HM1
Instruction
Manual

Manufactured By:
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GAGE Model HM1 Assembly and Instruction Manual

PARTS LIST

1	80006	Instruction Manual

Main Bag

1	39011	Abrasive Paper, 400 Grit
1	A2023	Flywheel Assy

Bag "A"

3	10001	Nut 0-80, 3/32 AF
5	10212	Machine Screw 0-80 X 3/16 Pan Head Slot
6	10808	Screw 0-80 X 1/8 Hex Head
4	10820	Screw 0-80 X 5/16 Hex Head
1	12608	Set Screw 2-56 X 1/8
8	12812	Screw 2-56 X 3/16 Hex Head
1	17808	Shoulder Bolt 0-80
1	19000	Nut 0-90
1	40009	O-Ring AS-568-009
1	40030	Wrench Hex Key .035 AF
1	40043	E-Ring E-18
1	51011	Wrench Combination Open End 3/32 - 5/64
1	51101	Wrench 3/32 AF Socket
1	51102	Wrench 1/8 AF Socket

Bag "B"

2	53068	Crosshead Guide Rods
1	53112	Cylinder Mount
1	53113	Cylinder
1	53115	Cylinder Cover Plain
1	53122	Ferrule, Crosshead To Piston Rod
1	53123	Fork, Piston Rod To Connecting Rod
1	53124	Crosshead Guide Support
1	53125	Connecting Rod
1	53127	'D' Slide Valve
1	53133	Steam Chest Cover

Bag "C"

1	A1005	Steam Pipe Assy
1	A1006	Exhaust Pipe Assy
1	A2015	Piston & Rod Assy
1	A2016	Crosshead Assy
1	A2017	Steam Chest Assy
2	A2018	Bearing Assy
1	A2020	Valve Spindle Assy
1	A2021	Cylinder Cover Assy With Seal
1	A2022	Crankshaft Assy

Bag "D"

1	53105	Base
1	A2019	Eccentric Strap Assy
1	80007	Gasket Set

INTRODUCTION

Thank you for purchasing the GAGE HM1 Horizontal Mill steam engine assembly kit. The kit is completely machined and will require only common hand tools for assembly.

The HM1 is not a scale model of any engine. It is a miniature steam engine that is in the style of steam engines used to power electric generators, small factories, machine shops and similar activities. These engines were common during the latter part of the 19th century and into the early decades of the 20th century.

As engines are reduced in size, the operating speed tends to increase. A large engine of this design would have a maximum speed of only a few hundred revolutions per minute (RPM). To provide a more realistic running appearance, the valve operation on the HM1 has been optimized for low speed operation. This increases the steam usage slightly compared to a design where efficiency is the prime concern. The HM1 has a maximum speed of 2000 to 2500 RPM. After the engine has been run for a few hours to "break it in" the minimum speed will be less than 400 RPM.

GENERAL NOTES

The first time a part is referenced in the text, the part number will follow the name of the part. In some cases the part number may be repeated later in the text to clarify situations where parts may have similar names. Part numbers are five characters long. Individual parts will have part numbers beginning with a number. Part number beginning with the letter "A" are assemblies consisting of two or more parts that have been pre-assembled.

The parts identification drawing shows each assembly along with the individual parts used in the assembly. The parts list shows only the assembly part number.

The HM1 can be adjusted to run either direction. The direction of rotation of a steam engine of this style was referred to as "running under" or "running over". When and engine is running over, the top of the flywheel is moving towards the cylinder, and when running under, the top of the flywheel is moving away from the cylinder. Unless there was a compelling reason not to, this style engine was always set to "run under". When running under, the vertical pressure on the crosshead by the connecting rod is always downward, the same direction as gravity. When running over, the pressure lifts the crosshead during power strokes. At the end of each power stroke gravity would cause the crosshead to fall. While this really did not hurt anything (a little extra wear) it did make a clanking noise that irritated the engine operating engineer and reflected badly on his reputation. The noise could only be eliminated if the crosshead to crosshead guide clearances were very carefully adjusted. On some engines this clearance was not adjustable.

