Go-Power Systems

"The Measure of Performance"

OPERATION, INSTALLATION, SERVICE and REPAIR of

DY SERIES DYNAMOMETER

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1. INSTALLATION &OPERATION

1.1 INSTALLATION

Construct a scatter shield of 1/4 inch steel plate, or of 1/2 inch aluminum, or of 1 inch plywood. Go-Power recommends that the scatter shield be placed between the operator and the dynamometer-engine combination. Make the scatter shield large enough so that the operator cannot in any way be struck by flying fragments in the event of an engine, flexible-coupling, or dynamometer failure. Mount the shield securely with brackets and braces. Also, bear in mind the possibility of such a failure when operating the dyno and always insure that bystanders keep behind the scatter shield for full protection.

WARNING:

USE A SAFETY (SCATTER) SHIELD

DYNO MOUNTING

The dynamometer should be securely mounted to a base plate of 1/4 inch or thicker steel or cast-iron. Cast-iron is definitely preferred over steel as it has better vibration-absorbing qualities. The steel bracket on the dyno is designed to place the center line of the shaft at 4-3/16 inch above the mounting base. See figure 1-1.

1.2 INSTALLATION

You may find that with your dyno it is slightly more or less than this figure due to minor production differences, but you can compress or expand the legs of the bracket to obtain the 4-3/16 inch height. This height is standard throughout the industrial-engine field.

Secure the base plate to a rigid structure which will also allow for mounting a scale and tachometer. If you plant to use the dynamometer in a permanent installation, it will be a good plan to mount the dyno on a base plate in such a manner that engines can be installed and removed easily. You may want to pur a concrete mount. If you do, remember to allow for wrench and finger space for installing and removing mounting bolts.

FLEXIBLE COUPLINGS

Hooking up the engine to the dynamometer can be easily accomplished with any one of several commercially available flexible couplings. These are available through bearing houses. You can also use a similar sprocket on the dyno impeller shaft and the engine shaft, then connect them with a double-row chain.

SCALE ARM

Each dyno is shipped with the scale arm mounted on the left side when looking at the hose-connection side of the dyno. This is the correct mounting when using the dyno with a left-mounting engine (drives sprocket counter-clockwise when you observe drive side of engine). The scale arm can be moved to the opposite side of the dynamometer housing if it is desired to run engines of opposite rotation, such as the McCulloch or any right-mounting engine.

The scale arm used on the Go-Power dyno is a "one-tenth arm" meaning that it is 1/10 the length of the standard dynamometer arm of 63 inches. The 1/10-arm value (measured from the center of the dyno impeller shaft to the center of the inner of the two 1/4 inch holes in the outer portion of the arm) is used to simplify calculations as described in a later paragraph.

1.3 INSTALLATION

The outermost 1/4 inch hole in the arm is provided for installation of an oil-type damper should scale readings prove to be erratic or "jumpy". If such a damper is used, be sure that it does not effect scale readings.

INLETS & OUTLETS, VALVES

Figure 1- has been included to indicate the function of the various integral hose fittings on the dynamometer casing. The two fittings clustered at the top are for water inlet and air-bleed. The bottom fitting at the very outer edge of the housing is for a water outlet.

Water inlet (usually from a source of city water under pressure) should be controlled with a gate-type valve. More water increases the load on the engine and thereby reduces RPM until load and engine speed stabilize. If stable-speed readings are being taken over several minutes' time, be sure that the water-outlet temperature does not rise above 100 degrees Fahrenheit (lukewarm). If the dyno casing gets more than comfortably warm to the touch, the heat could cause steam pockets to develope, perhaps "losing the load" and allowing he engine and dyno to exceed rated safe limits.

It is not necessary to valve the water outlet.

The air-bleed allow easy and quick readings by permitting water to run out of the unit rapidly when the load is being reduced. The water does not pump out quickly because the dyno has been designed to be a very inefficient pump. The air-bleed tubing should be held vertically, perhaps by tying it to your scale support. It will tend to fill with water under some load conditions.

Small hose clamps should be used to attach the hoses to the dynamometer casing. Be careful when attaching the hoses,, and in handling the dyno prior to bolting it to a base plate, as the hose attachment fittings are die-cast parts of the housing and can be broken off easily. Should you inadvertently break off one, it can be replaced with a short length of steel tubing, press-fitted into the case with LOCTITE.

1.4 INSTALLATION

SCALE

Scales used here at Go-Power are rebuilt produce scales with a 13-inch diameter 10 pound dial. Actually, these scales weight to 30 lbs, but the 10 lb. figure is seldom exceeded, especially with "A" Class kart engines which have under 5.8 cubic inch (95cc) displacement. A "fish" scale will work very well for comparative-type installations. Dial-type scales are recommended for more precise applications.

TACHOMETER

A 10,000-RPM tachometer is recommended for most installations. We prefer and recommend a direct drive 1:1 tachometer of the governor-type. These tachometers are more accurate than either the magnetic cup (similar to an automobile speedometer mechanism) or electronic type tachometers. Our own tests indicate that the governor-type is very accurate and is definitely capable of providing repeatable readings.

Repeatable readings are extremely important due to the fact that you are looking for very small power improvements (seldom more than 3% to 5% in a small two-cyle engine). You cannot tell if you have made an improvement if your tachometer is inaccurate by several percent, as is he case with most "electronic" and magnetic-cup types.

The standard tachometers supplied by Go-Power for use with the small engine dynamometer are the 2,000 to 16,000 RPM JONES Tachometer or the 1,000 to 10,000 JONES Tachometer. The 16,000 RPM unit is recommended where the user wants to install the tachometer on his kart or other equipment, as well as use it with the dyno, as the dynamometer is only to be operated up to 10,000 RPM. Also, there is some sacrifice of accuracy and ease of reading the RPM with the 16,000 RPM unit, as the 14,000 RPM total scale is spread out over the 3 inch diameter scale. The 10,000 RPM units spreads its 9,000 RPM range over the 3 inch dial, making it possible to obtain more accurate readings.

1.5 INSTALLATION

TACHOMETER CABLE

The cable and couplings supplied by Go-Power for the JONES Tachometers consists of several parts: as outer housing with coupling nuts at each end, a support for mounting the housing nut at the dyno end, an inner drive cable with drive fittings for the tachometer at one end and for the coupling and the coupling or dive which is driven into the end of the dyno's impeller shaft.

When installing the flexible cable, it is important that as great a length as possible be kept straight at each end to allow the end drive fittings to float freely, because a short bend at this point has a tendency to crowd the fittings to one side, resulting in excessive wear of the flexible shaft. Such misalignment can also cause binding of the operating parts with the possibility of such binding being carried into the tachometer and causing unsteadiness of the pointer movement and excessive wear. All bends at other points of the flexible shaft should be kept to a radius as large as possible: Never less than 12 inches.

Occasional removing of the inner cable from its housing and applying a very light coating of grease-- such as Vaseline-- along this inner cable will lengthen the life of the flexible shaft.

INITIAL TIGHTNESS OF SEALS

When you first receive the dynamometer, the shaft may seem hard to turn. Several revolutions will free up the seals so that this condition disappears.

SCALE PROTECTION

An anti-backlash stop must be installed to prevent the dyno scale arm from turning past the point at which it applies no load to the scale. If it is allowed to apply a reverse shock to the scale, serious damage can occur to the scale. As a suggestion, this stop can be wrapped with sponge rubber (or a sponge rubber ball can be used) to provide a shock absorbing action when the load is lightened suddenly, permitting the scale arm to slam to its zero position.

1.6 INSTALLATION

FILLING INSTRUCTIONS

1. Remove torque system from dynamometer.

2. Disconnect tubing and load cell from gage by the nut, leaving 90 degree elbow on gage.

3. Leaving tubing attached to fitting on load cell, unscrew 90 degree elbow from load cell.

4. Using a blunt instrument, push diaphragm down.

5. Fill oil can with silicone and pump till fluid comes out nozzle.

6. fill Load cell through fitting hole until fluid is at the top of the hole.

7. Screw 90 degree elbow and tubing assembly back into load cell.

NOTE: USE THREAD SEALANT OR TEFLON TAPE.

8. Slip 4 inch piece of 3/16 ID tubing over nozzle of oil can, leaving at least 1 inch over hang from end of nozzle. Pump oil can till tubing is filled with fluid.

9. Using finger, push piston into load cell so that fluid is forced into the load cell tubing. Continue pushing till fluid is dripping out open end of tubing.

10. Slip oil can tubing over load cell tubing. Pump oil can, forcing fluid back through tubing and into load cell. Continue pumping till system will not take any more fluid.

11. Quickly disconnect oil can and put open end of load cell tubing back into elbow on torque gage and tighten nut.

12. System is not full of fluid and ready for use.

13. If torque gage does not read zero when system is complete, this is caused by residual pressure in the system and in no way effect accuracy. To zero gage, loosen nut on load cell fitting till fluid starts to drip out between the nut and threads.

1.7 INSTALLATION

DO NOT DISCONNECT TUBING FROM LOAD CELL! Once gage has zeroed tighten nut and install system back into dynamometer.

INSTALLING THE LOAD CELL IN THE DYNAMOMETER

The load cell and gage assembly for your dynamometer has been packaged separately to protect the delicate gage mechanism form damage in shipment. The gage must be installed in the dynamometer before it can be used.

WARNING :

THE LOAD GAGE SYSTEM IS FLUID FILLED.

DO NOT DISCONNECT ANY PART OF THE SYSTEM.

1. Remove the retaining nuts and clamps from the back of the gage. Insert the load cell and line through the front of the gage mount casting and then slip the gage into place in the gage mount casting. Clamp the gage into place with the clamps and nuts which were attached to the gage.

WARNING:

THIS DYNAMOMETER HAS BEEN CAREFULLY CALIBRATED AT OUR FACTORY. DO NOT DISTURB THE CLEVIS POSITION ON THE TORQUE ARM.

2. The tubing fitting on the back of the load gage is pointing toward one side of the dynamometer. Route the load gage to load cell tubing in this same direction down past the water hoses and over to the load cell mounting bracket. Bring the load cell to a position below the clevis assembly. Be careful not to disturb the other water tubing and not to kink the load gage tubing.

3. Slip the 1/4 inch diameter rod from the clevis into the hole in the top of the piston in the load cell. Then raise the load cell into position through the load cell washer until the snap ring groove is above the washer. To mount the snap ring, open the lower end of

1.8 INSTALLATION

the snap ring and rotate it into the snap ring groove on the load cell.. Test to be sure the load cell snap ring is in place firmly by putting pressure on the torque arm and clevis assembly. **DO NOT EXCEED THE 15 POUND READING ON THE TORQUE GAGE.** See figure 1.2

TCA-7/9 INSTALLATION

1. Install stand-offs onto torque calibration arm. (Usually use shorter stand-off between torque calibration arm and absorption unit.) Be sure proper hole is used for particular dynamometer being calibrated. Hole marked 7 is for MD-8D and all DY-7 models. Hole marked 9 is for the DY-9D model.

2. Install calibration arm as per enclosed drawing.

3. Hang counter weights (customer supplied) on short end of arm until it is balanced.

4. Using known weights (customer suppled), hang 2 lb. weight on long end of arm. Again, be sure proper hole is used.

5. Use enclosed chart to determine gage readings. Tap top of instrument tower with palm of hand to relieve any hysteresis.

6. If gage reading is incorrect: DY-7, MD-8 loosen clevis and load cell mounting screws. Move clevis and load cell towards absorption unit for higher reading, away for lower.

DY-9 Use pointer set screw on back of torque gage for adjustments.

7. Check gage in low, mid, and high range to insure linearity.

8. If gage in non-linear, then it must be sent back to the factory for adjustments.

9. Torque calibration arm must be removed completely prior to running the dynamometer.

1.9 OPERATION

OPERATION

Maximum operating speed for which the Go-Power small-engine dynamometer is designed, is 10,000 revolutions per minute. Do Not exceed this speed! Excess speed could conceivably cause damage to the dynamometer and injury the operator.

Always operate the dynamometer with a working tachometer to insure that the 10,000 limit is not exceeded.

In relation to the above, note that bushing engines should not be run under full load below 3,000 RPM or above 5,5000 RPM to insure against rod bearing failure. Nothing is to be gained from a dyno test by flat-out running. What you are really looking for is the RPM at which peak torque is obtained and for an indication of the RPM vs TORQUE curve so you can choose the best gear ratios and tire sizes.

WARNING:

MAXIMUM SAFE DYNAMOMETER SPEED IS 10,000 RPM

KEEP THE ENGINE COOL

Most two-cycle engines will tend to run hotter when they are stationary than when they are being moved through the air, as on the back of a cart. This is especially true where the engine's blower and shroud assembly are no particularly efficient. However, in the case of McCulloch engines, their cooling systems seem to be adequate for any type of operation provided they are not operated with a lean mixture.

You will find that nearly all engines will require an additional blast of cooling air directed onto the cylinder head if prolonged full power runs are being made. Be sure to run a rich mixture; this helps the engine to run cool. The spark plug should be checked between runs for signs of blistering which indicate overhearing. This can be done during the cooling-off period which should be allowed after each run.

ALWAYS TAKE EVERY PRECAUTION AGAINST FIRE AND BE SURE TO HAVE A FIRE EXTINGUISHER HANDY.

HOW TO CALCULATE HORSEPOWER WITH THE DYNO

Horsepower calculations are made extremely simple by the design of the G0-Power dynamometer. Using the inner of the two outermost holes in the scale are, the reading you obtain on your scale will be actual horsepower at 10,000 RPM (rated safe limit for the dynamometer). At any lesser RPM, the h.p. will be obtained by a simple calculation thusly: assuming a 5 pound scale reading at 9,000 RPM.

9,000 RPM x 5 lbs. scale reading

10,000 (constant)

simplifies to 9/10 x 5 lbs. or: 0.9 x 5 =4.5 Horsepower

Other Examples

3,000 RPM scale reading of 3 lbs. is 0.3 x 3 or .09 h.p.

4,000 RPM scale reading of 7 lbs. is 0.4 x 7 or 2.8 h.p.

10,000 RPM scale reading of 8 lbs. is 1 x 8 or 8 h.p.

OBTAINING CONSISTENT TEST RESULTS

To obtain consistency in your test results, always make your tests at the same cylinder-head temperature. Cylinder-head temperature can best be measured with an airplane type cylinder-head temperature gauge. The "sending unit" used for this type of gauge is a thermocouple type spark plug washer. Use the washer in place of the normally used spark plug washer.

Other items which will be of help in obtaining consistency include the use of a standard fuel, freshly mixed and the use of temperature, humidity and barometric correction factors. Most such information can be obtained free of charge from your local weather bureau. Thus, you are relieved of the expense of purchasing a wet/dry bulb thermometer, barometer and thermometer.

Once you have the temperature, atmospheric pressure and relative humidity at the time of the test, you can use the figures to correct the raw h.p. reading obtained from your dyno to what the reading would be for Standard Temperature and Pressure and or Dry Air. Use the following formulas:

TEMPERATURE

$$\text{Corrected BHP} = \text{Raw BHP} \times \frac{273 + T1}{273 + T2}$$

Where T1 equals temperature in degrees Centigrade at time of test run and T2 equals Standard Temperature (15 degrees Centigrade).

