M. I. T. — SPERRY

KNOCKOMETER

MODEL KM-1

OPERATION and SERVICE INSTRUCTIONS

INSTRUCTION No. 23-128 AUGUST 1945

SPERRY GYROSCOPE COMPANY, INC., GREAT NECK, N. Y.

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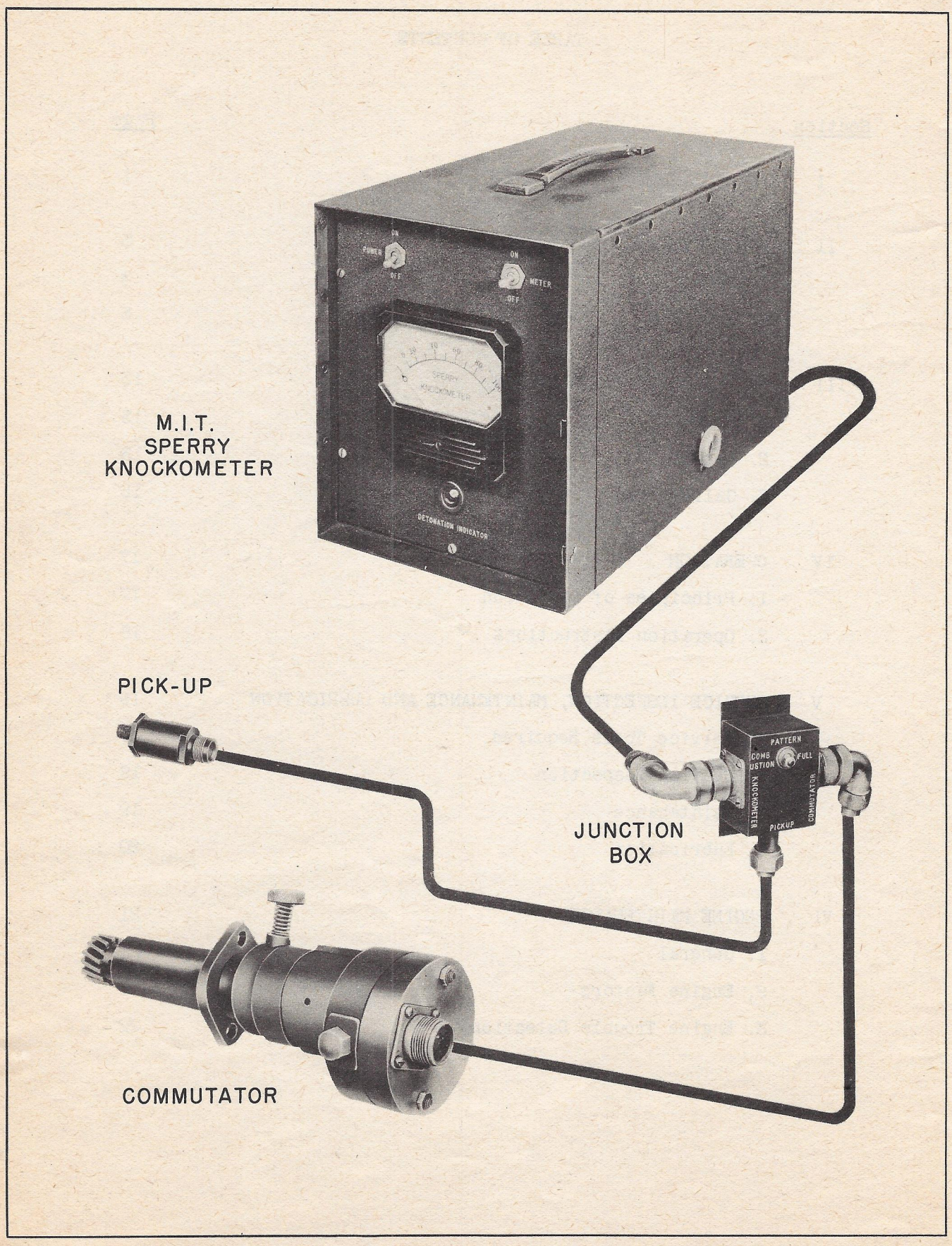

Figure 1 - The Knockometer Assembly

SECTION I

INTRODUCTION

1. The M.I.T.-SPERRY KNOCKOMETER*, Model KM-1, was specifically designed to detect detonation (knock) in single or multi-cylinder internal combustion engines during the process of rating fuels. It indicates this detonation by flashing a neon lamp and registering a reading on the meter indicator. This meter reading serves as a "constant" to indicate the point at which detonation level of fuels is identical. When the knock level of a standard reference fuel is identical with that of an unknown fuel, the rating of the unknown fuel is determined by plotting "fuel-air ratio" against "indicated mean effective pressure" and comparing to that of the reference fuel.

2. As the instrument determines detonation directly, it reduces the human errors prevalent in other methods to a minimum and provides a very accurate means of rating the anti-knock quality of fuels. Research data reveals that incipient detonation (or trace knock) curves can be reproduced by different operators, on different days, with practically identical results, usually within a pound of indicated mean effective pressure. Only a change in knock level affects the knockometer reading; other changes (pick-up output, engine power output, manifold pressure or engine modifications) have no effect except as these factors actually influence knock. (See figure 2.)

3. The Knockometer is responsive to very low level detonation vibrations, which are barely audible and which can be tolerated by an engine, without damage to it, for extended periods of time. It is so sensitive that during detonation, an increase in manifold pressure of 0.1 inch of mercury, under most conditions, will cause the meter reading to double. It is not, however, affected by the difference in sensitivity existing in production pick-up units.

Note

The arbitrary level chosen for the Knockometer operation was based on the average audible and acoustical conditions prevalent in the industry. This audible knock level was found to vary appreciably between installations.

*Trade Mark

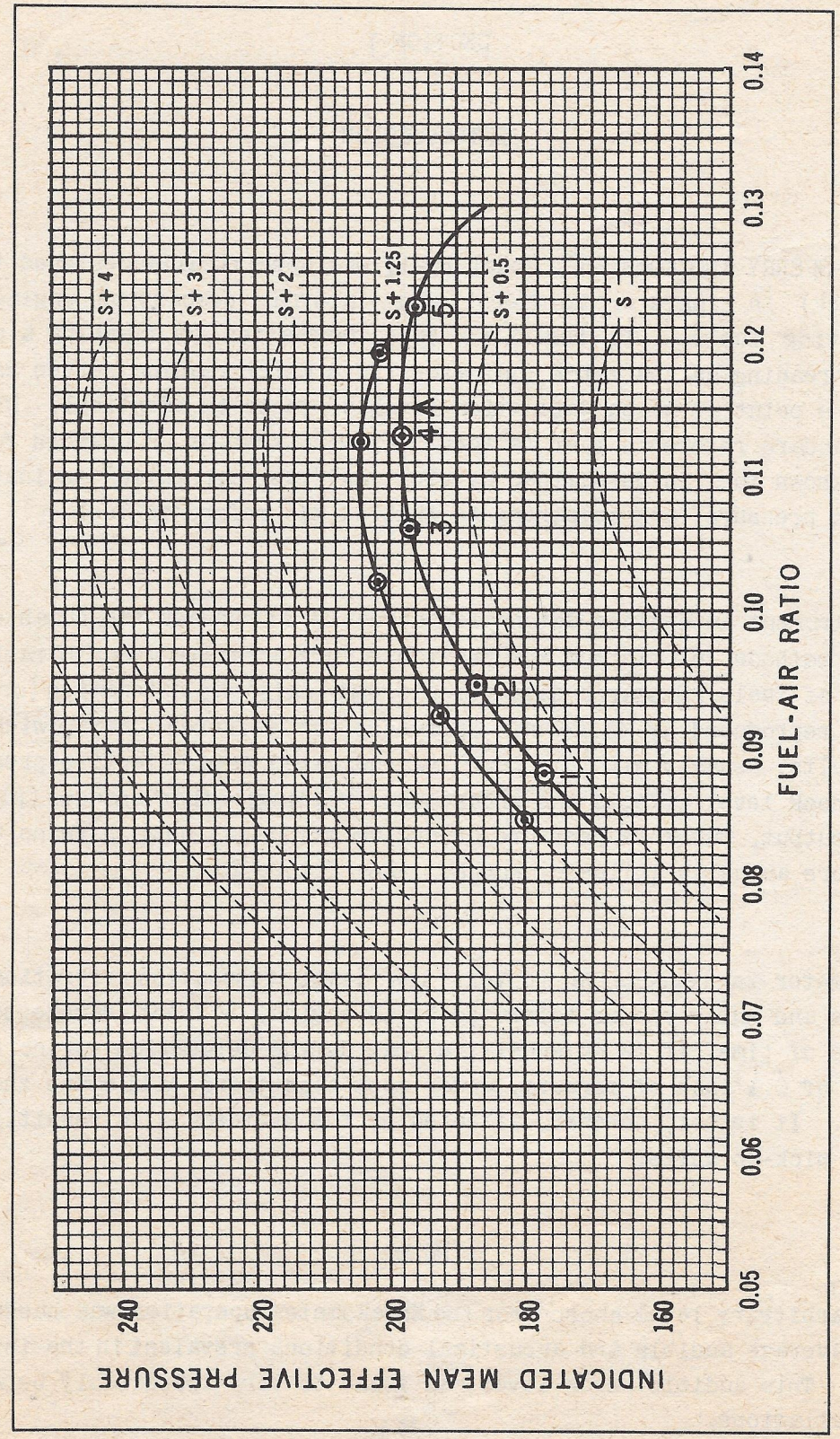

Figure 2 - Comparative Fuel Curves

SECTION II

DESCRIPTION

1. GENERAL. (See figures 1, 3 and 4.)

a. The KNOCKOMETER ASSEMBLY comprises:

(1) The PICK-UP, mounted on an engine cylinder, to detect vibrations caused by detonation and transform these vibrations into voltage signals. (See figure 3.)