In keeping with tradition, the assembly instructions will set the engine up to "run under". On the HM1 the flywheel will rotate clockwise when looking at the output shaft side. If you should want the engine to run in opposite direction, a paragraph at the end of the adjustment section tells you how. On an engine of this size, the direction of rotation will have no effect on operation.

Although all the parts are machined, you may wish to polish or refine the finish on the parts either before or during assembly. If you do, be careful not to distort the ports on the cylinder. The finishing of this face is detailed in the instructions. Mating surfaces on the steam chest, steam chest cover, cylinder covers, and cylinder ends also require care to keep them steam tight.

To remove machining marks, use waterproof abrasive paper such as is supplied in the kit. The abrasive paper supplied in the kit is 400 grit. Use a little light oil on the paper. If the surface is flat, lay the paper on a flat surface and rub the part against the paper. Start with 400 grit and then progress to 600 grit. Finish with 1000 grit if desired and then polish. While the polish will work best if used after 1000 grit, it is effective even if used after either 400 or 600 grit abrasive paper.

Fine grit waterproof abrasive papers are available at most hardware stores and automotive supply stores.

Polish is available from many sources. Many supermarkets and hardware stores have brass polish for polishing domestic items and aluminum polish is available from automotive supply departments and stores for polishing aluminum automobile wheels. All the aluminum polishes I have used have be very good for brass also. After polishing, be sure to clean all surfaces where polish could get inside the engine. The polish is an abrasive and will cause excess wear if allowed to get in the cylinder or bearing surfaces.

As an alternative to polishing, a semi-matte finish can be produced using a non-woven abrasive pad sold for cleaning pans in the kitchen. It can be used wet or dry.

TOOLS REQUIRED

Only two tools are required to assemble the kit. A flat blade screwdriver with a 3/32 inch blade and a small needle nose pliers. Other tools, which are not required but are very helpful, are tweezers, magnifying glass, and a sharp pointed modeling knife. A small flat needle file may prove helpful, but the abrasive paper supplied will work instead for deburring and fitting. It may be slower however. Additional tools are supplied with the kit. These include two hex socket wrenches. One (51101) fits the 0-80 hex head screws and the other (51102) fits the 2-56 hex head screws. Both of these wrenches have short 3/16 inch diameter handles. This is to improve the feel the torque being applied to the screws. Screws in this size range can be over torqued and broken easily. Use caution in tightening the small screws.

GENERAL PROCEDURES

A set of laser cut gaskets is included in the kit. The set includes two extra cylinder cover gaskets and one extra steam chest gasket. To remove the gaskets from the sheet it will be necessary to cut the small tabs holding the gaskets in place. When installing the gaskets, place a drop of oil on the gasket so the gasket becomes soaked with oil. This makes the gasket material softer so it will comply with any surface imperfections and helps hold the gasket in place while screws are inserted.

All mating surfaces must be finished flat and smooth. The process used is similar to lapping and will be referred to as lapping in the instructions, but it is not a true lapping method. To make a surface flat and smooth use the abrasive paper supplied in the kit. Place the abrasive paper on a hard flat surface with the abrasive side up. The surface does not need to be extremely flat like a surface plate. Common surfaces that are satisfactory are pressure laminate counter tops, table saw surfaces, or a piece of plate glass. Put a few drops of light oil on the abrasive paper. Place the part on the paper and rub it in a circular manner for a few strokes. Rotate the part 90 degrees and rub a few more strokes. Repeat until the part has be rotated a full circle. Remove the part and clean it so no trace of abrasive remains. Dishwashing detergent and a small brush used with hot water works well for cleaning. A simple wipe with a rag is not adequate.

Become familiar with the parts contained in the kit by comparing the parts with the parts identification drawing and the parts list. In most cases it will not be necessary to remove the parts from the packages. Look over the assembly drawings and photographs to get an overview of where and how the parts are installed.

The HM1 kit contains approximately 65 parts. As many of the parts are very small, be careful when opening the parts packages to prevent loss of any of these parts. A shallow tray or dinner plate is useful for holding parts while assembling the engine. A clean well lighted area is essential.

ASSEMBLY

During assembly it is suggested that you mark each paragraph of the instructions as you complete it. This will help you to avoid skipping a section should you be interrupted during the assembly process.