PRESSURE

$$\text{Corrected BHP} = \text{Raw BHP} \times \frac{29.92}{P}$$

Where P equals the atmospheric pressure in inches of Mercury(as read from a barometer) at the time of the test run. If you wish to purchase your own barometer, either an aneroid or open tube type will do.

RELATIVE HUMIDITY

$$\text{Corrected BHP} = \text{Raw BHP} \times \frac{29.92}{P-W}$$

Where P equals the atmospheric pressure in inches of Mercury at the time of the test and W equals the water vapor pressure in the air at the time of the test run (as ready from a wet/dry bulb thermometer).

COMPOSITE FORMULA

When it is wished to make corrections for all three variables at the same time, you can simply combine all three formulas into one so that

$$\text{Corrected BHP} = \text{Raw BHP} \times \frac{273 + T1}{273 + T2} \times \frac{29.92}{P} \times \frac{29.92}{P-W}$$

Using a chart where temperature in increments of 1 degree C is shown along the top and pressure in increments of 0.1 inch of Mercury down the side allows the percent correction of various combinations of these two variables to be read off immediately. A second chart can show the correction indicated for different atmospheric water vapor pressures. Getting true h.p. then only requires multiplying raw h.p. by these two percentages.

GO-POWER CORPORATION

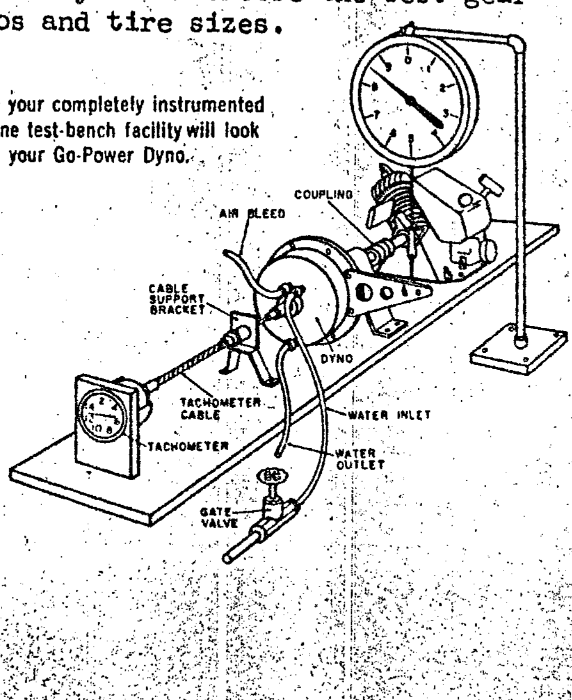
INSTALLING AND OPERATING YOUR GO-POWER DYNAMOMETER

WARNING: MAXIMUM SAFE DYNAMOMETER SPEED IS 10,000 RPM

Maximum operating speed for which the Go-Power small-engine dynamometer is designed is 10,000 revolutions per minute. Do not exceed this speed! Excess speed could conceivably cause damage to the dyanmometer and injury to the operator.

Always operate the dynamometer with a working tachometer to insure that the 10,000 limit is not exceeded.

In relation to the above, note that bushing engines should not be run under full load below 3,000 RPM or above 5,500 RPM to insure against rod-bearing failure. Nothing is to be gained from a dyno test by flat-out running. What you are really looking for is the RPM at which peak torque is obtained and for an indication of the RPM vs. torque curve so you can choose the best gear ratios and tire sizes.



How your completely instrumented engine test-bench facility will look with your Go-Power Dyno.

WARNING: USE A SAFETY (SCATTER) SHIELD

Construct a scatter shield of $\frac{1}{4}$-inch steel plate, or of $\frac{1}{2}$-inch aluminum, or of 1-inch plywood. Go-Power recommends that the scatter shield be placed between the operator and the dynamometer-engine combination. Make the scatter shield large enough so that the operator cannot in any way be struck by flying fragments in the event of an engine, flexible-coupling, or dynamometer failure. Mount the shield securely with brackets and braces. Also, bear in mind the possibility of such a failure when operating the dyno and always insure that bystanders keep behind the scatter shield for full protection.

Dyno Mounting

The dynamometer should be securely mounted to a baseplate of $\frac{1}{4}$" or thicker steel or cast-iron. Cast-iron is definitely to be preferred over steel as it has better vibration-absorbing qualities. The steel bracket on the dyno is designed to place the center line of the shaft at 4-3/16" above the mounting base. You may find that with your dyno it is slightly more or less than this figure due to minor production differences, but you can compress or expand the legs of the bracket to obtain the 4-3/16" height. Why was this height chosen? It is used as a standard throughout the industrial-engine field -- at least by the major kart-engine manufacturers.

Secure the baseplate to a rigid structure which will also allow for mounting a scale and tachometer. If you plan to use the dynamometer in a permanent installation, it will be a good plan to mount the dyno on a baseplate in such a manner that engines can be installed and removed easily. You may want to pour a concrete mount. If you do, remember to allow for wrench and finger space for installing and removing mounting bolts.

Flexible Couplings

Hooking up the engine to the dynamometer can be easily accomplished with any one of several commercially available flexible couplings. These are available through bearing houses. Or, you can use similar sprockets on the dyno impeller shaft and the engine shaft, then connect them with a double-row chain.

Scale Arm

Each dyno is shipped with the scale arm mounted on the left side when looking at the hose-connection side of the dyno. This is the correct mounting when using the dyno with a left-mounting engine (drives sprocket counter-clockwise when you observe drive side of engine). The scale arm can be moved to the opposite side of the dynamometer housing if it is desired to run engines of opposite rotation, such as the McCulloch or any right-mounting engine.

The scale arm used on the Go-Power dyno is a "one-tenth arm" meaning that it is 1/10 the length of the standard dynamometer arm of 63 inches. The 1/10-arm value (measured from the center of the dyno impeller shaft to the center of the inner of the two $\frac{1}{4}$" holes in the outer portion of the arm) is used to simplify calculations as described in a later paragraph.

The outermost $\frac{1}{4}$-inch hole in the arm is provided for installation of an oil-type damper should scale readings prove to be erratic or "jumpy." If such a damper is used, be sure that it does not affect scale readings.

Inlets & Outlets, Valves

A drawing has been included here to indicate the function of the various integral hose fittings on the dynamometer casing. The two fittings clustered at the top are for water inlet and air-bleed. The bottom fitting at the very outer edge of the housing is for a water outlet.

Water inlet (usually from a source of city water under pressure) should be controlled with a gate-type valve. More water increases the load on the engine and thereby reduces RPM until load and engine speed stabilize. If stable-speed readings are being taken over several minutes' time, be sure that the water-outlet temperature does not rise above 100° Fahrenheit (lukewarm). If the dyno casing gets more than comfortably warm to the touch, the heat could cause steam pockets to develop, perhaps "losing the load" and allowing the engine and dyno to exceed rated safe limits.

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Small hose clamps should be used to attach the hoses to the dynamometer casing. Be careful when attaching the hoses, and in handling the dyno prior to bolting it to a base plate, as the hose attachment fittings are die-cast parts of the housing and can be broken off easily. Should you inadvertently break off one, it can be replaced with a short length of steel tubing, press-fitted into the case with LOCTITE.

Scale

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10-pound dial. Actually, these scales weigh to 30 lbs, but the 10-lb. figure is seldom exceeded, especially with "A" Class kart engines which have under 5.8 cubic inch (95cc) displacement. A "fish" scale will work very well for comparative-type installations. Dial-type scales are recommended for more precise applications.

Tachometer

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Tachometer Cable

The cable and coupling supplied by Go-Power for the JONES Tachometers consists of several parts: an outer housing with coupling nuts at each end, a support for mounting the housing nut at the dyno end, an inner drive cable with drive fittings for the tachometer at one end and for the coupling and the coupling or drive which is driven into the end of the dyno's impeller shaft.

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Occasional removing of the inner cable from its housing and applying a very light coating of grease -- such as Vaseline -- along this inner cable will lenghten the life of the flexible shaft.

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When you first receive the dynamometer, the shaft may seem hard to turn. Several revolutions will free up the seals so that this condition disappears.

How To Calculate Horsepower With The Go-Power Dyno

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$$\frac{9{,}000 \text{ RPM}}{10{,}000 \text{ (constant)}} \times 5 \text{ lbs. scale reading}$$

simplifies to 9/10 x 5 lbs. or:
0.9 x 5 = 4.5 Horsepower

Other Examples

3,000 RPM, scale reading of 3 lbs. is 0.3 x 3 or 0.9 h.p.

4,000 RPM, scale reading of 7 lbs. is 0.4 x 7 or 2.8 h.p.

10,000 RPM, scale reading of 8 lbs. is 1 x 8 or 8 h.p.

Scale Protection

An anti-backlash stop must be installed to prevent the dyno scale arm from turning past the point at which it applies no load to the scale. If it is allowed to apply a reverse shock to the scale, serious damage can occur to the scale. As a suggestion, this stop can be wrapped with sponge rubber (or a sponge-rubber ball can be used) to provide a shock-absorbing action when the load is lightened suddenly, permitting the scale arm to slam to its zero position.

Keep The Engine Cool

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You will find that nearly all engines will require an additional blast of cooling air directed onto the cylinder head if prolonged full-power runs are being made. Be sure to run a rich mixture; this helps the engine to run cool. The spark plug should be checked between runs for signs of blistering which indicate overheating. This can be done during the cooling-off period which should be allowed after each run.

ALWAYS TAKE EVERY PRECAUTION AGAINST FIRE AND BE SURE TO HAVE A FIRE EXTINGUISHER HANDY

Obtaining Consistent Test Results

To obtain consistency in your test results, always make your tests at the same cylinder-head temperature. Cylinder-head temperature can best be measured with an airplane-type cylinder-head temperature gage. The "sending unit" used for this type of gauge is a thermocouple-type spark plug wash-washer. Use the washer in place of the normally used spark plug washer.

Other items which will be of help in obtaining consistency include the use of a standard fuel, freshly mixed; and use of temperature, humidity and barometric-correction factors. Most such information can be obtained free of charge from your local weather bureau. Thus, you are relieved of the expense of purchasing a wet/dry bulb thermometer, barometer and thermometer.

Once you have the temperature, atmospheric pressure and relative humidity at the time of the test, you can use the figures to correct the raw h.p. reading obtained from your dyno to what the reading would be for Standard Temperature and Pressure and for dry air. Use the following formulas:

Temperature

$$\text{Corrected BHP} = \text{Raw BHP} \times \sqrt{\frac{273 + t_1}{273 + t_2}}$$

Where t_1 equals temperature in degrees Centigrade at time of test run, and t_2 equals Standard Temperature (15° Centigrade).

Pressure

$$\text{Corrected BHP} = \text{Raw BHP} \times \frac{29.92}{P} \text{ where}$$

P equals the atmospheric pressure in inches of Mercury (as read from a barometer) at the time of the test run). If you wish to purchase your own barometer, either an aneroid or open-tube type will do.

Relative Humidity

Corrected BHP = Raw BHP x $\frac{29.92}{P-W}$ where P equals the atmospheric pressure in inches of Mercury at the time of the test, and W equals the water vapor pressure in the air at the time of the test run (as read from a wet/dry bulb thermometer).

Composite Formula

When it is wished to make corrections for all three variables at the same time, you can simply combine all three formulas into one so that Corrected BHP = Raw BHP x $\sqrt{\frac{273 + t_1}{273 + t_2}} \times \frac{29.92}{P} \times \frac{29.92}{P-W}$

Using a chart where temperature in increments of 1°C is shown along the top and pressure in increments of 0.1-inch of Mercury down the side allows the percent correction for various combinations of these two variables to be read off immediately. A second chart can show the correction indicated for different atmospheric water-vapor pressures. Getting true h.p. then only requires multiplying raw h.p. by these two percentages.

PLEASE USE THE STAMPED POSTCARD ATTACHED TO THE DYNAMOMETER SCALE ARM TO SEND US YOUR NAME AND ADDRESS AND THE OTHER INFORMATION REQUESTED ON THE CARD.

THIS WILL ASSURE YOUR NAME BEING ON THE LIST TO RECEIVE FURTHER INFORMATION ABOUT THE DYNAMOMETER AND NEW DYNAMOMETER ACCESSORIES AS THEY BECOME AVAILABLE.

GO-POWER CORPORATION

INSTRUCTIONS FOR FILLING MD-8D, DY-7D, AND DY-9D TORQUE SYSTEMS

1. Remove torque system from dynamometer.
2. Disconnect tubing and load cell from gage by the nut, leaving 90^{o} elbow on gage.
3. Leaving tubing attached to fitting on load cell, unscrew 90^{o} elbow from load cell.
4. Using a blunt instrument, push diaphragm down.
5. Fill oil can with silicone and pump till fluid comes out nozzel.
6. Fill load cell through fitting hole until fluid is at the top of the hole.
7. Screw 90^{o} elbow and tubing assembly back into load cell. Note: use thread sealant or teflon tape.
8. Slip 4" piece of 3/16 ID tubing over nozzel of oil can, leaving at least 1 inch over hang from end of nozzel. Pump oil can till tubing is filled with fluid.
9. Using finger, push piston into load cell so that fluid is forced into the load cell tubing. Continue pushing till fluid is dripping out open end of tubing.
10. Slip oil can tubing over load cell tubing. Pump oil can, forcing fluid back through tubing and into load cell. Continue pumping till system will not take any more fluid.
11. Quickly disconnect oil can and put open end of load cell tubing back into elbow on torque gage and tighten nut.
12. System is now full of fluid and ready for use.
13. If torque gage does not read zero when system is complete, this is caused by residual pressure in the system and in no way effects accuracy. To zero gage, loosen nut on load cell fitting till fluid starts to drip out between the nut and threads. Do not disconnect tubing from load cell! Once gage has zeroed tighten nut and install system back into dynamometer.

DR/ms

GO-POWER SYSTEMS

INSTALLING THE LOAD CELL IN THE DYNAMOMETER

The load cell and gage assembly for your dynamometer has been packaged separately to protect the delicate gage mechanism from damage in shipment. The gage must be installed in the dynamometer before it can be used.

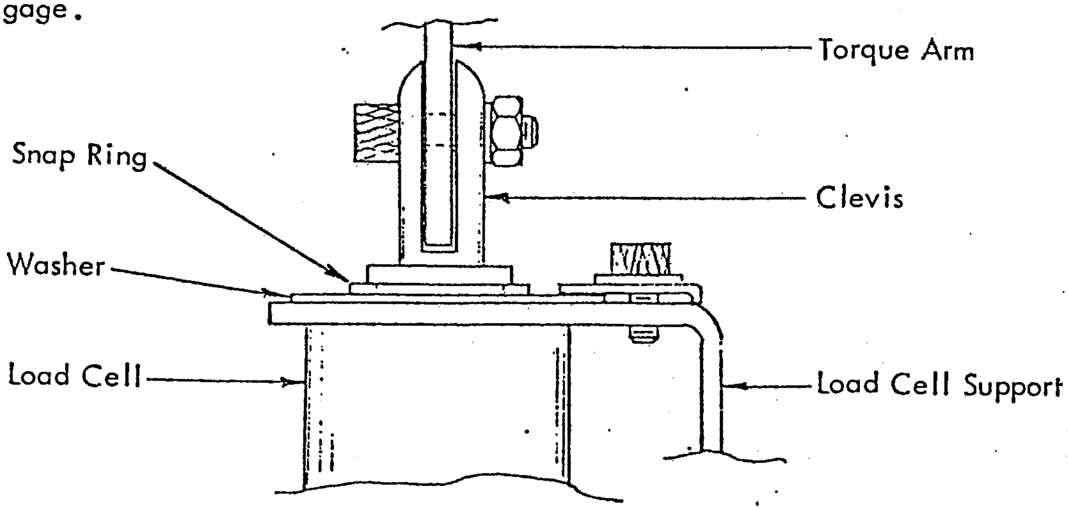
WARNING: The load gage system is fluid filled. Do not disconnect any part of the system.

