speed governor is one which maintains uniform speed of the engine with varying load conditions yet the desired speed may be varied at will by the Operator.

Idling speed may be varied by an adjusting screw. Maximum speed is controlled by the governor spring. The governor may be set at any speed between idle and maximum speed and held within the limits of the governor droop.

The entire speed range of the engine is controlled by the speed control lever (23), which varies the tension on the governor spring. A stop lever (27), on the governor cover, moves the injector links (42) and (43) —to the OFF or RUN position as the case may be.

Two conditions must be met when two engines are coupled to and drive a common load where either engine may be declutched while the other engine is loaded, or partly loaded, as is the case in this discussion:

1. The two engines must divide the load equally under all conditions of load and speed.
2. Each governor must control its own engine independently should different loads be demanded from the two engines.

Condition "1" is met by using a equalizer (cross) link (45) between the injector control tube levers (30) and (44) on the two engines—hereinafter known as "B" and "D" engines. This link is adjusted so that the injector racks of the two engines reach full load position simultaneously. It follows then, that in any intermediate position, between FULL and OFF position, the same quantity of fuel oil will be injected into each engine.

Condition "2" is met by incorporating a swivel joint between the injector control tube lever (30) and the equalizer link lever (31) at the "B" engine.

Lever (30) is pinned to the injector rack control tube (33), lever (31) swivels on the control tube (33).

An equalizer spring (35) is fastened to the injector control tube lever (30) and an adjusting screw (37) in the equalizer link lever (31), bears against the free end of the equalizer spring. A link (42) from the governor on the "B" engine attaches to the lever (30) on the injector control tube, while a similar link (43) attaches to the injector control tube lever (44) on the "D" engine.

Throttle control rods (21) to each engine governor (28) are connected to bell cranks (13) which are in turn connected to the throttle levers (5) by adjustable control rods (11) and (12). A slotted link (24), at the governor end of each control rod (21), moves the governor shutdown lever (27) to the STOP position when the master throttle is moved to OFF position; when the master throttle is moved to IDLE position, link (24) allows the stop lever to move—by the retracting spring (26)—to RUN position before engaging the governor spring with the speed control lever (23). Farther opening of the master throttle allows link (24) to pick up the speed control lever (23), increase the tension on the governor spring and increase the engine speed. IDLE position of the master throttle is likewise idling speed on the governor. Any opening of the throttle past idling speed engages the governor spring and increases the engine speed accordingly.

Opening the master throttle past IDLE brings a booster spring (13) into play at each governor to

