Final Written Report- Team 17 December 18, 2000

Caltex Pumps, Inc.

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Group Members: **Vincent**

Executive Summary

Caltex Pumps, Inc. was presented with the task of designing and building a working human powered pump. This was to be completed within a 16-week period.

We choose to design a peristaltic pump for both efficiency and compactness. A pump of this type allows for quick transportation to and from the desired areas and a reliable and efficient means of pumping water. To stay within our allotted time for the project and to keep under budget, tasks we divided among the group members.

Our pump worked quite well and our flow measurement was fairly accurate. With a few minor adjustments to the design, the pump would flow a fair amount of water with great efficiency and accuracy. A finished version of the pump would meet the needs of various applications worldwide.

Introduction / Background / Motivation

The main objective of Caltex Pumps, Inc. was to design and manufacture a working human powered pump within certain design specifications (see table 1). Throughout the project many variables and designs were taken into consideration in order to produce the best pump possible. By staying within our budget and time parameters we were able to accomplish this as well as many of the goals we set for ourselves throughout the project. Our decision to use a peristaltic pump was due to their great efficiency and compact size.

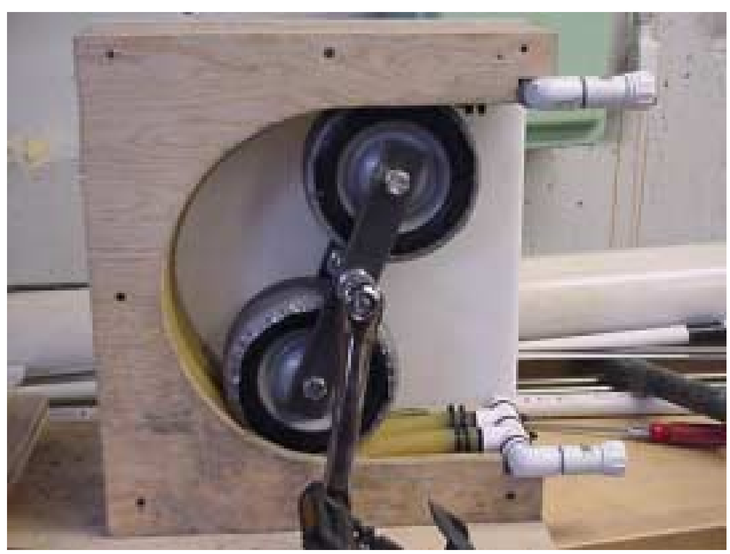
Characteristic	Specification
Cost	$100.00
Power	Human
Flow	Lots
Assembly Time	15 minutes
Disassembly Time	10 minutes
Size	Portable

Table 1- design specifications

The materials used were chosen for quality, cost, and ease of manufacture. The pump is mainly constructed of wood and plastic, which drastically cuts weight and production time, while remaining easy to manufacture within very low tolerances. Assembly and disassembly time was taken into consideration during the design of the pump. With this in mind our pump was designed so that it could be set up and ready to pump or taken apart for transportation in less than one minute thirty seconds. Appearance was also a factor when choosing the materials for the housing. The finished product displays a clean compact look for both aesthetics and mobility. For the entire project we set two main goals to adhere by: safety and quality. These two goals were our motivation for creating a pump that met and exceeded our expectations.

Prototype Description and Principles of Operation

Caltex's pump is divided into four interlocking sub-systems: 1) Pump Housing; 2) Pump Wheel Assembly; 3) Drive Mechanism; 4) Inlet/Outlet manifold. These systems work together to draw water in and pump it out during the same revolution. During the first half revolution, the first pump wheel seals the pumping tubes creating a suction that draws water into the pump via the inlet manifold. Then during the second half of the revolution, the second pump wheel seals the tubes and forces water out of the outlet manifold while simultaneously drawing water into the pump. The process repeats itself every revolution with minute water loss. When all the parts (see Appendix B) are fully assembled (see figure 1; Appendix A), the entire pump is self- contained to minimize damage from external sources.



To further understand the inner workings of the pump each sub-system will be described individually beginning with the pump housing. The pump housing (see Appendix C) is horse shoe shaped enclosed with a PVC sideboard (see Appendix D) on either side. It is constructed of plywood measuring 15.5in x 17.5in x 5.5in with a 7in inside radius and a 6.25in outside radius. The PVC sideboards measure 15.5in x 17.5in x 5.5in. Their purpose is to support the axle for the drive mechanism as well as protect the inner workings of the pump from dust, debris, or external forces. The entire enclosure houses the pump wheel assembly, the drive mechanism, the inlet and outlet manifolds, and the pliable pumping tubes.

The second system is the pump wheel assembly (see Appendix E). The pump wheel assembly is constructed of the 8in x 0.75in main axle (see Appendix F), two 4.5in x 0.5in secondary axles which the wheels are mounted to, two 10.5in x 1.5in x 0.25in steel plates (see Appendix G), two 0.75in lock washers, and four 0.75in bolts. The assembly is powered by the drive mechanism to create the necessary suction to move water over the desired distance.