Begin by "lapping" all the mating and working surfaces. Refer to the General Procedures section on lapping if necessary. The areas that require lapping are:

- Both open ends of the cylinder (53113).
- The port face of the cylinder. (The side with the 3 openings.)
- The valve face (53127) with the shallow rectangular opening.
- Both sides of the steam chest assembly (A2017) with 4 holes.
- The flat side of the steam chest cover (53133).
- The flat side of the cylinder cover assembly (A2021).
- One side of the plain cylinder cover (53115).

If you intend to polish your engine, polish these parts at the same time you lap them.

Clean all of the lapped parts. Be sure no abrasive residue remains in the steam passages in the cylinder on in the seals on each end of the steam chest and cylinder cover assembly.

Install the piston "O" ring (40009) in the groove of the piston assembly (A2015).

Place the cylinder on end with the port face to the left and the mounting face toward you.

Install the cylinder cover assembly on the top end of the cylinder using an oiled gasket. Using the 3/32 hex socket wrench (51101), install four 0-80 x 1/8 hex head screws (10808) to attach the cylinder cover. Snug but DO NOT tighten the bolts.

Place a drop of oil in the piston rod hole on the cylinder cover assembly. Place a drop of oil on the "O" ring on the piston assembly and on the piston rod.

Insert the piston assembly, rod end first, into the open end of the cylinder, passing the piston rod through the seal in the cylinder cover assembly.

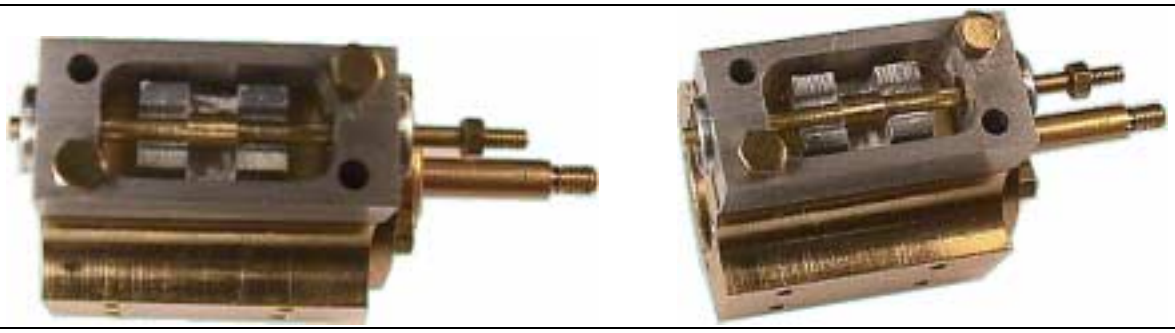
Press the piston completely into the cylinder so it touches the cylinder cover assembly. Loosen the four bolts holding the cylinder cover, then gently snug the two screws away from the port face. Now tighten the two screws nearest the port face. Now remove the two screws farthest away from the port face. Later the two cross guide rods (53068) will be installed where screws were removed.

The purpose of this last exercise is to center the cylinder cover assembly and seal on the cylinder bore. To check this, slide the piston from one end to the other in the cylinder using the piston rod. It may feel a little stiff as the seals will remain tight until the engine has run for a few hours, but it should feel even from one end to the other.

Test fit the valve spindle assembly in the slots in the valve (53127). The spindle must drop into the narrow slots with the enlarged section engaged in the wide slot. The valve must be free to move on the spindle so it can seat on the cylinder port face. If the spindle is tight in any of the valve slots open the slot up SLIGHTLY with a small file or the abrasive paper supplied in the kit.

Remove the valve spindle from the valve. Place a drop of oil in the hole on each end of the steam chest (A2017). This is to lubricate the seals that the valve spindle passes through. Insert the threaded end of the valve spindle through one of the seal holes from the inside of the steam chest. Slide it in until the other end will fit inside the steam chest. Then slide this end through the seal on the other end of the steam chest. Center the enlarged portion of the spindle in the steam chest.

Coat the port face of the cylinder with oil. Place a gasket on the port face. Place the valve on the port face with the shallow recess covering the port openings in the cylinder. With the threaded end of the valve spindle in the same direction as the threaded end of the piston rod, set the steam chest on the cylinder and align it so the valve spindle drops into the slots in the valve.