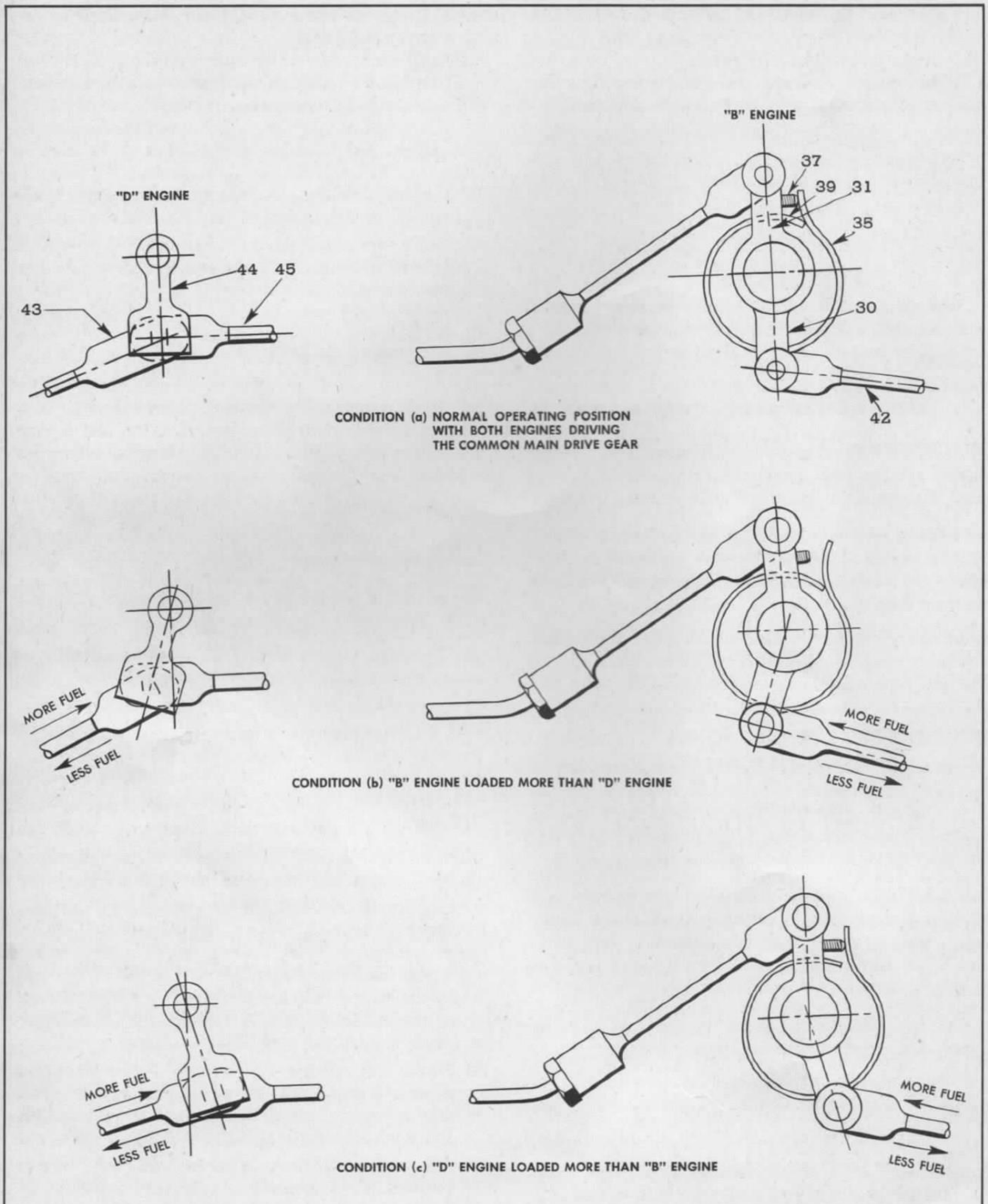


Fig. 38—Positions of Throttle Linkage Between Twin Engines with Equal Load on Engines, also when Unequally Loaded

assist in moving the throttle against the tension on the governor spring. As will be seen from Fig. 37, the forward end of each booster spring is fastened to an adjustable bolt in the speed control lever (23) the opposite end is held in an adjustable eye bolt. By raising or lowering the forward end of the spring and decreasing or increasing the spring tension with the eye bolt, any desired booster effect on the speed control lever (23) is made possible.

OPERATION—The function of the link (45) between the two injector control tubes (33), the swivel joint at the injector control tube on the "B" engine, and the equalizer spring (35) is best explained by reference to conditions (a), (b), and (c) in Fig. 38.

Condition (a) depicts the normal operating position when both engines are clutched to the common drive so that both governors allow the engines to run at exactly the same speed. The equalizer spring adjusting screw (37) is pressing against the free end of the equalizer spring (35), but the force is not sufficient to lift the spring from the spring stop (39).

This force is obtained by setting the governors so that the "D" engine wants a little more fuel than the "B" engine, i.e., the "D" engine governor is set a little high with respect to the "B" engine governor. It is impractical to build two governors exactly alike as to spring rates, governor weight masses, linkage ratios and clearance so that when they are run at exactly the same speed they position the injector racks in the same location. Therefore, at various loads and speeds, the force on the equalizer spring (35), at the swivel joint on the "B" engine, will vary according to the differences in the two governors.

Condition (b) illustrates the position of the linkage when the "B" engine is loaded more than "D" engine. In this case, the clutch of the "D" engine has been disengaged and the governor on the "D" engine will withdraw the equalizer spring adjusting screw (37) away from the spring (35) in order to decrease fuel to the "D" engine.

