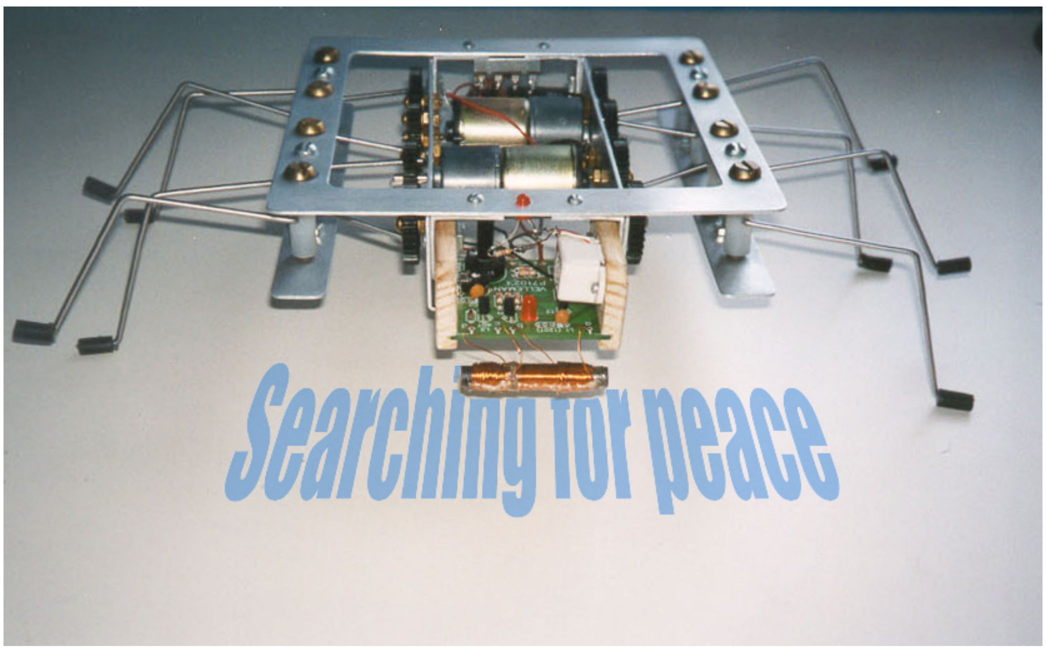
PHILIP BAPTISTA PERSONAL PROJECT

Octoped



MENTOR: LEON LLEWELLYN APRIL 2ND 2002

Octoped:
Searching for Peace

Personal Project
presented to:
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Introduction

Since novels like H.G. Wells' The War of the Worlds where Martians used walking robots to invade Earth, human imagination has soared with the idea of fictional robots. Many authors, writers and directors have experimented with the idea of intelligent machines and their uses. The word robot was "first used in the 1921 play R.U.R. (Rossum's Universal Robots) by the Czech novelist and playwright Karel Capek. The word robot has been used since to refer to a machine that performs work to assist people or work that humans find difficult or undesirable." (*"Robots,"* *Encarta Reference Suite 2001*) This is exactly what my robot does. It performs a dangerous task which is undesirable for humans.

One of these dangerous tasks can be minesweeping. Since as early as the American Civil War, underground explosions have been used in warfare. But, the landmine like we know today has only been employed since World War II where it was extensively used by the Germans. Since then, almost all major conflicts have involved the use of antipersonnel mines transforming 74 countries like Bosnia and Herzegovina, Korea, Cambodia, Afghanistan, Iraq, Angola, and Egypt into presently dangerous minefields killing or maiming 26 000 people every year. Today, we inherit the horrible situation in which more than 100 million landmines are left to be removed[1]. This happened because of the landmine's killing effectiveness for such a low cost (3 to 10 dollars) and their cost to be removed (300 to 3000 dollars). In an effort to return peace to mine infested countries; many of which are no longer at war, Canada and other nations are dedicating funds to research and landmine removal. This is very important *Community Service*, because these soldiers that are removing mines in war devastated countries are greatly helping the community by allowing it to grow without threat from mines. These mines are a serious threat to the health (*Health and Social Education*) of these people. Not only do they kill, but they maim leaving a society with the burden of a handicapped population. These people deserve a safe *Environment* where they can live without the fear of death. Also, mine swept fields can be used for agriculture which is in dire need in many of these countries.

[1] Refer to figure 2.1 (Appendix II) for a world map of countries affected by landmines

After reading about landmines, inspiration for this project was easy. Because of my interest for robotics, I decided to build a robot that would be able to detect mines. What is better suited for a dangerous, meticulous and repetitive task like minesweeping than a robot?

My goal for this project was to produce a prototype of an autonomous mine-detecting robot. It would have to posses the following qualities:

- ability to detect mines through a sensor
- ability to move on rough terrain (grass, gravel, dirt)
- have onboard power
- give an audible and visual warning when a mine is detected
- lighter than 5 kg so that it doesn’t set off mines
- should be small, compact, sturdy and resistant

My objective for this project is to build a robot while keeping in mind the Areas of Interaction. Without them, my robot would not have a use. I will relate my creation to all the Areas since my research on robotics demonstrated that my robot includes them all.

Octoped: The Minesweeping Robot

Description[1]

Table 1: List of Octoped's specifications

OCTOPED'S SPECIFICATIONS		
Size (W x H x D)	**without legs**	18 cm x 4 cm x 23 cm
	with legs	38 cm x 8 cm x 23 cm
Weight		750 grams
Power Source		9 VDC battery
Number of legs		8 legs
Forward speed		2 metres per minute
Time for all legs to complete 1 step		2.75 seconds
Step height (maximum obstacle height)		3 cm
Slope limitation		20°

What it does

Octoped's only purpose is to seek out the location of mines. The reason mine removal is necessary is because of its effects on humans. A landmine covered *Environment* is a hazard for humans, this is why they must modify and improve their environment through the use of a minesweeping robot so this environment can be used by humans again.

Octoped has a very simple operation with three different modes in which it can be set into; forward motion with the metal detector on, reverse motion with the metal detector off, and completely off.

When set in forward motion, the robot will walk forward in a straight line. It will automatically walk over small obstacles easily because it uses legs and not wheels. Once the metal detector passes over enough iron content, it will trigger causing a flashing light and a buzzer to activate as well as the motors[2] to stop. The robot will then only continue if either the mine is removed, if it's switched into reverse or moved away from the mine.

