Small Engine Dynamometer

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Abstract

A dynamometer is a machine which can measure torque, RPM, and therefore horsepower. For the past semester a small engine dynamometer has been worked on. The output of this dyno has been transmitted to an oil pump which results in a pressure output and an oil flow rate. These outputs can be converted to horsepower through calculations. The dyno will be used for small engines such as those used in the sprint karting industry. A dyno can benefit racers, engine builders and kart manufacturers. By comparing two different engines, or different components on the same engine, kart racers can find which set-up will help them win races. The advantages of this dyno are the cost, and it's semi-portability. Most dynos run between $2000 and $3000 dollars and are large and bulky, this one has cost about $1000, and is portable by truck.

Specification Parameters

The dyno consists of three major parts, the instrumentation (gauge panel), the mounting stand, and the actual body of the dyno. Some of these parts have been made in the Messiah College Engineering Department's model shop, but most of them have been either ordered from industry or donated by Swain Technology or Roadrunner Karts.

Instrumentation

- Glycerine filled pressure gage: Capable of measuring up to 3000 psi.
- 4" Flow meter: Capable of measuring 15 gallons/minute.
- Load Control Valve: Restricts oil flow for more accurate reading.
- Digatron: Tachometer, engine temperature **gage**. Readings up to 15,000 rpm and 500 Fahrenheit.
- Gauge panel housing
- Computer software: Quattro Pro; for conversion to horsepower.

Mounting Stand

- 2" Angle iron: This will make up the legs and the main frame of the stand. Dimensions - 38" x 33.5" x 32" (See drawing for details)
- Engine mount plate: This will consist of 2 pieces of flat stock steel (8" x 4" x .25") with two 3/8" nuts, bolts and washers.

Main Body

- Hydraulic oil pump: Run by the engine. Creates outputs for pressure gage and flowmeter.
- Hydraulic oil
- 1" Steel Axle
- 1" Pillow blocks: For mounting axle
- Gear hub: For mounting sprocket
- Sprocket
- Chain
- Coupling: To connect the 1" axle to the 3/4" pump output shaft
- Engine (2-Cycle or 4-Cycle)
- Clutch
- Oil reservoir: To avoid overheating of hydraulic oil. Dimensions 12" x 12" x 22"
- Remote throttle control
- Hydraulic hoses and fittings: To connect pump to flowmeter to

reservoir. Heater: To heat oil so that it has a consistent viscosity.

RESULTS OF DESIGN

The overall design objectives for this project were met with great specificity. There were a few changes that were made which will be discussed. Ultimately, the dyno came together quite well. Time constraints were not a problem, and very few design problems were encountered along the way.

Most of the changes that were made involved dimension changes in the mounting stand and the components of it. First of all, the biggest change that was made involved the scatter shields. After doing some further research on engine types that we might want to test on the dyno, a decision was made that the scatter shields might inhibit the size of engine that could be tested. Some engines have longer crankshafts than Briggs and Stratton 4-cycle and Yamaha 2-cycle engines (which were the engine types the dyno was designed around). Therefore, the clutch may have ended up where the scatter shields were supposed to be. So the shields were omitted from the design.

Another change involved the dimensions of the mounting stand top (see drawings in appendix F for details). Originally the dimensions were supposed to be 36" x 33". After doing the research on other engines (mentioned above) I decided that it needed to be slightly larger. The new dimensions are 38" x 33.5". The extra space will allow for more movement of the sprocket and hub, so that larger engines can be placed on the dyno.

The reservoir also had its dimensions changed. The original dimensions were 16" x 16" x 24". These turned out to be slightly larger than were necessary, so the dimensions were made to be a little bit smaller. They were changed to 16" x 12" x 22". These parameters still meet the necessary volume specification. The return hose is mounted 7.5" from the bottom of the reservoir. This allows for about 10 gallons of hydraulic oil to be placed in the reservoir without coming up higher than the return hose hole. After running tests this amount of oil was found to be. sufficient for testing.

Another dimensional change which was made involved the engine mount plates. Originally they were going to be 12" long. However this might allow for too much flex when the engine is placed on them. After talking with Roadrunner Karts, I acquired two plates which were only 8" long. This still allowed enough movement in the engine so that the chain could be tightened, but it also reduced the amount of beam deflection in the plates.

One addition that was made was that of a heater for the hydraulic oil. Viscosity is very important in the running of these tests. After a test has been running for a little while, the energy output will cause the oil to heat up. The heater which will be placed on the bottom of the reservoir will be used to preheat the oil, so that it is already at the viscosity which it will reach during the test.