Condition (c) shows the position of the linkage when the "D" engine is loaded more than "B" engine. If the clutch on the "B" engine is disengaged for any reason, this engine will tend to run away. This condition is prevented by the governor on the "B" engine which overpowers the preload on the equalizer spring (35) through the swivel joint between the injector control tube lever (30) and the equalizer link lever (31) to reduce the quantity of fuel to the free ("B") engine.

NOTE: *The "B" engine will have a higher no load speed at wide open throttle than the "D" engine, because the governor of the "B" engine has the equalizer spring (35) at the swivel joint to overcome in addition to its own spring.*

XII. THROTTLE ADJUSTMENTS FOR LOAD EQUALIZATION—TWINS AND QUADS (ENGINES STOPPED—EQUALIZER CROSS LINK DISCONNECTED)

Each twin unit consists of two and each quad unit of four engines. The object of the throttle adjustment is to cause each engine of the unit to carry its share of the load. On units equipped with variable speed governors, equal speeds and equal load distribution can be assured only by having equal governor speed control lever travels.

To obtain equal travel of all governor speed control levers (23), Fig. 37, the control linkage must be set so that the various levers used in the system travel in identical arcs and are in identical positions in those arcs at any particular master throttle setting.

Having made the necessary adjustments on the individual engines as outlined under items I through IX above, the throttle linkage may be adjusted to divide the load on each of the engines equally.

Refer to Fig. 37 and adjust throttle linkage as follows:

1. Satisfactory throttle adjustment cannot be made with excess play in ball joints and clevis pins. Adjust all ball joints by removing cotter pins (20) from the various ball joints (9) and turn the ball joint nut in until it bottoms. Then, back off on nut to the nearest position where slot in nut aligns with holes in end of ball joint. Insert cotter pin.
2. Lock throttle levers (5) to quadrant on all four engines (3) by means of locking pins (7).
3. Loosen clamp bolt (4) on one of the quadrants (3) and move all four throttle levers (5) to a vertical position. Tighten clamp bolts (4) and lock quadrants on quadrant shaft (3a).
4. While maintaining the throttle levers (5) in a vertical position, adjust the throttle to bell crank rods (10) and (11) of all engines to such length that the ball joint centers of the athwart arms of bell cranks (13) lie on a center line "AA" drawn through the centers of the bell crank fulcrums, as shown in Fig. 37.

   To adjust the length of the short rod (10), remove the ball of the ball joint (9) from the bell crank (13) then loosen lock nut and turn the rod as desired. The long rod (11) may be adjusted without removing the ball joint by loosening the lock nuts and turning the turnbuckle (12).

5. With all four throttle levers (5) locked to quadrants (3), move all throttles toward FULL throttle position until the stop bosses (36) on the aft side of quadrants (3) contact the brackets (2). Loosen lock nuts (3d) and turn in the stop screw (3c) into stop bosses (3b) of both quadrants (3) until each screw projects $\frac{1}{32}''$ or slightly more through its boss, but with both screws contacting the throttle brackets (2). Tighten lock nuts (3d), temporarily.

6. While holding all throttles (5) in FULL throttle position, adjust the four bell crank to governor control rods (21) so that all governor speed control levers (23) reach FULL throttle simultaneously. [All governor speed control levers (23) will be at wide open, or the extreme aft position, when both stop screws (3c) are resting against the throttle brackets (2).]

7. Now loosen lock nuts (3d) on both stop bolts (3c) and turn bolts in $\frac{1}{8}$ turn. Tighten lock nuts permanently.

XIII. ADJUST EQUALIZER CROSS LINK (ENGINES STOPPED)

1. Refer to Fig. 37 and back out equalizer spring adjusting screw (37) so there is a definite clearance between the screw and the free end of the equalizer spring (35).

2. Loosen lock nut at turnbuckle (47) on equalizer link for "B" engine and remove pin (40) that connects link (46) to lever (31).