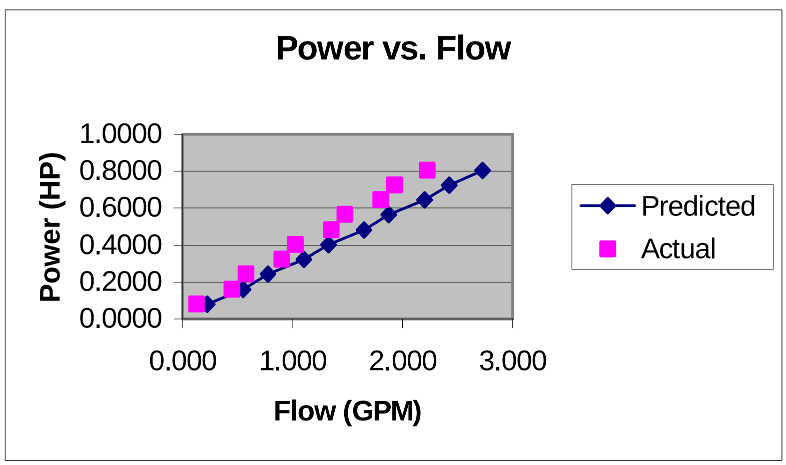
The next system is the drive mechanism. This consists of two cranks (see Appendix A) connected to the main axle of the pump wheel assembly. Using this integrated system our pump utilizes a direct drive system for maximum power and minimal energy loss due to friction and eliminates the need for gear reduction.

The last system incorporated into the pump is the inlet/outlet manifold (see Appendix H). Identical manifolds are used for both the inlet and outlet manifolds. This eliminates different parts for repairs and maintenance. The inlet manifold is connected to a hose, which draws water from the source and then feeds it into two pliable tubes. The pliable tubes run from the inlet manifold to the outlet manifold emptying into a single hose running to the desired location. When combined, these systems provide for a very reliable and efficient water pump.

Analysis and Testing

The analysis and testing performed by Caltex Pumps was done to find an optimum operating power that would yield good flow while remaining easy enough for people of most sizes and shapes to operate. We concluded that 45 rpm would be an excellent operating speed for nearly anyone, although physically fit people could operate at a much higher speed. Our graph (see figure 2;) shows that the actual flow rate is lower than our predicted as power increases. This is due to poor sealing at higher operating speeds. The poor sealing was due to a miscalculation when the housing was manufactured.

Figure 2 – Power vs. Flow



We tested our pump to a head of over ten feet to ensure that we could generate the suction needed. We were able to do accomplish this while pulling the water through 75ft of garden hose. While our testing yielded a total of 22 gallons in fifteen minutes, we estimate that 15-20 gallons of water was still in the hose. We also experienced a problem with our pumping tubes. For the first two pumping intervals we placed the pump on the table. The weight of the water caused our tubes to collapse under the pressure. For the third interval we moved the pump to the ground, which gave us much better results. These two factors made our flow meter less accurate than hoped and caused us to have the amount of error (see figure 3) that we did.

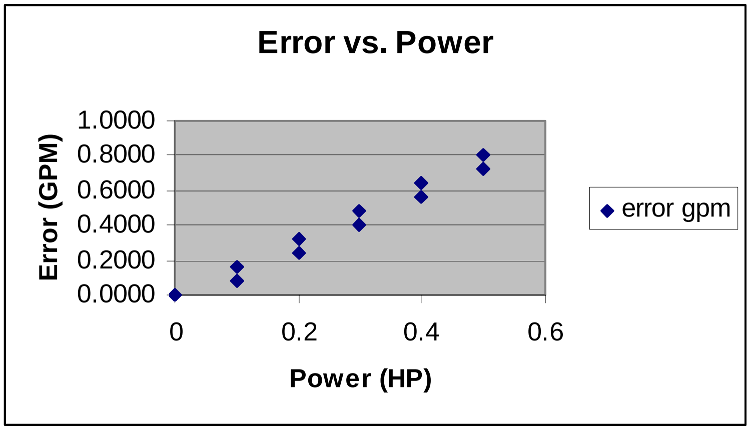


Figure 3 – Error vs. Power

Project Management

Caltex Pumps had a limited budget with which to work with. All expenditures were recorded and listed on our parts list (see Appendix B). With only three members, we were granted $100.00 instead of $75.00. With this extended budget we made sure to use the best materials for each part. Overall we were just under budget with $0.

We at Caltex Pumps managed our time to ensure that every task was completed by deadline. Each member had a number of things to do for every report, presentation, and tests. Garrett Roy was named the project manager after the untimely departure of the initial manager. Garrett arranged our meetings, gave members their tasks, and kept track of the schedule and budget. Matt Sewell was responsible for the presentations, reports, and drawings. Vincent Ray was the primary designer of the pump and also worked on the assembly drawings. All three members manufactured the pump and tested it.