Lastly, tabs were welded onto the bottom of the legs. These tabs had 3/8" holes drilled in the middle of them so that a bolt could be placed in them. When the dyno reaches its final destination, it will be able to be bolted to the floor to prevent vibration.

PROJECT BUDGET

Although an absolute goal was not set for the budget of the project, I feel that the general goal was met. The overall price of the dyno turned out to be somewhere around $1000. Similar models that I have seen have gone for over $2000. Other karting dynos of a different type and accuracy go for as much as $3000 or more. The biggest part of the cost was funded by Swain Technology. I also received some help from the Engineering Department for some of my materials, and Roadrunner donated a few parts to also help with the cost.

In the future, the price of the gages could be better researched. The bulk of the cost of the project was involved in the gages. If cheaper prices could be found, the overall cost of the dyno could go down even more.

Testing Procedure

Testing an engine on this dynamometer will first of all require the engine to be removed from the kart and placed on the engine mount stand on the dyno. The chain then must be connected from the sprocket to the clutch. The engine then must be started and run with the remote throttle control. The engine rotates the axle which is coupled to the pump. The pump then creates a pressure which is read on the pressure gage and a flow which is read on the flowmeter. The RPM's are read on the digatron which has a sensor connected to the sparkplug. Every revolution the engine makes creates a spark, and therefore RPM's can be read through the sparkplug.

Horsepower can be determined by using conversions from the flowmeter. However, most tests will involve comparisons between two engines or different parts on the same engine. This can be done easily and quickly by running the test for each engine, and recording the maximum pressure output. Whichever engine gives a higher pressure output, that one is putting out more horsepower.

For a specific set of directions see Appendix C for details.

FABRICATION

The main part of the fabrication process involved the measuring, cutting, and welding of the mount stand. Also, the components had to be placed on the stand, and the entire dyno had to be self contained.

As specified the mount stand consisted mainly of 2" angle iron. First of all the legs, cross pieces, and top pieces were all measured from 4 pieces of 20' x 2" angAe iron. Then they were cut using the circular saw. The top pieces then had to have 45 degree angles cut at the end so that they could be pieced together to make a rectangular top. The cutting of these 45 degree angles was done on the band saw.

After all of the pieces were cut, they were readied for the welding process. To do the welding, each part had to be carefully secured. Special holes were drilled and tapped into the welding table, so that parts could be secured. Clamping devices were also used around the edges, so that it could me firmly held in place.

The welding process that was used was MIG welding (See appendix D for details). All of the parts in the mount stand were MIG welded. This added to both the rigidity and the strength of the entire dyno. The top of the stand and the cross pieces were welded first. This included the pillow block mounts, and the engine mount plates. Then the legs were added. Lastly, the bolting tabs were added.

After the welding process was complete, some of the components were ready to be placed on. The pillow block mounts had holes drilled in them so that the pillow blocks could be mounted on them. This was done using 1/4" bolts. Next, the oil pump mount had to be placed on the dyno. At first it was going to be welded on. After some thought, I decided to bolt it on, so that there would be a little bit of movement in it. Since the pillow blocks could be moved slightly, the oil pump should be somewhat flexible. This also was placed on using 1/4" bolts.

The piece that bolts the engine to the engine mount plate was the next order of business. It was made out of 3/8" flat stock aluminum. The dimensions were 7.5" x 5.5" x .25". Four 1/4" bolts were placed in the bottom to accept the engine, and 2 - 3/8" bolts were placed in the top to bolt this piece to the engine mount plate.

Next the oil reservoir was ready to go into place. It was simply lowered down into its space in the mount stand, and bolted to the frame. It was then filled with 10 gallons of hydraulic oil through the breather hole in the top.

After all of the components were placed on the stand, some odds and ends were taken of. The axle was placed in the pillow blocks. The engine was put into place, and the chain was connected from the clutch to the sprocket. Then the oil pump was placed in its mount, and coupled to the axle. The heater was placed on the bottom of the reservoir.

All of the connections were then made. The supply hose, return hose, and intermediate hose were all put in place. The digatron had its leads for engine head temperature, and rpm's hooked up to the spark plug. And the heater was hooked to the heater light.

After a few adjustments and modifications the dyno was ready for painting and testing.

FUTURE

The small engine dynamometer is on the market at present. However, most of them are quite expensive. The project that I have worked on has turned out to be a reliable and cheaper alternative. In the future I would like to research other dynamometer ideas, such as inertia dynos. This involves a spinning bar with a weight on it. The set up for this could be even simpler than the oil pump type dyno.

With some further research and the facilities, I have thought about the idea of possibly building and marketing my small engine dyno idea. After racing, and talking to racers and engine builders this summer, I would like to find out what the interest would be for others. If the interest is high enough I would like to build them for others.