1. Remove the retaining nuts and clamps from the back of the gage. Insert the load cell and line through the front of the gage mount casting and then slip the gage into place in the gage mount casting. Clamp the gage into place with the clamps and nuts which were attached to the gage.

WARNING: This dynamometer has been carefully calibrated at our factory. Do not disturb the clevis position on the torque arm.

2. The tubing fitting on the back of the load gage is pointing toward one side of the dynamometer. Route the load gage to load cell tubing in this same direction down past the water hoses and over to the load cell mounting bracket. Bring the load cell to a position below the celvis assembly. Be careful not to disturb the other water tubing and not to kink the load gage tubing.

3. Slip the 1/4 inch diameter rod from the clevis into the hole in the top of the piston in the load cell. Then raise the load cell into position through the load cell washer until the snap ring groove is above the washer. To mount the snap ring, open the lower end of the snap ring and rotate it into the snap ring groove on the load cell. Test to be sure the load cell snap ring is in place firmly by putting pressure on the torque arm and clevis assembly. DO NOT exceed the 15 pound reading on the torque gage.



February, 1980

GO-POWER SYSTEMS

INSTRUCTIONS FOR INSTALLING TCA-7/9

1. Install stand-offs onto torque calibration arm. (Usually use shorter stand-off between torque calibration arm and absorption unit.) Be sure proper hole is used for particular dynamometer being calibrated. Hole marked 7 is for MD-8D and all DY-7 models. Hole marked 9 is for the DY-9D model.

2. Install calibration arm as per enclosed drawing.

3. Hang counter weights (customer supplied) on short end of arm until it is balanced.

4. Using known weights (customer supplied), hang 2 lb. weight on long end of arm. Again, be sure proper hole is used.

5. Use enclosed chart to determine gage readings. Tap top of instrument tower with palm of hand to relieve any hysteresis.

6. If gage reading is incorrect:
   DY-7, MD-8: Loosen clevis and load cell mounting screws. Move clevis and load cell towards absorption unit for higher reading, away for lower.

   DY-9: Use pointer set screw on back of torque gage for adjustments.

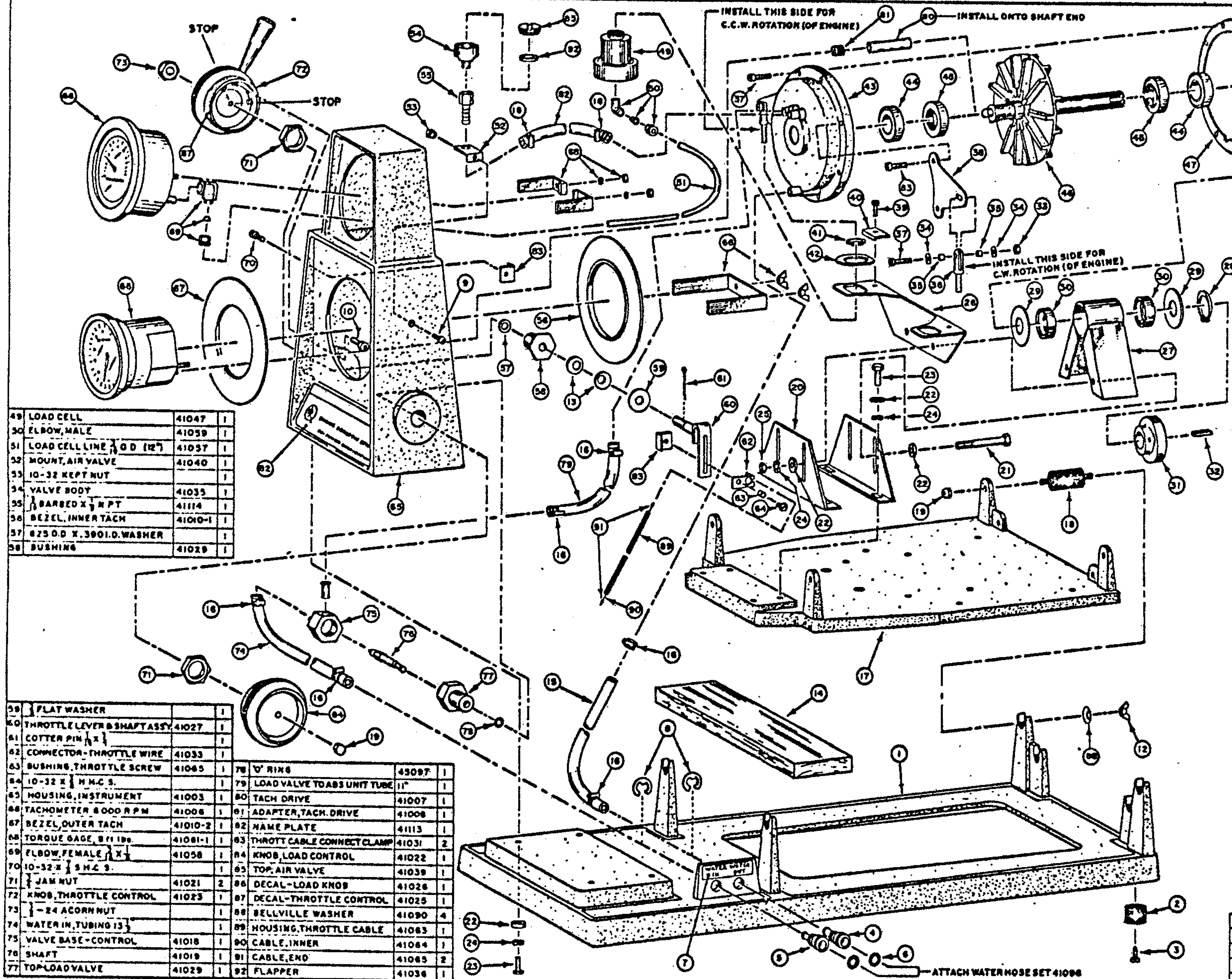
7. Check gage in low, mid, and high range to insure linearaty.

8. If gage is non-linear, then it must be sent back to the factory for adjustments.

9. Torque calibration arm must be removed completely prior to running the dynamometer.

DR/fd

F#355



ITEM	DESCRIPTION	PART No.	QUANT
1	BASE, MAIN	41001	1
2	RUBBER FOOT	41004	4
3	10-32 X [illegible] TYPE 'F' SCREW		4
4	CONNECTOR, WATER OUT	41013-2	1
5	CONNECTOR, WATER IN	41013-1	1
6	'O' RING	41014	2
7	DECAL, WATER IN, WATER OUT.	41015	1
8	RETAINING RING	41011	2
9	10-32 X [illegible] S.H.C.S.		1
10	1/4-20 X 1 [illegible] S.H.C.S		1
11	10-32 LOCK NUT		8
12	1/4-20 WING NUT		4
13	BELLVILLE WASHER	41090-1	2
14	BOARD, ENGINE BASE	41109	1
15	WATER OUT HOSE [illegible] O.D.		1
16	[illegible] CLAMP HOSE	41098	8
17	BASE, ENGINE	41002-1	1
18	SHOCK MOUNT 30 lbs.	41005-1	4
19	1/4-20 ACORN NUT		5
20	BASE BRACKETS, ABSORP. UNIT	41086	2
21	1/4-20 X 2 [illegible] H.H.C.S.		4
22	1/4 FLAT WASHER		12
23	1/4-20 X [illegible] HEX HD. CAP SCR.		8
24	1/4 SPLIT LOCK WASHER		10
25	1/4-20 HEX NUT		2
26	LOAD CELL BRACKET	41088-1	1
27	SUPPORT, ABSORPTION UNIT	41082	1
28	RETAINING RING	41085	1
29	WASHER	41084	2
30	ABSORTION UNIT BEARING	41083	2
31	FLANGE	41066-4	1
32	KEY [illegible] X [illegible] X [illegible]	41089	1
33	10-32 HEX NUT		1
34	#10 FLAT WASHER		2
35	BUSHING, LOAD CELL	41053	2
36	CLEVIS, LOAD CELL	41052	1
37	10-32 X [illegible] S.H.C.S.		7
38	TORQUE ARM	41081-1	1
39	10-32 X [illegible] S.H.C.S.		1
40	LOAD CELL CLAMP	41056	1
41	RETAINING RING	41054	1
42	LOAD CELL WASHER	41055	1
43	HOUSING, FRONT	41074	1
44	BEARING	41078	2
45	SEAL	41080	2
46	IMPELLER	41076	1
47	GASKET	41077	1
48	HOUSING, REAR ASS'Y	41075	1

49	LOAD CELL	41047	1
50	ELBOW, MALE	41059	1
51	LOAD CELL LINE 3/16 O.D. (12")	41057	1
52	MOUNT, AIR VALVE	41040	1
53	10-32 KEPT NUT		1
54	VALVE BODY	41035	1
55	3/16 BARBED X 1/8 N.P.T.	41114	1
56	BEZEL, INNER TACH	41010-1	1
57	.625 O.D. X .390 I.D. WASHER		1
58	BUSHING	41029	1

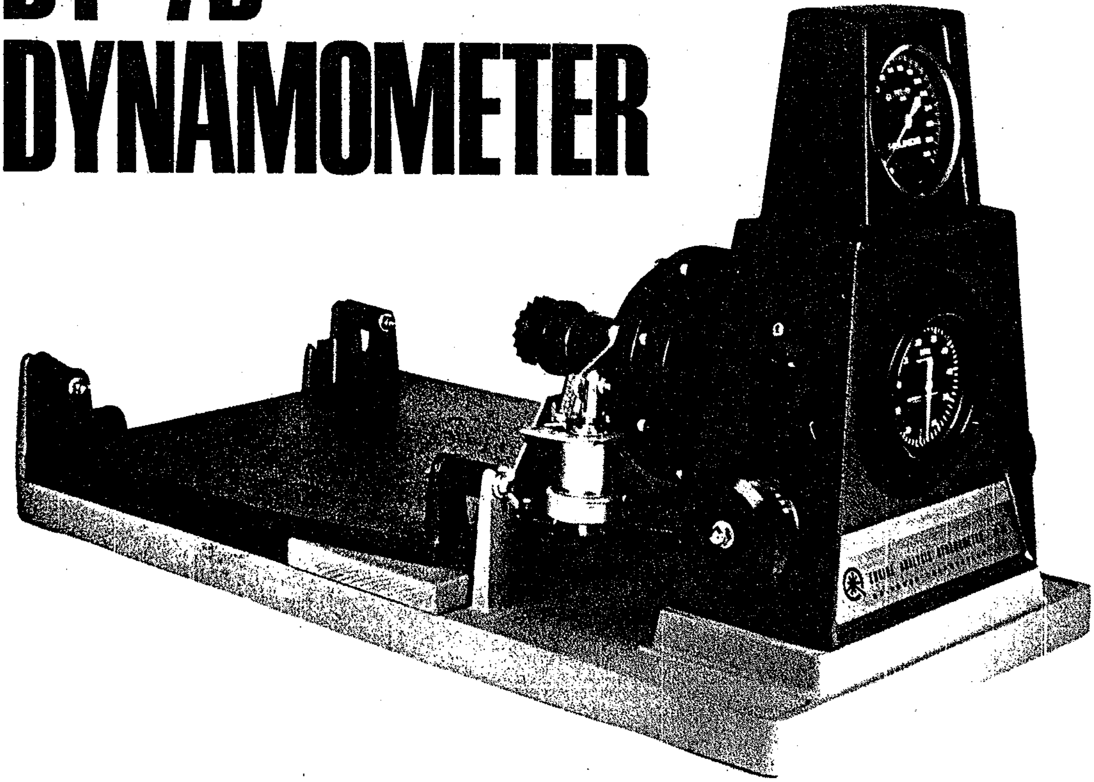
59	[illegible] FLAT WASHER		1
60	THROTTLE LEVER & SHAFT ASS'Y	41027	1
61	COTTER PIN [illegible] X [illegible]		1
62	CONNECTOR-THROTTLE WIRE	41033	1
63	BUSHING, THROTTLE SCREW	41065	1
64	10-32 X [illegible] H.H.C.S.		1
65	HOUSING, INSTRUMENT	41003	1
66	TACHOMETER 8,000 R.P.M.	41006	1
67	BEZEL, OUTER TACH	41010-2	1
68	TORQUE GAGE, 8 ft lbs.	41081-1	1
69	ELBOW, FEMALE [illegible] X [illegible]	41058	1
70	10-32 X [illegible] S.H.C.S.		1
71	[illegible] JAM NUT	41021	2
72	KNOB, THROTTLE CONTROL	41023	1
73	[illegible]-24 ACORN NUT		1
74	WATER IN, TUBING 13 [illegible]		1
75	VALVE BASE-CONTROL	41018	1
76	SHAFT	41019	1
77	TOP-LOAD VALVE	41029	1

78	'O' RING	43097	1
79	LOAD VALVE TO ABS UNIT TUBE	11"	1
80	TACH DRIVE	41007	1
81	ADAPTER, TACH. DRIVE	41008	1
82	NAME PLATE	41113	1
83	THROTT CABLE CONNECT CLAMP	41031	2
84	KNOB, LOAD CONTROL	41022	1
85	TOP, AIR VALVE	41039	1
86	DECAL-LOAD KNOB	41026	1
87	DECAL-THROTTLE CONTROL	41025	1
88	BELLVILLE WASHER	41090	4
89	HOUSING, THROTTLE CABLE	41063	1
90	CABLE, INNER	41064	1
91	CABLE, END	41065	2
92	FLAPPER	41036	1