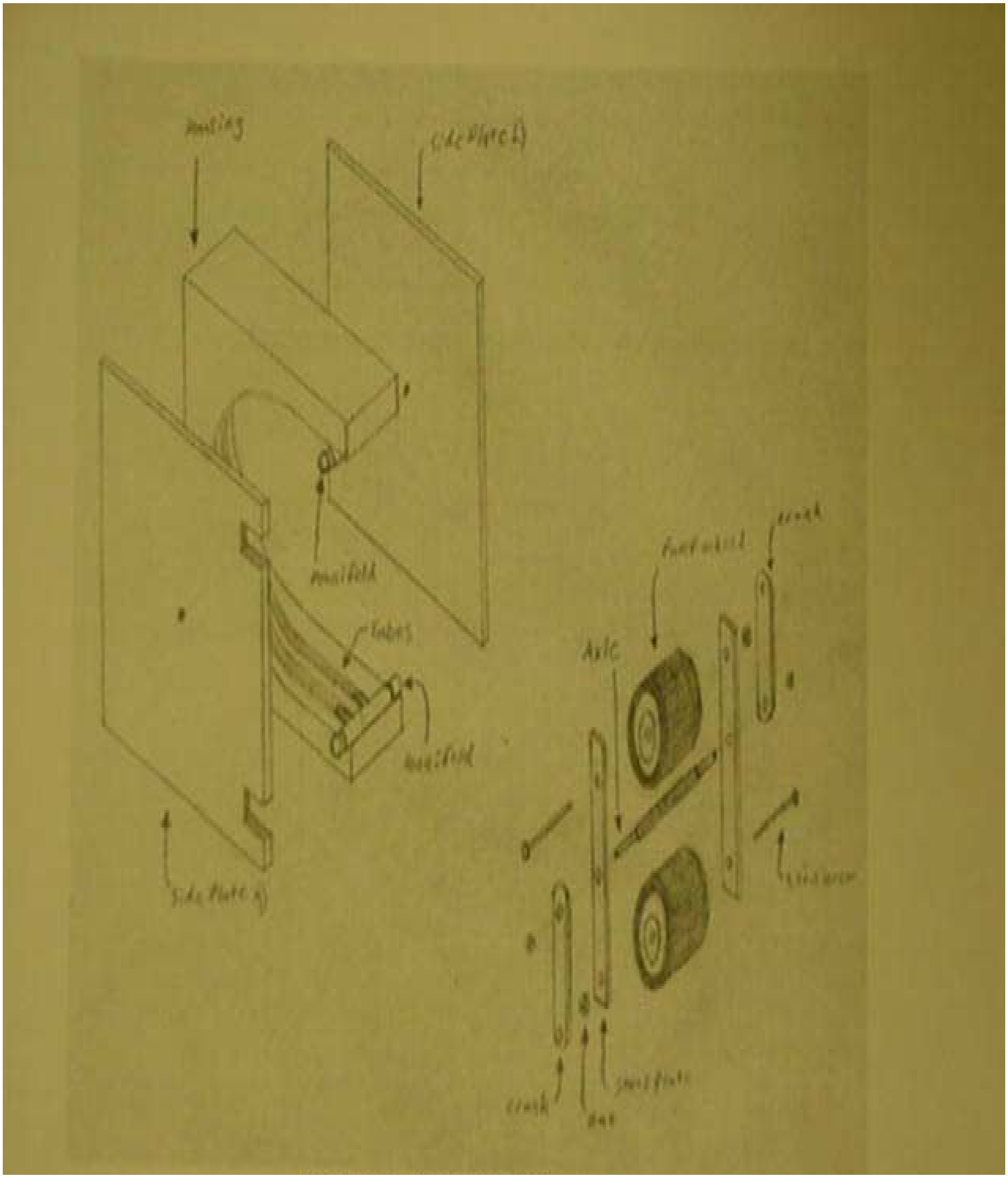
We maintained our schedule throughout the project and met every deadline (see Appendix I). Meetings were held every week where the responsibilities were given. The manufacturing process took place during the weekend and lasted two weeks. The final weeks were spent preparing for testing and the reports. The communication at Caltex was good but could have been better if we had everyone's phone numbers besides the email addresses.

Summary and Recommendations

Caltex Pumps, Inc. met every requirement and exceeded some. Our pump worked well under optimum conditions and we also proved that it would work sufficiently under extreme conditions. Our flow meter was less accurate than hoped, but with some re-engineering we would be able to fix the problem. On the up side, our pump was the most compact design developed. This is due to the nature of peristaltic pumps. It can be fitted to ordinary garden hose and uses any seat provided by the user. With more time Caltex would re-manufacture the housing to tighter specifications to ensure proper sealing of the tube. A more precise flow meter would be designed and the pump wheel housing would be more uniform. The design would be perfect for low flow applications such as plumbing for houses (running water), drinking water, the irrigation of private gardens, etc… Higher flow applications could be serviced with a larger pump diameter and longer tubes.

Appendix A

Exploded view assembly diagram of pump.