CONCLUSION

Overall, with the help of Swain Technology, Road Runner Karts, Prototype Engine Sales, and Dr. James Scroggin, the entire small engine dynamometer project went very well. Here are a list of the objectives which I came up with at the beginning of the year.

1. To build an engine dynamometer capable of measuring engine temperature, torque, rpm, and horsepower.

2. To make the dynamometer of such size that it is semi-portable.

3. To use computer software so as to make all calculations as simplified as possible.

4. To minimize cost, yet at the same time incorporate both reliability and function.

5. To simplify the design so as to enable the individual karter to use the dynamometer.

6. To learn more about the parts and mechanics of an engine. I feel that each and everyone of these objectives were met. I also feel that I learned a great deal more than I expected. The outcome of the project has brought about a lot of ideas for future work on dynamometers. Hopefully with its help both the Swain Technology and Road Runner Karts Racing teams will be winning a lot of races this year.

APPENDIX A

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Appendix B

Results

The results of the test that was run were very encouraging. After playing with the dyno for a little while and getting used to how the engine responded to the load control valve, a test was run.

The engine that was used was a stock 5 horsepower Briggs and Stratton engine. Methanol was used to power it instead of gasoline, because that is the racing fuel that is used for sprint karts.

The results of the test can be seen on the horsepower conversion chart. The maximum RPM that the engine put out was 5.14 horsepower. The slight deviation from 5 horsepower can be explained from the fact that methanol is a more efficient burning fuel than gasoline.