(2) The COMMUTATOR, rotated by the engine crankshaft, to eliminate all signals except those generated during the combustion stroke of the engine piston. (See figure 4.)

(3) The JUNCTION BOX, to serve as a junction point for cables from the pick-up, the commutator and the amplifier and to divert current by means of a switch. (See figure 1.)

(4) The AMPLIFIER, to amplify the voltage signals from the pick-up and at the same time to control their gain.

(5) The METER INDICATOR, to filter out non-detonation voltage by means of a neon lamp, to indicate detonation voltage by flashes of this neon lamp, and to register it on the meter.

(6) The POWER SUPPLY, to adapt the alternating current input for the amplifier.

b. Four cables are furnished with the assembly.

(1) Two shielded cables, each enclosing three wires, join the Knockometer and the commutator to the junction box; a third shielded one, with a single lead, connects the pick-up to the junction box. The shielding on these cables serves to ground the system.

(2) A power cable is also provided.

c. Two plugs are supplied: one for the cable to the oscilloscope, another for the meter indicator to serve as a shunt to increase the meter range.

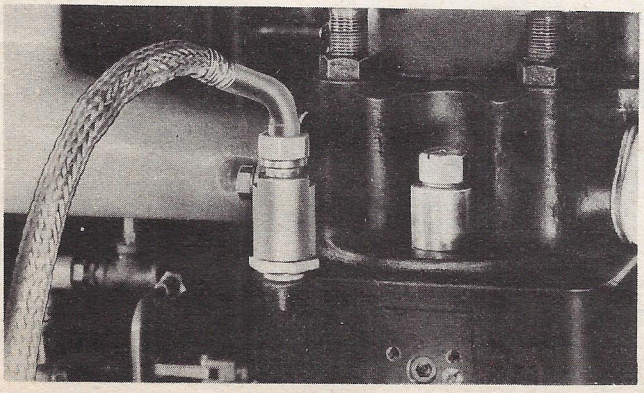

Figure 3 - Pick-Up Installed

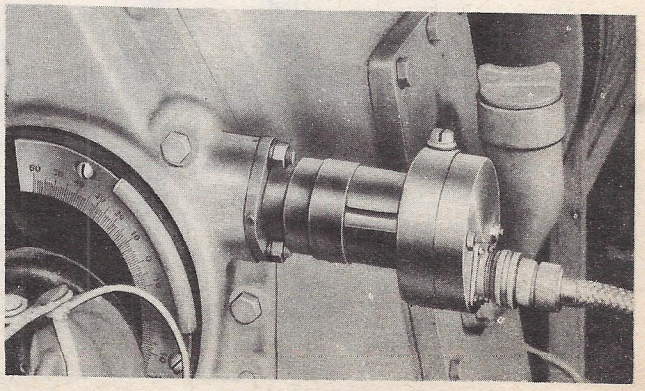

Figure 4 - Commutator Installed

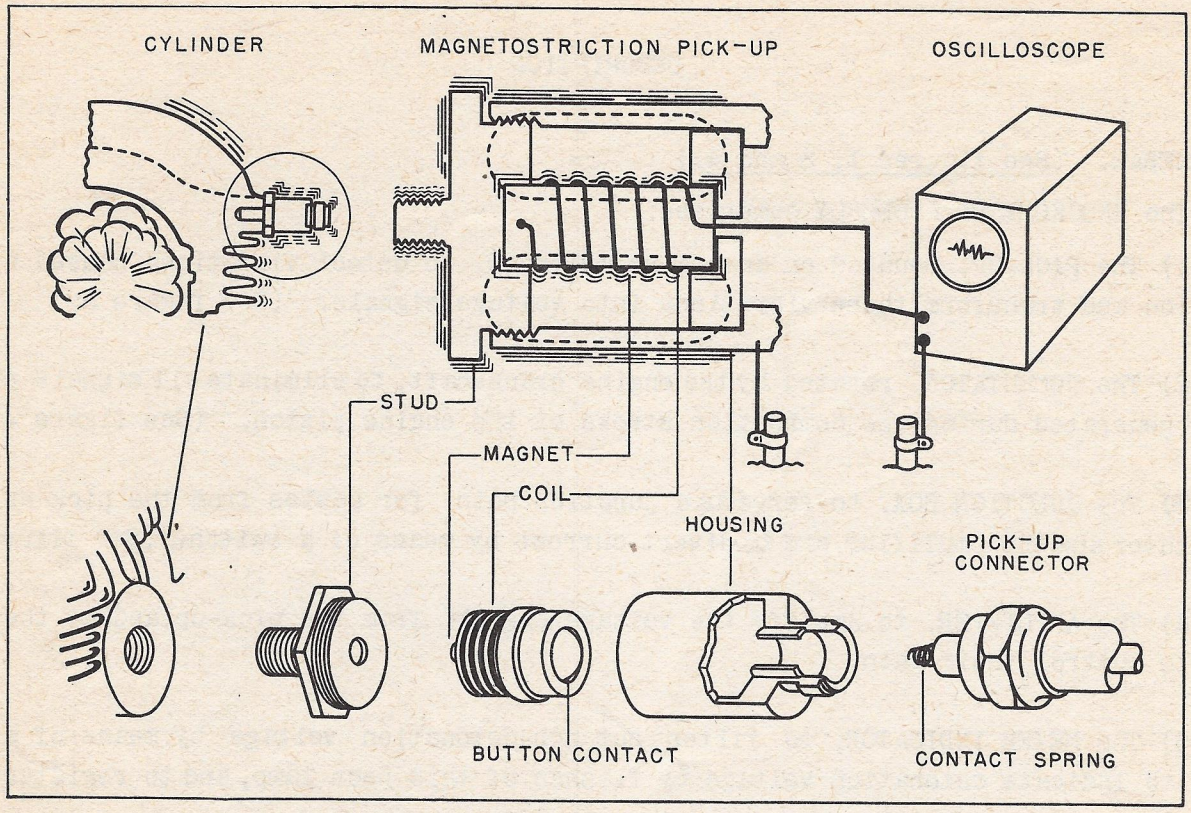

Figure 5 - Schematic of Pick-Up Operation

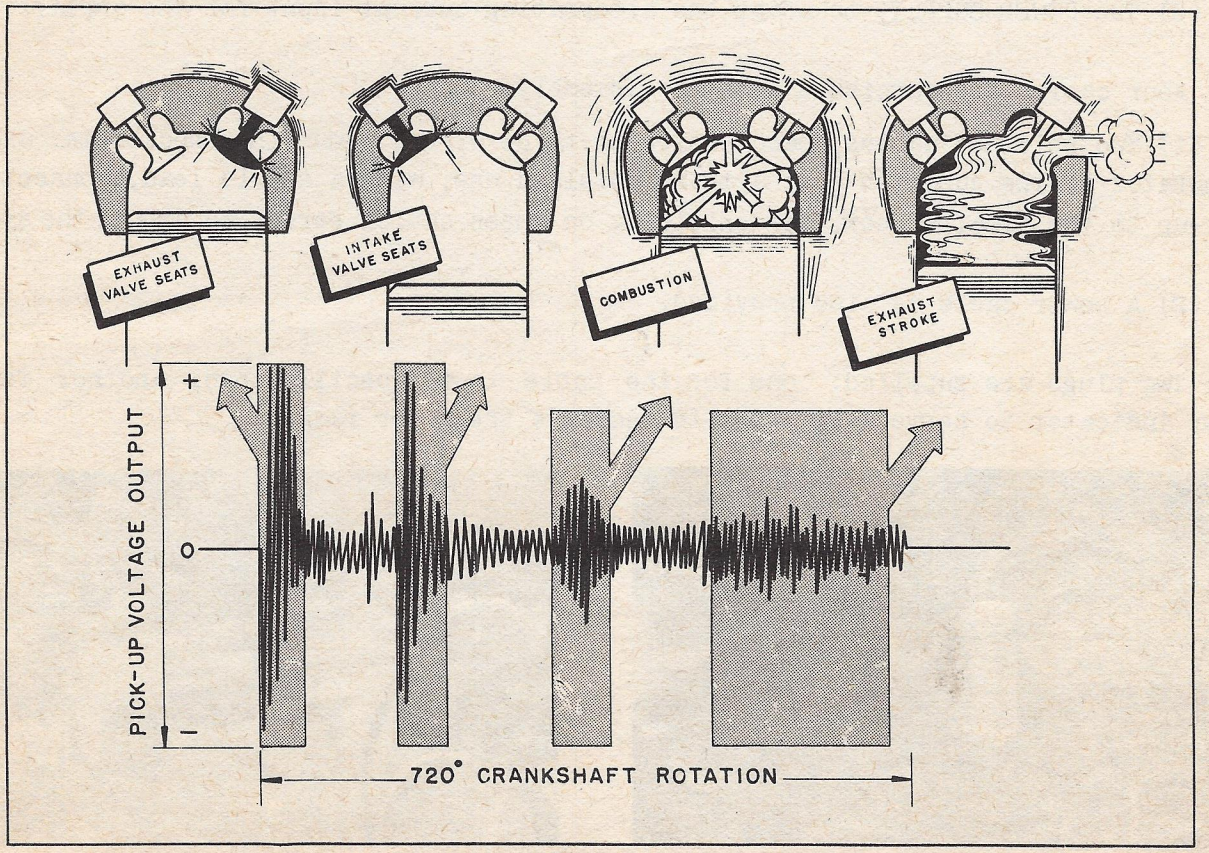

Figure 6 - Schematic - Oscilloscope Impressed with Full Engine Pattern

2. DETAILED.

a. MAGNETOSTRICTION PICK-UP. (See figures 5, 6 and 7.) - The pick-up transforms the mechanical vibrations of the cylinder wall into electrical signal impulses.