Appendix B

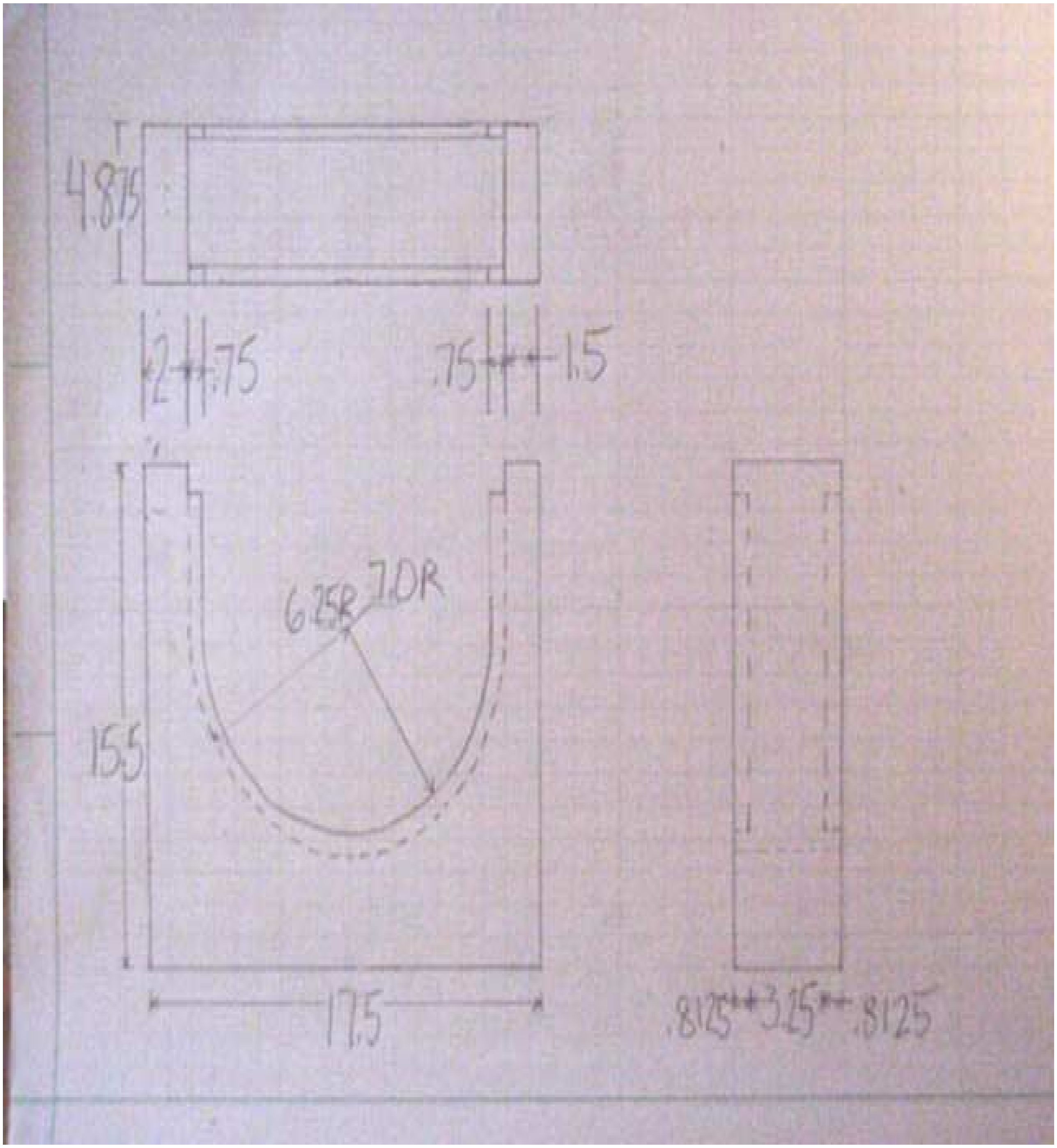
Parts and costs list.

Part No.	Part Descr.	Qty.	Cost ea.	Cost
1	6ft x 19in plywood board	1	$5.33	5.33
2	6in x 1.5in rubber wheel	4	$5.02	20.08
3	12in x 0.75in all thread rod	1	$3.27	3.27
4	0.75in galvanized nut	4	$0.62	2.48
5	0.625in lockwaher	4	$0.29	1.16
6	PVC glue	1	$3.20	3.20
7	3ft x 2in x 0.25in flat steel	1	$7.19	7.19
8	10ft x 0.5in PVC pipe	1	$0.98	0.98
9	0.5in PVC 90 degree pipe	4	$0.43	1.72
10	6in x 0.5in PVC flex riser	2	$0.48	0.96
11	0.5in PVC plug	2	$0.48	0.96
12	0.5in PVC fitting	2	$1.29	2.58
13	crank arm set	1	$9.27	9.27
14	20in x 17in x 0.5in PVC board	2	$9.59	19.18
15	5ft 0.75in ID pliable tube	1	$13.77	13.77
16	4.5in x 0.75in steel threaded bolt	2	$0.94	1.88
17	Misc screws, nuts, tape	1	$5.56	5.56
			Total	99.57