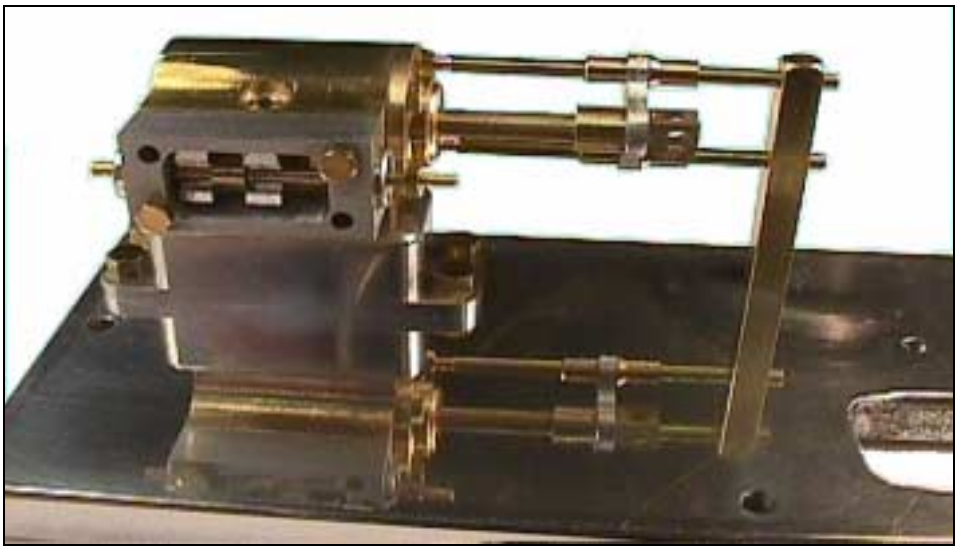
Secure the chest to the cylinder using two 0-80 x 5/16 hex head screws (10820). Do NOT attempt to tighten these screws as the threaded holes in the cylinder are not deep enough to permit the screws to tighten onto the steam chest.

Thread the 00-90 nut on the valve spindle, but do not tighten it.

Mount the cylinder to the cylinder mount (53112) using four 0-80 x 3/16 pan head slotted screws (10212).

Attach the cylinder mount to the base (53105) using four 2-56 x 3/16 hex head screws. The threaded ends of the piston rod and valve spindle face the opposite end of the base.

Thread a 0-80 nut (10001) on each crosshead guide rod (53068).



Install the crosshead guide rods into the two empty holes in the cylinder cover. The rods should be threaded in as far as possible with only finger pressure, and for appearance purposes should then be adjusted so the ends are an equal distance from the cylinder. Tighten the nuts onto the cylinder cover.

Slide the crosshead assembly (A2016) on the crosshead guide rods so the large hole is centered on the piston rod. The taper on the crosshead guide bearing can face either toward or away from the cylinder.

Slide the crosshead guide support (53124) on the crosshead guide rods and secure it to the base with a 0-80 x 3/16 pan head screw.