(1) The force exerted by engine vibration on the magnet (figure 5) of the pick-up produces stress variations. The stress variations produce flux changes in the surrounding coil thereby inducing an a-c voltage. The voltage so generated is proportional to the rate of change of stress on the magnet and is, therefore, a function of the amplitude and frequency of vibration.

(2) An engine in operation continuously subjects its cylinder walls to vibration which increases markedly when the exhaust and intake valves close, and, in lesser degree, when combustion takes place and evacuation of the burned charge, through the exhaust manifold, occurs. The pick-up responds to these vibrations and continuously generates proportional voltage output. This output can be impressed on an oscilloscope. (See figure 6.)

(3) Should detonation occur during the combustion stroke of the piston, the amplitude pattern formed for that period will at least reach and extend beyond the lines marked "minimum vibration level for detonating combustion" in figure 7.

Note

Detonation is not the only disturbance which produces voltage levels capable of flashing the neon lamp. Valves striking their seats produce the same effects. In like manner, malfunctioning of the engine can indicate similar abnormal amplitude in the pattern and cause the lamp to flash. (Refer to section VI.)

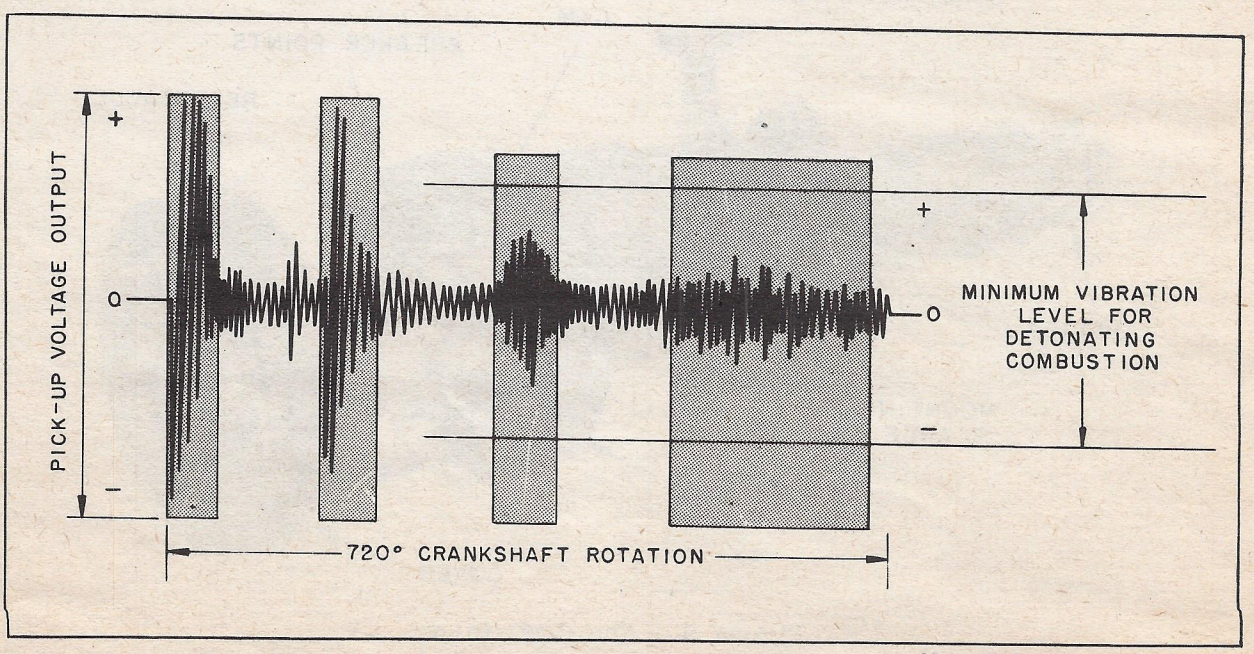

Figure 7 - Minimum Amplitude of Detonating Combustion

b. COMMUTATOR. (See figures 8 and 9.) - The commutator diverts the pick-up signals to the Knockometer, during the 100 degrees of crankshaft rotation within which combustion takes place, thereby eliminating the undesired signals generated during the remaining 620 degrees of rotation when intake, compression, and exhaust of gases take place. (See figure 8.)

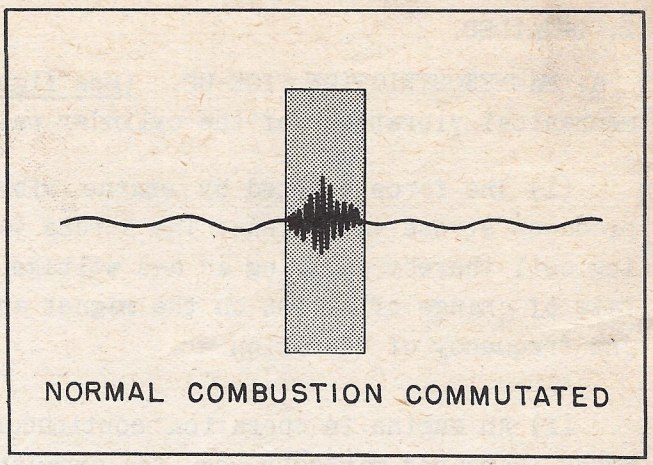

Figure 8 - Combustion Pattern

(1) The commutator (figure 9) contains a shaft to which are affixed a helical gear and a cam. The cam operates a pair of breaker points, one of which is grounded to the case. Except during the combustion period the breaker points short circuit the pick-up signal.

(2) The helical gear (figure 9) meshes with a gear secured to the engine crankshaft and rotates the commutator shaft at half the engine speed.

(3) The clamping screw (figure 9), when loosened, enables the operator, by rotating the commutator housing, to synchronize the duration of breaker point opening with the combustion stroke of the piston.

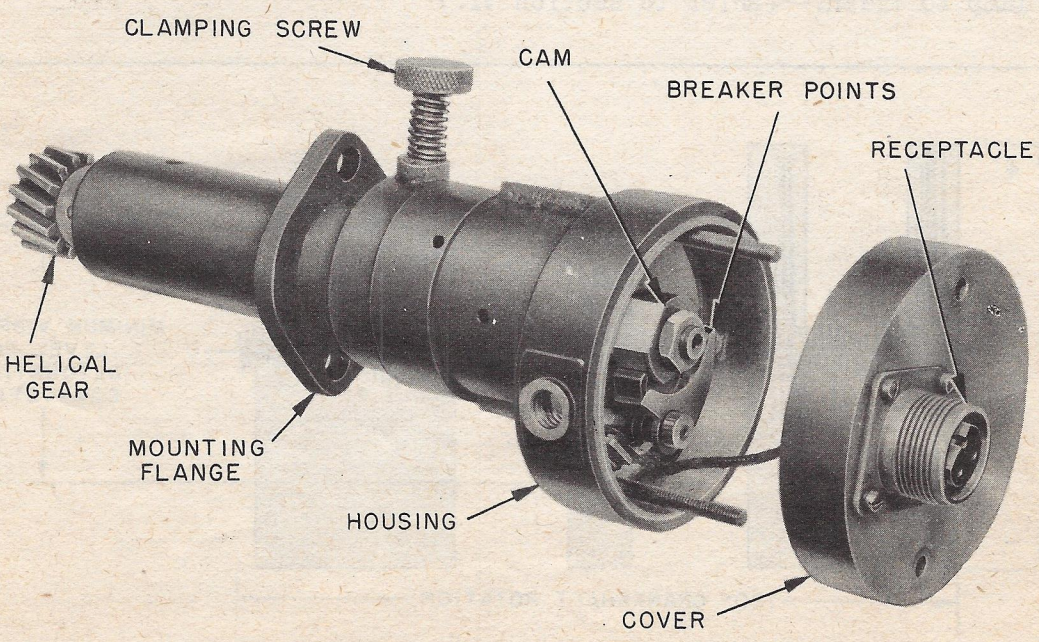

Figure 9 - The Commutator

c. JUNCTION BOX. (See figure 10.) - The junction box accepts cables from the pick-up, the commutator, and the amplifier; the receptacles are clearly marked. It also incorporates a switch marked "PATTERN."

(1) In the "COMBUSTION" position of this switch, the commutator is placed into the circuit so that only the combustion period signals pass through the system.

(2) In the "FULL" position, the switch allows all signals to pass through. This position is used when the amplitude pattern for 720 degrees of crankshaft rotation is to be impressed on the oscilloscope for checking the timing of the commutator, for checking the operation of the Knockometer, or for detecting the malfunctioning of the engine.

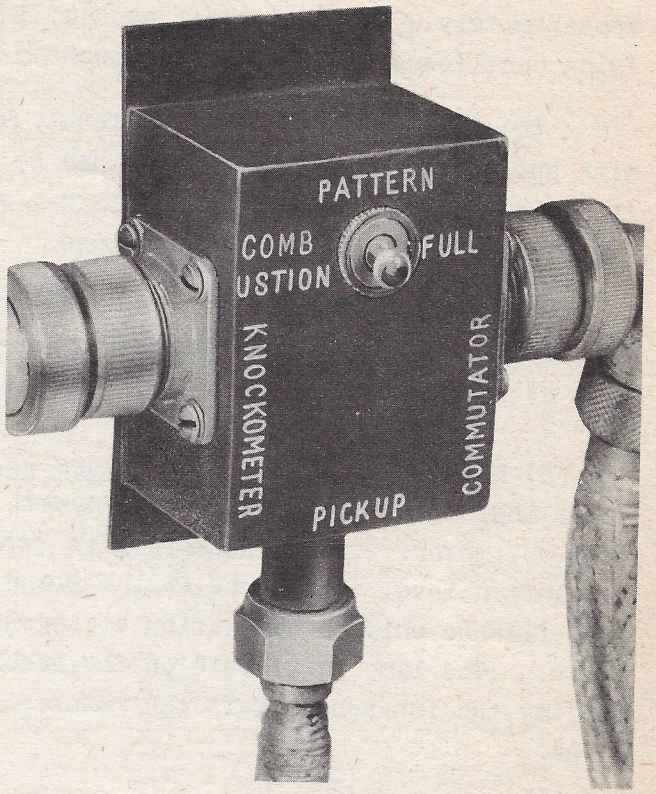

Figure 10 - The Junction Box

d. KNOCKOMETER. (See figures 11 and 12.)