parts list and cost

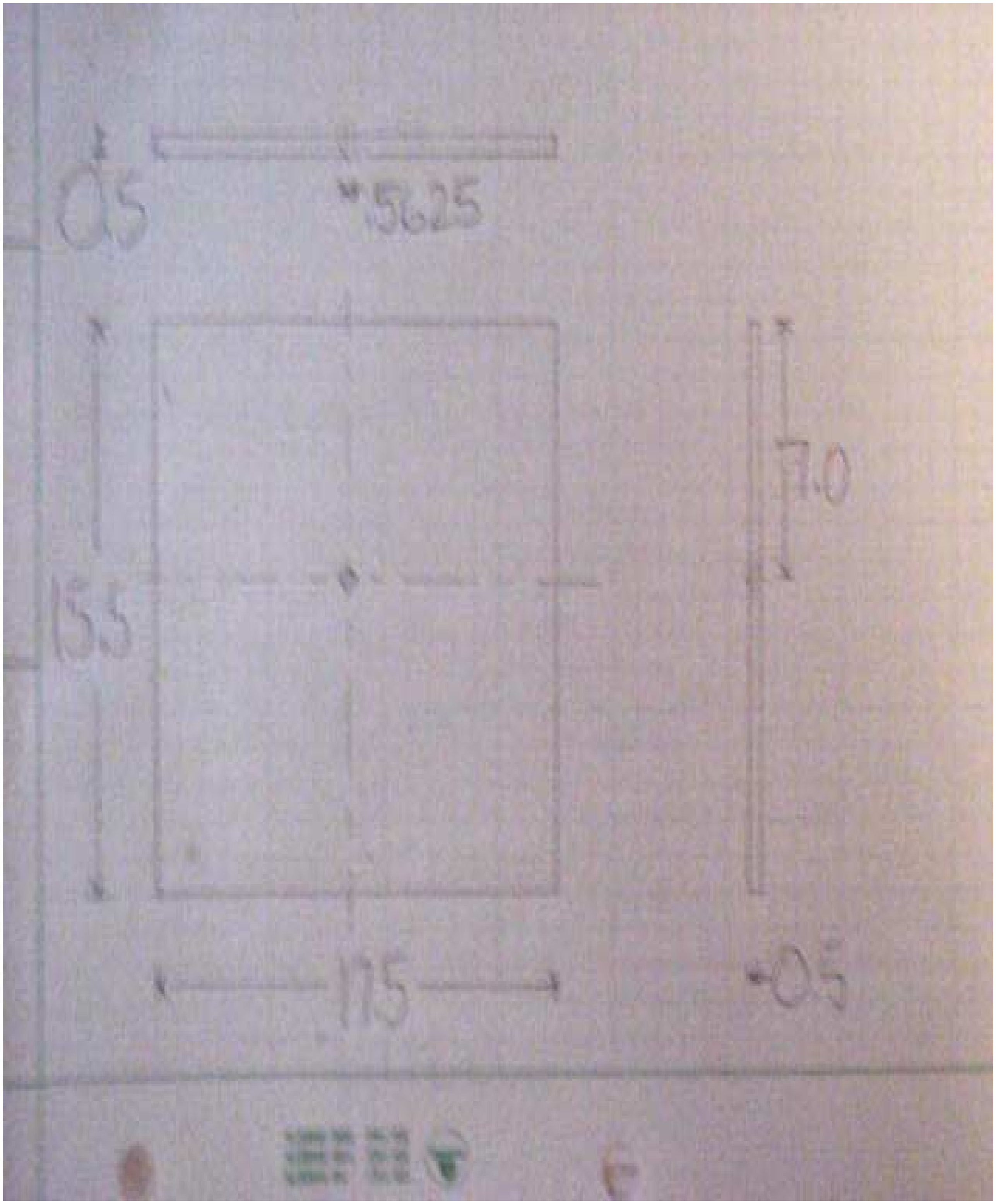
Appendix C

Pump housing three-view.