3. Set equalizer link lever (31) at "B" engine so that its clevis pin (40) center is directly over the center of the injector rack control tube (33). Set equalizer link lever (44) at "D" engine so that its clevis pin center is directly beneath the center of its injector rack control tube.

4. Adjust the length of link (46) so that pin (40) at the "B" engine can just be slipped in place with levers (31) and (44) held in the positions given in item "3" above. Tighten turnbuckle lock nut and install cotter pin.

5. Check as follows: Rotate the injector rack control tube (33) of the "D" engine until the cross link clevis pin is directly under the center of the injector control tube: i.e., on an imaginary vertical line passing through the center of the two pieces. Holding this position, check to see that the clevis pin on the other end of the cross link is directly over the center of the injector rack control tube of the "B" engine. **Careful adjustment of the cross link length, as closely as can be judged by the eye, is essential to proper operation.**

6. Start engines and warm up, with engines declutched and running at idle carefully screw in the equalizer spring adjusting screws (37) in the equalizer links (31) at the "B" engines until the idle speed of the "B" engine is increased from 525 RPM to 550 RPM and the idle speed of the "D" engines is decreased from 575 RPM to 550 RPM.

STARTING AND STOPPING TWIN OR QUAD ENGINES EQUIPPED WITH VARIABLE SPEED GOVERNORS

Starting Twins and Quads—When starting twin or quad engines equipped with the variable speed governor open the master throttle to any position greater than "IDLE" and press the starter button.

NOTE: *If master throttle is set in "IDLE" position and the "B" engine is started first, difficulty may be encountered in attempting to start the "D" engine. This is because the "B" engine governor is tending to hold injector control tubes in the idle position.*

If the "B" engine only is to be used, hold the "D" engine stop lever (27), Fig. 32 in the "OFF" position by unhooking the retracting spring (26) and fastening it toward the front of the engine.

Stopping—Stop the engines by moving the master throttle to the "OFF" position. This moves the stop lever (22) on the top of the governor to the "OFF" position by means of the link (24) on the throttle control rod (21).

LUBRICATION REQUIREMENTS FOR G. M. SERIES 71 TWO-CYCLE AUTOMOTIVE DIESEL ENGINES

Quality—Lubricating oils for Series "71" Diesel engines must possess high oxidation resistance, low tendency towards formation of carbon deposits and non-corrosiveness to copper-lead bearings.

Commonly quoted oil inspection data, such Gravity, Flash Point, and Carbon Residue, bear little significance on the performance of the lubricant in an engine under actual service conditions.

The operator is, therefore, entirely dependent on the experience and reliability of his oil supplier.

Satisfactory operation of heavy-duty engines for long periods of time, requires use of the specially compounded "Heavy-Duty Lubricants."

These superior oils provide better lubrication, possess more heat resistance, and counteract sludge formation more effectively than ordinary motor oils. Their higher initial cost is more than offset by greatly increased life.

Heavy-Duty Lubricants are marketed, by most oil companies, for use in high-speed Diesel and Gasoline engines.

Viscosity—The recommended viscosity grade for all operating conditions is *SAE-30.*

Only when prolonged engine exposure to temperatures below freezing is unavoidable, use of the following lighter grades of oil is permissible to facilitate cold starting.

ATMOSPHERIC TEMPERATURE	VISCOSITY GRADE
+32° F to 0° F	SAE—20W
Below 0° F	SAE—10W

Filtration—Satisfactory engine lubrication requires continuous cleaning of the oil.

Heavy-Duty Lubricants will always appear dark-colored on account of their exceptional ability to keep fine carbon particles in suspension.

Since the color of the oil can no longer be used as an indicator for proper filter action, removal of abrasive dust, metal and carbon must be insured by periodic replacement of the absorption filter elements.

FILTER ELEMENTS MUST BE CHANGED AT EVERY OIL CHANGE.

Engines equipped with Ful-Flow oil strainers require additional cleaning of the edge-type strainer elements at every third oil change.

Renewal—All mineral oils deteriorate in service. To remove the acidic and resinous materials thus formed, the crankcase content must be renewed at regular intervals. No flushing oils or other solvents should be used.