Horsepower

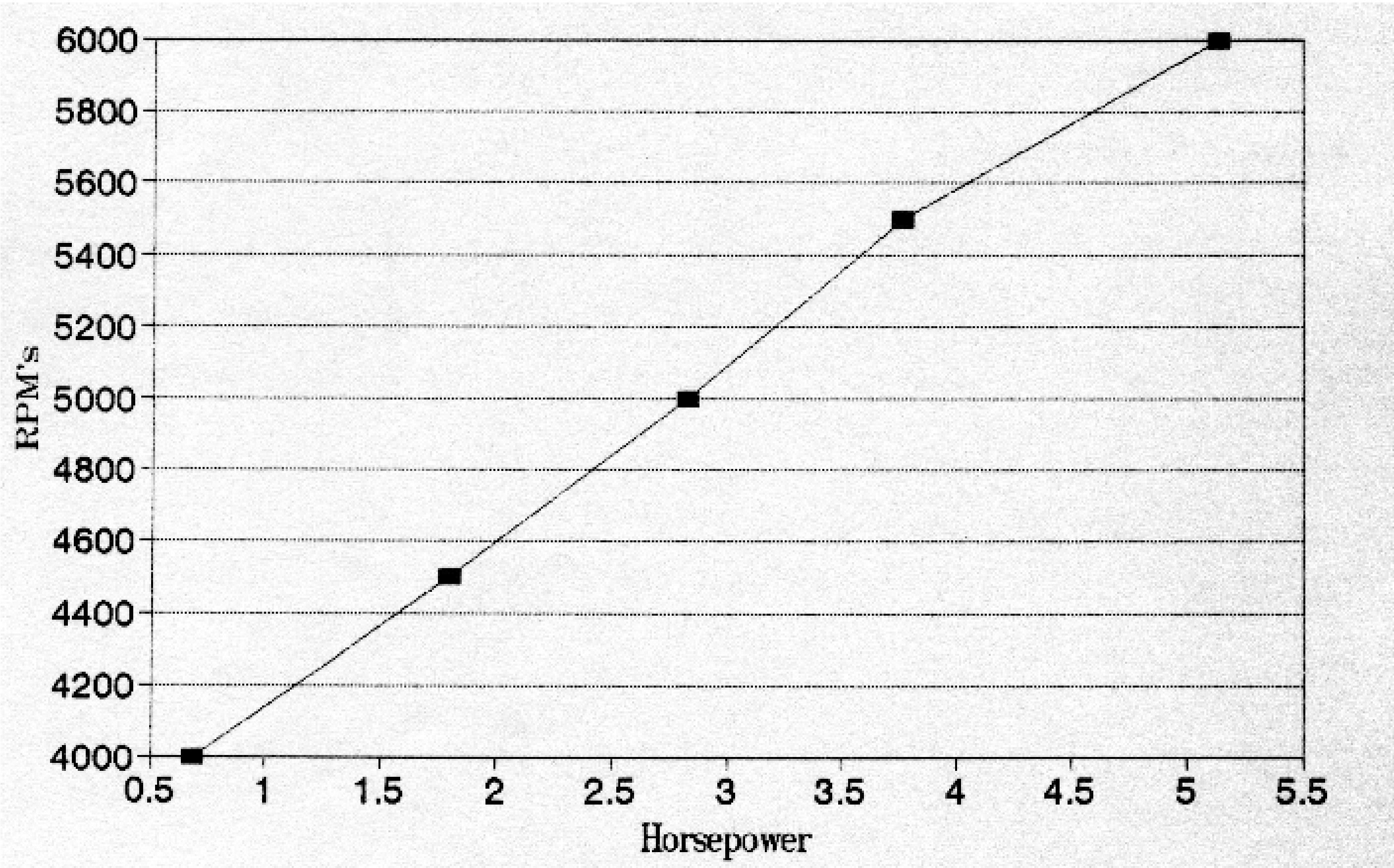
Conversion

Date=> 4/21/93 Engine
=> Brings 5hp Oil Type
=> Mobil 1 Temperature
=> 72 F Engine Temp =>
310 F Air Density =>
unknown

RPM's	Temp	Pressure	Fbw	Horse
Reading	DegF	Reading	Reading	power
4000	204	250	4	0.68
4500	210	500	5.25	1.80
5000	245	750	5.5	2.83
5500	290	1100	5	3.77
6000	310	1500	5	5.14

Formula => (PSI * GPM)/1460 =
Horsepower

Horsepower Curve



16 Appendix C

Direction For a Test

1. Turn heater on until the oil reaches the correct temperature (120-125 degrees). After establishing the correct oil temperature turn the heater off. The engine will maintain the temperature.

2. Attach the correct gear to sprocket hub for testing.

3. Mount engine with motor mount on engine mount plates.

4. Connect the chain to gear and clutch.
5. Before testing an engine test all nuts and bolts for tightness.

6. Start engine.

7. Increase engine rpm's to 2500 with throttle control.

   - Turning control valve in will decrease rpm's

   - Turning control valve out will increase rpm's
8. Turn control valve (Located between the pressure gage and the flowmeter) in until the pressure gage moves.