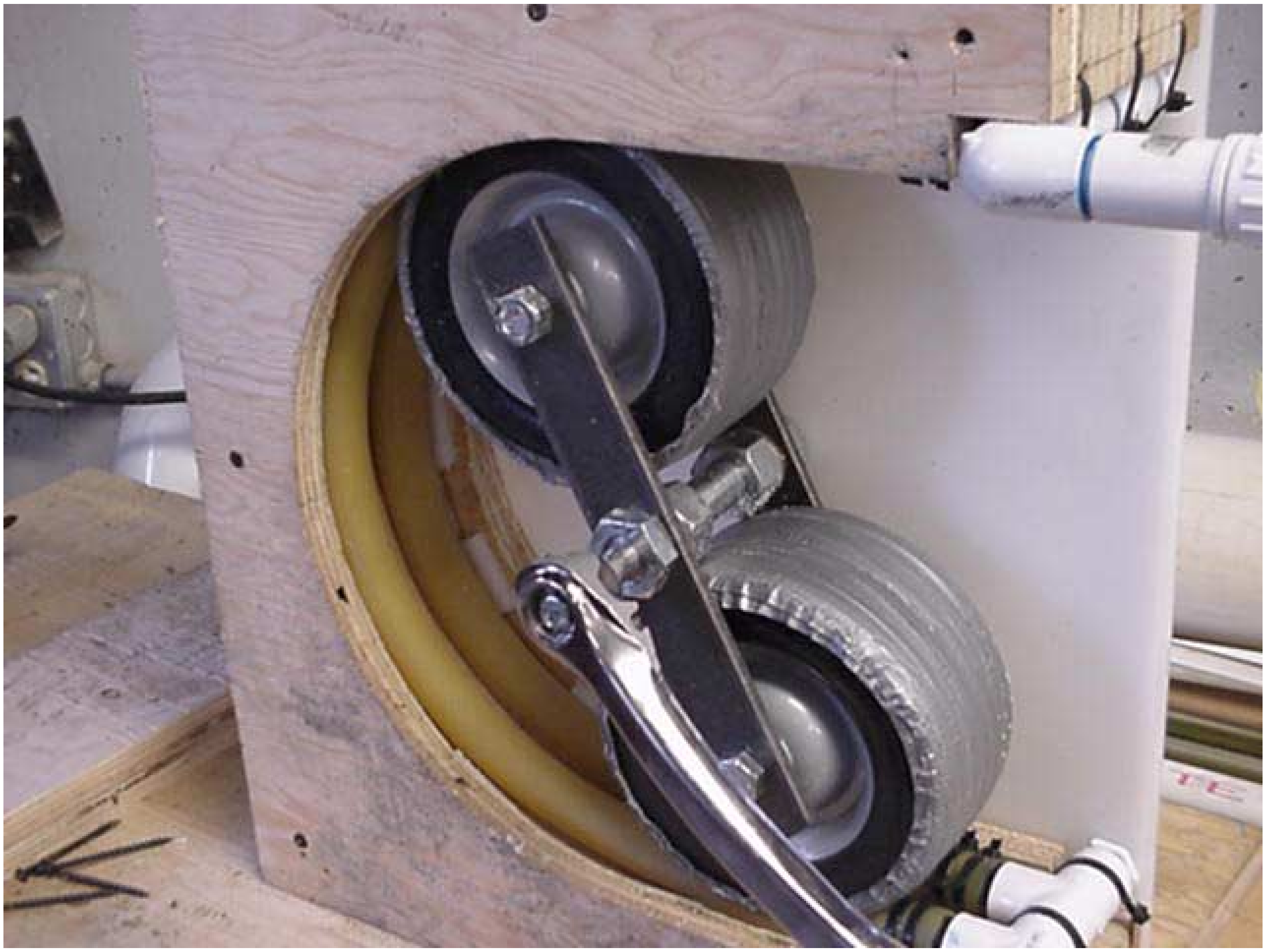
Appendix D

PVC side-board three-view



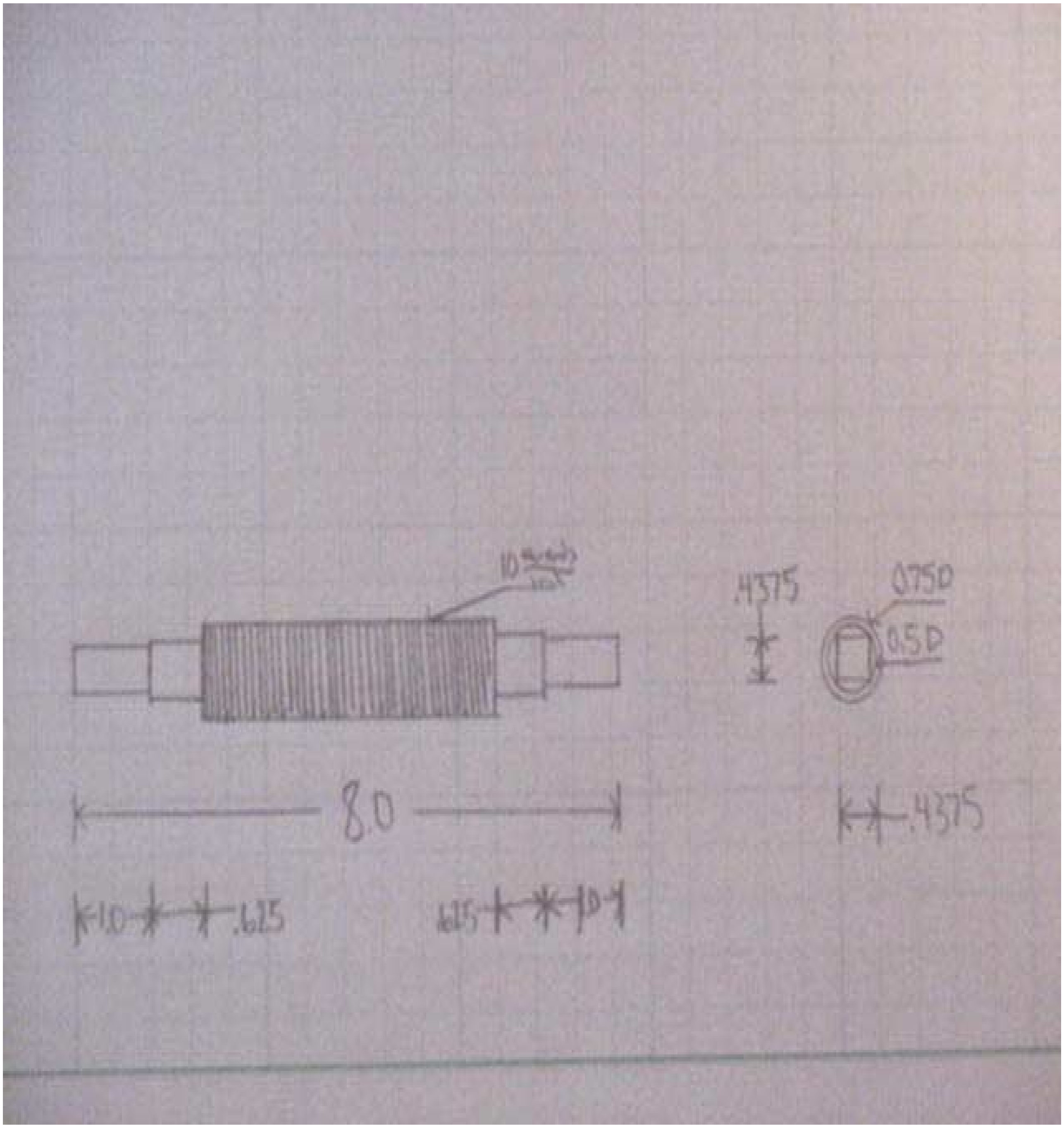
Appendix E

Picture of pump wheel



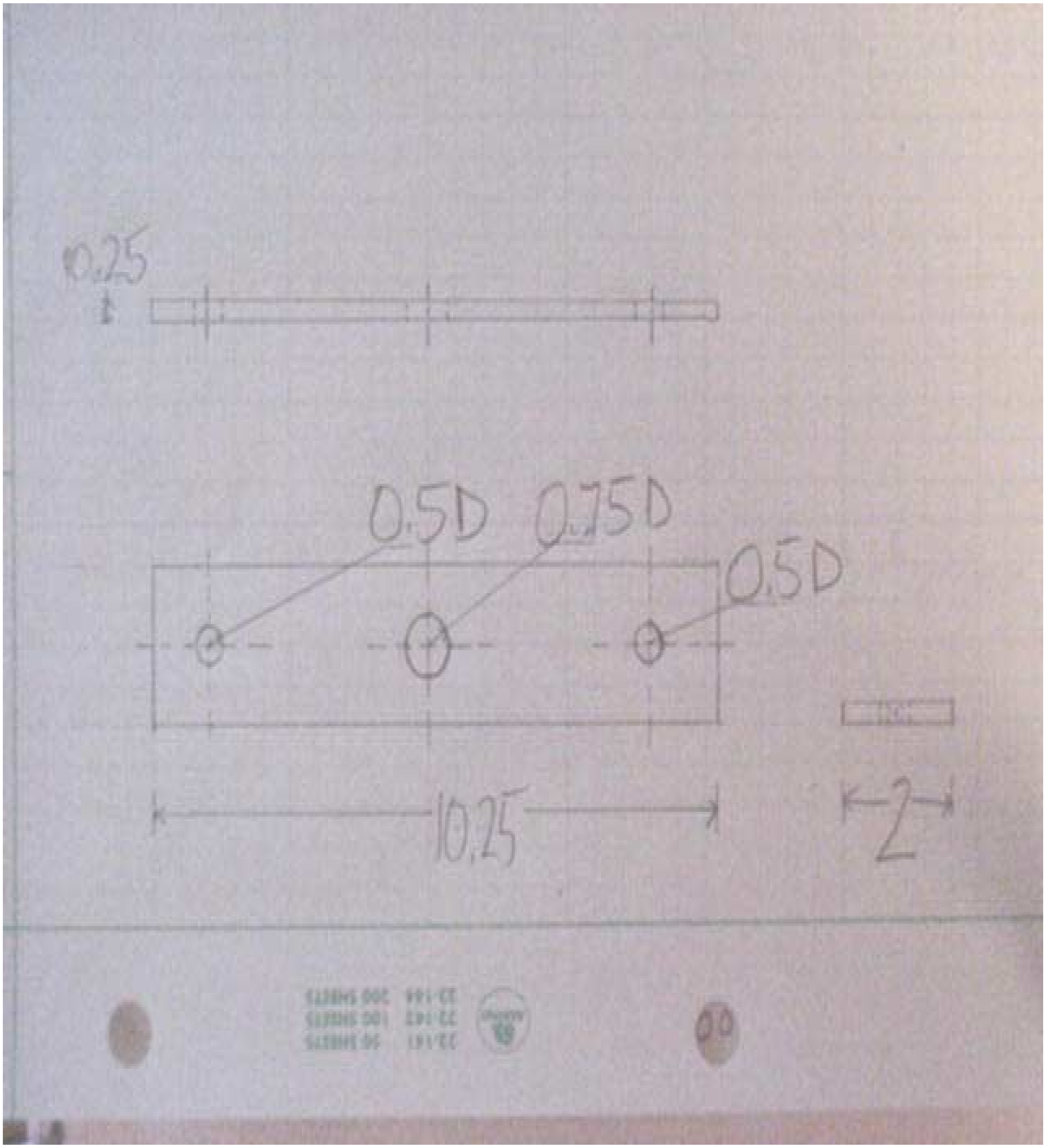
Appendix F