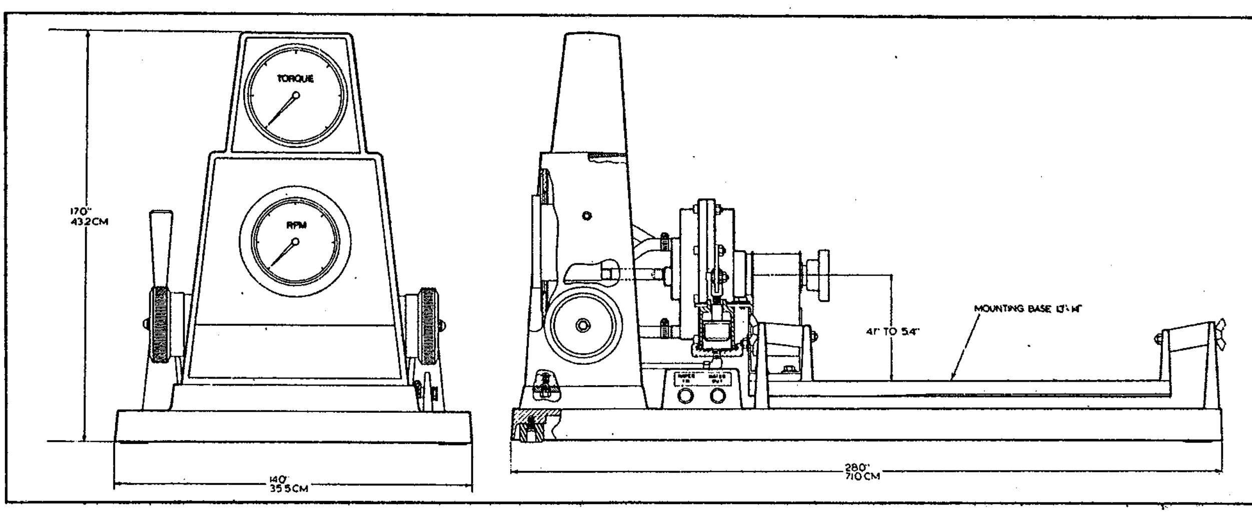
DATE 2-17-76	GO-POWER SYSTEMS	
DRAFTS. R Quarterman		
1/4 SCALE TRIMETRIC	DY-7D DYNOMOMETER ASS'Y.	
MODEL NUMBER		
DY-7D	I.D. NUMBER 41000	No. 1

GO-POWER

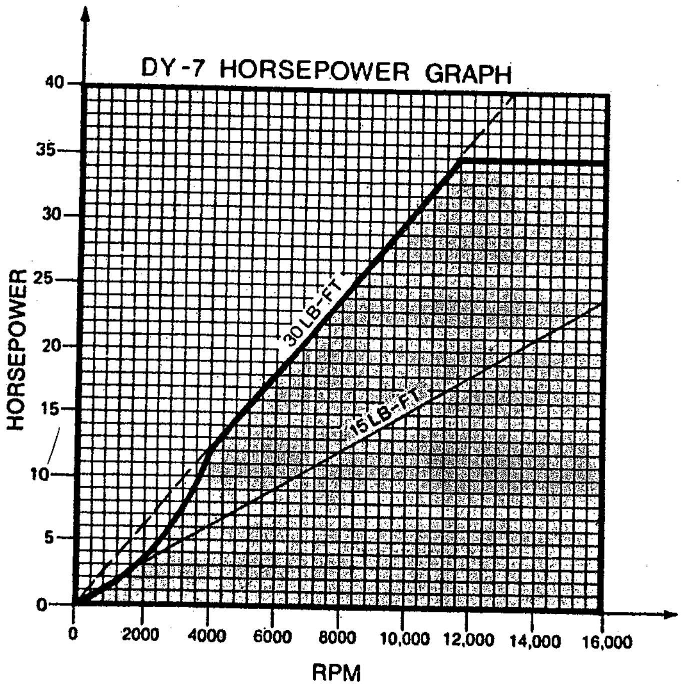
DY-7D DYNAMOMETER

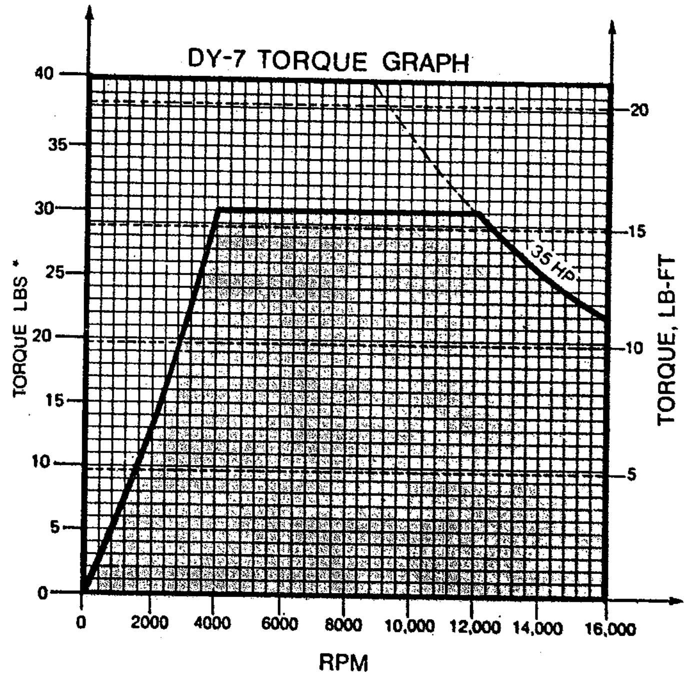


The GO-POWER DY-7D Dynamometer will handle engines to 35 hp and speeds to 16,000 rpm. The dynamometer is a turbulent action waterbrake which converts the rotating torque of the engine to stationary torque which is monitored. The shaft power is converted into heat which is carried away by water flowing through the unit. The DY-7D can be operated continuously at any power level within its capacity. Engine load is controlled by a valve which regulates flow into the absorption unit. The dynamometer contains no water and absorbs no power at the zero load setting. At the 100% load setting, the dynamomter is completely filled with water and its power absorption is at a maximum.



DY-7 OPERATING LIMITS





SPECIFICATIONS

Absorption Unit	
Direction of rotation	bi-directional
Operating range	to 16,000 rpm
Torque measuring system	hydraulic
Speed measuring system	mechanical
Shaft adapters*	3/8", 1/2", 5/8" 3/4", 7/8", 1"
(For shaft sizes listed)	McCulloch Taper
Instrument Tower	
Controls	load throttle
Tachometer**	
Ranges	500-6,000 1,000-10,000 2,000-16,000
Accuracy	±1.5%
Repeatability	±0.5%
Torque Gauges***	
Ranges	0-15 lb. 0-30 lb.
Accuracy	±0.5%
Overall system accuracy	±2%
Overall system repeatability	±1%
Weight	48 lbs.
Engine Support Plate	Mounted on base with vibration shock mounts****
Standard Equipment	Water inlet and outlet hoses One tachometer One torque gauge One shaft adapter

* Select one of seven shown
** Select one of three shown
*** Select one of two shown
**** Specify engine weight

*Units on the ordinate of graph are pounds at .525 ft. radius. Lb-ft can be calculated if desired by multiplying pounds x .525.

How to Specify

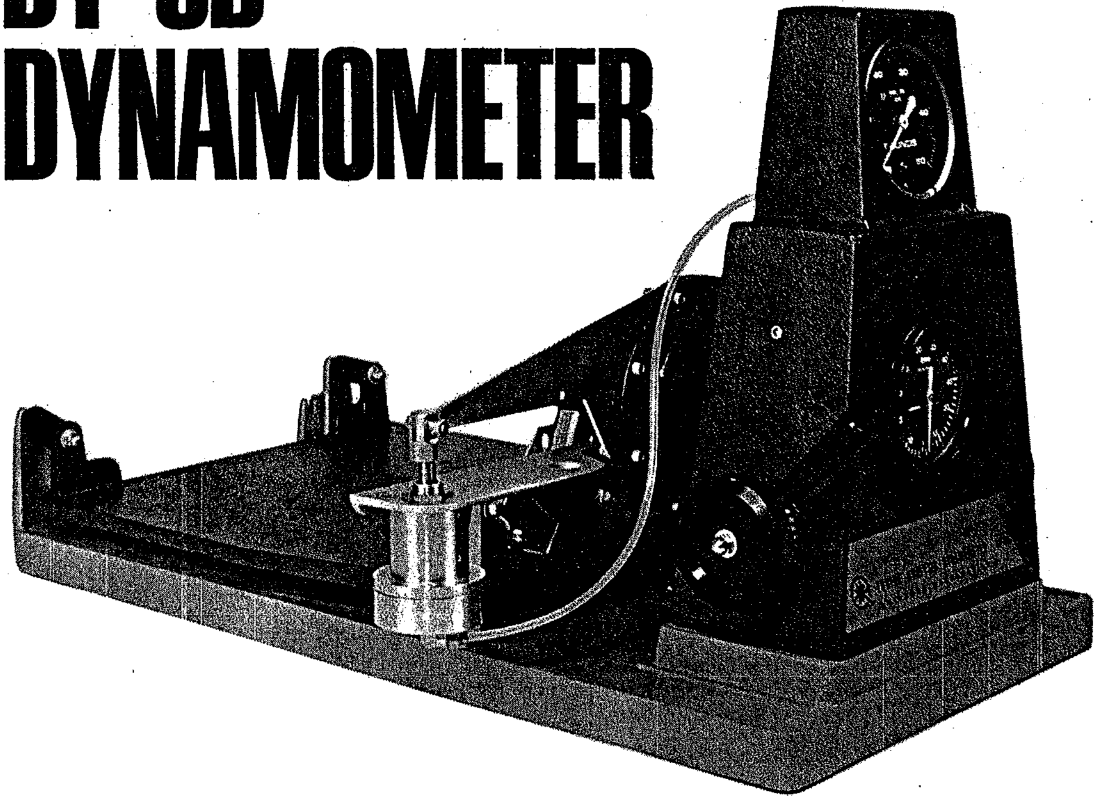
Each dynamometer comes with one tachometer, one torque gauge, and one shaft adapter. When ordering specify DY-7D dynamometer, torque gauge and shaft adapter required.

SALES & SERVICE
1419 Upfield Drive
Carrollton, Texas 75006
Tel: (972) 446-2046
(800) 235-0849
FAX: (972) 446-2031

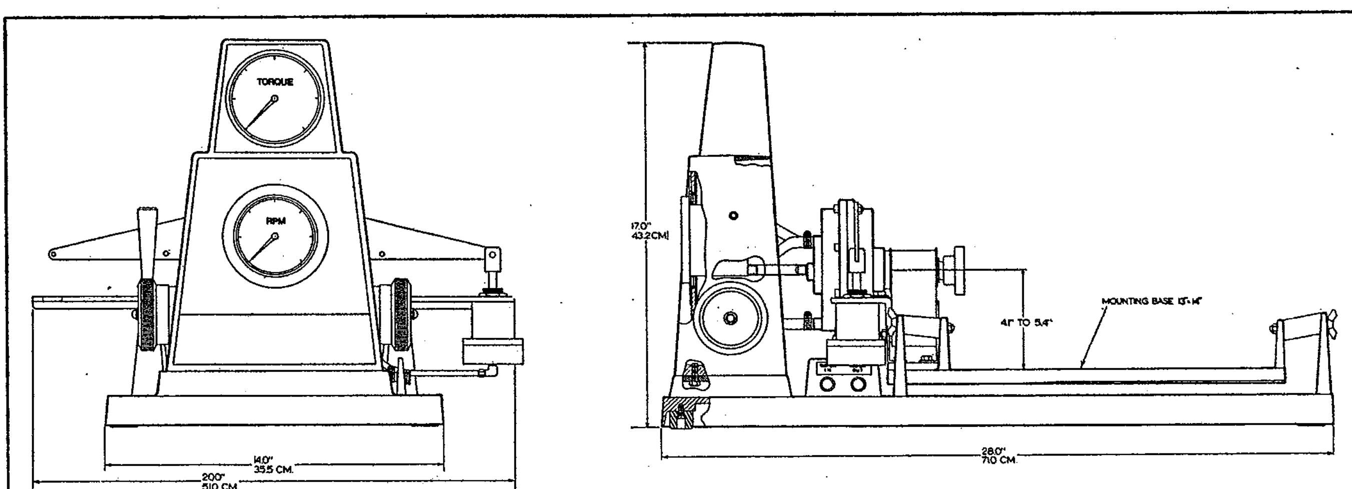
Printed in U.S.A.

GO-POWER

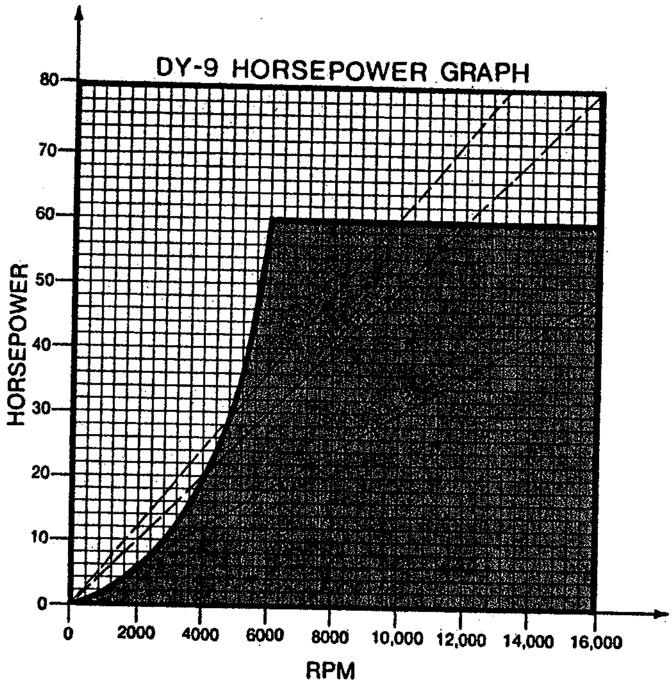
DY-9D DYNAMOMETER

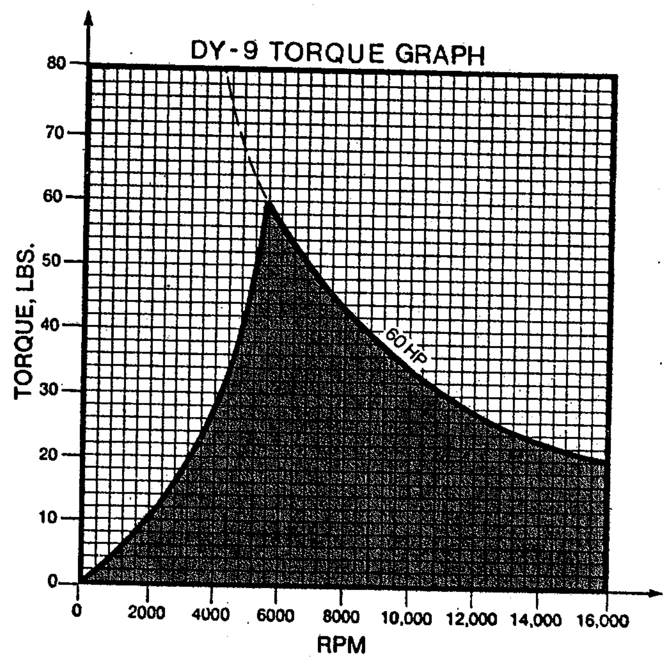


The GO-POWER DY-9D Dynamometer will handle engines to 60 hp and speeds to 16,000 rpm. The dynamometer is a turbulent action waterbrake which converts the rotating torque of the engine to stationary torque which is monitored. The shaft power is converted into heat which is carried away by water flowing through the unit. The DY-9D can be operated continuously at any power level within its capacity. Engine load is controlled by a valve which regulates flow into the absorption unit. The dynamometer contains no water and absorbs no power at the zero load setting. At the 100% load setting, the dynamometer is completely filled with water and its power absorption is at a maximum.