[1] Refer to figure 3.1 (Appendix III) for a photograph of Octoped

[2] Refer to figure 3.9 (Appendix III) for a photograph of a motor

How it works

Mechanics

The key to the walking motion of this robot is the fixed point; another of man's inventions (*Homo Faber*) which originated from the wheel. What basically happens is a leg placed through a fix point and into a gear rotates in a rowing motion as the gear spins[1]. The rowing motion pushes the robot forward. The second important concept is the linking of the legs. Each leg has its own large gear which is interconnected to the other large gears with small gears[2]. This means that the powered gear spins the other three legs in the same direction. Each leg is placed in the hole 180° opposite to the legs next to it. This ensures that there are always at least two legs touching the ground at all times on both sides, avoiding tipping.

Electronics[3]

Electronics are one of the most recent and fastest evolving creations of *Homo Faber*. Without electronics, this robot would never have been possible since it is the core of the robot's control. For Octoped, the electronics revolve around the robot's only sensor; the metal detector[4]. Simply said, when away from metal the two coils of the detector are in balance and the light is off. But, when metal is brought near the coils, the balance is disrupted because of the magnetic field produced by the metal. This triggers the detector, lighting the light.

The metal detector also sends current to the relay switch[5] which activates. When activated, the switch cuts power to the motors, shutting them off, and opens current flow to the flashing light and buzzer turning them on. When the metal is removed, the robot continues walking and the flashing light and buzzer are turned off.

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[1] Refer to figure 2.2 (Appendix II) for a drawing of the fixed-point concept

[2] Refer to figure 2.3 (Appendix II) for a drawing of seven interconnect gears (one side), to figure 3.6 (Appendix III) for a photograph of the interconnected gears and to figure 3.8 (Appendix III) for a photograph of a big and a small gear

[3] Refer to figure 2.4 (Appendix II) for the schematic of the entire electronic component of the robot

[4] Refer to figure 3.10 (Appendix III) for a photograph of the metal detector

[5] Refer to figure 3.2 (Appendix III) for a photograph of the relay switch (black square between bottom motor and battery)

Materials Used

Because weight is an important consideration in this type of project, the materials used had to be light. The main body of the robot[1] is made of rigid aluminium which provides a good strength weight ratio. As for the fixed points, I used plastic tubing which is light and flexible. The legs are made from coat hangers which also provide enough strength to hold up the robot. The metal detector holder had to be made of a non-metallic element (I used wood) as not to disrupt the detector. All these materials are found in our *Environment* except for plastic which is a transformed material. This is an example of man's genius to modify his environment to extract the materials he needs.

Design and Construction

Initial Decisions

Before I could begin even designing the robot, I had to make a few very important decisions.

Walking

The first decision was legs or wheels. I opted for legs because in our *Environment*, we notice that no insect or animal uses wheels to move. Even though more complex; legs provide much better mobility on irregular terrain. Because of this, Octoped's design is directly inspired from nature as it looks and walks very similarly to a spider.

I chose a simple walking system for my robot. It only requires two motors to power eight legs. It was the most effective way I was able to find. This walking method was great because it provided a stable and smooth walking motion even over uneven terrain.

Energy Source

There are basically three options for the power source; power, battery power, or AC power. The following is a table comparing these possibilities.

[1] Refer to figure 3.7 (Appendix III) for a photograph of the dismounted aluminium body

Table 2: Comparison of the possible power sources

POSSIBLE POWER SOURCES			
Factors	**AC Power**	**Solar Power**	**Battery Power**
Range	Limited to length of wire which may also hinder movement	Unlimited as long as there is enough light	Limited to battery life which is considerably long
Power	Very powerful	Weak, inconsistent power output	Average power
Simplicity	Very simple, only requires an adaptor	Complex because of solar engine construction	Very simple

Because mobility is very important, AC power was eliminated right away. This left battery and solar power. Because of the motors the robot uses, the solar panels would have to be very large and the power is inconsistent, which is useless for the metal detector. Battery power was the only possibility.

Sensor

A sensor is necessary because it allows Octoped to interact with its Environment. As humans, we have five senses through which we can identify our environment (*Health and Social Education*), Octoped will only have one. Deciding which was a simple decision. The only affordable means of detecting mines is a metal detector. Other methods such as a penetrating radar, thermal imaging or artificial noses are too expensive and unfeasible for this project.

Intelligence Level

I decided to simplify its intelligence by not including a microprocessor and making its only intelligence the metal detector, which proved to be more than enough after preliminary tests[1].

Design

Much of my time was dedicated to the design. All the possible problems had to be eliminated before construction because they would be too difficult to fix once everything was started.

[1] Refer to Appendix I 3rd par. for information on the possibilities of a microprocessor

Most of the planning was done in my room because it is a quite *Environment* where I could think about solutions to design problems. I used Lego, paper models, my prototype model and a computer drawing program to make the design. While carefully considering every piece and its size, I drew up a first 2D plan in Adobe Photoshop. I then tested it, made the necessary modifications and the final plans for the body were complete[1].

The planning for the electronics was simpler since the circuit is not very complicated. The hardest part was choosing the right way to invert the polarity of the motors. Once design was finished (a very important process of *Homo Faber*'s creation process) I could start the construction.

Construction

This proved to be much easier than I initially believed thanks to meticulous planning and the use of proper tools. I used my garage for the actual building of the robot. There, I had access to all the power tools (table saw, vertical drill[2], spinning stone, soldering iron[3], etc.) and the space I needed to make my robot. Using the printed plans, I traced the body onto my sheet of aluminium. Then with a table saw and a metal file, I made all the cuts and sanding necessary. I made all the holes using a vertical drill. Once the body was made, it was almost like building a Lego spider. All I had to do was screw the four aluminium parts together, install the motors, screw in the gears, bend the legs into shape and install them into the fix points in the right positions. The mechanics were virtually complete. The next stage was the electronics. This required the wiring and soldering of the three-way switch, the building of the metal detector from the kit, the wiring of the relay switch and the flashing light and buzzer.

Difficulties and Improvements

During the first test walk, the legs would trip over each other not allowing the robot to walk one centimetre. I was forced to shorten them, and redesign their shape so that they would rotate freely.