(1) POWER SUPPLY. (See figure 12.) - This unit is mounted on a separate chassis which plugs into the amplifier chassis. It modifies the 110-volt a-c input to a 250-volt plate supply for all tubes by means of a vacuum tube 117Z6GT. The 12-volt a-c filament supply for all tubes is obtained from a secondary winding on the power transformer.

(a) Mounted on top of this unit is the OFF-ON switch. (See figure 12.) It controls the circuit from the power supply switch to this unit. When pushed toward the meter indicator, it is in the "ON" position. A red jeweled lamp, adjacent to it, glows to confirm this fact. This switch should be in the "ON" position at all times.

(b) The POWER switch (figure 11), located on the face panel of the cabinet above the meter indicator, controls all current to the Knockometer.

(c) A "LITTELFUSE" of 2 ampere capacity, mounted within the power supply cabinet, protects the system. In a separate bracket adjacent to it, a spare is supplied.

(2) THE AMPLIFIER. (See figure 12.) - The amplifier is mounted on a separate chassis in the Knockometer cabinet and serves to amplify the signal voltage of the pick-up and at the same time keeps it at a constant level.

(a) Amplification is accomplished through four stages of 12SJ7 vacuum tubes. The fourth stage contains a tuned circuit of inductance and capacitance which resonates at approximately 9,000 cycles per second. This frequency discrimination assists in clarifying oscilloscope patterns when such an instrument is used with the knockometer.

(b) The constant amplified level, for the complete range of signal level variations with speeds and powers, is maintained by the automatic gain control voltage applied to the grid of the second stage. This d-c voltage is obtained by rectifying the amplifier signal output with a 12H6 vacuum tube.

(c) Mounted on the amplifier chassis is the two-position SINGLE-MULTI switch. (See figure 11.) This switch changes the amplifier output level in accordance with the type of engine being used, either single or multi-cylinder.

(3) METER INDICATOR. (See figure 11.) - The output of the amplifier is fed to the meter indicator which contains a 1/4-watt neon lamp, an integrating network, and a vacuum tube voltmeter. The automatic gain control action of the amplifier maintains normal combustion level voltage below the flash voltage of the neon lamp. Consequently, the lamp flashes only on detonation voltages and only these are recorded on the meter indicator. The lamp is visible on the panel and serves a further useful purpose of offsetting the inherent lag in the meter reading by giving an instantaneous indication of knock.

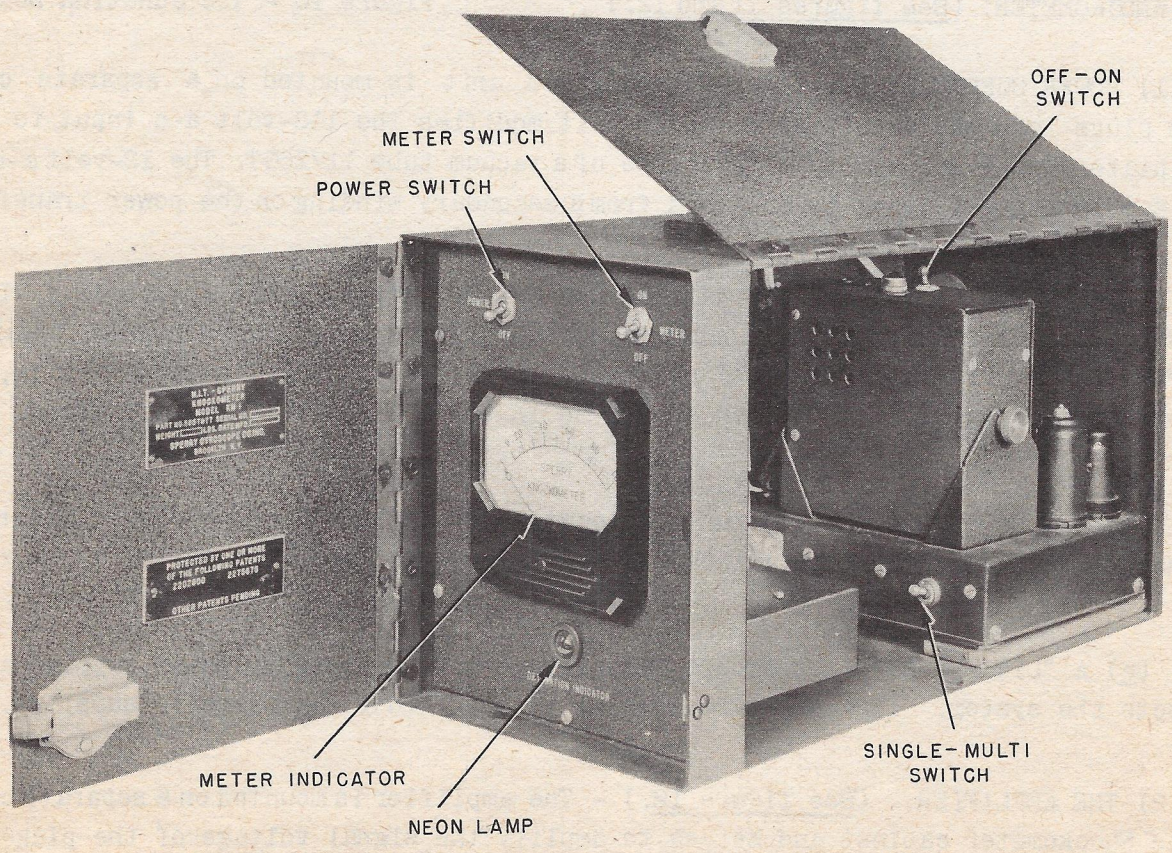

Figure 11 - The Knockometer (Face View)

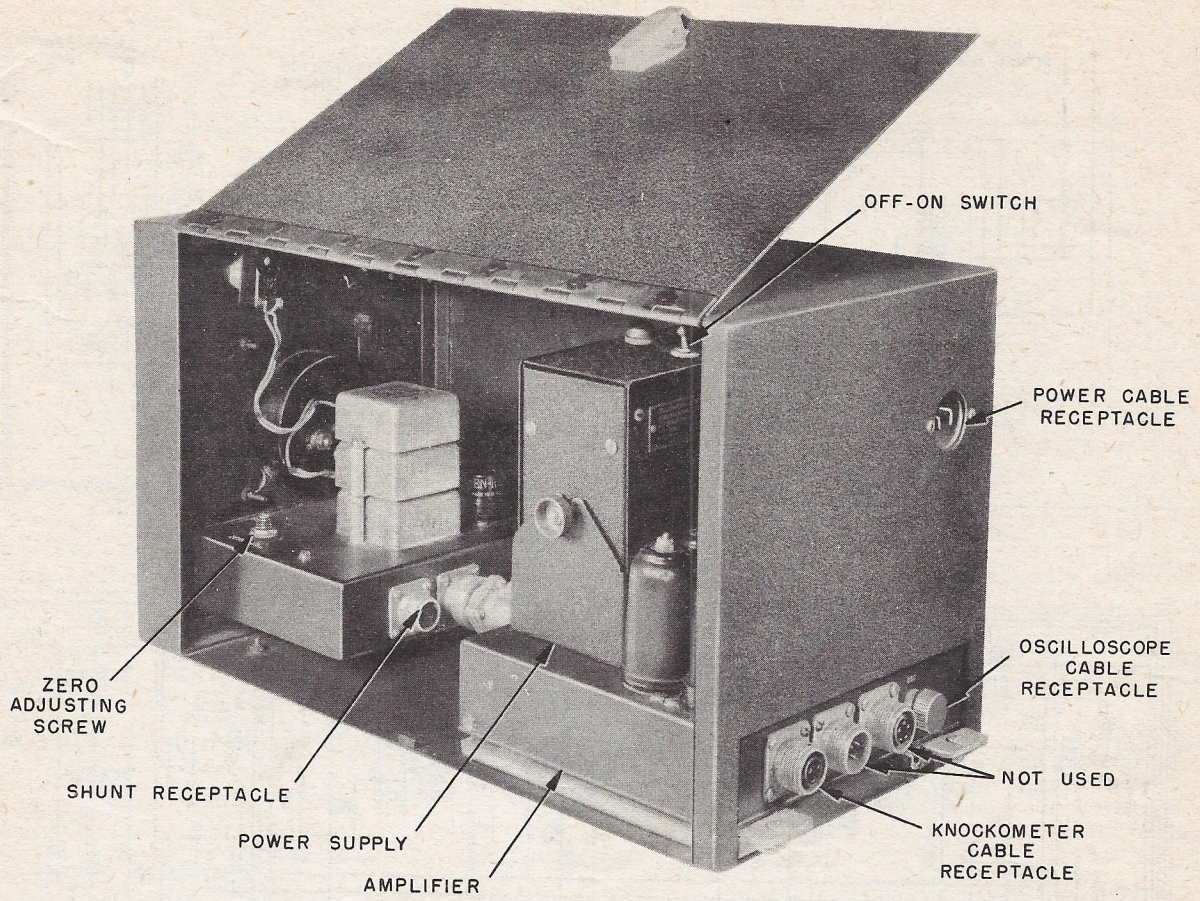

Figure 12 - The Knockometer (Rear View)

(a) The METER switch (figure 11), located above the meter indicator on the face panel of the cabinet, turns the meter circuit on and off.

(b) A potentiometer zero adjusting screw (figure 12), mounted on the meter indicator chassis, sets the pointer to "0."

(c) A receptacle (figure 12) is provided on the rear of the meter indicator chassis for a plug which serves as a shunt to extend the meter range.

