THE MECHANISM OF A MECHANICAL AND ELECTRONIC SIREN PROTOTYPE

CINDY HIEW

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CINDY HIEW
HS 2004-3117

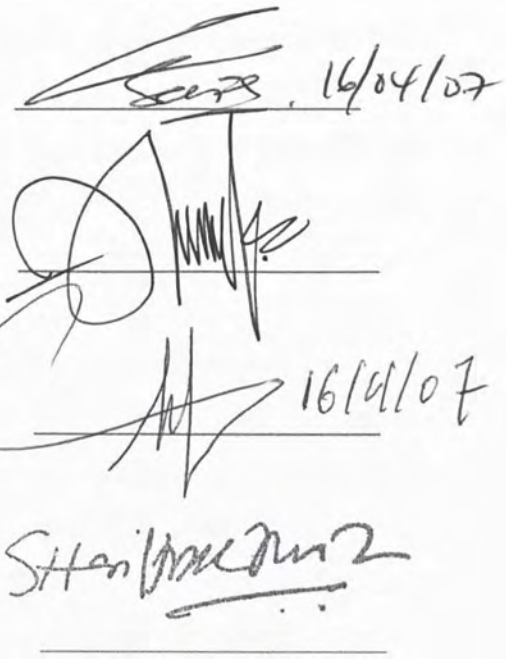
CERTIFIED BY

1) **SUPERVISOR**
   (MISS FAUZIAH SULAIMAN)

2) **EXAMINER 1**
   (MR ALVIE LO SIN VOI)

3) **EXAMINER 2**
   (DR HAIDER F.ABDUL AMIR)

4) **DEAN**
   (SUPT/ KS PROF MADYA DR SHARIFF A.K OMANG)



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Lastly, I thank all of you who are reading this, I hope that by this dissertation, whether it is the style of writing, some part of the ideas or even the format that I am applying, may inspire you to generate your creativity and also to comply with the standards decided by the Science and Technology School.

ABSTRACT

This dissertation is to apply as many basic electrical and electronically knowledge gained during the 3 years study in the Physics with Electronics course into something practical, with primary intention of being educational. The idea is to set up a simple mechanical and also an electronic siren prototype, which is usually available in an ambulance or a police car. Because of the dangers of using real spark plugs and simulating their processes, the prototype will instead be empowered by a 12 volt lead battery and 12 volt, 45 watt direct current (DC) motor. A long, around 5 feet rod steel is welded to support the shafts and small bottles which represent pistons movements in a car engine. This DC motor is taken out from a submerge motor casing available in mechanic shops, which means this motor possibly can power up a motor boat. In real life, the movement of the shafts of a car engine powers up the vehicle and its components inside, including the air conditioner, radio and digital clock. But it seldom heard that a siren can be put into a car. So, in this project, it is the intention mainly focused on the ambulance siren, which is only used during emergency. Simple explanations will only be used about the movement of a mechanical, which is the car engine and what is the process of voltage circulating inside the electronic siren circuit, without involving complicated calculations.

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LIST OF SYMBOLS AND SHORTFORMS

Ω	phi (symbol for resistor's value, ohm)
μ	miu (equivalent to 10^{-6})
LED	Light Emitting Diode
k	kilo (equivalent to 10^{3})
n	nano (equivalent to 10^{-9})
m	mili (equivalent to 10^{-1})
M	mega (equivalent to10^{6})
V	voltage value
I	current value
R	Resistor value
P	Power value
DC	Direct Current
A	Ampere
BJT	Bipolar Junction Transistor
V_1	Voltage 1
V_T	Total of voltage
V_{cc}	The voltage from battery to transistor's collector
V_B	The voltage of the transistor's base
V_{BE}	The voltage from the transistor's base to the transistor's emitter
V_{CE}	The voltage from the transistor's collector to the transistor's emitter
I_C	The current of the transistor's emitter
I_B	The current of the transistor's base

LIST OF PHOTOS

CHAPTER 1

PREFACE

1.1 INTRODUCTION

Every day, we use many applications without really knowing how the operations that are happening inside the items are. Studying in the course of Physics with Electronics helps students to identify basic electrical and electronic components, others than also to know conversion and conservation of energies.

In this dissertation, the ideas being suggested are the mechanism setup combined mechanical and mini electronic siren prototypes. The mechanical here is that of pistons of a car engine. These are done to illustrate the conversion of electrical energy to mechanical and sound energies respectively.

Because of the dangers of using real spark plugs and other complications, which might cause a big fire if there are mistakes in wiring, so in this dissertation, the welded rod supporting the shafts and pistons will be empowered totally by a 12 volt (V), 45 (watt)W direct current (DC) motor.

The motor, in return, will be empowered by a 12V, 5 Ampere (A) lead battery. By right, in real life, the electronic siren is supposed to be empowered by the movement of the welded metal rod, which also powers up lightings, radio and digital clock.