DY-9 OPERATING LIMITS





SPECIFICATIONS

Absorption Unit	
Direction of rotation	bi-directional
Operating range	to 16,000 rpm
Torque measuring system	hydraulic
Speed measuring system	mechanical
Shaft adapters* (For shaft sizes listed and for power levels up to 15 hp)	⅜", ½", ⅝" ¾" McCulloch Taper
Instrument Tower	
Controls	load throttle
Tachometer**	
Ranges	500-6,000 1,000-10,000 2,000-16,000
Accuracy	±1.5%
Repeatability	±0.5%
Torque Gauges***	0-30 lb.-ft. 0-50 lb.-ft.
(Gauge capacity can be doubled by moving load cell)	
Accuracy	±0.5%
Overall system accuracy	±2%
Overall system repeatability	±1%
Weight	50 lbs.
Engine Support Plate	Mounted to base with vibration isolation shock mounts****
Standard Equipment	water inlet and outlet hoses one tachometer one torque gauge one shaft adapter

*select one of five shown
** select one of three shown
*** select one of two shown
**** specify engine weight

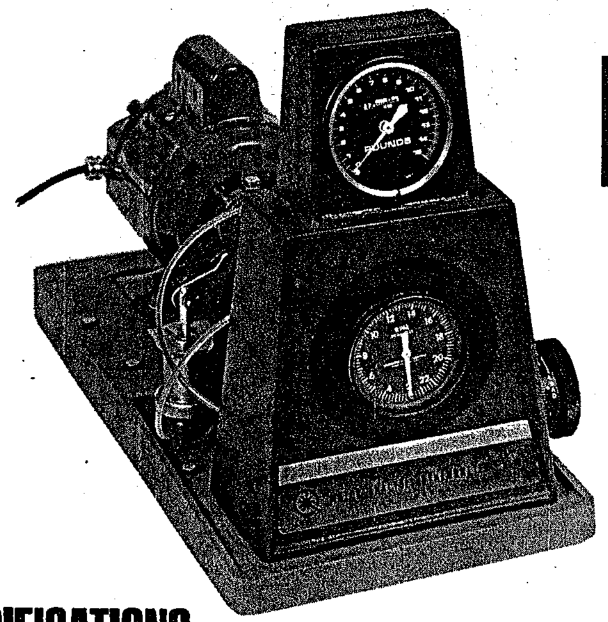
How to Specify

Each dynamometer comes with one tachometer, one torque gauge, and one shaft adapter. When ordering specify DY-9D dynamometer with tachometer, torque gauge and shaft adapter required.

SALES & SERVICE
1419 Upfield Drive
Carrollton, Texas 75006
Tel: (972) 446-2046
(800) 235-0849
FAX: (972) 446-2031

Printed in U.S.A.

FUNDAMENTAL ELECTRIC POWER MOTOR MECHANICS ANALYSIS SYSTEM



Model MD-80

The Model MD-80 Electric Motor Analysis System is designed to help students learn the basic principles and operating characteristics of electric motors and to develop problem solving techniques which can be applied to electric motors in industry. Students can relate "energy in" to "energy out" and evaluate the efficiency of each motor type and determine its best practical applications. The complete system includes a dynamometer and one each of the following electric motors: capacitor start, split phase, repulsion/induction, shaded pole, AC/DC universal, and 3-phase induction. An Electric Power Meter will extend the analysis capability of the system.

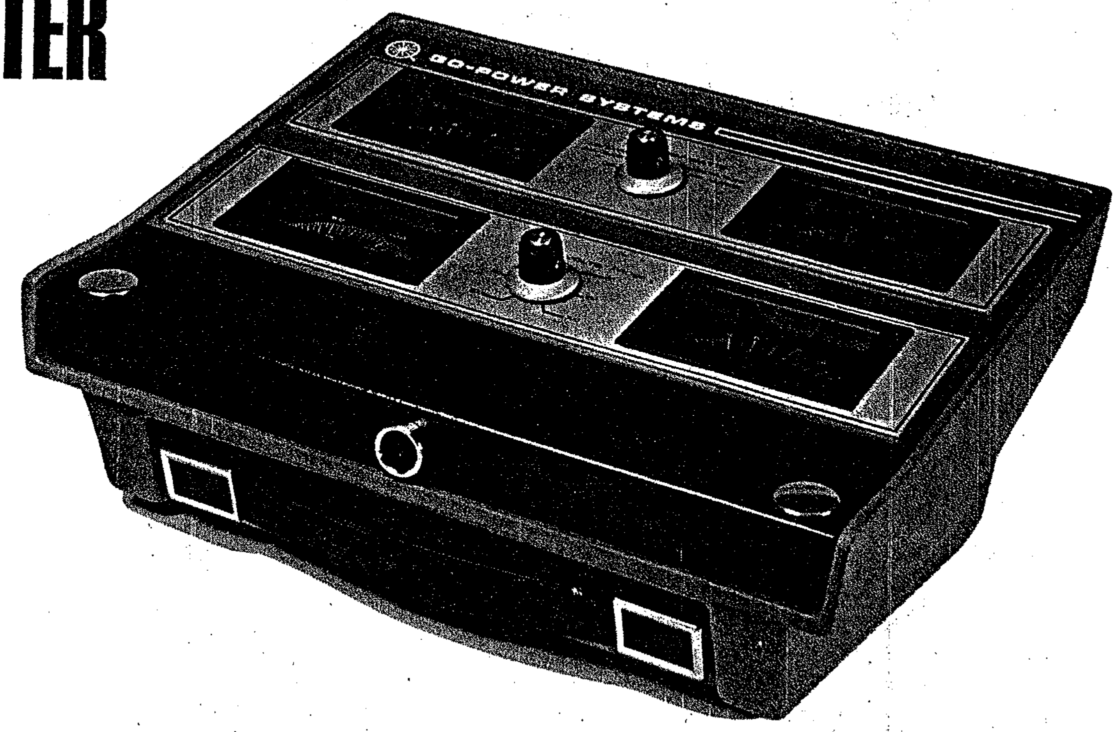
SPECIFICATIONS

Dynamometer	2 hp maximum
Dynamometer load gauge	8 lb./ft.
Accuracy	±0.5%
Tachometer*	200-2400 rpm 100-10,000 rpm
Accuracy	±1.0%
Motors (for use on 120 V single-phase 60 Hz)	½ hp capacitor start ½ hp split phase
	¼ hp shaded pole ½ hp AC/DC universal ½ hp 3-phase induction**
System Accuracy	±2%
System Repeatability	±1%
Weight	166 lbs.

*Both tachometers listed are included with each unit.
**208V 60 Hz

Printed in U.S.A.

ELECTRIC POWER METER



Model W-5000

The GO-POWER Electric Power Meter Set is designed to work as a companion to the MD-80 Motor Analysis Set for teaching students the basic principles of AC electric power. The Electric Power Meter allows students to easily compare the "electrical input power" to "motor output horsepower" measured by the dynamometer.

SPECIFICATIONS

AC volt range	30VAC, 150VAC, 300VAC, accuracy ±2%
AC ampere range	5A, 10A, 20A, 50A, accuracy ±2%
AC watt range	750W, 1500W, 3000W, 7500W, accuracy ±2%
AC power factor	1.0-0 (unity to 90° lag)

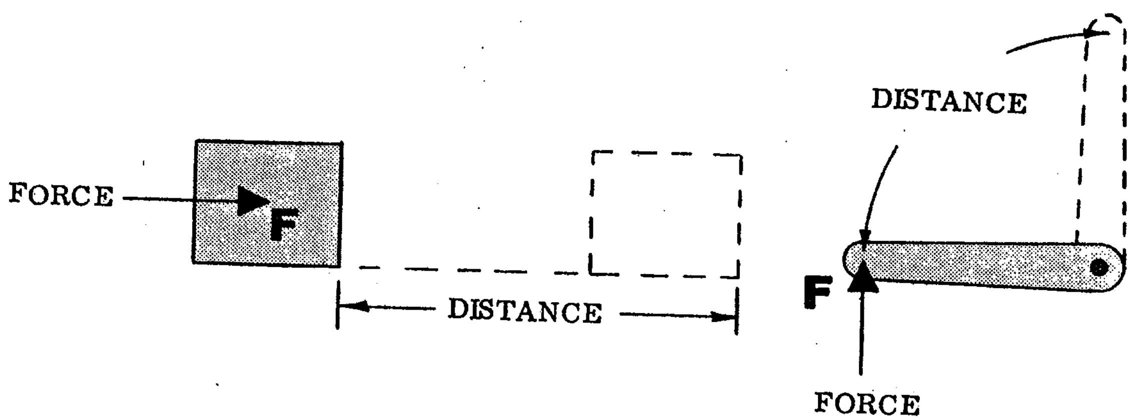
A test lead set is provided to allow independent voltage measurements up to 300 VAC. Input and output cords are provided to connect the W5000 to the MD-80 dynamometer system.

THE GO-POWER MD-8D DYNAMOMETER

I. WORK, POWER AND HORSEPOWER

WORK

In everday life, we use the word work to describe almost any activity that requires any physical or mental effort. In the study of methods of energy conversion, however, work has a very specific meaning. Work is accomplished only when a force travels thru a certain distance.



Work = Force x Distance

In the United States, force is usually described in pounds and distance is generally described in feet, so the amount of work is usually described as so many foot-pounds of work.

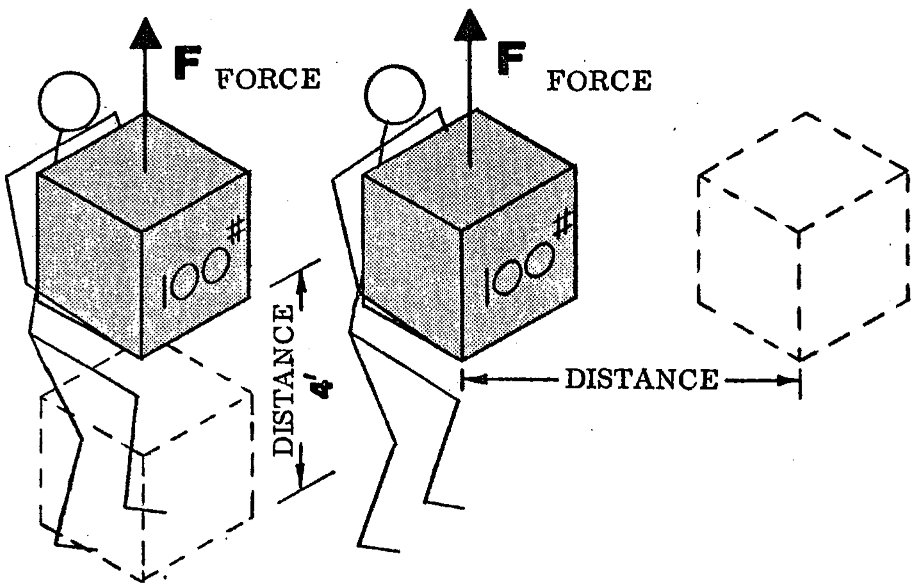
Work = Foot-Pounds

Work is done when a weight is lifted, when a spring is stretched, or when air is compressed in a cylinder. But if you pushed very hard against an object and it did not move, then no work was done because the force (push) did not travel thru a distance.

If you lift a television set, work is done. The amount of work is the weight (the force in this case) times the height (the distance).

WORK	=	100 pounds	x	4 feet	=	400 ft-lbs.
(lifting the television)	=	(television weight)	x	(distance)		

But if you walk across the floor carrying the television set, no work is accomplished because though you were exerting a force upward to support the television set, there was no distance traveled in the direction of your upward force. Work is accomplished only when a force travels thru a distance.



WORK IS DONE NO WORK IS DONE

POWER

The element of time is not involved in the definition of work. It makes no difference if you take 1 second or 10 seconds to lift the television set, yet obviously you could do ten times as much work if you were fast and lifted the television set 10 times in 10 seconds. Therefore we need a term to describe how fast work is done.

Power is defined as the rate of doing work. It is commonly described as work (foot-pounds) per length of time (seconds) or foot-pounds/second.

Therefore:

$$\text{Power} = \frac{\text{Force x Distance}}{\text{Time}} = \frac{\text{Pounds x Feet}}{\text{Seconds}}$$

If you lifted the television set once in one second, your power output would be:

$$\text{Power} = \frac{100 \text{ lbs. x } 4 \text{ ft.}}{1 \text{ sec.}} = 400 \frac{\text{ft. lbs.}}{\text{sec.}}$$

But if you lifted the television set once, but took ten seconds instead of one second, your power output would be:

$$\text{Power} = \frac{100 \text{ lbs. x } 4 \text{ ft.}}{10 \text{ sec.}} = 40 \frac{\text{ft. lbs.}}{\text{sec.}}$$

The work is the same in both cases, but the power is 10 times as great in the first case. Power is the rate of doing work.

HORSEPOWER

One of the units of power is one foot-pound per second. But this unit is rather small so a larger unit called horsepower is now commonly used. In the United States, one horsepower is defined as:

$$\text{Horsepower (U.S.)} = 550 \frac{\text{ft.-lbs.}}{\text{sec.}} = 33{,}000 \frac{\text{ft. lbs.}}{\text{min.}}$$

If you lifted the television set in one second, you produced:

$$\text{Horsepower (U.S.)} = \frac{1}{550} \times 400 \frac{\text{ft. lb.}}{\text{sec.}} = .729 \text{ HP}$$

One horsepower is supposed to be approximately equal to the average power output that an average horse can produce for an average work day. In Europe, they apparently assessed the capacity of their average horses to be slightly different, because they use the following values:

$$\text{Horsepower (Metric)} = 553 \frac{\text{ft. lbs.}}{\text{sec.}}$$

$$\text{Horsepower (European)} = 543 \frac{\text{ft. lbs.}}{\text{sec.}}$$

WATTS

Just as in the United States a unit of work is a foot-pound, in the metric system, a unit of work is a Newton-meter. One Newton-meter is called a Joule.

Just as one foot-pound per second is a unit of power, one Joule per second is a unit of power. One Joule per second is called a watt of power.

$$\text{Power} = \frac{\text{Newton-Meters}}{\text{Sec.}} = \frac{\text{Joules}}{\text{Sec.}} = \text{Watts}$$

It is a common misconception that there is something inherently electrical about a watt. This is not the case. It is true that electrical power is generally expressed in watts, but the power used by a light bulb could be equally as well expressed in horsepower and the power of an automobile engine could be described in terms of watts.

$$1 \text{ Horsepower} = 746 \text{ Watts}$$

By lifting the television set, you produced:

$$\text{Power} = \frac{100 \text{ lbs. x } 4 \text{ ft.}}{1 \text{ sec.}} = 400 \frac{\text{ft. lbs.}}{\text{sec.}} = .728 \text{ HP} = 542 \text{ Watts}$$

The watt term is used for electrical equipment because electrical engineers and scientists commonly use the metric system of measurement (Newtons and meters) while mechanical engineers in the United States use feet and pounds for measurement.

In electric motors, the power goes in as electrical power, but comes out as mechanical power, so the electrical engineers describe the power going in as watts, while the mechanical engineers describe the power coming out as horsepower.