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[1] Refer to figure 2.5 and 2.6 (Appendix II) for full sized plans of the body

[2] Refer to figure 3.12 (Appendix III) for a photograph of the vertical drilling holes in the aluminium

[3] Refer to figure 3.11 (Appendix III) for a photograph of the soldering iron being used to solder the metal detector

As for the electronics, the metal detector had its share of problems. I had trouble winding the coils[1], I accidentally inverted the battery's polarity and I did not strip the coil's connections. Once the detector was working, the relay switch which turns off the engines began to cause problems because it required too much current which the detector did not supply. After experimenting with a capacitor, I was forced to give up and change the relay switch.

After a few test walks, I realised I had to improve the gears' axles. I had originally installed the gears using sharp tipped screws with no bolts. But, they proved to be too shaky and would unscrew too easily. So I replaced them with flat tip screws and added bolts. This greatly reduced friction and improved the speed and performance of the robot.

Another improvement, suggested to my by Mr. Llewellyn dealt with the buzzer. At first, I had the buzzer wired in parallel to the relay switch, where it did not have enough power to buzz loudly. So, I rewired it in such a way so that it draws current directly from the battery allowing a much louder buzz. I also added a flashing light which provides a visual warning.

[1] Refer to figure 3.10 (Appendix III) for a photograph of the coils (top of green PCB board)

Conclusion

Octoped is a prototype that can probably be modified for actual mine detection, meaning I attained my goal accomplishing all the requirements. I am quite satisfied with the final product considering this is only the second robot that I've ever built. Yet, the entire process was more difficult than I had initially prepared for. I am very happy I spent many hours making the design, because now more than ever I realise its importance. This project also allowed me to learn quite a bit more about robotics and especially electronics than I knew before. I learned how a metal detector works, how to use a relay switch and properly invert a motor's direction. I also gained a lot of experience with soldering and robotics that will always be useful to me in the future. These are essential skills that I can use when I work with electronics, for example repairing something or a future project. It was a great learning experience that proved to be very successful in the end.

I was also able to accomplish my objective to relate my project to all the Areas of Interaction. I had many relations to *Environment* because of the nature of my robot. Its goal is to interact with its environment in such a way as to make it liveable place. This is where *Community Service* comes in because Octoped is a solution to helping these communities grow without fear of death. Of course, less deaths and injuries mean a healthier community which is no longer maimed by mines, that is how *Health and Social Education* plays a part. Also, since I created Octoped using many tools and concepts also created by man, this is a perfect example of one of *Homo Faber*'s creations. And of course, this creation would not have been possible without materials provided by nature or even needed if humans did not have the necessity to improve their *Environment*. Not only does this project relate to all the Areas, but it also links them all together bringing them full circle from *Environment*, to *Community Service*, to *Health and Social Education*, to *Homo Faber* and back again to *Environment*.

Even if Octoped is a prototype, it is definitely the path future landmine detectors will take to increase efficiency, decrease danger to humans and maybe one day, find peace.

Bibliography

Baptista, Paul. Electronic Engineer. Ericsson. Personal Interview. 16 Dec. 2001

Bekey, George A. "Robot." Microsoft Encarta Reference Suite 2001.

Black, Jeremy. Cambridge Illustrated Atlas of Warfare. University Press, 1996.

Bolt, Steven. "Pitronics – about robots." The Spider. 27 Nov. 2001 <http://www.xs4all.nl/~sbolt/e-spider.html>

"Building your own metal detector." Simple BFO Metal Detector. <http://home.clara.net/saxons/bfo.htm>.

Burnett, Thane. "The Killing Fields." Toronto Sun. 5 Dec. 1999

Conan the Librarian. "Beam Bestiary." Walkers. 4 Feb. 2002 <http://bestiary.solarbotics.net/>.

"Links for landmine detection. Mines Action Canada Competition. <http://www.doe.carleton.ca/~jknight/LandMines/weplinks.htm>.

Llanso, Steven L. "Mine (warfare)." Microsoft Encarta Reference Suite 2001.

Mertl, Melissa. "An E-Nose for Trouble." Discover Magazine. Sep. 2001.

Appendix I: Personal Comment

At this point, I can safely say that this project was a complete success. I feel very proud that I was able to organize my time and work to accomplish a long-term, complex project. The feeling I felt when I finally put my robot down and watched it crawl across the floor is indescribable. All the hours of work and dedication were quickly forgotten.

As I look back, I could easily see the factors that allowed this project to be successful. I owe most of the success and smooth construction process to meticulous planning. But I also owe much of the avoided problems and solutions to my mentor, Mr. Leon Llewellyn, who constantly suggested improvements and new possibilities. Also, my father, António Baptista, was a great help with the construction process since two hands are never enough.

On a more technical aspect, since my robot is a prototype, there is much room for improvement. The essential functionality is present, but, there are some modifications to be made. First of all, for this robot to be used efficiently as a mine detector, it would have to have some sort of artificial intelligence. At first I had planned to include a microchip that would provide it, but due to cost, lack of time and experience, I left this for a future possibility. With the intelligence upgrade, Octoped would be able to follow a precise map pre-programmed into the microchip. It would be able to virtually mark positions of possible mines which could then be uploaded to a computer. Also, a more potent and practical detector would have to be installed. To increase Octoped's functionality in non-metallic minefields, a second type of sensor would have to be installed.

Appendix II: Schematics and Diagrams

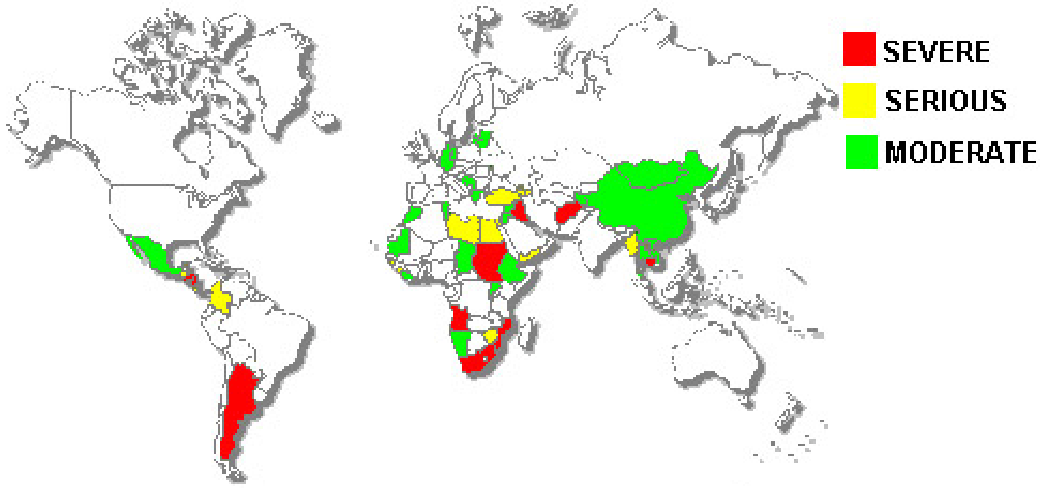

Figure 2.1: Severity of world landmine problem *(from United Nations statistics compiled by Humanitarian De-mining)*