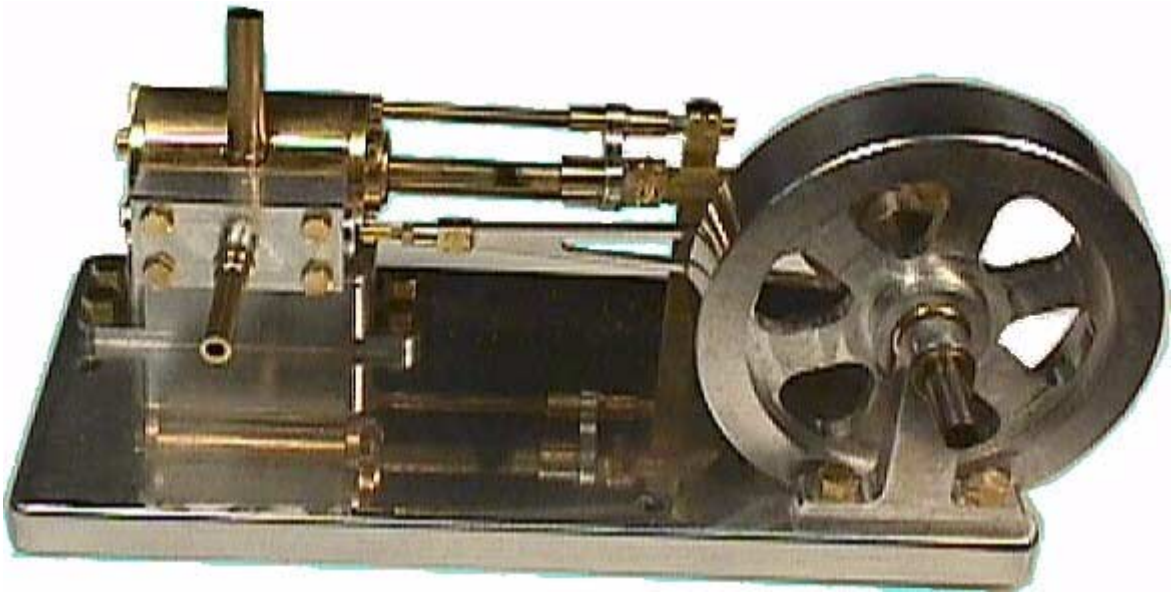
Slide the crosshead assembly against the crosshead guide support.

Place the ferrule (53122) on the piston rod with the small hole in the ferrule facing the cylinder. The threads on the piston rod will be concealed inside the ferrule.

Insert the connecting rod fork (53123) through the crosshead assembly and slide the assembly to the piston rod. The round end of the connecting rod fork will start to enter the ferrule on the piston rod. Insert a 3/32” blade screwdriver in the slot on the piston and thread the piston rod into the fork. Leave it slightly loose so the fork can be rotated. It will be tightened later.

Thread the eccentric strap assembly (A2019) 5 turns onto the valve spindle. Then rotate it until the side that has the bearing protruding faces the slot in the base. Do NOT tighten the 00-90 nut on the valve spindle.

Attach one bearing assembly (A2018) to the base near the center of the base using 2-56 x 3/16 hex head screws. The side with the protruding bearing is away from the slot in the base.



Slide the eccentric portion of the flywheel hub (A2023) into the eccentric strap assembly bearing. Lower the flywheel into the slot in the base. Slide the crankshaft assembly (A2022) through the bearing and then through the flywheel.

Slide the other bearing assembly on the crankshaft with the protruding bearing away from the flywheel. Secure the bearing assembly to the base with 2-66 X 3/16 hex head screws.

Oil the crankshaft bearings and the eccentric.

Check that the crankshaft turns freely in the bearing assemblies. It may be a slightly stiff, but should not be binding while rotating. If the crankshaft does not turn freely, loosen all the screws holding the bearing assemblies to the base and then tighten them a little at a time so all the screws are tightened evenly.

Carefully inspect the connecting rod (53125). Notice that on one end the rod has a slight protrusion around the hole on one side. Slide the connecting rod onto the crankpin of the crankshaft assembly so this protrusion is next to the crankdisk of the crankshaft. This spaces the connecting rod away from the crankdisk so it does not rub.

Place the other end of the connecting rod in the slot in the fork attached to the crosshead. Move the piston and/or rotate the crankshaft until the holes in the fork line up with hole in the connecting rod. Place the head of the shoulder bolt (17808) into the 3/32 hex wrench and use it to hold the bolt while you insert the bolt through the fork and connecting rod starting it from the side nearest the crosshead guide rods. Place a 0-80 nut on the shoulder bolt and tighten.

Hold the connecting rod with needle nose pliers near the crosshead. Place tape or paper on the jaws of the pliers to keep from scratching the connecting rod. Now tighten the piston into the crosshead guide with a screwdriver in the slot of the piston while keeping the fork from rotating by holding the connecting rod with the pliers. When finished, the fork must not bind on the connecting rod.