The frequency of these oil changes depends on the quality of the lubricant, the efficiency of filtration, and the severity of engine service.

The following maximum oil change intervals are suggested when using recognized oils of the "Heavy-Duty" type.

ENGINE INSTALLATION	OIL CHANGE INTERVALS
Marine	200 hours

Selection of a reliable oil supplier, strict observation of his oil change recommendations and proper filter maintenance serve best to insure trouble-free lubrication.

FUEL OIL REQUIREMENTS FOR G. M. SERIES 71 TWO-CYCLE AUTOMOTIVE DIESEL ENGINES

General Requirements—In view of the dominating influence of the fuel on engine performance, high-speed Diesel engine fuels should be procured from a reputable source. Quality and suitability of the fuel are responsibilities of the supplier, and he should first be consulted if fuel difficulties are experienced.

For satisfactory operation of high-speed Diesel engines over long periods of time, clean, completely distilled petroleum fuel oils must be used.

Specifications—As a guide for the purchase of suitable fuels, the following specification data are recommended:

	SUMMER	WINTER	ASTM TEST METHOD NUMBER
Flash Point	See Note 3		D-93
Initial Boiling Point, Minimum	325° F		D-158
90% Boiling Point, Maximum	625° F	550° F	D-158
Final Boiling Point, Maximum	675° F	590° F	D-158
Distillation Recovery, Minimum	97%		D-158
Carbon Residue, Maximum	0.15% (Note 2)		D-189
Ash, Maximum	0.01%		D-482
Viscosity @ 100° F, Centistokes	1.8—4.5	1.8—3.0	D-445
Saybolt Seconds	32.0—40.7	32.0—36.0	D-446
Cloud Point	See Note 4		D-97
Total Sulfur Content, Maximum	0.50%	0.25%	D-129
Corrosive Sulfur Content	See Note 1		D-130
Water and Sediment, Maximum	0.05%		D-96
Cetane No., Minimum	See Page **48**		D-613

NOTES: 1. Test to be conducted for three hours @ 212° F. No more than a slight discoloration of the copper strip is permissible.

2. Carbon Residue to be determined on final 10% distillation residum.

3. The Flash Point of a fuel oil has no influence on its performance in an engine but may have to be specified by the purchaser for storage or legal reasons.

4. The fluidity of a fuel oil at low temperatures is indicated by its "Cloud Point". To insure adequate fuel flow in cold weather, the "Cloud Point" must be specified below the lowest expected fuel temperature. If the "Pour Point" is used, it must be specified from 10° F to 15° F below the lowest expected fuel temperature.

Fuel Selection—Efficient combustion in high-speed Diesel engines depends primarily upon two fuel properties: *Volatility* and *Ignition Quality*.

The large number of distilled fuel oils available in the range of the above specifications makes it necessary to consider these two properties together.

Volatility—The volatility of fuel oils is numerically represented by their boiling temperature range. Low boiling fuels vaporize in the engine more readily and burn more completely than fuels with a higher boiling range.