9. Open throttle control completely.
10. Take control of engine with the control valve, and bring the engine to the required rpm for the first test.

11. For each engine 5 tests should be run at:

    6000, 5500, 5000, 4500, and 4000 rpm's.

12. Use the horsepower formula for conversions.

    (PSI reading) x (GPM reading)/1460 = Horsepower

Appendix D

MIG Welding

A lot of the work and fabrication of the dyno involved welding. The type of welding that was used was Metal Inert Gas (MIG) Welding. MIG welding is also known as Gas Metal-Arc Welding.

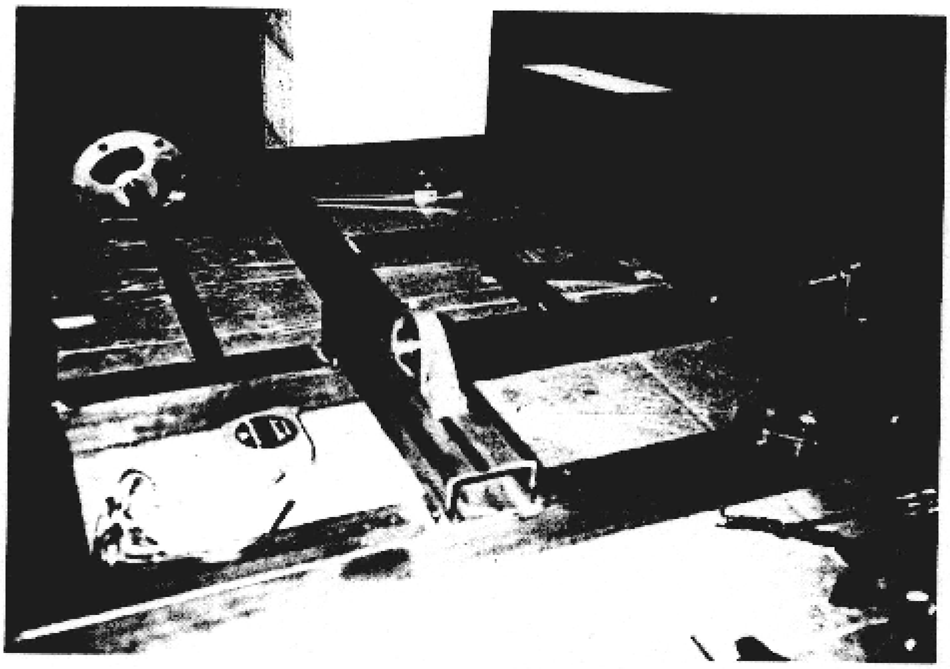
In MIG Welding a consumable metal electrode, fed through the welding gun, is shielded by an inert gas. It is suitable for most metals. No slag is formed and several layers can be built up with little or no intermediate cleaning. Argon is a suitable gas for all materials; helium is sometimes preferred-because of its higher ionization potential and, therefore, higher rate of heat generation-for the welding of aluminum and copper; Ar with 20-50% Carbon Dioxide is generally used for carbon steels.