In electricity, a watt is also:

Watts = Volts x Amps

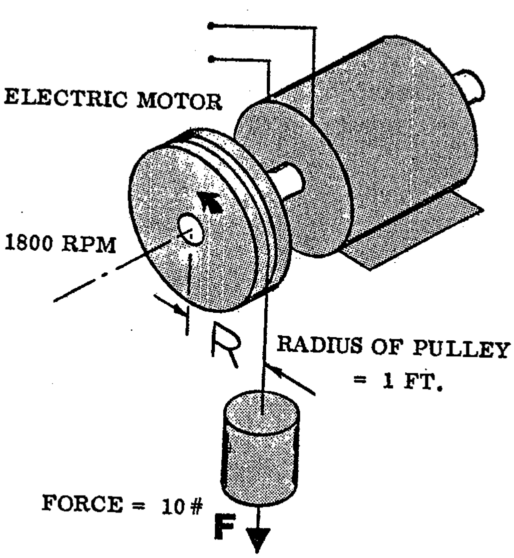
If a 110 volt light bulb draws 2 amps of electrical current, the power consumed would be:

$$\text{Power} = 110 \times 2 = 220 \text{ watts} = \frac{220}{746} \text{ Horsepower}$$

II. MEASUREMENT OF POWER

Power is the rate of doing work, and work is the result of a force acting through a distance. For an engine or an electric motor to produce power, it must exert a force thru a distance at a velocity (distance/time). To measure the power of an engine or electric motor, we much measure the force and the distance traveled per unit time.

In the example below, the electric motor lifts a 10 pound weight by winding a rope around a 2 foot diameter drum. If the motor is rotating at 1800 RPM, the horsepower produced is 3.4 HP, (see calculations below).



$$\text{Power} = \text{Force} \times \frac{\text{Distance}}{\text{Time}}$$

$$\text{Power} = F \times \frac{2\pi R \times \text{RPM}}{60}$$

$$\text{Power} = 10 \text{ lbs.} \times 2\pi \times 1 \text{ ft.} \times \frac{1800}{60}$$

$$= 1884 \text{ ft. lbs./sec.}$$

$$\text{Horsepower} = \frac{1}{550} \times \text{Power} = \frac{1884}{550} = 3.4 \text{ HP}$$

In practice it would not be convenient to use drums and ropes and weights to measure rotary power because the equipment would be too cumbersome and only very short tests could be run before all the rope was used up. For testing purposes, a specialized piece of equipment was developed to measure rotary power. This piece of equipment is called a dynamometer.

There are many types of dynamometers, but almost all of them determine horsepower by measuring torque and the RPM of the engine or motor.

$$\text{Power} = \frac{\text{Force x Distance}}{\text{Time}} = \text{Force x } \frac{\text{Distance}}{\text{Time}}$$

For rotary power:

$$\frac{\text{Distance}}{\text{Time}} = \frac{2\pi R \text{ x RPM}}{60} = R \text{ x } \frac{2\pi}{60} \text{ x RPM}$$

Therefore,

$$\text{Power} = \underbrace{\text{Force x R}}_{\text{Torque (Lbs.-Ft.)}} \text{ x RPM x } \frac{2\pi}{60}$$

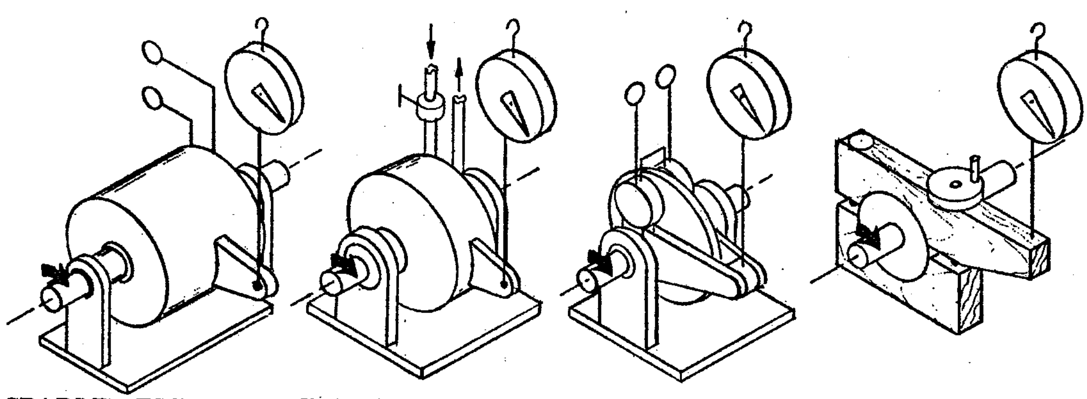
$$\text{Horsepower} = \frac{1}{550} \times \text{Power} = \text{Torque x RPM x } \frac{2\pi}{60 \text{ x } 550}$$

$$\boxed{\text{Horsepower} = \frac{\text{Torque x RPM}}{5250}}$$

So you can see that the original formula for power can just be re-arranged to obtain the new formula for rotary power measured by dynamometers.

$$\text{Power} = \frac{\text{Force x Distance}}{\text{Time}} = \frac{\text{Torque x RPM x } 2\pi}{60}$$

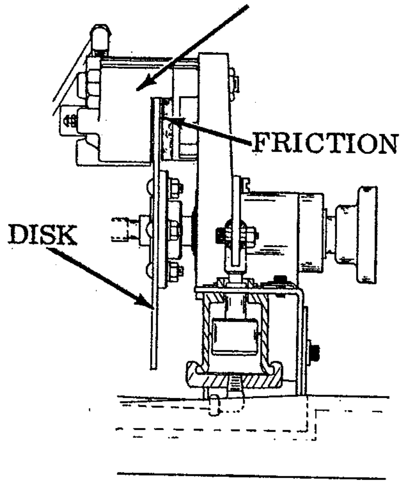
When a motor or engine shaft is stationary, you can easily measure the torque output with a torque wrench, but when the shaft is rotating at high speed, it is more difficult to measure the torque. Most dynamometers measure the torque of an engine or motor by transforming the rotating torque to a stationary torque. The stationary torque is then measured with a scale, hanging weight, load cell, strain gauge or other force measuring device. Some of the dynamometer devices for changing a rotating torque to a stationary torque are shown below.

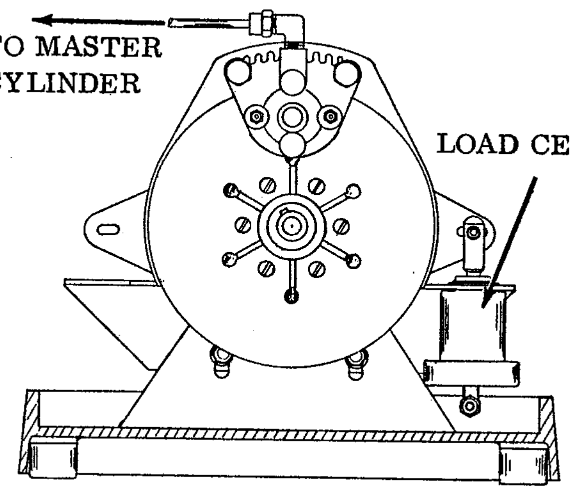


CRADLED ELECTRIC GENERATOR — HYDRAULIC WATER BRAKE — EDDY CURRENT BRAKE — PRONY BRAKE

III. POWER ABSORPTION UNIT

The Go-Power Model MD-8D dynamometer uses a hydraulic-actuated disk-brake to change the rotating torque to a stationary torque and absorb the power. The power absorption unit consists of a precision ground disk spinning between two friction pads. The load is applied by turning the load control knob inward (clockwise) to create a hydraulic pressure in the brake master cylinder. The hydraulic pressure is transmitted to the brake caliper and causes the friction pads to clamp the disk. The torque generated by the brake caliper on the rotating disk is measured by a force-measuring load cell which restricts the brake caliper mount from rotating.





The hydraulic brake master-cylinder contains a by-pass system which automatically compensates for pad wear or loss of hydraulic fluid. The by-pass can be actuated by turning the load control knob all the way out (counter-clockwise). If the brake does not develop full torque when the load control knob is turned all the way in, back the knob all the way out to re-fill the system thru the by-pass and then re-actuate the load system.

The brake caliper pads are bonded to the brake caliper and cannot be replaced except at the factory. If the pads wear down to less than 1/8" thick, return the brake caliper to the Go-Power factory for new pads.

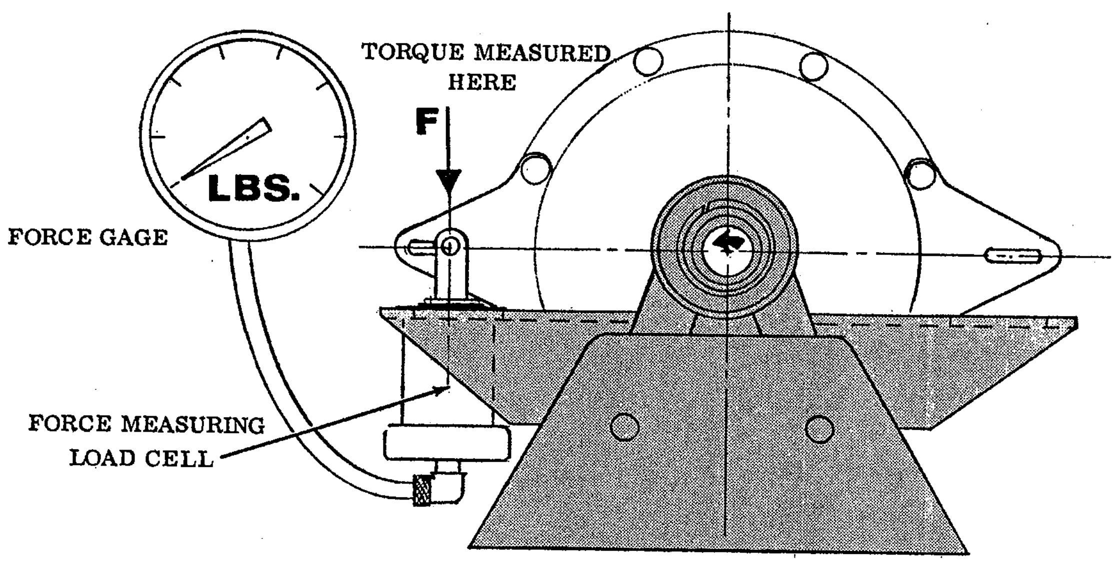
The brake hydraulic system should only be re-filled with red aircraft hydraulic fluid (AN 5606). The fluid is available from Go-Power in 2 oz. bottles. See the parts list.

To re-bleed the brake system after dis-assembly, remove the load control knob and remove the 1" hex-nut which holds the brake master cylinder to the control tower casting. Remove the master cylinder assembly from the control tower and remove the brake caliper from its mount. Lay the brake caliper on its side with one of the bleeder fittings in a 12 O'clock position. Then fill the master cylinder with red aircraft hydraulic fluid. Elevate the master cylinder above the brake caliper and open the upper brake bleeder screw to allow the fluid to flow down from the master cylinder into the brake caliper. It may be necessary to blow in the top of the master cylinder to get the flow started. When clear, bubble-free fluid flows from the bleeder fitting, tighten the bleeder, re-fill the master cylinder, and re-install the brake and master cylinder on the dynamometer.

> NOTE
>
> The fluid will not flow from the master cylinder into the brake unless the load actuator screw is backed all the way out (counter clockwise) to open the by-pass in the master cylinder.

The maximum torque capacity of the Go-Power Model MD-8D dynamometer is limited by the capacity of the torque gage. The 15# gage is limited to 94 inch-pounds and the optional 30# gage is limited 188 inch-pounds of torque. At higher speeds and torques, the capacity of the dynamometer is also limited by the energy dissipation capacity of the friction disk. With motors up to about 2 HP, this is generally not a problem. If the disk should become hot enough to dis-color, the dynamometer should be allowed to cool.

The disk rotor shafts of the MD-8D are not precision balanced and so at light loads above 6000 RPM, vibration sometimes makes accurate readings difficult. The disk and rotor shaft can be balanced for better results.



IV. TORQUE MEASURING SYSTEM

On the Go-Power dynamometer the torque exerted by the power absorption unit is measured by a hydraulic load cell which is connected to a pressure gage. The gage reads in 0 to 15 pounds of force (0 to 30 pounds optional).

Recall from section II,

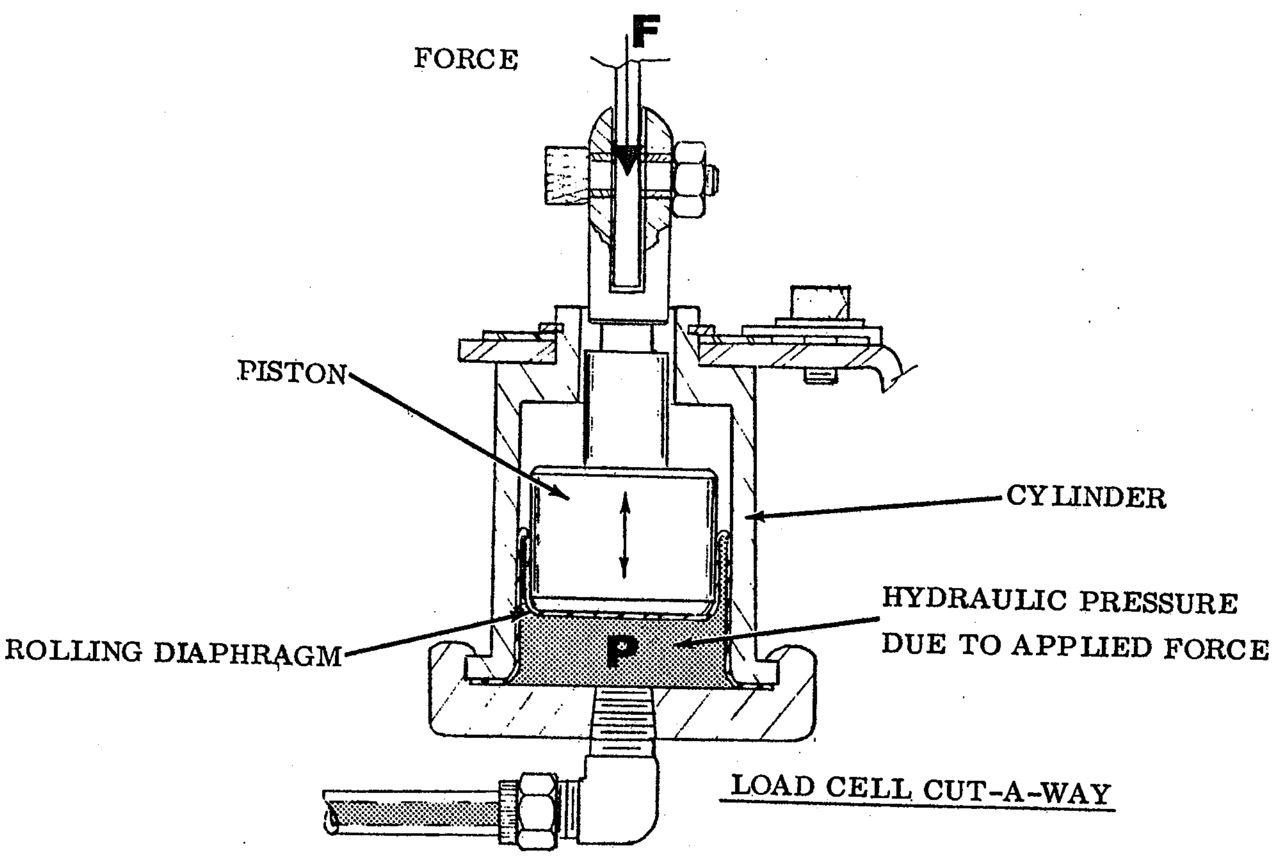
$$\text{Horsepower} = \frac{\text{Torque x RPM}}{5250} = \frac{\text{Force x Radius x RPM}}{5250}$$