(4) RECEPTACLES. (See figure 12.) - On the side of the Knockometer opposite the meter indicator, five cable receptacles are provided. The power cable is plugged into the receptacle in the upper right half of the panel. Of the four lower ones, mounted on the amplifier chassis, the two inner receptacles, one for battery, the other for the indicator, are not presently used but await additional uses of the instrument. The receptacle for the oscilloscope is protected by a cover when not in use; the other receptacle accepts the Knockometer cable from the junction box.

(5) WIRING SCHEMATIC. (See figure 13.) - The wiring schematic indicates the path of the electrical circuits through the entire system, and how the toggle switches divert current into proper channels for each operation.

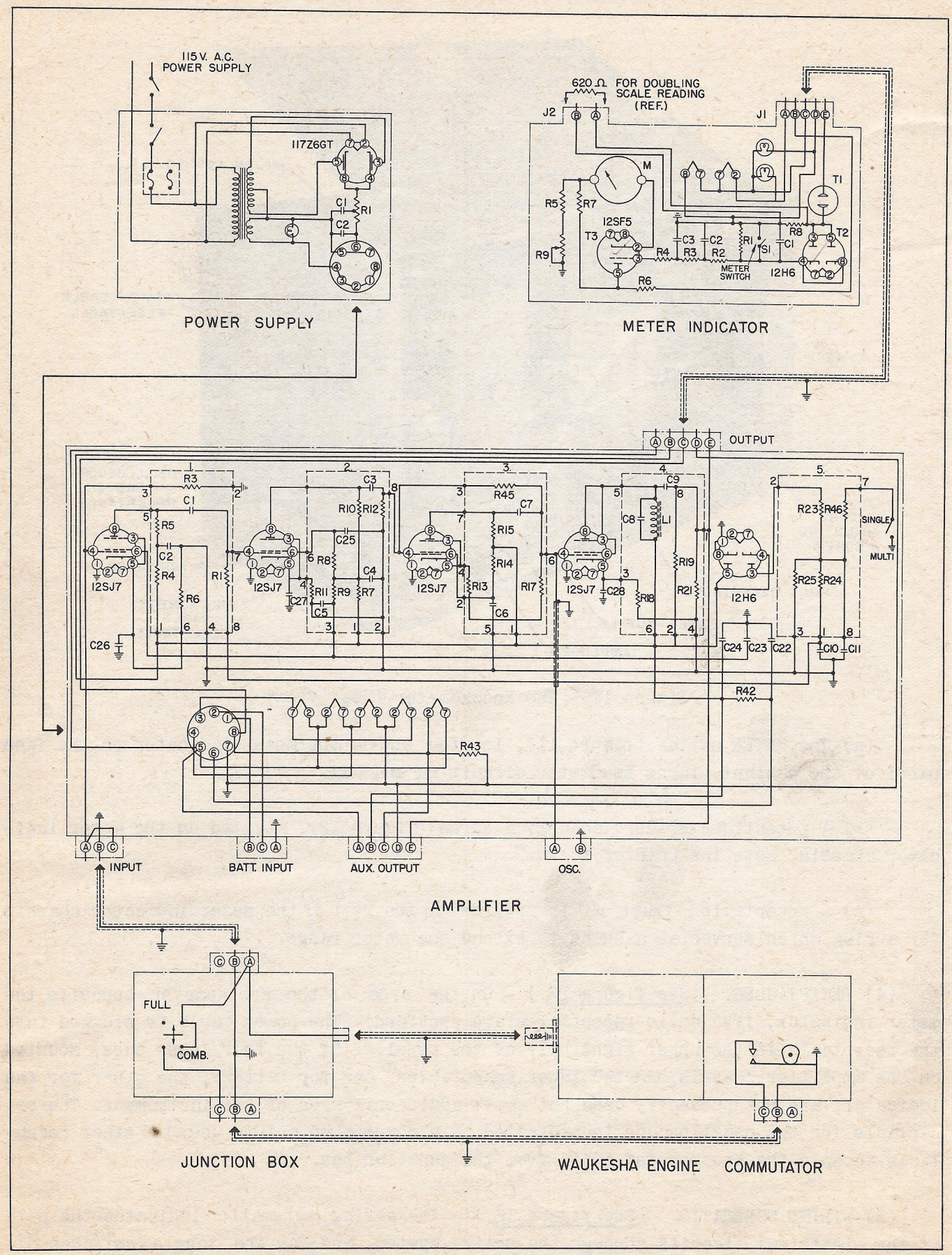

Figure 13 - Wiring Schematic

AMPLIFIER PARTS LIST

SYMBOL	PART NUMBER	DESCRIPTION	VALUE
R1	0300-101	JAN-R-11, TYPE RC10BF154J	.15 MEG 1/2W
R3	0300-97	JAN-R-11, TYPE RC10BF104J	.1 MEG 1/2W
R4	0300-97	JAN-R-11, TYPE RC10BF104J	.1 MEG 1/2W
R5	0300-106	JAN-R-11, TYPE RC10BF244J	.24 MEG 1/2W
R6	0300-49	JAN-R-11, TYPE RC10BF102J	1000 OHMS 1/2W
R7	0300-90	JAN-R-11, TYPE RC10BF513J	51000 OHMS 1/2W
R8	0300-121	JAN-R-11, TYPE RC10BF105J	1 MEG 1/2W
R9	0300-121	JAN-R-11, TYPE RC10BF105J	1 MEG 1/2W
R10	0300-107	JAN-R-11, TYPE RC10BF274J	.27 MEG 1/2W
R11	0300-49	JAN-R-11, TYPE RC10BF102J	1000 OHMS 1/2W
R12	0300-121	JAN-R-11, TYPE RC10BF105J	1 MEG 1/2W
R13	0300-49	JAN-R-11, TYPE RC10BF102J	1000 OHMS 1/2W
R14	0300-106	JAN-R-11, TYPE RC10BF244J	.24 MEG 1/2W
R15	0300-97	JAN-R-11, TYPE RC10BF104J	.1 MEG 1/2W
R17	0300-87	JAN-R-11, TYPE RC10BF393J	39000 OHMS 1/2W
R18	0300-49	JAN-R-11, TYPE RC10BF102J	1000 OHMS 1/2W
R19	0300-90	JAN-R-11, TYPE RC10BF513J	51000 OHMS 1/2W
R21	0300-145	JAN-R-11, TYPE RC10BF145J	10 MEG 1/2W
R23	0300-101	JAN-R-11, TYPE RC10BF154J	.15 MEG 1/2W
R24	0300-138	JAN-R-11, TYPE RC10BF515J	5.1 MEG 1/2W
R25	0300-145	JAN-R-11, TYPE RC10BF106J	10 MEG 1/2W
R42	193818	I.R.C. TYPE MW2	200 OHMS 7.4W
R43	5223725	I.R.C. TYPE MW2	83 OHMS 7.4W
R45	0300-121	JAN-R-11, TYPE RC10BF105J	1 MEG 1/2W
R46	0300-124	JAN-R-11, TYPE RC10BF135J	1.3 MEG 1/2W
C1	190707	CORNELL-DUBILIER TYPE 1W ±10%	.005 MFD 300V
C2	190709	CORNELL-DUBILIER TYPE 1W ±10%	.01 MFD 300V
C3	011-31	CORNELL-DUBILIER TYPE 5RS ±5%	100 MMFD 500V
C4	190709	CORNELL-DUBILIER TYPE 1W ±5%	.01 MFD 300V
C5	190708	CORNELL-DUBILIER TYPE 5W5T5 ±10%	.0005 MFD 500V
C6	190709	CORNELL-DUBILIER TYPE 1W ±10%	.01 MFD 300V
C7	190709	CORNELL-DUBILIER TYPE 1W ±10%	.01 MFD 300V
C8	015-10	JAN TYPE CM-30	.0024 MFD 500V
C9	015-25	JAN TYPE CM-35	.01 MFD 300V
C10	033-3	2 x .5 MFD ±10%	.5-.5 MFD 600V
C11	033-3	2 x .5 MFD ±10%	.5-.5 MFD 600V
C22	243169	3 x .1 MFD ±20%	.1-.1-.1 MFD 600V
C23	243169	3 x .1 MFD ±20%	.1-.1-.1 MFD 600V
C24	243169	3 x .1 MFD ±20%	.1-.1-.1 MFD 600V
C25	190708	CORNELL-DUBILIER 5W5T5 ±10%	.0005 MFD 500V
C26	243169	3 x .1 MFD ±20%	.1-.1-.1 MFD 600V
C27	243169	3 x .1 MFD ±20%	.1-.1-.1 MFD 600V
C28	243169	3 x .1 MFD ±20%	.1-.1-.1 MFD 600V
L1	803645	CHOKE COIL	125 MH

METER INDICATOR PARTS LIST

R1	01-128	TYPE RC21BF205J	2 MEG 1/2W
R2	01-121	TYPE RC21BF105J	1 MEG 1/2W
R3	01-114	TYPE RC21BF514J	.51 MEG 1/2W
R4	01-121	TYPE RC21BF105J	1 MEG 1/2W
R5	163465	I.R.C. TYPE BW1/2	750 OHMS 1/2W
R6	243293	SHALLCROSS MFG. CO. TYPE #190	.1 MEG 1W
R7	243294	I.R.C. TYPE WW7	25000 OHMS 1W
R8	R5228351	TYPE RC20BF752J	7500 OHMS 1/2W
R9	R5223711	TYPE RA20AISD501AK	500 OHMS 1/2W
C1	R5223814	4 MFD ±10%, 50V D.C.W.	4 MFD
C2	R5223814	4 MFD ±10%, 50V D.C.W.	4 MFD
C3	R5223814	4 MFD ±10%, 50V D.C.W.	4 MFD
M	815041	METER	0-100 MICROAMPS
T1	195758	NEON LAMP	
T2	804148	TUBE	
T3	811057	TUBE	
J1	188964	RECEPTACLE	AN3102-14S-5P
S1	R5216853	SWITCH	SPST
J2	190691	RECEPTACLE	AN3102-12S-3S

POWER SUPPLY PARTS LIST

R1	195235	I.R.C. TYPE MW2	6000 OHMS 7.4W
C1	195233	CORNELL-DUBILIER TYPE BRL 8845	8-8 MFD 450V D.C.
C2	195233	CORNELL-DUBILIER TYPE BRL 8845	8-8 MFD 450V D.C.