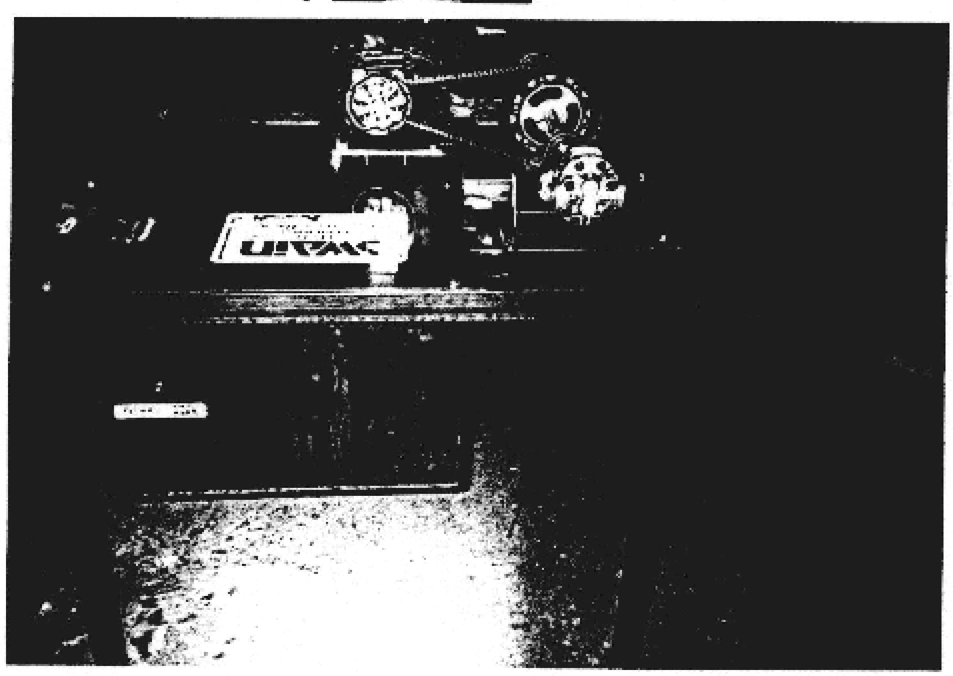
The electrode is usually connected to the positive terminal. At high current densities metal is transferred from the electrode to the weld zone in a fine spray.