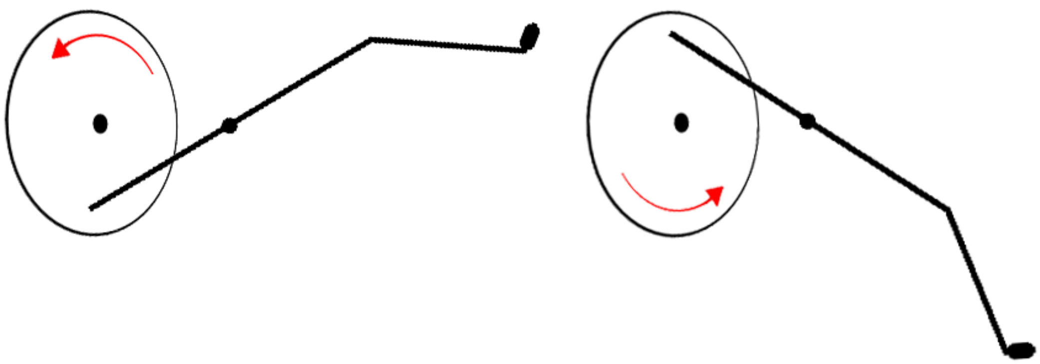

Figure 2.2: Fixed point leg movement
right: leg is at highest point, left: leg is at lowest point and touching the ground

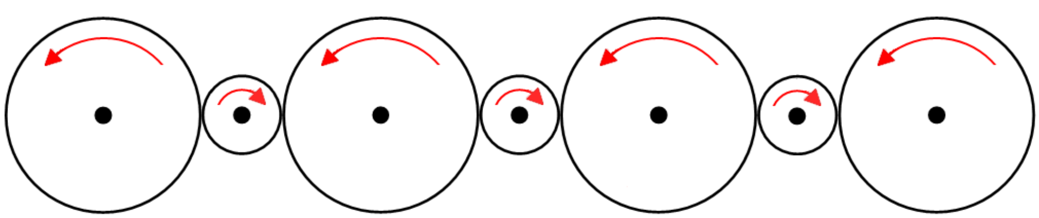

Figure 2.3: Diagram of the robot's gear train with the turning direction of the gears

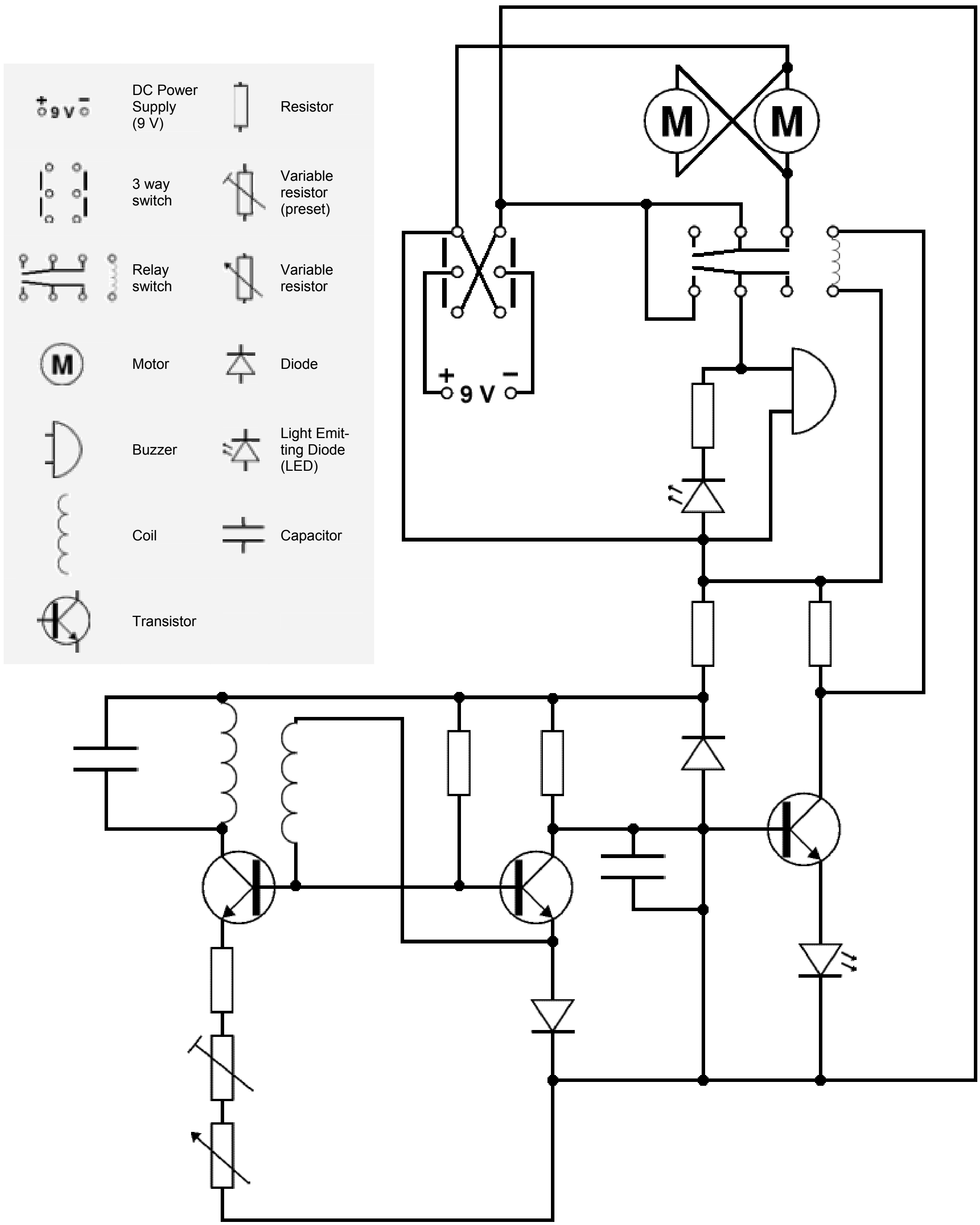

Figure 2.4: Schematic of the entire electronic component of the robot including the metal detector