Key to Figure 13

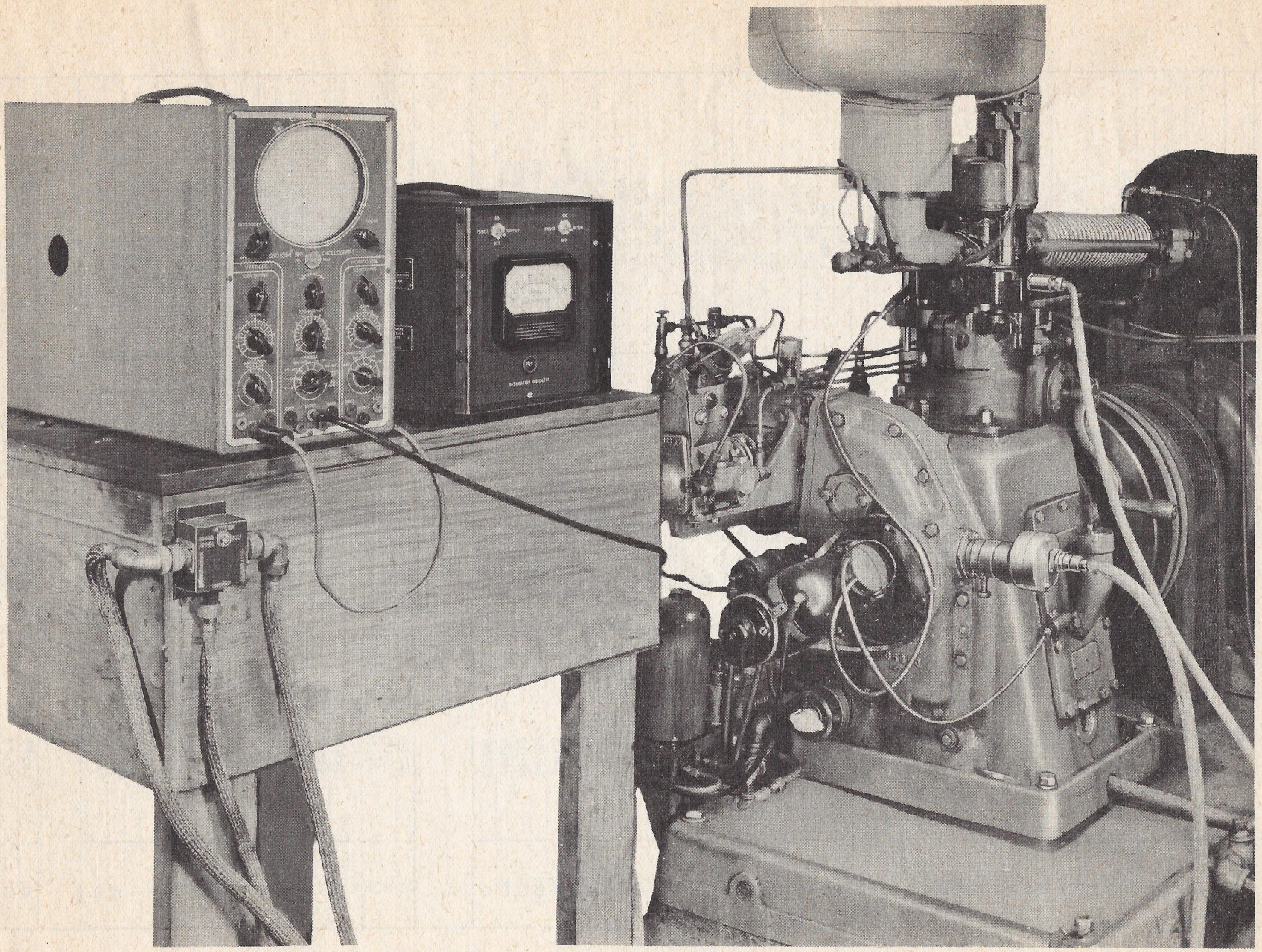

Figure 14 - A Typical Installation

SECTION III

INSTALLATION INSTRUCTIONS

1. GENERAL.

a. The Knockometer equipment must be kept away from large electrical currents where stray magnetic flux may be encountered.

b. The equipment must be connected to a single-phase, 105- to 125-volt, 50- to 400-cycle, a-c power supply.

CAUTION

As the chassis of the meter indicator is not shock-mounted, care should be taken not to subject the instrument to rough handling or unusual vibration.

2. DETAILED.

a. PICK-UP. - Install the pick-up on the cylinder head or wall of the engine as near the combustion chamber and as far away from the valves as possible.

(1) On the Waukeshau CFR engine an existing hole, integral with the top of the cylinder head, may be redrilled and tapped for a 3/8-24 thread which will accept the pick-up.

(2) If a hole must be drilled and tapped to mount the pick-up, care should be exercised not to pierce the wall of the combustion chamber. The hole depth should not exceed 5/8 inch, while a minimum of 1/8 inch of wall should be maintained between the bottom of the hole and the combustion chamber.

(3) Before attaching the pick-up, lubricate the threads with anti-seize compound and be sure the plain and lock washer are in place on the stud, then screw the pick-up in place with a torque wrench, using 125 to 150 pound-inches torque. Pick-ups are provided with safety wire holes which may be used to secure them.

b. COMMUTATOR. (See figure 15.)

(1) Check the breaker points in the maximum open position for a clearance of .005 ±.001 inch. (Refer to section V, paragraph 3.d.(1).)

(2) With the engine stopped and the flywheel adjusted to "0" degree setting on the combustion stroke, remove the cover plate on the engine housing.

(3) Insert the commutator with the shaft slot (oil vent intake up) on top, mesh the gears, and then lock the commutator to the engine housing.

(4) Insert chamber leads into the B and C pin openings of the receptacle (figure 15) on the front of the commutator.

(5) Loosen the commutator housing clamping screw (figure 15) and rotate the housing counterclockwise to a point where the ohmmeter first indicates an open circuit.

Note

This point should be checked carefully. A slight clockwise rotation of the housing should close the circuit; a slight counterclockwise rotation should open it.

(6) Lock the housing in the open circuit position.

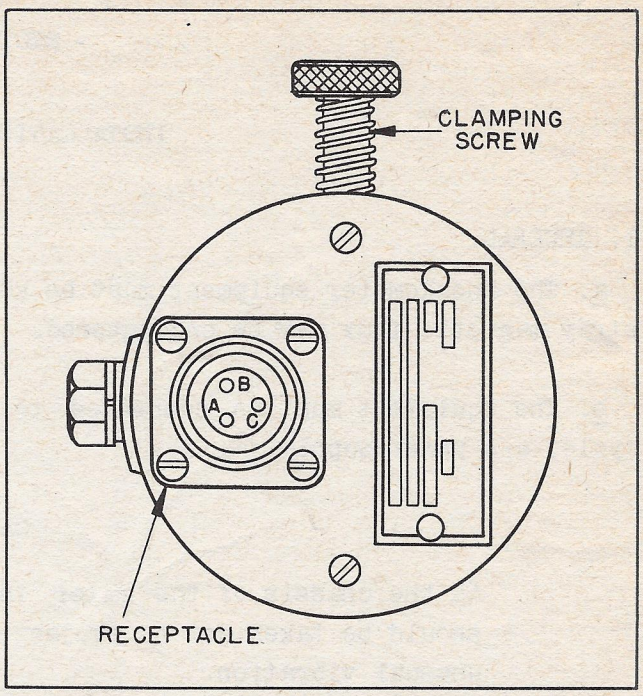

Figure 15 - Commutator (Front View)

(7) Rotate the flywheel slowly clockwise and counterclockwise and note the number of degrees that the flywheel rotates between the first closing of contacts and when they again open. This reading should be recorded for future checking of commutator wear.

c. JUNCTION BOX. - Mount the junction box in a location convenient for the operator. Drill holes through the mounting plate and secure it with screws. (See figure 14.)

d. KNOCKOMETER. - Place the Knockometer on a bench where it may be observed readily by the operator. (See figure 14.)

e. CABLES. (See figures 5, 10, 15 and 17.) - As the grounding of the entire system is dependent upon the shielding of the cables, make certain that all connections are tight and secure.

(1) After checking that the contact button and spring (figure 5) are clean and that the spring has sufficient tension to establish firm contact, attach the pick-up connector to the pick-up.

(2) Connect the cable plugs to the clearly marked receptacles on the junction box. (See figure 10.)

(3) Attach the cables from the junction box to the Knockometer cable receptacle (4, figure 17) on the cabinet and to the commutator receptacle (figure 15).

(4) Attach the cable from the oscilloscope to the plug furnished with the Knockometer.

(5) If an oscilloscope is to be used with the instrument, unscrew the cover, and insert the cable plug into the receptacle (3, figure 17).

(6) Attach the power cable plug to the receptacle (2, figure 17) on the cabinet, twist it slightly clockwise to lock it, and plug the free end of the cable into a 105- to 125-volt, 50- to 400-cycle, a-c outlet.

CAUTION

Do not connect the instrument to any other but a 105- to 125-volt, 50- to 400-cycle, a-c supply. Under no circumstances should a battery cable be connected to the battery receptacle on the amplifier chassis, when the a-c supply is plugged in.