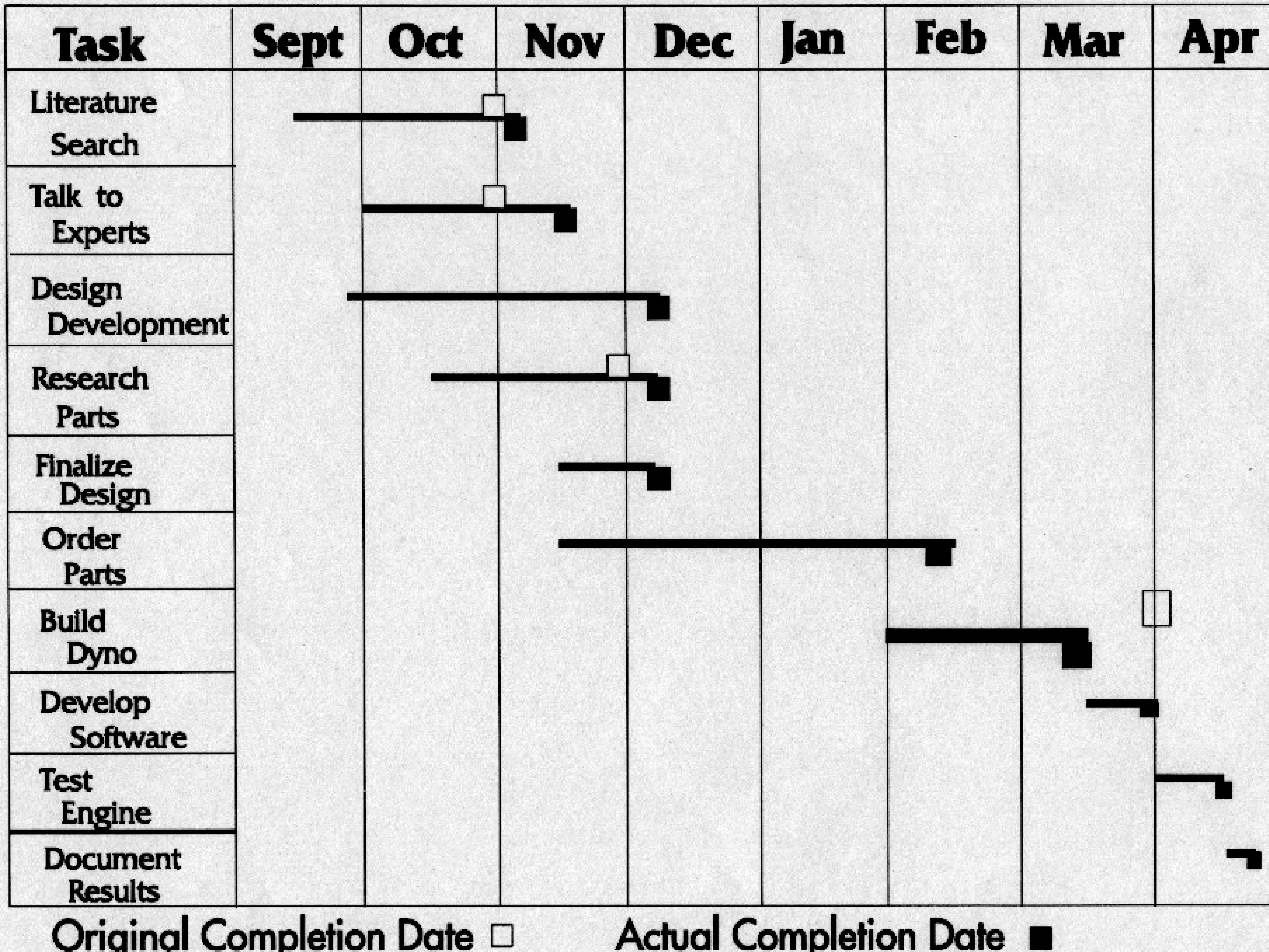
Appendix E

Pictures

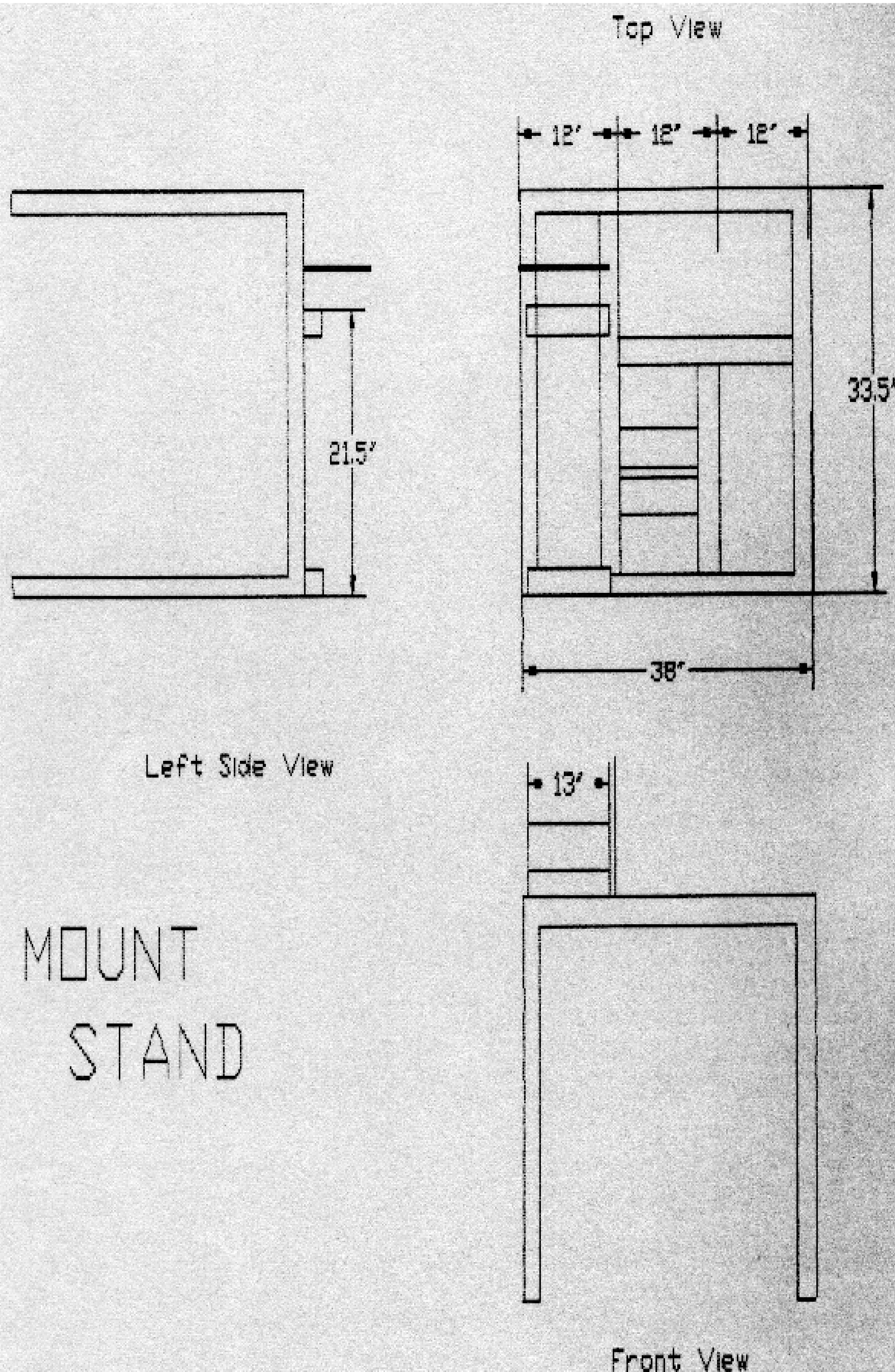
The pictures here represent the dyno at different stages of its development.