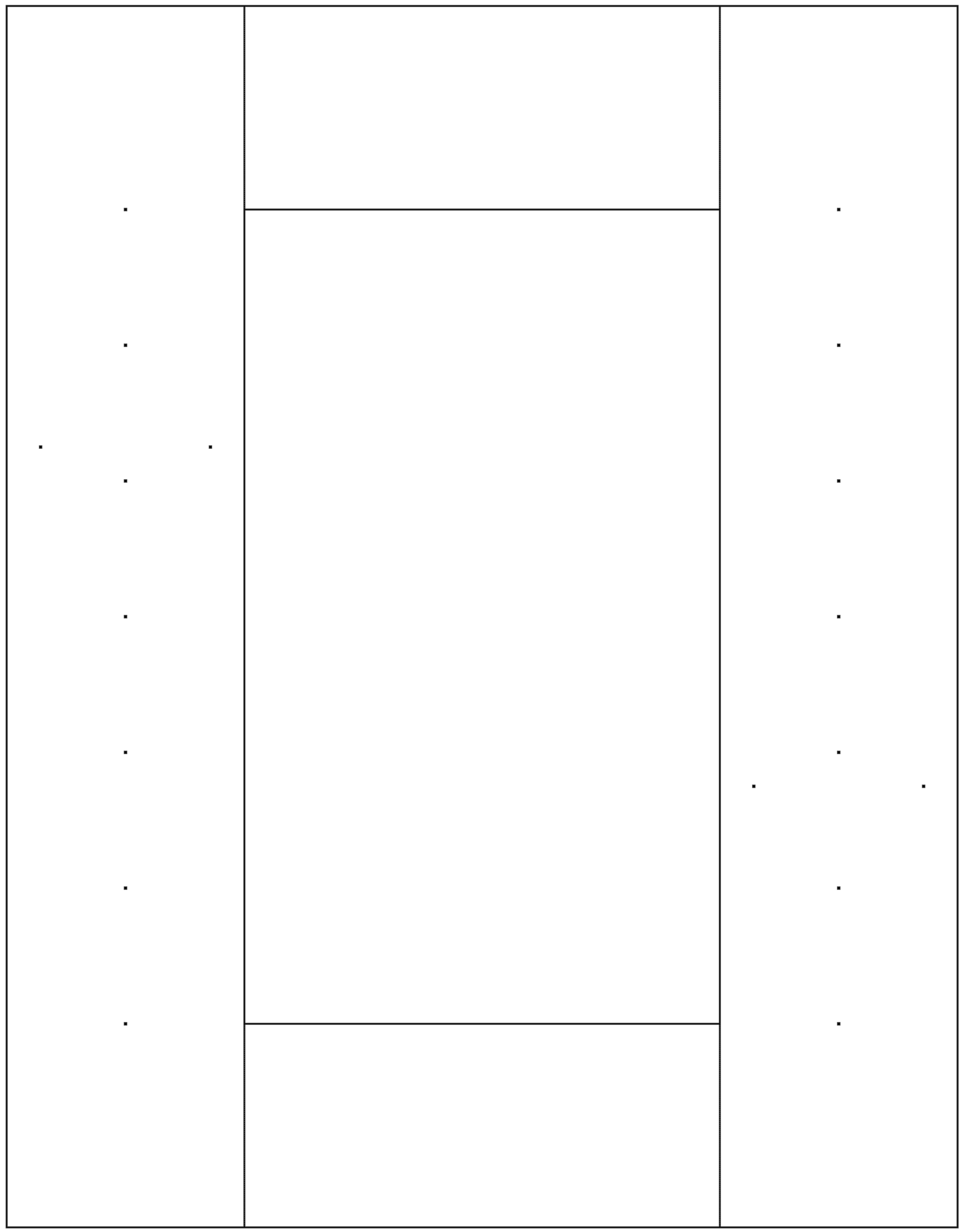

Figure 2.5: Actual size plan of middle body component with drill holes

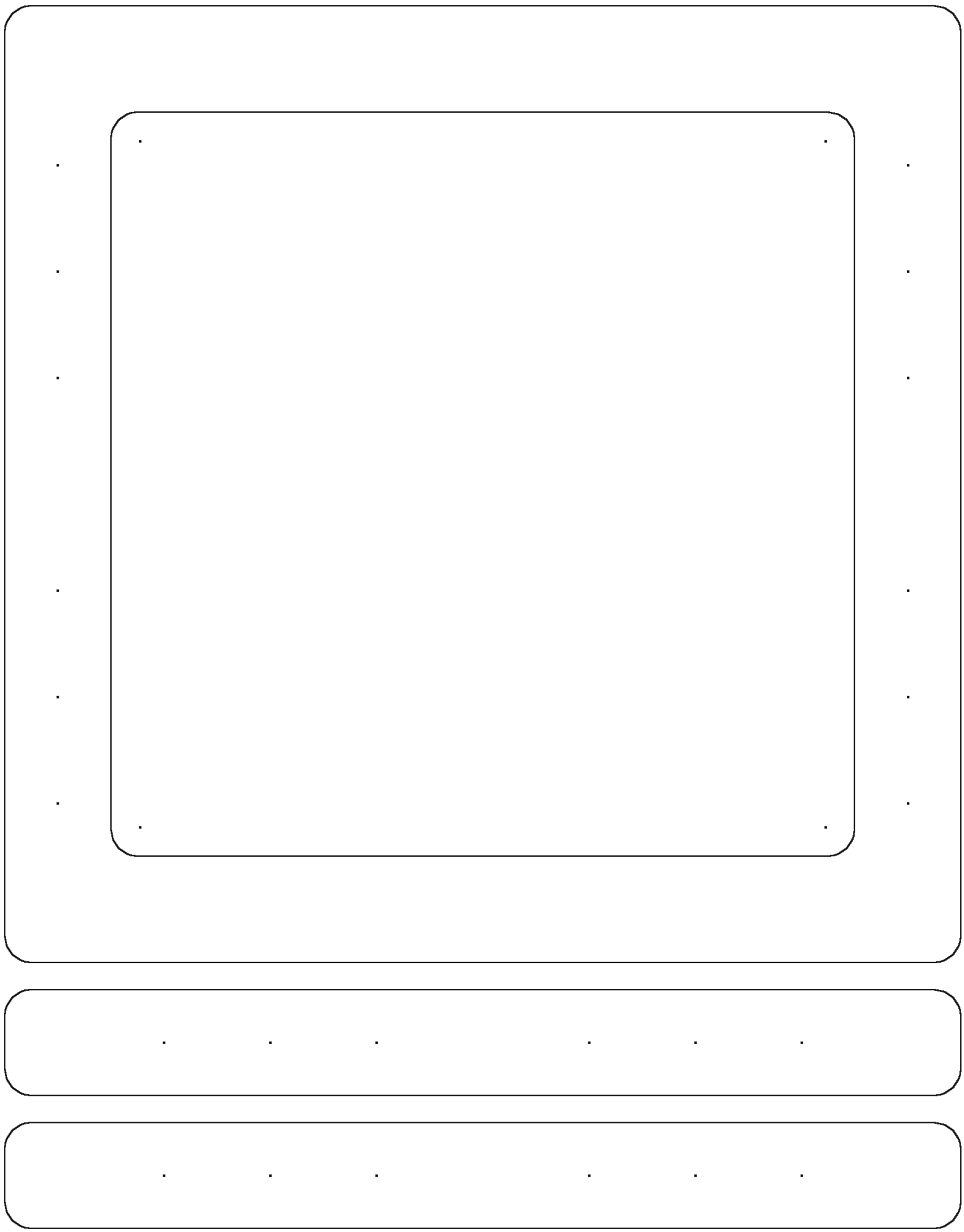

Figure 2.6: Actual size plan of top body component (top) and fixed point holders (bottom) with drill holes