The Go-Power dynamometer is designed so that the effective radius of the torque arm is .525 feet so that the denominator in the horsepower equation becomes 10,000 for easier calculations:

$$\text{Horsepower} = \text{Force x RPM x } \frac{\text{Radius}}{5250}$$

$$= \text{Pounds x RPM x } \frac{.525}{5250} = \text{Pounds x } \frac{\text{RPM}}{10,000}$$

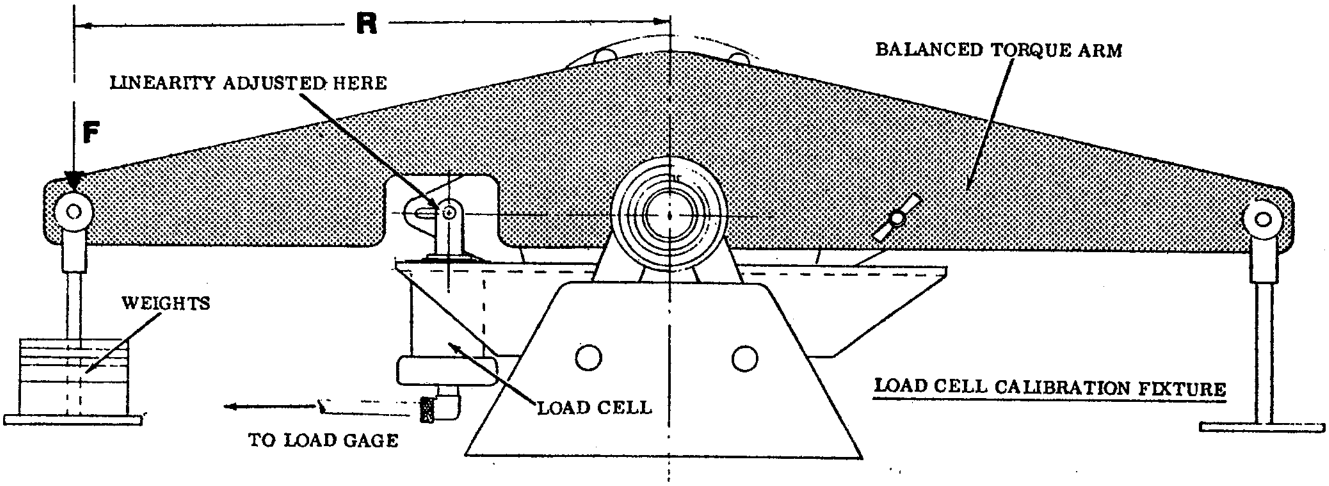
Actually the torque arm on the absorption unit is shorter than .525 feet and the area of the load cell is greater in the same proportion to offset the shortened torque arm. This change makes the absorption unit and torque measuring system more compact, but the gage still reads in pounds at .525 feet radius.



LOAD CELL CUT-A-WAY

The load cell consists of a piston and cylinder sealed by a rolling diaphragm. This special diaphragm has very low friction and hysterysis as the piston moves. When a force is exerted on the piston by the absorption unit, a hydraulic pressure is generated in the load cell and transmitted to the pressure gage.

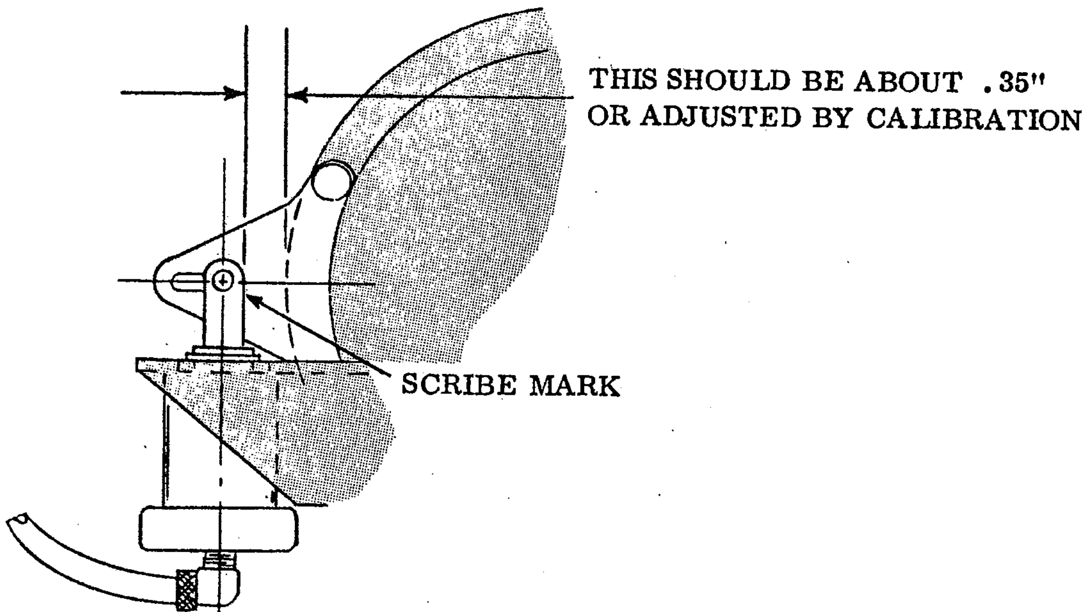
High frequency torque variations are damped out by the viscosity of the hydraulic fluid in the load cell system. A small amount of air is also left in the load cell system to absorb the shock of any torque variations. You can see the air bubbles pass through the hydraulic line to the gage as the load is applied.



Each load cell system is calibrated at the Go-Power factory by mounting a special balanced torque arm onto the absorption unit and then hanging precision weights onto the torque arm to produce a known torque. The linearity of the system is adjusted by sliding the clevis inwards or outwards on the slotted torque arm and then realigning the load cell under the clevis and clamping both in place. The slot allows for an adjustment of ± 3%. When the gage is adjusted so that it is linear within 2% from 1/3 scale to full scale, the zero adjust screw in back of the gage is used to adjust the gage to read true torque at half scale. The average torque system errors are shown below:

	15 # Gage		30 # Gage	
1/3 scale	+ 0.1#	+2.5%	+ 0.2#	+2.5%
half scale	± 0.0#	0%	± 0.0#	0%
full scale	-0.1#	-0.6%	-0.2#	-0.6%

After calibration at the factory, a mark is scribed on the torque arm at each side of the load cell clevis so that you can replace the clevis to the proper position if the dynamometer should be disassembled. If you should move the load cell to the other side of the absorption unit for motors of the opposite direction of rotation, position the clevis the same distance out from the absorption unit casting as it was on the other side or the gage accuracy will be affected. Also be sure to re-clamp the load cell directly under the clevis.



V. SPEED MEASURING SYSTEM

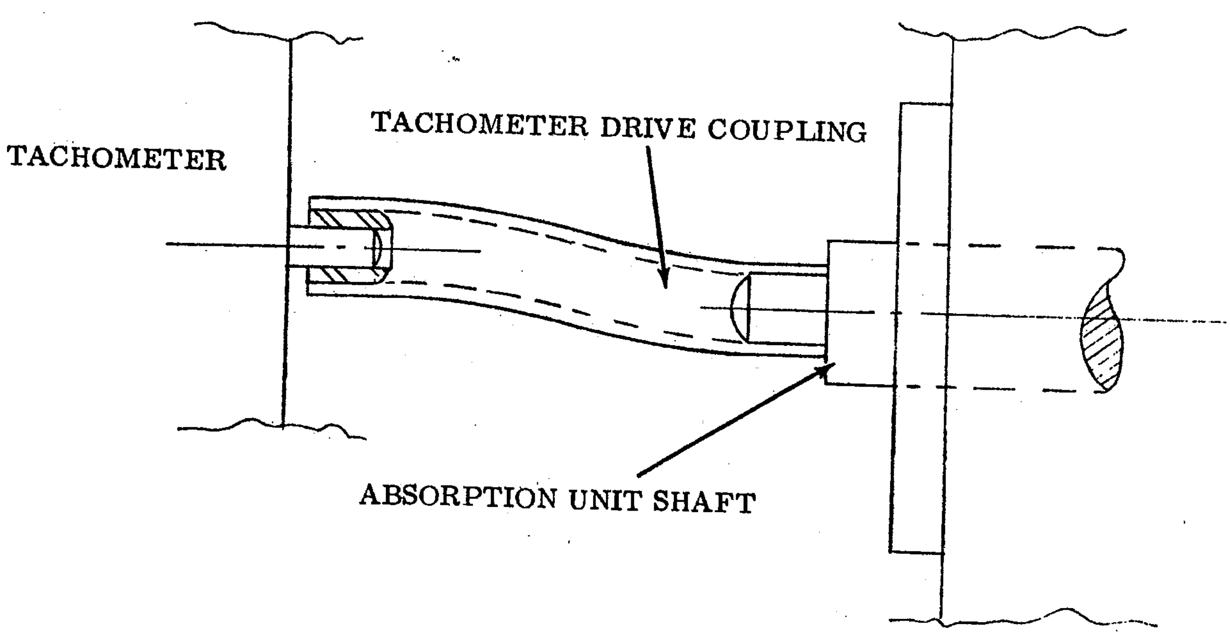
The speed (RPM) of engines or electric motors mounted to the Go-Power dynamometer is measured by a mechanical tachometer which is driven off of the end of the absorption unit shaft. The tachometer is of the centrifugal type and uses an internal three ball governor movement to actuate the tachometer pointer. This type of tachometer is normally unaffected by temperature changes, moisture, stray electric currents or magnetic conditions. The tachometers will operate in either direction of rotation without alteration.

The tachometers are individually calibrated at the factory to read true RPM within 2% of the full scale value (for instance, 22 RPM on a 2,200 RPM tachometer). Then the tachometer is adjusted to read true RPM at half scale. A typical calibration result on a 2,200 RPM tachometer would be:

Indicated RPM	1000	1500	2000
Acutal RPM	980	1500	2020
% Error	+2%	0%	-1%

Most of the testing on the motors supplied with the Go-Power dynamometers is done between 1,200 and 1,800 RPM.

The tachometer is driven by a piece of flexible polyethylene tubing with a small aluminum adapter pressed in one end to connect the tubing to the tachometer input drive. This tubing will withstand offsets of about 40% of its length so perfect alignment of the tachometer and the absorption unit shaft is not required. Above 6000 RPM, the piece of polyethylene tubing must be clamped to the shaft with a 7/16" hose clamp.



VI. INSTALLING MOTORS ON THE DYNAMOMETER

The National Electrical Manufacturer's Association (NEMA) have established several standard motor configurations which cover most of the motors in the 1/10 to 1 HP range.

NEMA Frame	Shaft Height	Shaft Diameter
42	2.625"	.375"
48	3.000"	.500"
56	3.500"	.625"
66	4.125"	.750"
182	4.500"	.875"
184	4.500"	.875"

All motors which have the above frame styles can be mounted onto the Go-Power MD-8D dynamometer. However on type 66 motors, it is necessary to put a 1/4" thick extension plate under the motor or to shorten the output shaft 3/4".

Shaft Heights - The absorption unit shaft height can be adjusted from 3.25" to 4.50" by loosening the adjusting bolts and sliding the absorption unit up or down. When re-tightening the bolts, be sure to keep the absorption unit and load cell support level. For type 42 or 48 motors, a spacer must be placed under the motor to raise it to a 3.500" shaft height.

Shaft Coupling - Motors purchased from Go-Power already have the proper shaft coupling installed. For other motors, additional shaft couplings are available as listed below.

Shaft Diameter	Part No.	List Price
3/8"	DY-794-6	$2.25/ea.
1/2	DY-794-8	2.25
5/8	DY-794-10	2.25
3/4	DY-794-12	2.25
7/8	DY-794-14	6.80
1	DY-749-16	6.80
McCulloch Taper	DY-794-MC	4.80

The motor and absorption unit should be adjusted so that the couplings are aligned within 1/32" of each other. Then after the motor is bolted in place, shove one of the coupling halves along the shaft toward the other coupling half to eliminate any end play between the couplings and the rubber connecter sleeve. Then retighten the shaft set-screws.

Bolting On the Motor - After the above operations have been performed, set the motor on the motor base and line the motor shaft up with the absorption unit shaft. If the mounting holes are not already in the base, mark the position of the mounting holes and remove the motor. Then center punch the holes. If the motor base does not have tapped holes, drill thru the base with a #7 drill and tap the holes to 1/4-20 UNC threads. Only two bolts are needed to hold the motors in place on the motor mounting base.

Tachometer Alignment - When the motor is bolted in place and aligned with the absorption unit, loosen the adjustment nuts on the back of the tachometer and slide the tachometer to align itself with the absorption unit shaft. Perfect alignment is not critical.

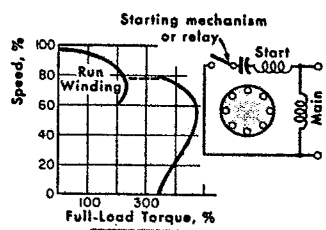
Tachometer Changing - The 2,200 RPM tachometer can be interchanged with the 10,000 RPM tachometer by loosening the two wing nuts on the rear of the tachometer and removing the tachometer. For operation above 6,000 RPM, the piece of polyethylene tubing must be clamped to the absorption unit shaft with a 7/16" hose clamp.

VII. SPECIAL NOTES ON MOTOR TESTING

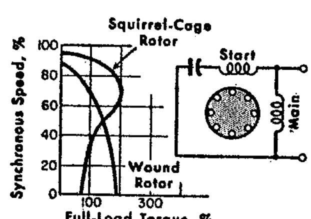
The Go-Power MD-8D dynamometer can only measure motor torques in the portion of the torque curve where the motor torque is increasing as the speed decreases. With many motors, the torque will increase with decreasing speed down to about 70% of maximum speed, but then the motor will stall and stop when the torque begins to decrease with the decreasing speed.

Motors can be tested in the unstable region of the torque curve, but only by more sophisticated dynamometers with feed-back speed control systems. Because the motors stall out under actual loads in much the manner as they do on the dynamometer, a test in the upper portion of the torque curve is generally sufficient. Stall torques and in-rush watts can still be tested at zero speed.

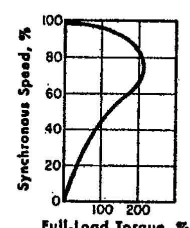
Several typical torque curves including the unstable portion of the curve, are shown below for various types of motors.