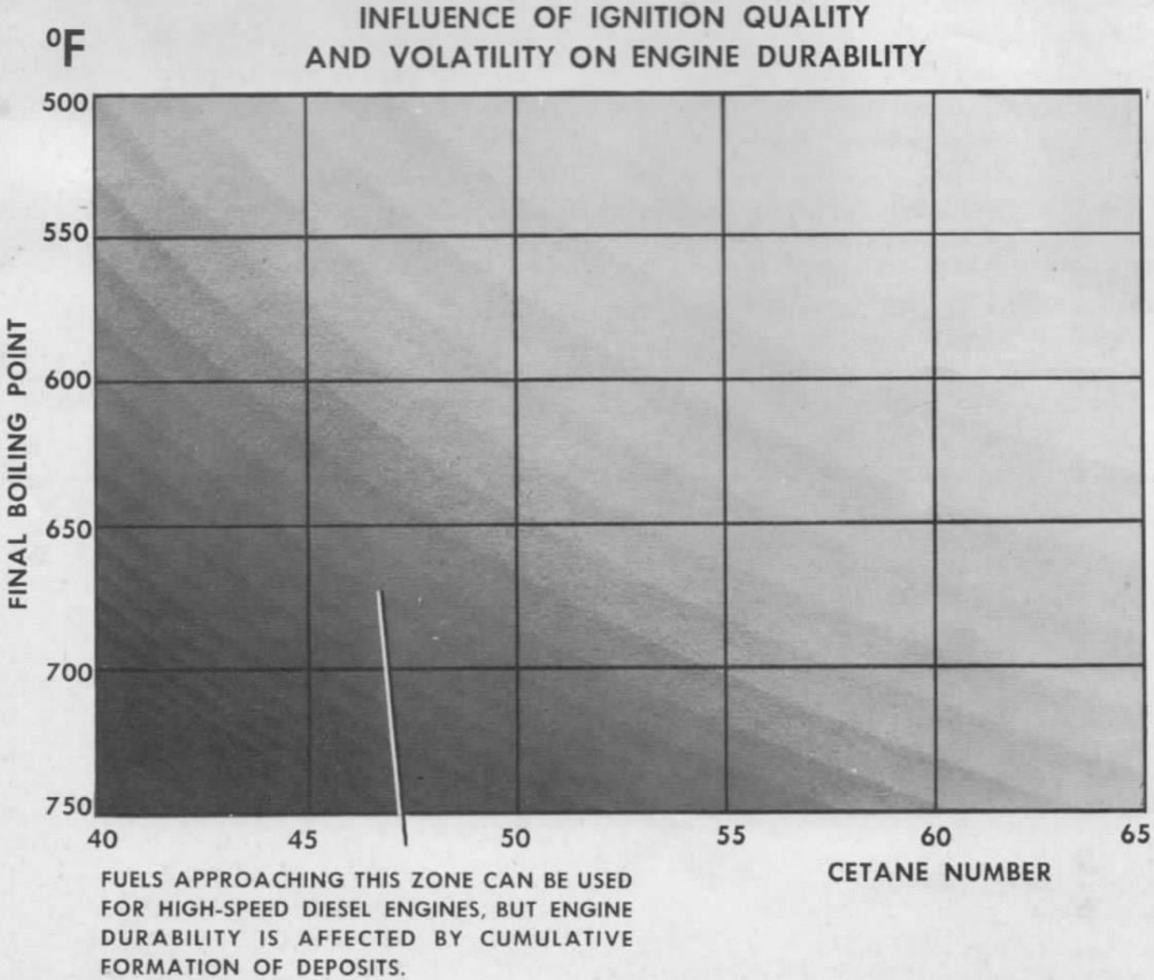
Stationary engines running at constant speed are less critical in their fuel volatility requirements than automotive engines operating over a wide range of speeds with frequent load changes. Consequently, suitability of a Diesel fuel depends to a large extent on the type of service for which the engine is being used.

The lighter fuels specified above for Winter operation may, therefore, be used to advantage all year around on vehicle engines.

Ignition Quality—The ignitibility of Diesel fuels is expressed in terms of "Cetane Number", high values indicating easy starting, short ignition delay, and smooth combustion.

As the cetane number decreases or the final boiling point goes higher, the combustion cleanliness is ad-

INFLUENCE OF IGNITION QUALITY AND VOLATILITY ON ENGINE DURABILITY



versely affected. This is indicated by the black area on the following chart. Exhaust smoke, rapid blackening of the lubricating oil, short oil filter life, and formation of carbon deposits on piston and piston rings accompany this condition.

For best operating satisfaction, fuels falling in the light area should be selected. The minimum acceptable Cetane number depends, therefore, upon the fuel volatility. For a Cetane number of 52, for instance, the final boiling point must be lower than 675° F.

If the Cetane number is 42, the final boiling point must be lowered to 590° F for equally satisfactory service.

Operation in below freezing weather requires Cetane ratings above 50, particularly if no auxiliary starting equipment is being used.