Appendix III: Photographs

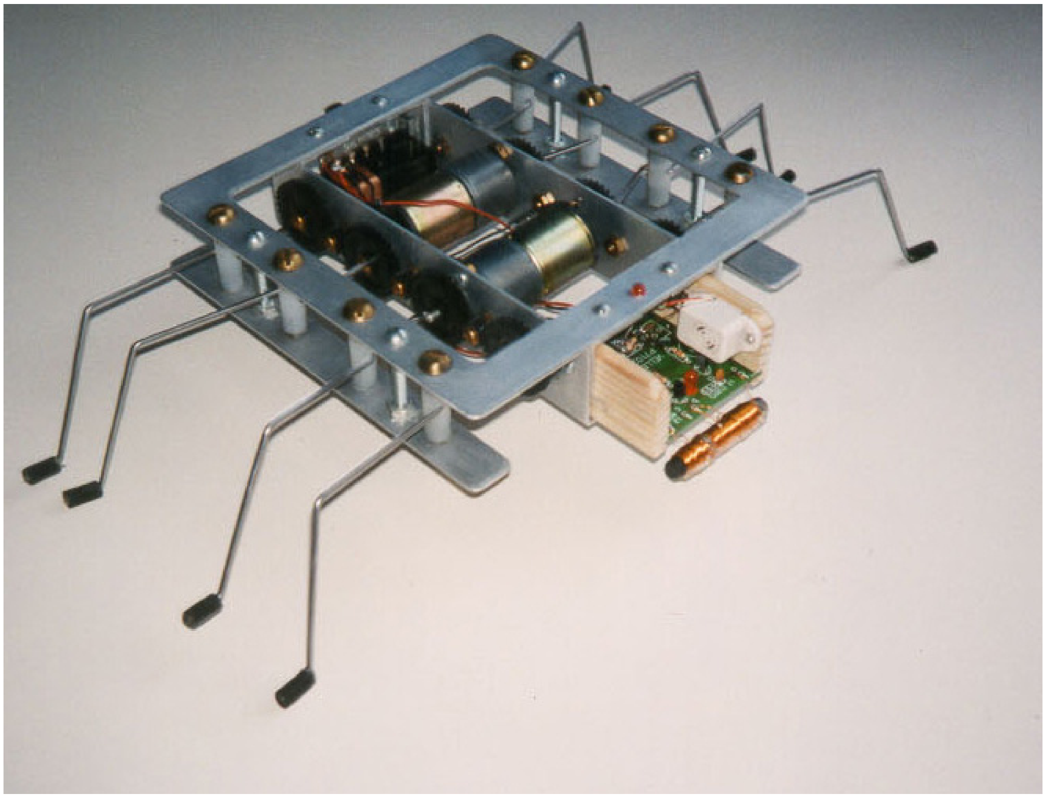

Figure 3.1: Overview shot of the final robot

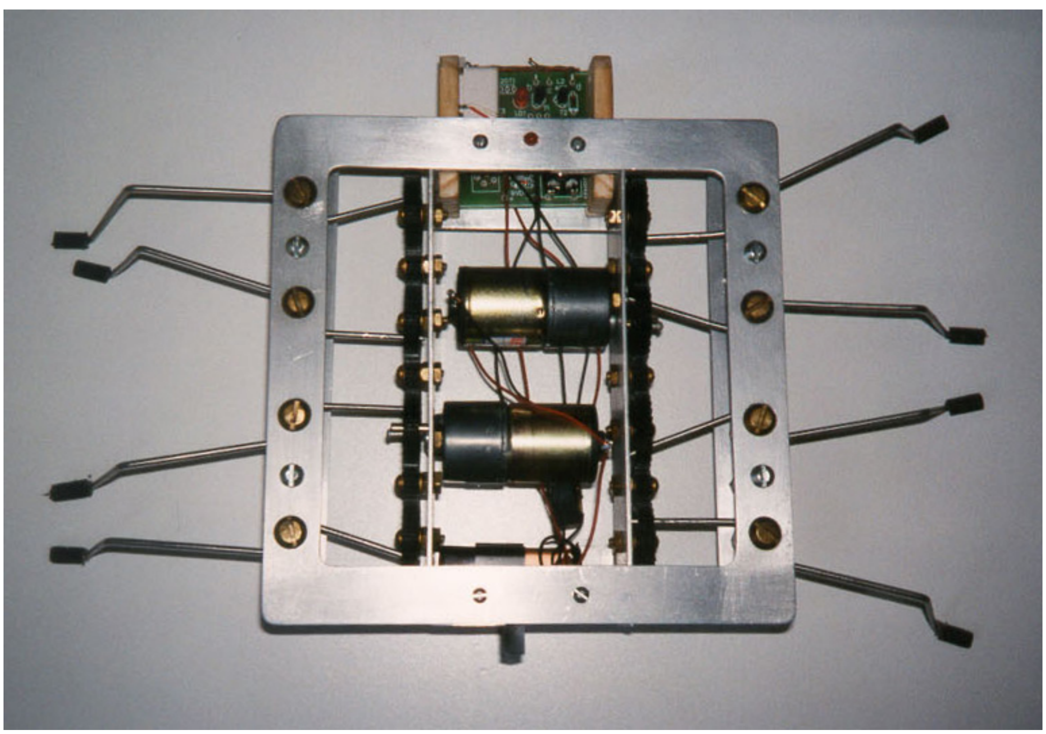

Figure 3.2: Top view

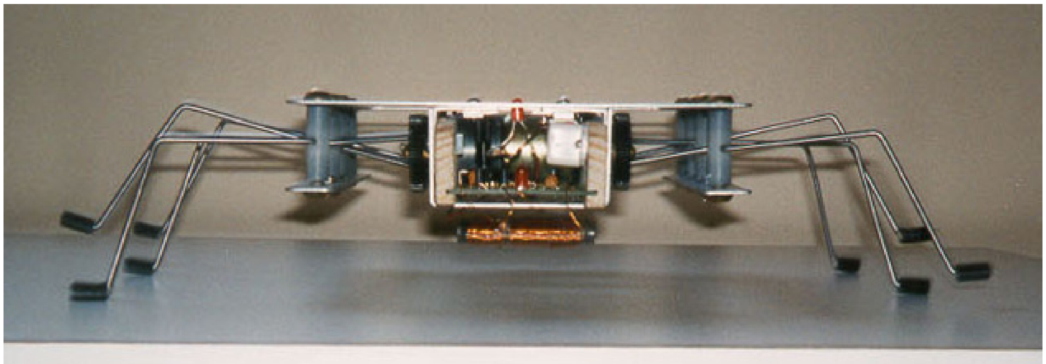

Figure 3.3: Front view

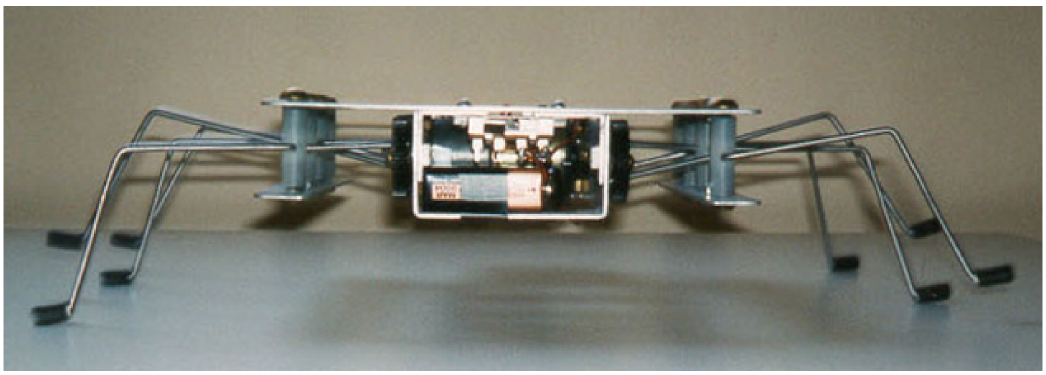

Figure 3.4: Back view

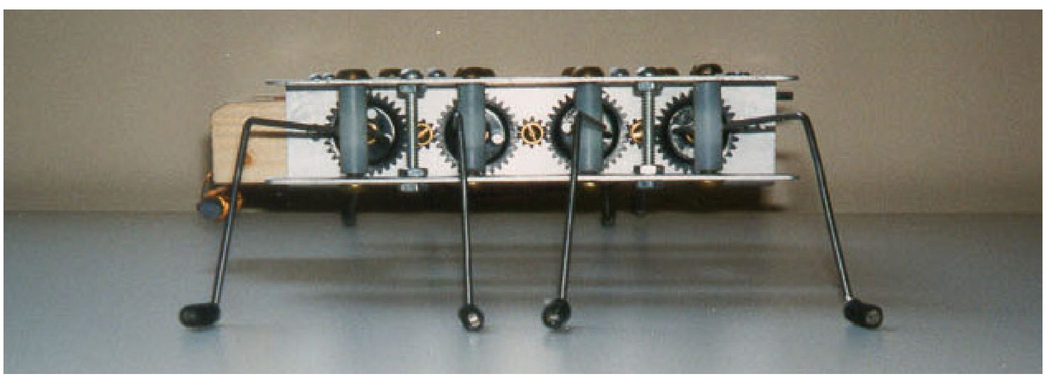

Figure 3.5: Side view