The principle of this mechanical prototype is by using a sealed lead battery to provide enough voltage to run the mechanical motor, where the process of electrical energy is changed to mechanical energy. And at the same time, the conversion of electrical energy can be made to sound energy.

1.2 OBJECTIVES

One of the objectives of this research is to know how these two prototypes use different physics methods learnt for the past three years, as to also apply what suitable electric and electronic components learnt in the subjects of 'Basic Electronics' and 'Advanced Electronics'.

Besides that, it is also to identify which areas in these two setups are able to be upgraded in order to function more smoothly and less faulty over time.

The hypothesis which is being done for this dissertation is that when the power supply is functioning at 12 volts (V), the Direct Current (DC) motor will function more efficiently and faster compared to 6V, 4A battery, and so does the electronic siren, which works at 9V.

1.3 SCOPE

The scope will involve the usage of fixed resistor of 82 ohm (Ω), as well as DC motor of 12 V, 45W and a sealed lead battery of 12 V, 5 A. This will also involve an electronic siren circuit which will also use directly from the battery supply, to simulate that the car engine does indeed empower other parts of our interior vehicle, but particularly a police siren.

1.4 PURPOSE

The purpose of doing this research is basically an advanced project designed for a science fair. It is done to make school-going students to understand, thus also remember the simple mechanisms of simulations of Otto engine mechanical movements and the electronic emergency siren; both which are hidden from their daily viewing.

For the Otto engine mechanical movements, it can be applied to much complex working mechanisms of motors and engines which have more components to expel heat and exhaust smoke. For the electronic siren simulation, it applies to physics concepts such as charge and discharge of capacitance, voltage reduction and energy transformation; which is from electrical to sound. Calculations are not necessarily need to be done, as long as it can function the way they supposed to be.

CHAPTER 2

LITERATURE REVIEW

2.1 THE MECHANISM OF THE COMBUSTION ENGINE (4 STROKE ENGINE)

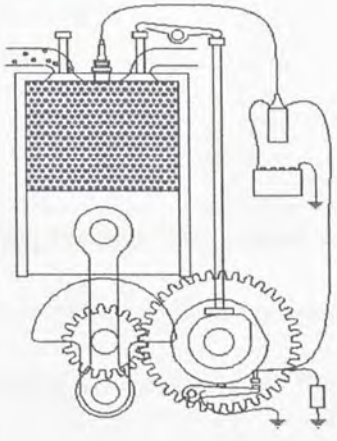
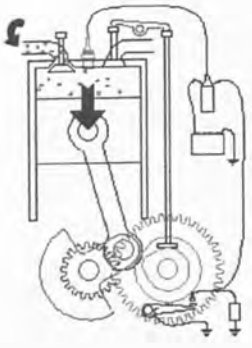


Figure 2.1 An imagery of an Otto engine in a car

(Keveney, Matt, 4-Stroke Engine, www.keveney.com/ otto.html)

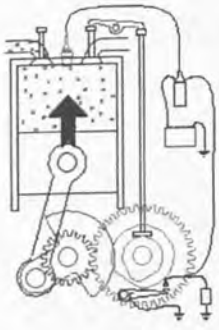
The function of a car's engine is to make a car move. The four stroke engine was originally demonstrated by Nikolaus Otto in 1876; hence it is also known as the *Otto cycle*. The technically correct term is actually *four stroking cycles*.

The four strokes of the cycle comprise of intake, compression, power, and exhaust processes. Each corresponds to one full stroke of the piston; therefore the complete cycle requires two revolutions of the crankshaft (cylindrical shaft) to complete.



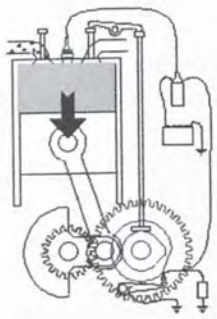
Intake- The piston moves downward, indicated by the arrow, taking in fresh vaporized fuel/air mixture (left side of figure). The illustrated engine features a 'poppet' intake valve which is drawn open by the vacuum produced by the intake stroke. The exhaust valve is held shut.

Figure 2.2 The Intake process



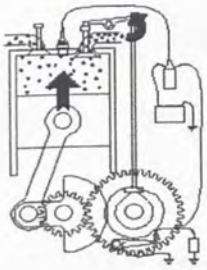
Compression- The poppet valve is forced shut by the increased cylinder pressure. The piston goes upward, compressing the fuel/air mixture.

Figure 2.3 The Compression process



Power-The spark plug produces small fire, igniting the compressed fuel. As the fuel burns, its contents expand, driving the piston downward.

Figure 2.4 The Power process



Exhaust- The exhaust valve is opened by the cam/lifter mechanism (at the right side of figure). The upward piston drives the exhausted fuel out of the cylinder.