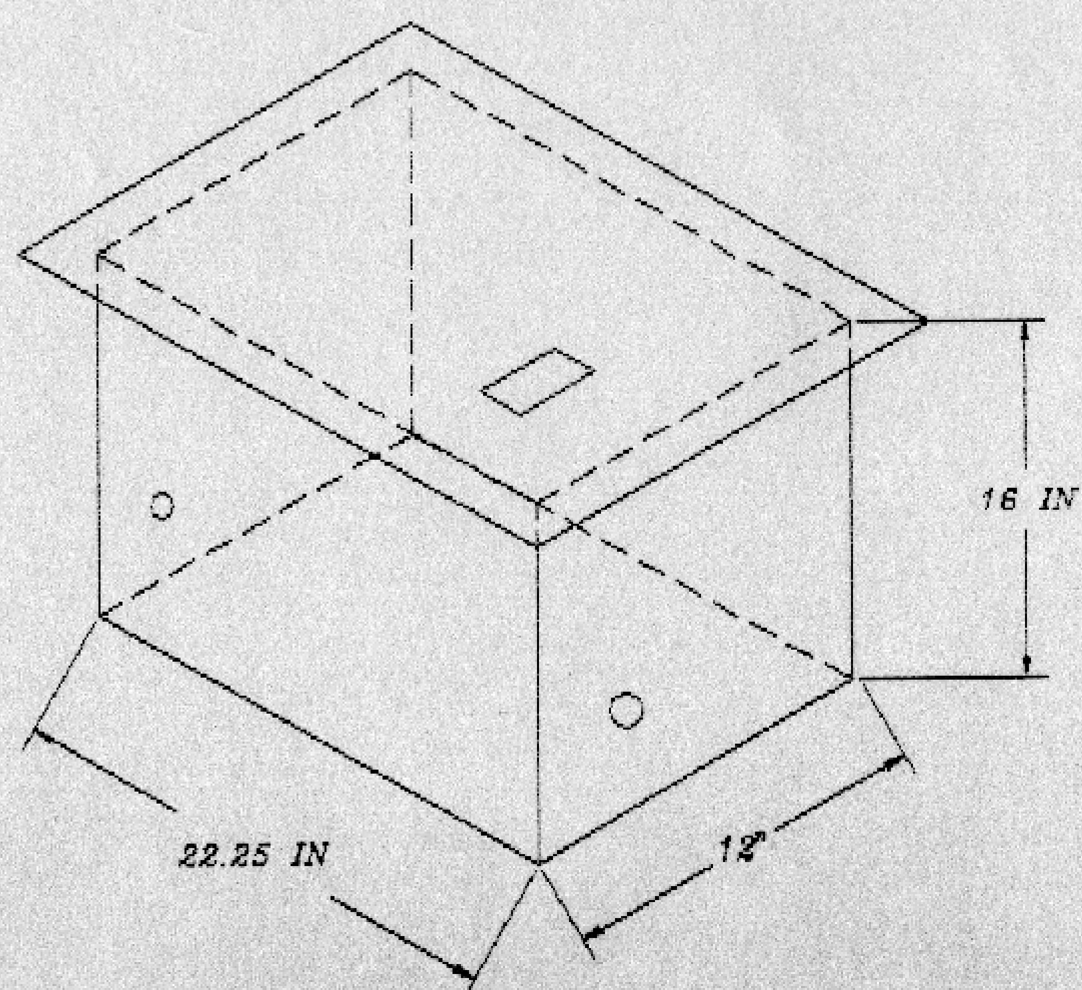




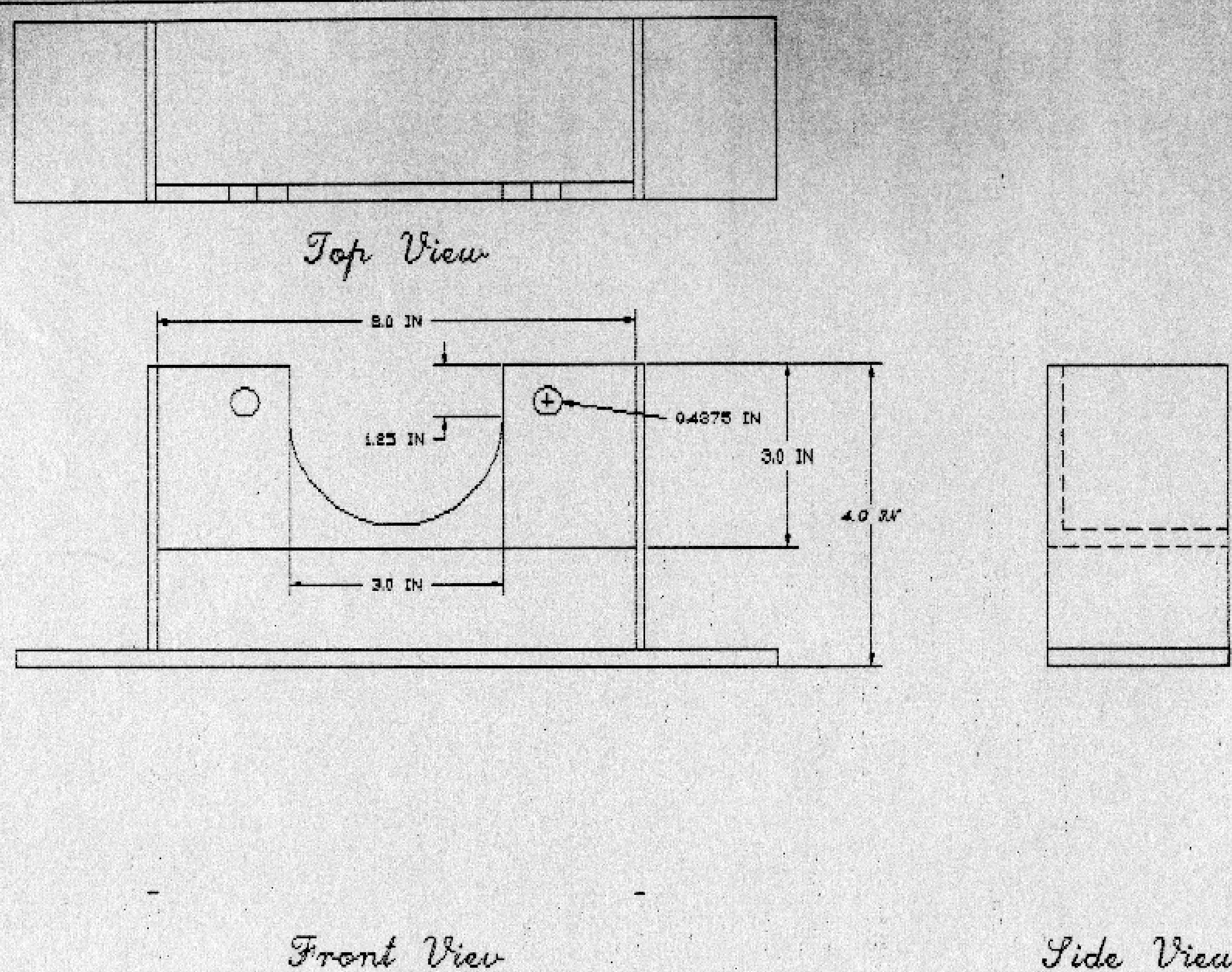


Updated Gantt Chart for Small Engine Dynamometer


Top View
12"
12"
12"
33.5"
38"
21.5"
Left Side View
13"
MOUNT
STAND
Front View



Oil Reservoir



Oil Pump Mounting Bracket

Gage Panel