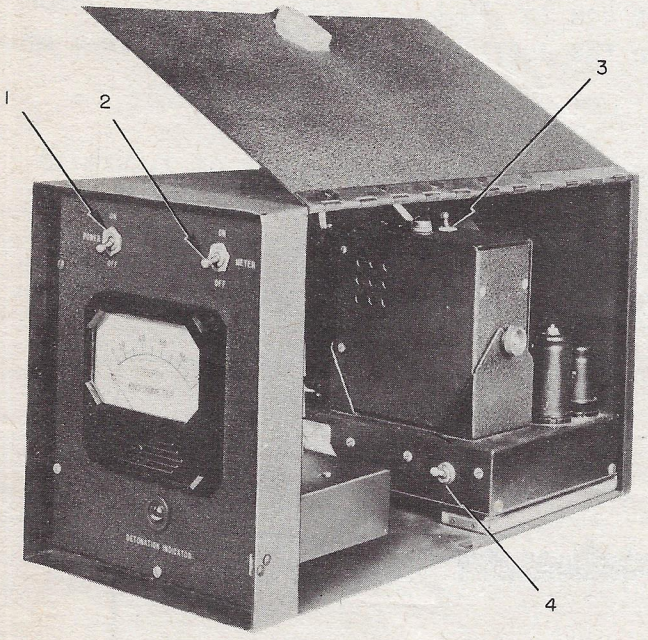

Figure 16 - Knockometer Switches

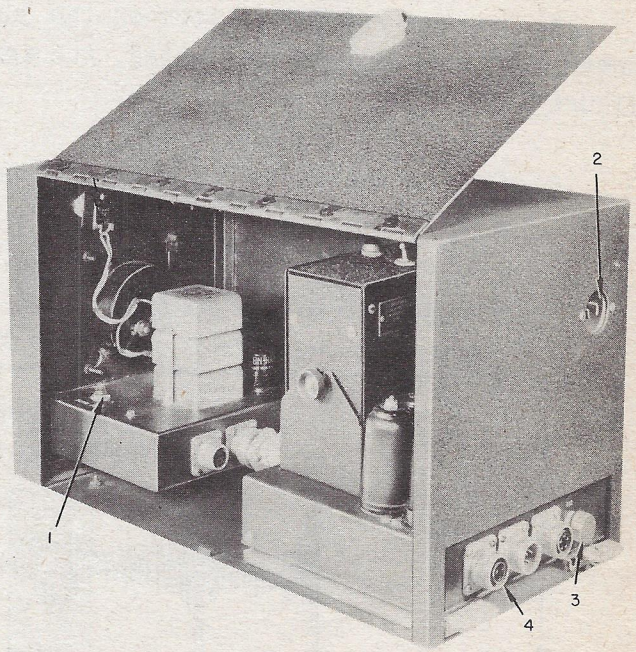

Figure 17 - Receptacles and Zero Adjusting Screw

3. CALIBRATION.

a. KNOCKOMETER. (See figures 16 and 17.)

(1) Check that the OFF-ON switch (3, figure 16) on the power supply unit is in the "ON" position. It should always be in that position.

(2) Check that the SINGLE-MULTI switch (4, figure 16) on the amplifier chassis is set for either single or multi-cylinder engine use. This switch is accessible through the side hinged panel of the cabinet.

(3) With the engine not running throw the POWER and METER switches (1 and 2, figure 16) to the "ON" position.

(4) After a 5-minute warm-up period, adjust the meter zero adjustment potentiometer, until the meter pointer is set at "0." The adjusting screw (1, figure 17) is located on the meter chassis, and is accessible through the side hinged panel of the cabinet.

b. COMMUTATOR TIMING. (See figure 18.)

CAUTION

The PATTERN switch on the junction box must be in "COMBUSTION" position whenever the METER switch on the Knockometer cabinet is turned to "ON." Failure to observe this precaution may damage the meter.

(1) Check that the METER switch is in the "OFF" position.

(2) With the engine running, connect the cable from an oscilloscope to the receptacle marked "OSC" on the amplifier chassis.

(3) Set the PATTERN switch on the junction box to "FULL." With the oscilloscope sweep frequency properly adjusted, the image on the oscilloscope should resemble A of figure 18.

(4) Set the switch to "COMBUSTION;" the image should be similar to B of figure 18.

Note

Should detonation be present in the "COMBUSTION" position, the pattern will resemble C of figure 18.

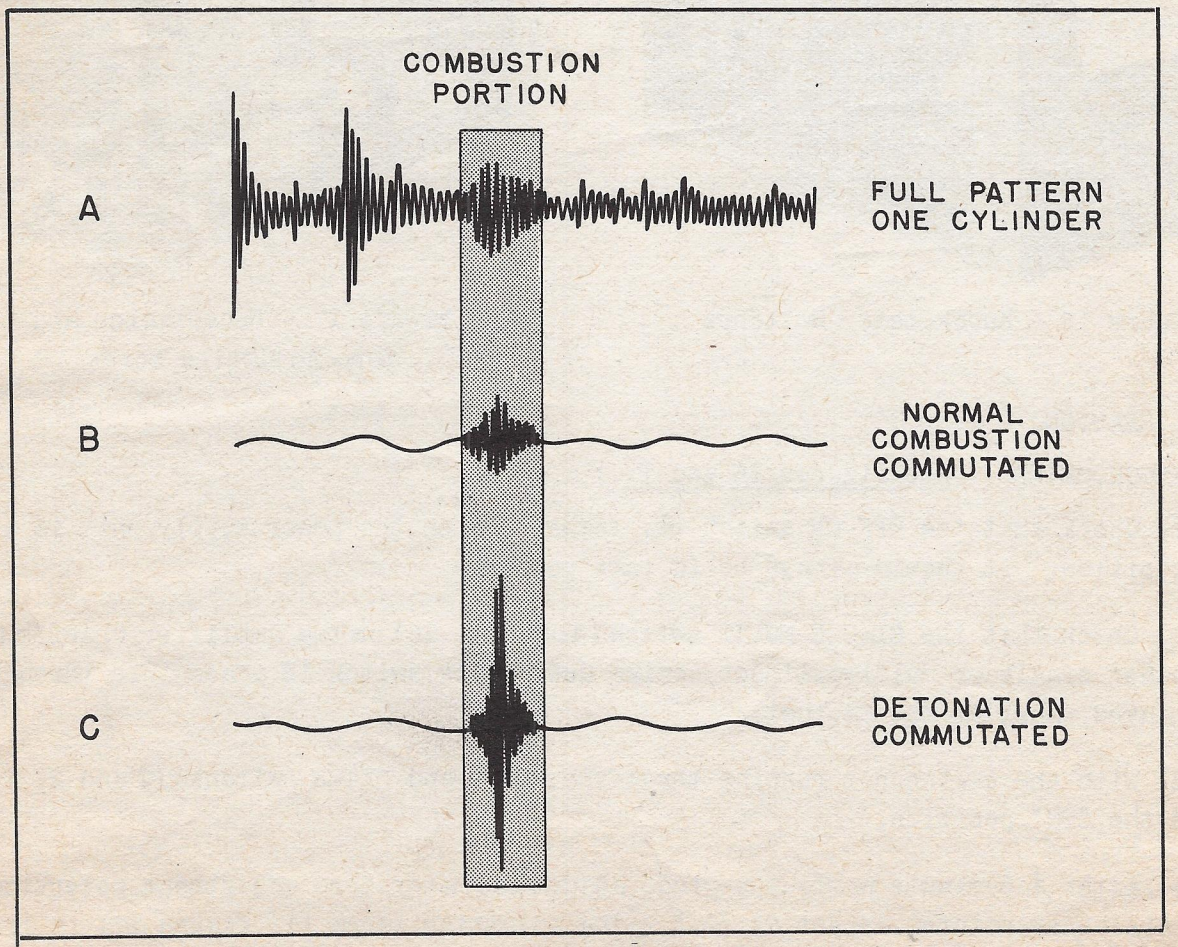

Figure 18 - Oscilloscope Patterns

SECTION IV

OPERATION

1. PRINCIPLES OF OPERATION.

a. Fuel manufacturers and users, through years of experimentation, have developed methods of rating fuels according to chemical constituents, volatility, flash point, or knock rating.

b. To date, the only method of determining knock rating is by burning the fuel in the engine in which it actually will be used, or in a standard engine designed and operated similarly to the actual engine. By plotting "fuel-air ratio" at which knock becomes apparent against "indicated mean effective pressure," the amount of power which can be obtained without knocking is determined. This is the knock rating of that fuel. Fuel of unknown rating is compared with a standard reference fuel of known rating. Thus the fuel is rated by comparison with standard reference fuels.

c. Determination of the level at which knock becomes apparent is a vital part of determining knock rating. The operator's ear or instruments of like reliability are used, resulting in the inability to reproduce similar knock levels from day to day, even with the same engine and the same operator. To remedy this condition, the M.I.T.-Sperry Knockometer was designed. It accurately indicates knock level and assures that a constant knock level is being used at all times, provided engine variables do not cause abnormal vibration.

Note

The Knockometer measures knock level only; it does not rate fuel and it does not compensate for variables in engine conditions. Though it may indicate improper engine conditions, it does not determine what is incorrect.

d. If engine variables cause abnormal vibrations, provision is made to connect an oscilloscope to the Knockometer to determine the cause of these vibrations.

(1) Some mechanical engine variables which cause incorrect fuel ratings are: fouled spark plugs; fouled magnetic contacts; dirty fuel strainer; sticking injector valves; leaky air intake system; faulty temperature control devices; faulty air or fuel measuring systems; sticking intake or exhaust valves; and improper timing and valve adjustments.

(2) Some operational engine variables which cause low octane rating, even with a constant fuel-air ratio, are: higher compression ratio; higher temperature of cylinder walls or intake air; poorer fuel; advanced spark; higher indicated mean effective pressure (engine load); decreased rpm; and increased manifold pressure. The reverse of these variables will cause high octane rating.

2. OPERATION INSTRUCTIONS.

a. GENERAL.