Figure 2.5 The Exhaust Process

2.2 THE IMPORTANCE OF PHYSICS TO THE SOCIETY

Physics is an essential part of the educational system and of an advanced society. This is because:

1) Physics is an exciting intellectual adventure that inspires young people and expands the frontiers of our knowledge about Nature.

2) Physics generates fundamental knowledge (i.e.: about electronics and mechanical movements) *needed for the future technological advances that will continue to drive the economic engines of the world.*

3) Physics improves our quality of life by providing the basic understanding necessary for developing new instrumentation and techniques for medical applications, such as computer tomography, magnetic resonance imaging, positron emission tomography, ultrasonic imaging, and laser surgery. (*IUPAP, March 1999*, http://www.triumf.info/hosted/iupap/C12/IUPAP_AIMS.html)

To sum up, this dissertation is to make physics more fun to learn, to apply physics concepts into the real world (if possible, to recreate it in a simpler way) and to grow in wisdom how to improve physics technology.

2.3 LEAD ACID BATTERY

The lead-acid battery is a rechargeable storage cell, ' most commonly used as automobile batteries'.(Slone, 2000) The charge and discharge cycle can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. Inside a lead acid battery, the positive and negative electrodes consist of a group of plates welded to a connecting strap.

The plates are immersed in the electrolyte, consisting of 8 parts of water to 3 parts of concentrated sulfuric acid. During the manufacturing of the cell, a forming charge produces the positive and negative electrodes. In the forming process, the active material in the positive plate is changed to lead peroxide (PbO_2), while the negative electrode is spongy lead, plumbum.

In the battery service condition the following reaction can be shown :

$$PbO_2 + 2H^+ + SO_4^{-2} = PbSO_4 + H_2O + \tfrac{1}{2} O_2$$

PbO_2 + (oxidizable separator material) + H_2SO_4 = $PbSO_4$ + (oxidized material)

Shortforms explanation:

$2H^+$ = Hydrogen ion

SO_4^{-2} = Sulphate ion

$PbSO_4$ = Plumbum sulphate

H_2O = Water

O_2 = Oxygen

H_2SO_4 = Acid sulphate

Moreover, the battery service temperature can be as high as 70 to 80 degrees Celsius. The separator must be capable of resisting thermal degradation as far as possible. (Grob and Shultz, 2003)

Figure 2.6 Sealed Lead Acid Battery (www.wikipedia.com)

2.4 ELECTROLYTIC CAPACITOR

The electrolytic capacitor is capacitor with a larger capacitance per unit volume, making them valuable in relatively high-current and low-frequency electrical circuits. They store charge needed to regulate output voltage and current fluctuations, in rectifier output, and especially in the absence of rechargeable batteries that can provide similar low-frequency current capacity.

They are also widely used as coupling capacitors in circuits where AC should be conducted but DC should not as the large value of the capacitance allows them to pass very low frequencies.

'This capacitor consists of pasty semi liquid electrolyte between aluminum foil electrodes. Internally, an electrolytic capacitor resembles the construction of a paper capacitor, except just one electrode is used and the dielectric is a thin oxide film on its surface. One side of the electrode (positive side) is specially treated to form this thin oxide film on its surface.' (Horn, 1992)

The electrolytic capacitors should not be reverse-biased, as 'the thin layer of oxide film could be punctured, ruining the capacitor.' (Horn, 1992)

Figure 2.7 Electrolytic capacitors (www.wikipedia.com)

2.5 ELECTRIC MOTOR (DC MOTOR)

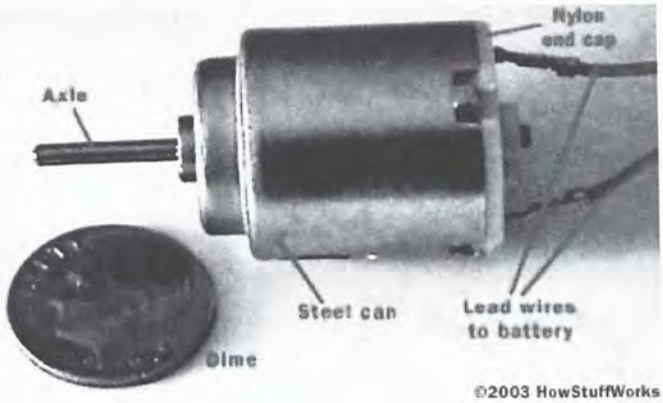


Figure 2.8 The DC motor (Brain, Marshall, How Electric Motors Work, www.howstuffworks.com, 2003)

One of the first electromagnetic rotary motors was invented by Michael Faraday in 1821 and consisted of a free-hanging wire dipping into a pool of mercury. A permanent magnet was placed in the middle of the pool of mercury. When a current was passed through the wire, the wire rotated around the magnet, showing that the current gave rise to a circular magnetic field around the wire. The type of DC motor which will be used in this dissertation is the submerge motor, which works very well under water.

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