Slide the eccentric strap back onto the eccentric hub of the flywheel because it will have probably fallen off by now. A groove will be visible in the eccentric. Rotate the flywheel so the eccentric strap moves as far away from the base as possible. The setscrew hole in the flywheel will be approximately on top. Place the points of the E-ring (40043) into the groove of the eccentric. Press the ring down until it snaps in place. The points will center up on the crankshaft to keep the ring from rotating. Rotate the flywheel while observing the E-Ring. If properly installed, the outer edge of the ring will be concentric with the eccentric strap.

Install the 2-56 x 1/8 setscrew (12608) in the flywheel hub, but do not tighten.

NOTE: When tightening the setscrew in the following two steps, position the flywheel on the crankshaft so it is near but not touching the bearing at the crankdisk end of the crankshaft. The crankdisk should be touching the bearing.

Observe the valve in the steam chest while rotating the flywheel. The valve will uncover a portion of the cylinder ports at each end of it travel. At each extreme of travel the amount of the port uncovered should be the same. If it is not, rotate the valve spindle with needle nose pliers until the amount of port uncovered at each end is the same.

Rotate the crankshaft until the crankpin is nearest the cylinder. While holding the crankshaft in position, rotate the flywheel until the setscrew is on approximately on top. Observe the valve in the steam chest. Rotate the flywheel until both of the ports are covered by the valve. Tighten the setscrew on the flywheel.

Now rotate the flywheel until the crankpin is away from the cylinder. Observe the valve. Both ports should be covered. If both ports are not covered, loosen the setscrew and repeat the last two steps until the ports are covered in both positions of the flywheel.

Tighten the 00-90 nut on the valve spindle.

Place two drops of oil in the steam chest around the valve. Press the valve against the cylinder port face. The oil will help hold the valve in place.

Remove the two bolts holding the steam chest in place. Install the steam chest cover (53133) using an oiled gasket and the two screws just removed plus two more 0-80 x 5/16 hex head screws. Try to ensure the valve stays against the cylinder face.

Install the cylinder cover (53115) with an oiled gasket using four 0-80 x 1/8 hex head screws.

Screw the 3/32 diameter steam pipe assembly (A1005) into the steam chest cover.

Screw the 1/8 diameter exhaust pipe assembly (A1006) into the cylinder.

STARTING UP

While the engine can be broken in on steam, it is much easier to run it for the first few hours on air to develop a running fit on all the parts. It will require 15 to 20 pounds per square inch of air pressure to start the engine the first time. After about 15 minutes running, the required air pressure will drop to about 10 PSI. After several hours of running, the engine will run at low speeds at 5 PSI.

Before starting the engine the first time, **OIL EVERYTHING**. The places that must have oil are:

- Crankshaft bearings
- Crosshead guide rods
- Eccentric hub on the flywheel
- Valve rod fork
- Both ends of the connecting rod

When running on air, place a few drops of oil in the air line every few hours of operation.

Connect a 15 to 20 psi air source to the engine using plastic tubing on the steam pipe assembly on the steam chest cover. Rotate the flywheel so the top of the flywheel moves away from the cylinder. The engine should start to run on it own after just a few tries.

Do not exceed 20 psi air pressure for the first hour of operation. After that, air pressure up to 35 psi can be used. The speed will not increase greatly at the higher pressures, but torque will increase.

STEAM OPERATION

Do not attempt operation on steam until the engine has run for at least one hour on compressed air.

When operating on steam, the boiler MUST have a safety pressure valve set at no higher than 35 PSI and 30 PSI is preferred. Pressure higher than 35 PSI may cause mechanical failure in the engine.

When operating on steam, the engine will require more lubrication than when operating on air. Steam is very effective at removing grease and oil and is used for this purpose.

The most effective way to lubricate the engine is with a lubricator in line with the steam supply. The most popular type of lubricator is the displacement lubricator. If it is used, is should be mounted as close to the engine as possible, and after any steam regulating valves or governors. This type of regulator will not work with compressed air. It works on the principle of a small amount of steam condensing into water, and the oil floating on the condensed water.

A special steam cylinder oil is recommended for lubrication. It is compounded so it does not wash away from the surfaces as easily with steam as does more common oils. If any superheat is applied to the steam, it is essential.

It is not recommended that superheated steam be used with this engine. If any is used, it should be only moderately superheated. The use of saturated steam is recommended as the condensation of the steam will provide additional lubrication to the engine.