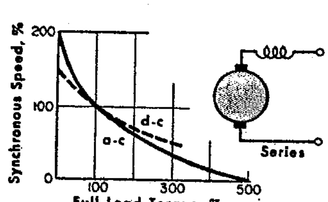
Capacitor-Start Motor



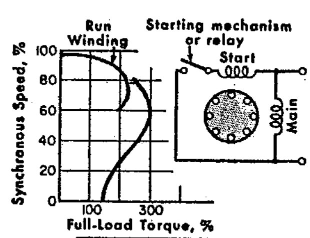
Permanent-Split Capacitor Motor



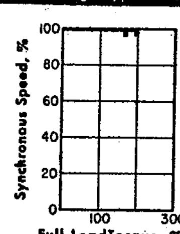
Three-Phase Squirrel-Cage Type Motor



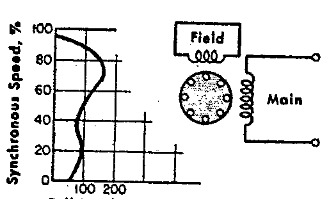
Series-Wound Universal Motor



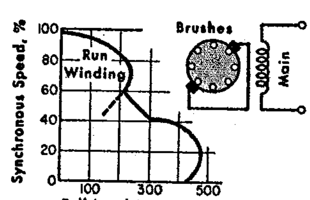
Split-Phase Motor



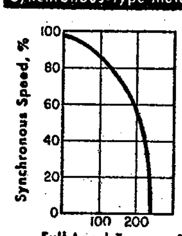
Three-Phase Synchronous-Type Motor



Shaded-Pole Motor



Repulsion-Start Motor



Three-Phase Wound-Rotor-Type Motor

On the motors with centrifugal phase switching, the switch generally is activated at 80% to 90% of the maximum motor speed. An 1800 RPM motor will switch phases when loaded down to 1400 to 1600 RPM. On some motors, you can continue to test the motor on past the phase switching point, but others will stall out due to the shape of their torque curves.

The AC-DC Universal motor supplied with the MD-80 kit will operate at no load as high as 11,000 RPM, but at these speeds, the dynamometer vibrates substantially and it is difficult to obtain practical test results. We recommend that this motor be tested only with loads of 1.0 pounds or more (below 7000 RPM).

VIII. WATTS, VOLTS AND AMPS

To measure the efficiency of an electric motor, you must measure both the power going in (watts) and the power delivered at the shaft (watts or horsepower). When an electrical load is only resistive, such as a light bulb, the watts in can be determined by measuring the volts and the amps. The watts are equal to volts x amps. But an electric motor electrical load is composed of both resistive and inductive components. Consquently, the volts and amps are thrown out of phase and watts are no longer equal to simply the volts x amps as measured by a volt or amp meter.

To measure the electrical power consumed by a motor, it is necessary to use a special watt meter which takes into account the phase differences between the volts and amps. The ratio of the watts to the apparent volts x amps is called the power factor. The power factor will be different at different motor loads and for different motors.

$$\text{Power Factor} = \frac{\text{True Watts}}{\text{Volts-amps input}}$$

The power factor should not be confused with motor efficiency. Motor efficiency is the ratio of power output to power input.

$$\text{Motor Efficiency (\%)} = \frac{\text{Watts output}}{\text{True Watts input}} \times 100\%$$

For the MD-8D dynamometer:

$$\text{Watts output} = .0746 \times \text{Pounds} \times \text{RPM}$$

MOTOR ANALYSIS DATA SHEET

Test Date______________

Motor Manufacturer________________________ Model______________ Serial No.______________

Motor Type______________________________ Frame______________ Temp. Rise______________

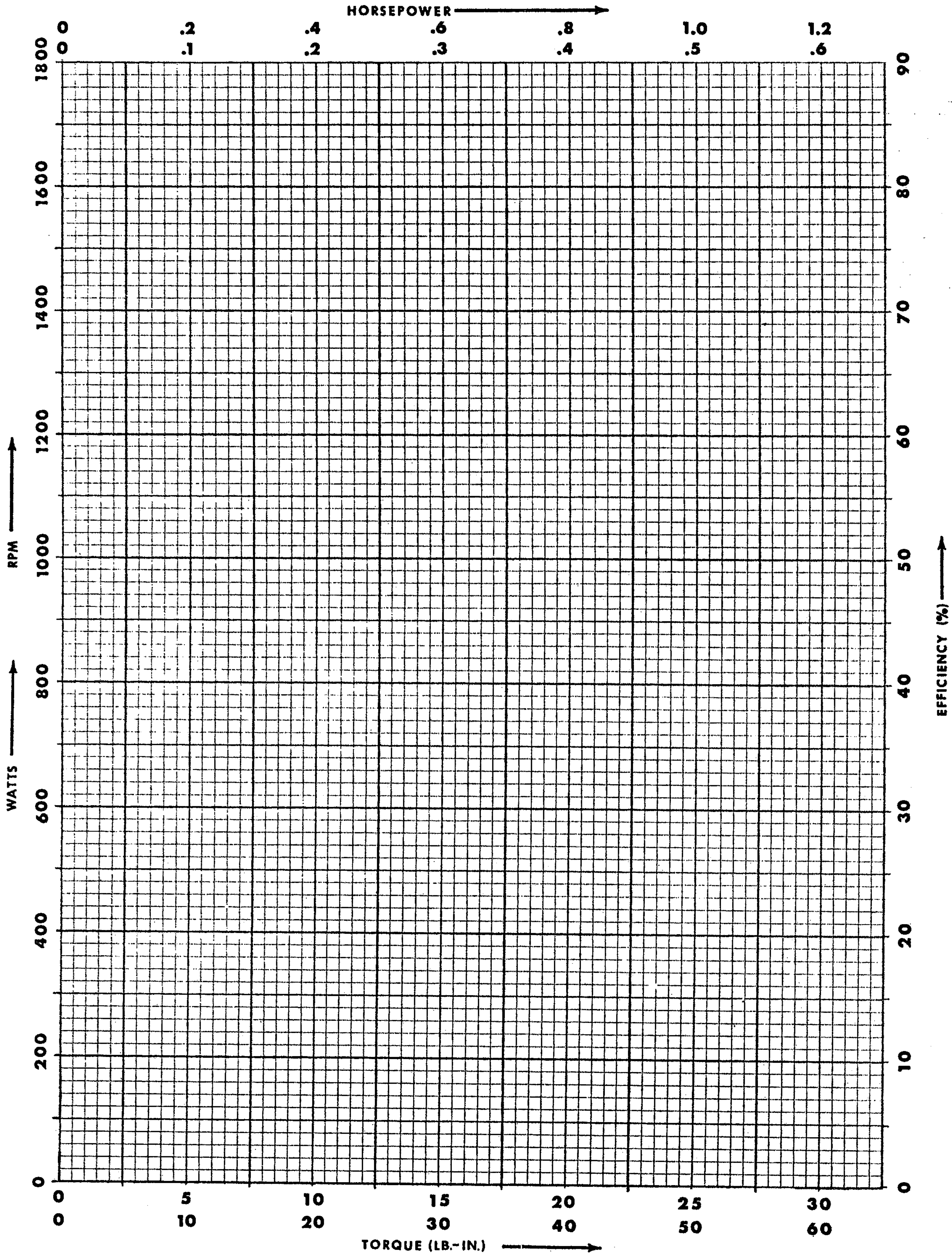
Motor HP Rating__________________________ Volts______________ Amps______________

Test Observers____

POUNDS	TORQUE (IN. LBS.)	RPM	WATTS IN	APPARENT AMPS	HP OUT	EFFICIENCY	POWER FACTOR	
		Stall						
.1	.63							
.5	3.15							
1.0	6.30							
1.5	9.45							
2.0	12.60							
2.5	15.75							
3.0	18.90							
3.5	22.05							
4.0	25.20							
4.5	28.35							
5.0	31.50							
5.5	34.65							
6.0	37.80							
6.5	41.05							
7.0	44.10							
7.5	47.25							
8.0	50.40							
8.5	53.55							
9.0	56.70							
9.5	59.85							
10.0	63.00							
10.5	66.15							
11.0	69.30							
11.5	72.45							
12.0	75.60							

LITHO IN U.S.A.

MOTOR TEST DATA GRAPH



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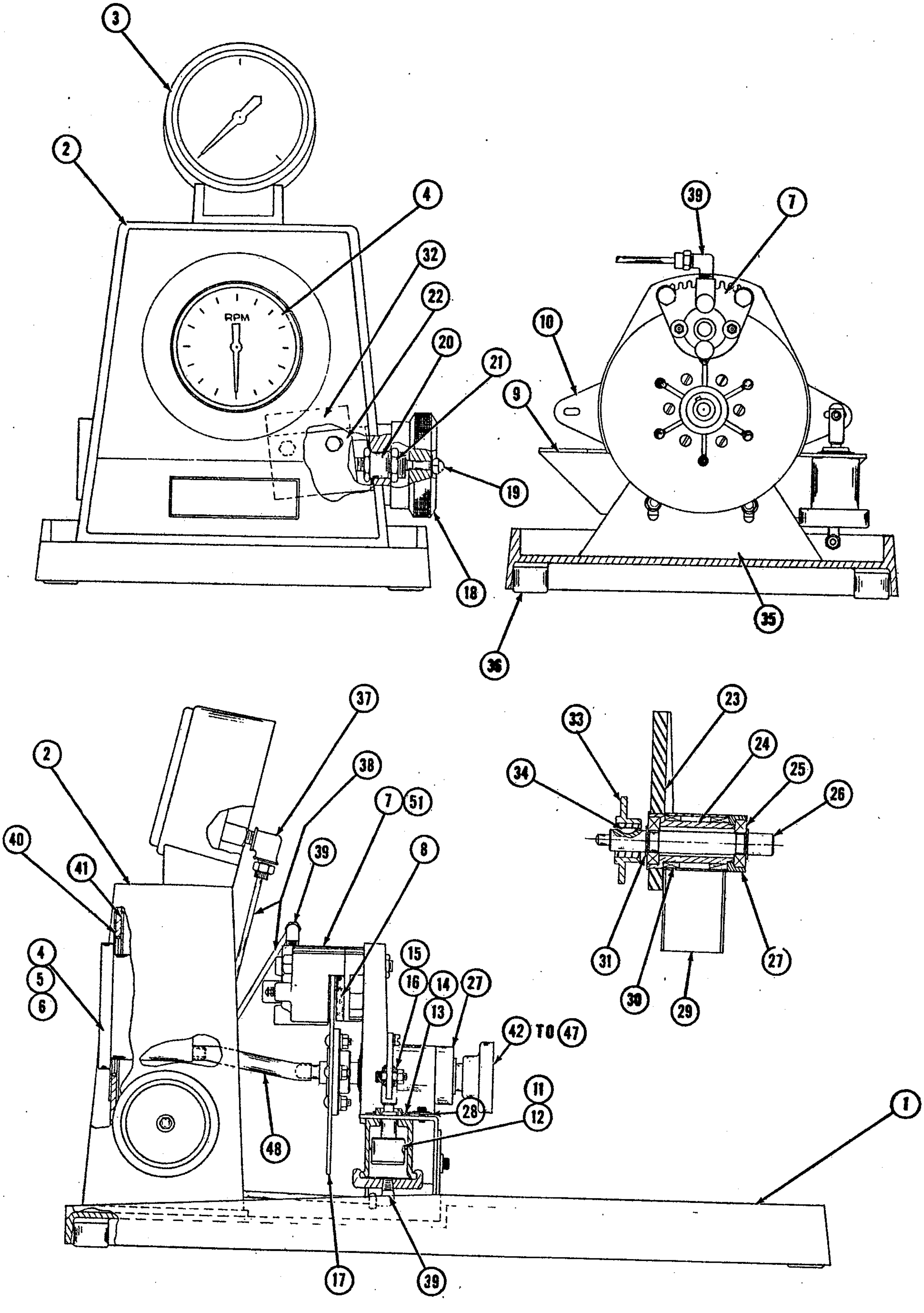
GO-POWER CORPORATION

ILLUSTRATED PARTS LIST



PARTS LIST

GO -POWER MD-8D DYNAMOMETER

Item No.	Qty./ Unit	Description	Part Number
	1	Dynamometer	MD-8D
1	1	Base, Main	MD-831A
2	1	Housing, Instrument	DY-712B
3	1	Mount, Load Gage	DY-762A
4	1	Tachometer, 2,200 RPM	MD-836A
5		Tachometer, 6,000 RPM	DY-716A
6	1	Tachometer, 10,000 RPM	DY-717A
7	1	Torque Caliper	MD-837A
8	2	Friction Pad	MD-839A
9	1	Support, Load Cell	MD-878A
10	2	Torque Arm	DY-1K
11	1	Load Cell Assembly	DY-770A
12		Fluid, Load Cell, 2 oz.	DY-789A
13	1	Snap Ring, 3/4	5100-75
14	1	Washer, Load Cell	DY-787A
15	(1)	Clevis, Load Cell	DY-774A
16	(2)	Bushing, Load Cell	DY-775A
17	1	Disk	MD-835A
18	1	Knob, Load Control	MD-870A
19	1	Shaft, Load Control	MD-841A
20	1	Bushing, Load Control	MD-842A
21	1	Nut, 3/4 UNF Jam	DY-728A
22	1	Bracket, Load Actuator	MD-843A
23	1	Support, Caliper	MD-854A
24	1	Bearing Mount Tube	MD-848A
25	2	Bearing, Ball R-10-ZZ	MD-851A
26	1	Shaft, Main	MD-846A
27	1	Bearing Mount, End	MD-847A
28	1	Clamp, Load Cell	DY-788A
29	1	Support, Absorption Unit	DY-1S
30	2	Bearing, Support	DY-1T
31	2	Snap Ring, 5/8	MD-850A
32	1	Load Actuator	MD-838A
33	1	Hub, Disk Mount	MD-845A
34	1	Key, 3/16 Th. x 5/8 D. Woodruff	MD-849A
35	2	Support Leg	DY-1Q
36	4	Foot, Main Base Rubber	DY-713A
37	1	Connector, 3/16" OD to 1/8" FNTP	DY-759A
38	2'	Tubing, 3/16" OD Polyvinyl	DY-761A
39	3	Connector, 3/16 OD to 1/8" MNTP	DY-760A
40	1	Bezel, Tachometer Front	DY-721A
41	1	Bezel, Tachometer Rear	DY-620A

Item No.	Qty./ Unit	Description	Part Number
42	1	Coupling, 3/8" D.	DY-794-6
43	1	Coupling, 1/2" D.	DY-794-8
44	1	Coupling, 5/8" D.	DY-794-10
45	1	Coupling, 3/4" D.	DY-794-12
46		Coupling, 7/8" D.	DY-794-14
47		Coupling, 1 D.	DY-794-16
48	1	Drive Coupling, Tachometer	MD-874A
49	1	Gage, Load 0 to 15#	DY-792A
50		Gage, Load 0 to 30#	DY-793A
51	1	Caliper Hydraulic Fluid, 2 oz.	MD-875A
52	1	Motor, 1/2 HP Capacitor Start	MD-876A
53	1	Motor, 1/2 HP Split Phase	MD-877A
54	1	Motor, 1/2 HP A.C./D.C. Universal	MD-878A
55	1	Motor, 1/2 HP Repulsion	MD-879A
56	1	Motor, 1/2 HP 3-Phase	MD-880A
57	1	Motor, 1/4 HP Shaded Pole	MD-881A
58	100	Motor Analysis Data Sheets	MD-882A
59	100	Motor Analysis Data Graphs	MD-883A