(1) Install and mount the equipment as directed in section III, paragraphs 1. and 2.

(2) Calibrate the Knockometer and time the commutator as described in section III, paragraph 3.

b. FUEL RATING.

(1) Set PATTERN switch on the junction box to "COMBUSTION," and the POWER and METER switches on the Knockometer cabinet to "ON."

(2) With no detonation present, adjust the fuel flow to a desired value.

(3) Increase the manifold pressure until the neon bulb starts to flash. The meter pointer will start to deflect a few seconds later.

(4) Increase the pressure in steps of 0.1 inch of mercury, allowing approximately 30 seconds to elapse for each step, until the average meter reading is near mid-scale. Allow one minute to assure that the average meter reading is maintained near mid-scale. Data for this point may then be taken.

Note

The operation of the Knockometer amplifier with automatic gain control depends upon uniform combustion and engine output. Therefore, do not attempt to rate fuels unless engine output (I.M.E.P.) and combustion are uniform.

(5) When checking the friction mean effective brake pressure (F.M.E.B.) the METER switch must be turned to "OFF" until the detonation period that follows resumption of steady fuel flow is over.

(6) Repeat operations described in this section, paragraphs (2) to (5) inclusive, for each succeeding point in the fuel rating curve.

(7) Experience has shown that the results obtained by previous methods of determining knock do not agree with those obtained by the Knockometer. As the Knockometer has proven in all cases to be the more accurate means, it is suggested that if results do not agree with previous theories or results, the data be repeated. If the data is consistent for three runs, it must be correct. If not, the Knockometer should be checked with an oscilloscope as indicated in section V, paragraph 2., or engine factors must be investigated. (Refer to section VI, paragraph 2.)

SECTION V

SERVICE INSPECTION, MAINTENANCE, AND LUBRICATION

1. SERVICE TOOLS REQUIRED.

No special tools are required; the regulation laboratory maintenance kit contains all those necessary.

2. SERVICE INSPECTION.

A daily operational check should be made.

a. Set the PATTERN switch on the junction box to "COMBUSTION," and the POWER switch on the Knockometer cabinet to "ON." The meter should light up.

b. Set the METER switch to "ON" and allow the amplifier to warm up for a period of 5 minutes. If necessary, readjust the meter pointer to "0" on the scale.

Note

If for any reason - detonation or interference pick-up - there is a signal output sufficient to keep the meter pointer off scale, throw the METER switch to "OFF." If detonation is the cause, adjust the fuel ratio until the neon lamp stops flashing. If interference is the cause, remedy the trouble by relocating the equipment or otherwise eliminating the interfering cause.

c. Adjust the fuel flow to obtain approximately .09 fuel-air ratio, at a manifold pressure below that at which detonation takes place. The neon lamp should show no light and the meter pointer should rest at "0."

d. Slowly increase the manifold pressure until the neon lamp starts flashing and the meter pointer starts to deflect. Adjust the pressure to maintain a meter reading of 30 or less.

Note

An increase in manifold pressure of 1 inch of mercury should drive the pointer to 100 or more. If it does not, make the checks described in this section, paragraph 3. If it still does not, refer to section VI, Engine Maintenance.

3. MAINTENANCE.

a. PICK-UP. - Should the pick-up fail to deliver a signal, check its d-c resistance. If its resistance is not 105 ± 5 ohms at 20°C (68°F), replace it.

b. CABLES. - Check all cables for open or grounded leads. Clean and resolder all poorly soldered connections. Replace all broken or damaged leads.

c. PICK-UP CONNECTOR. - Detach the pick-up cable connector each month. Clean the contact spring and button and check the spring tension. Re-attach the connector and make sure all clamping rings are drawn tight. Erratic results may be obtained if the cables are not connected tightly enough to ground various parts to each other.

d. COMMUTATOR. (See figure 19.) - Remove all grease and oil from the contacts after every 50 hours of operation by washing with carbon tetrachloride. Wipe them with a clean, dry cloth. Do not disturb the timing. Check contacts for .005 ± .001 maximum opening.

(1) To check the clearance of the breaker points and adjust them proceed as follows:

(a) Remove the two fillister head screws that hold the commutator cover to the housing.

(b) Rotate the cam, by means of the helical gear, until the breaker points are in the maximum open position. Check the gap with a feeler gage; the .004 inch blade should enter, the .007 inch blade should not.

(c) If the adjustment is not within the required tolerance, loosen the two breaker binding screws (figure 19) slightly and adjust the clearance by rotating the eccentric screw. Retighten the two breaker binding screws and replace the commutator cover.

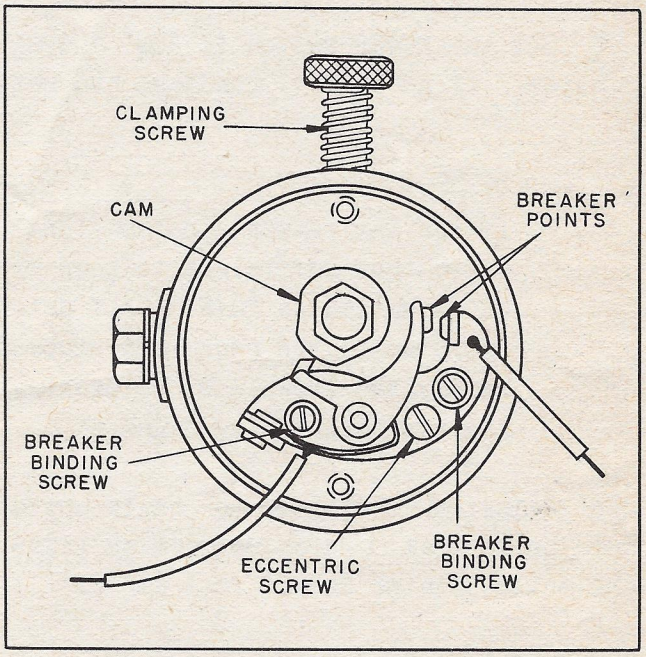

Figure 19 - Commutator (Cover Removed)

e. KNOCKOMETER. - Check all tubes every three months. Remove all dust and dirt from the case with clean, dry, compressed air. Make sure that the switch on top of the power supply unit is in the "ON" position.

4. LUBRICATION.

The commutator shaft is lubricated by the oil from the crankcase of the engine. All other parts being electrical in operation, require no lubricants.

Note

In event of difficulties with this equipment, that cannot be solved by the instructions herein contained, the nearest Sperry Gyroscope Co., Inc. office should be consulted.

SECTION VI

ENGINE MAINTENANCE

1. GENERAL.

a. Irregularities in the functioning of the M.I.T.-Sperry Knockometer have been traced to poor technique in the installation of the units, to pick-up from stray electrical fields, or to faulty engine performance.

b. To obtain maximum efficiency from the Knockometer, particular care must be taken to assure peak engine performance. Badly worn and poorly lubricated parts produce fuel rating errors. Non-uniform combustion and engine output also may be causes. Other contributing factors listed in this section, paragraph 2., also may be responsible.

c. To check the performance of an engine, use a standard reference fuel in it and compute the output. Any departure from the standard indicated mean effective pressure (I.M.E.P.) values would indicate malfunctioning of the engine.

2. ENGINE FACTORS.

The following engine factors lead to a false determination of knock level:

a. MECHANICAL.

(1) Loose main bearings.

(2) Leaking valves.

(3) Sticking valves.

(4) Improper valve setting.

(5) Scored cylinder walls.

(6) Defective rings.

(7) Defective couplings. (Dynamometer to engine and engine to fuel pump.)

(8) Loss of compression through the spark plug and head vent.

b. FUEL INJECTION SYSTEM.

(1) Excessive wear on fuel pump.

(2) Improperly seated fuel flow valve.

(3) Sticking injection valve.

(4) Improper injection valve adjustments.

(5) Loose micrometer. (Allowing movement through vibration during point setting.)

(6) Presence of air in the fuel distribution system.

(7) Leaks in couplings and joints.

(8) Dirty fuel strainer.

(9) Wrongly labeled fuel.

c. AIR INJECTION SYSTEM.

(1) Erratic control of intake air temperature.

(2) Leaks in system.

(3) Failure of relief valves.

(4) Presence of excessive moisture and oil in the system.

d. IGNITION.

(1) Defective setting of points.

(2) Improper timing.

(3) Open or shorted capacitor.

(4) Defective plugs.

(5) Dirty or pitted points.

e. ACCESSORIES.

(1) Cradle bearing friction.

(2) Erratic operation of ignition timer.

(3) Failure or erratic operation of thermostat controls.

(4) Defective pressure gages.

f. ELECTRICAL INTERFERENCE.

(1) Radiated fields from heater coils, solenoids, and relays.

(2) Improper engine grounding.

3. ENGINE TROUBLE DETECTION.

a. By attaching the oscilloscope to the Knockometer and setting the PATTERN switch on the junction box to "FULL," a complete study of the amplitude pattern, formed during the four piston strokes that complete the cycle of the engine, can be made. Any deviation from the typical pattern (A, figure 18) would indicate malfunctioning of the engine and means should be taken to correct the condition.

CAUTION

Whenever the amplitude of the four piston strokes is to be impressed on the oscilloscope, the METER switch must be in the "OFF" position to prevent damage to the meter.

(1) Sticking valves will shift the valve pattern from its normal position, or will eliminate it entirely. Bouncing valves will change the shape of the pattern.

(2) A mild flashing of the neon lamp during the combustion period, normally would indicate detonation, whereas an extremely lean fuel-air ratio may be causing the engine to skip. In this case the combustion pattern disappears completely from the oscilloscope. Engine skipping that is caused by poor fuel injection is difficult to detect because of engine and dynamometer noises. Removal of the exhaust stacks makes this skipping audible.

(3) Damaged engine parts cause additional vibrations which are evident on the oscilloscope. Inspection of the engine will reveal such parts.