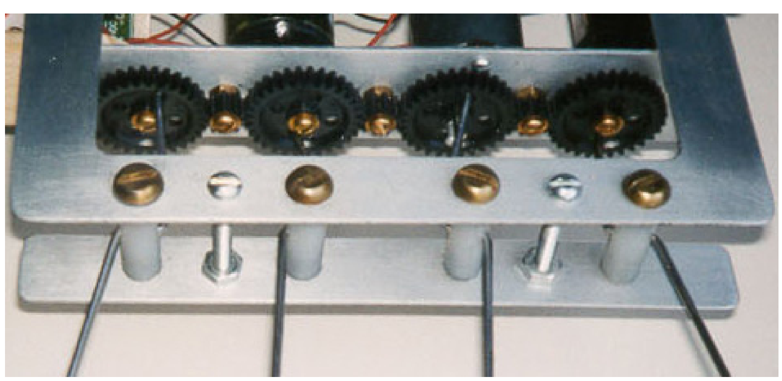

Figure 3.6: Close up view of the gear train and fixed points

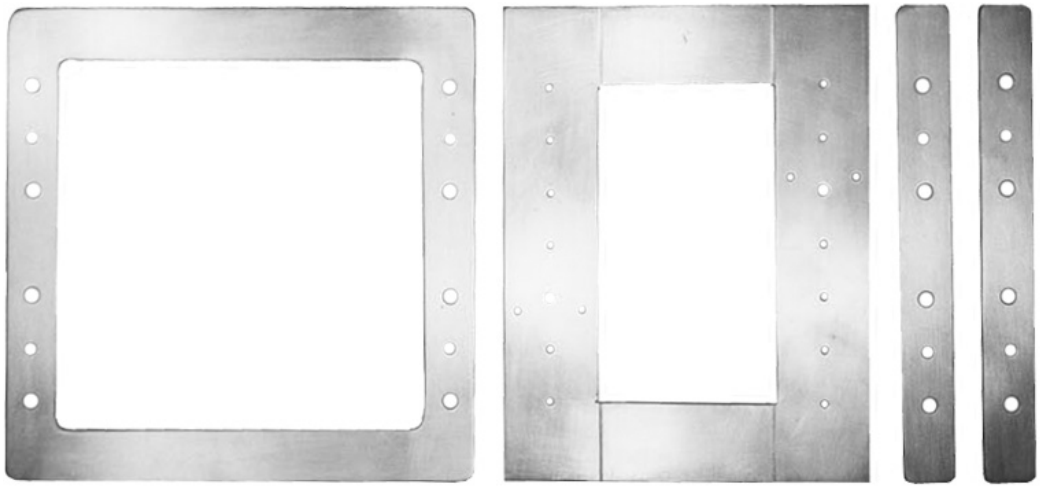

Figure 3.7: Dismounted aluminium body

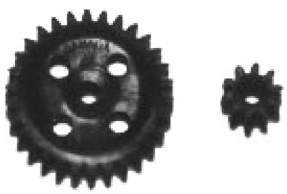

Figure 3.8: Dismounted big and small gear

Figure 3.9: Dismounted motor with gear

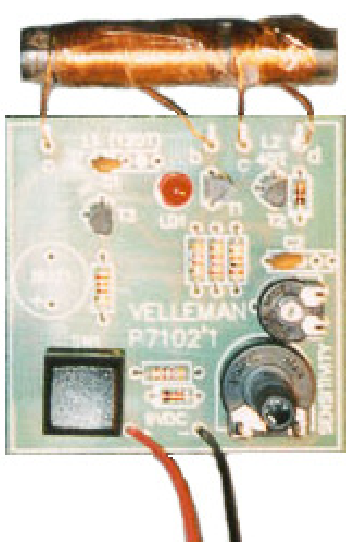

Figure 3.10: Dismounted metal detector *(Note: In this picture