Main Axle three-view



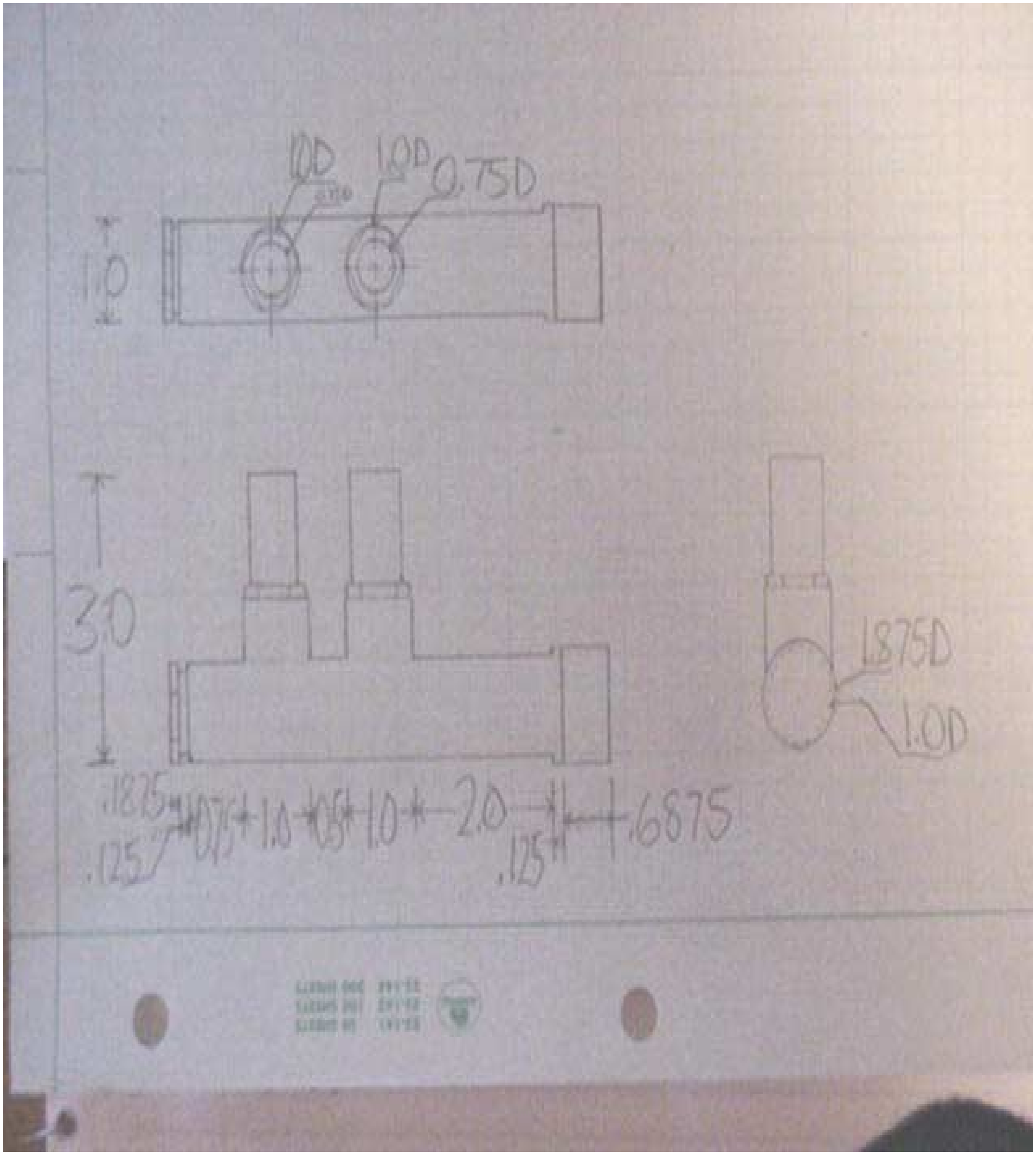
Appendix G

Steel plate three-view



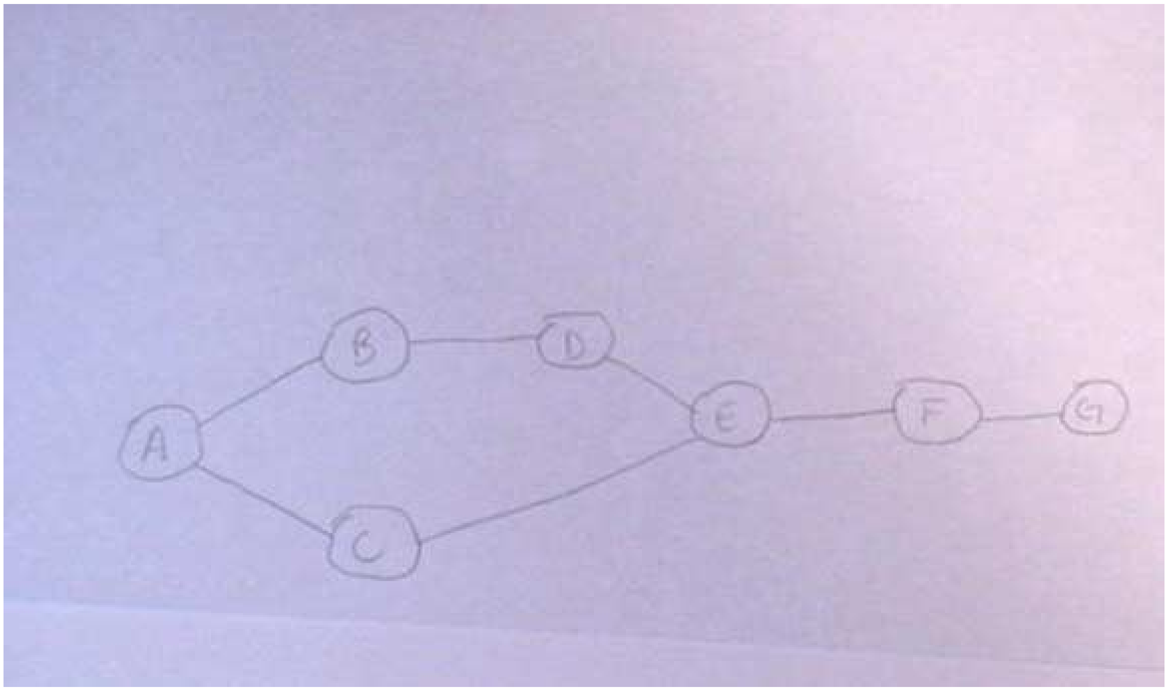
Appendix H

Inlet/Outlet manifold three-view



Appendix I

CPM chart



A. Design 4 weeks
B. Concept design paper 2 weeks
C. Prototype Manufacture 4 weeks
D. Testing and Analysis 2 weeks
E. Prototype presentation and report 2 weeks
F. Testing 2 weeks
G. Final presentation and report 3 weeks