the metal detector still has the square black push button switch. It was then removed and its contacts shorted before the metal detector was mounted.)*

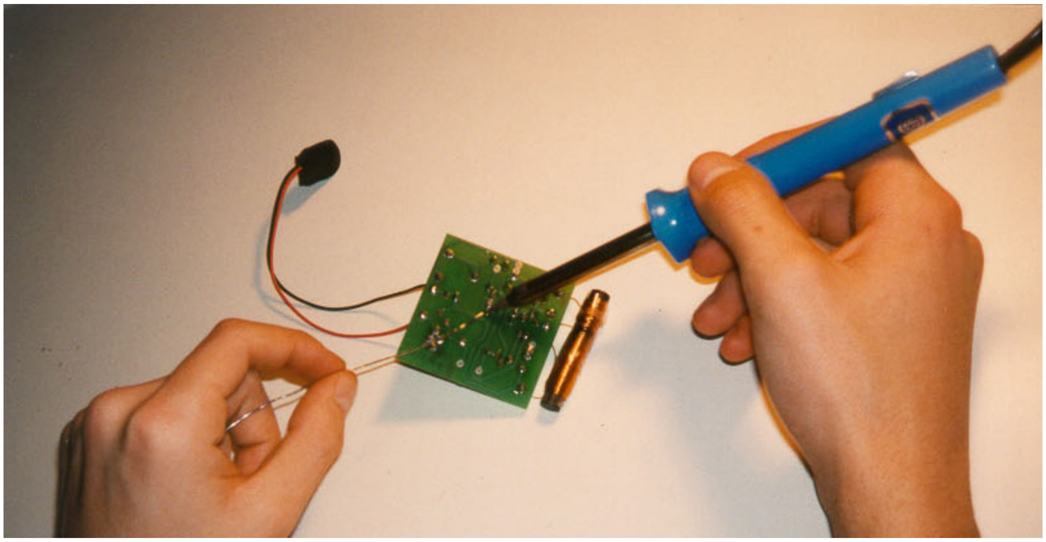

Figure 3.11: Soldering of the metal detectors components using a soldering iron

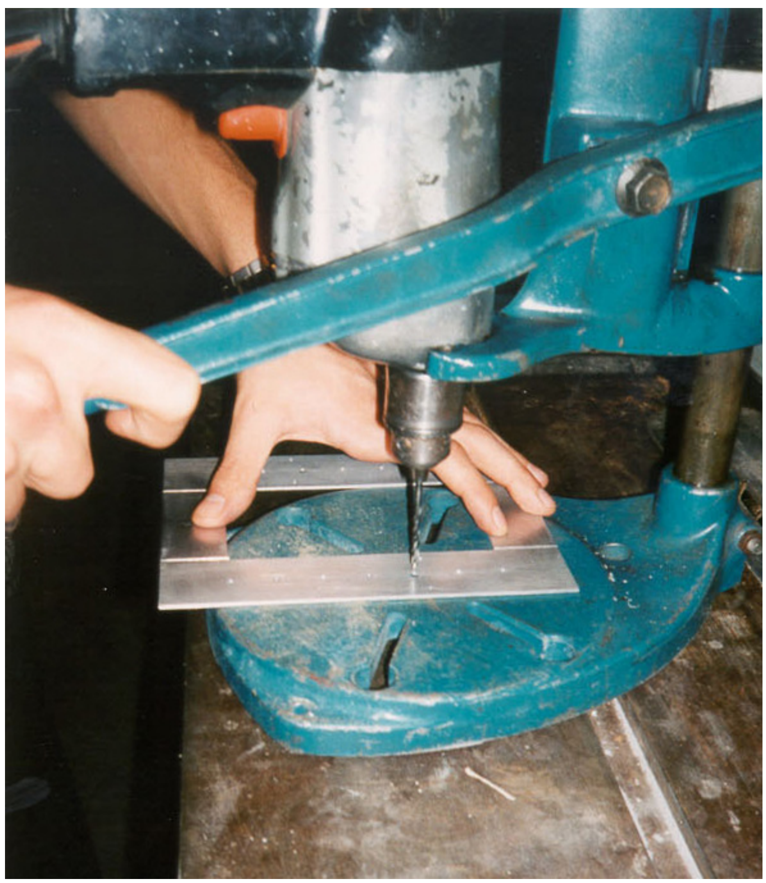

Figure 3.12: Drilling holes into the aluminium body using the vertical drill