THE DESIGN OF ELECTRIC FIRE ENGINE

©*Yao Yi, ORCID: 0009-0008-3597-3378, Jiangsu University of Science and Technology, Zhenjiang, China, 963106686@qq.com*
©*Bai Yike, ORCID: 0009-0000-9819-711X, Jiangsu University of Science and Technology, Zhenjiang, China, 935148103@qq.com*
©*Zheng Shouqing, Jiangsu University of Science and Technology, Zhenjiang, China*

КОНСТРУКЦИЯ ЭЛЕКТРИЧЕСКОГО ПОЖАРНОГО ДВИГАТЕЛЯ

©*Яо И, ORCID: 0009-0008-3597-3378, Цзянсуский университет науки и технологии, г. Чжэньцзян, Китай, 963106686@qq.com*
©*Бай Икэ, ORCID: 0009-0000-9819-711X, Цзянсуский университет науки и технологии, г. Чжэньцзян, Китай, 935148103@qq.com*
©*Чжэн Шоуцин, Цзянсуский университет науки и технологии, г. Чжэньцзян, Китай*

Abstract. The electric fire engine is based on the single chip microcomputer as the control core. In order to better realize the fire extinguishing function, the latest electric fire engine has added the tracking module, wireless transceiver module, etc., to realize the intelligent fire engine to detect the fire source and extinguish the flame. This design combines the principle of single chip microcomputer with the hardware and software circuit program to realize the function of automatic tracking and fire extinguishing, without the fire personnel risking their lives to carry out on-site operation. This kind of electric intelligent fire truck adds some practical small functions, brings us a lot of convenience, can better serve human beings. The main model of this design is a small toy car model with universal wheel and motor control wheel. The chassis is installed with a variety of sensors with different functions to achieve the purpose of moving forward and backward, steering and avoiding obstacles and eventually extinguishing the fire source. At the same time, the car can also realize wireless remote control. By comparing the shortcomings of the traditional fire truck, some improvements are made, the circuit diagram of intelligent control is designed, and the method of wireless control car for fire fighting is explored with the combination of practice and thinking, so as to further improve the fire truck and make it intelligent. The main purpose of this design is to reduce the fire casualties and improve the need for fire personnel to take the risk of life operation of the traditional fire truck function. Its advantages are automatic tracking, avoidance of obstacles, wireless control, measuring the source of fire.

Аннотация. Интеллектуальное пожарное оборудование становится все более популярным. Электрические пожарные машины управляются центрами управления с помощью отдельных машин, которые добавляют модули поиска, беспроводные передатчики и т.д. Это разработано для того, чтобы объединить принцип монолитного устройства с программной схемой для автоматического обнаружения и тушения пожаров, не требуя от пожарных рискованных операций на местах. Такие электроумные пожарные машины добавляют несколько практических функций, которые дают нам много удобств и возможностей лучше служить человечеству. Основной моделью этого плана является миниатюрная модель игрушечного автомобиля с универсальными колесами и электромашинным управлением, с различными функциями сенсоров, установленных на шасси, для достижения движения вперед и назад, для маневра и для маневра, а также для

того, чтобы в конечном счете отключить источник огня, а также для беспроводного дистанционного управления. Сравнивая недостатки традиционной пожарной машины, были произведены некоторые усовершенствования, разработанные схемы интеллектуального управления, с помощью которых можно было бы изучить методы беспроводного контроля над маленькими автомобилями для последующего совершенствования их разумного использования. Основной целью работы стало совершенствование функций традиционной пожарной машины, которая требует от пожарных рискованных операций на местах. Преимущество — автоматическое обнаружение, уклонение от барьеров, беспроводное управление, тушение огня с помощью источника.

Keywords: electric fire engine, fire extinguishing, remote control.

Ключевые слова: электрическая пожарная машина, пожаротушение, дистанционное управление.

Introduction

With the continuous development of science and technology, intelligent and humanized design has a wide range of applications in various fields. Intelligent fire fighting equipment is increasingly favored by people [1]. All kinds of fire hazards in life, under people's carelessness, will lead to the occurrence of all kinds of fires, so life needs to have a fire extinguishing tool. In order to make the fire extinguishing tool convenient to reach the fire extinguishing site, it can be designed as a car body model. John Foster, B.SC., Deputy Director of the Fire Experimental Unit, introduced some recent work on fire engine design in the fire experimental unit [2]. The research on electric fire engines has gradually developed and become very popular, because it has great appeal. Thus, in the 1970s, the "Pessetar" fire engine was born, followed by the "Rosemary" small fire engine was born, and later due to the need, there was a special chassis for the fire engine, and later, there was a water-borne sprinkler type fire engine. In this era of high scientific level, but also accompanied by larger and more complex fire hazards, this is a huge threat to human safety and economic development. In order to kill this danger and minimize the loss, the traditional fire engine must be upgraded to multi-function, intelligent upgrade.

After so many years of development, the type of fire engine is gradually more, and the classification standard of this car is gradually more. It is usually classified according to the load capacity of the fire truck chassis, the arrangement of the passenger seat and the installation position of the water pump on the fire truck [3]. Fire trucks will put some essential goods, divided into heavy fire trucks loaded more things and light fire trucks loaded less things and medium fire trucks loaded moderate things. Others are classified according to the role of fire engines. Some are specially used to extinguish fires, some are used to put out fires in the air, and some are used in airports and medical care. The latest research achievements of fire engine are automatic control type fire pump vehicle, spray foam and chemical vehicle using dry powder extinguishing agent.

Material and research methods

Design a small electric fire truck, can go to the fire site according to the size of the fire choose to use fans or water. As shown in Figure 1, a fire site is designed. Because of the small size and convenience of the candle, it can be used as a fire source to detect the fire extinguishing situation of the fire engine. The candles were then placed in separate locations, allowing electric fire trucks and carts to trace the fire. Figure 1 shows the fire extinguishing site.
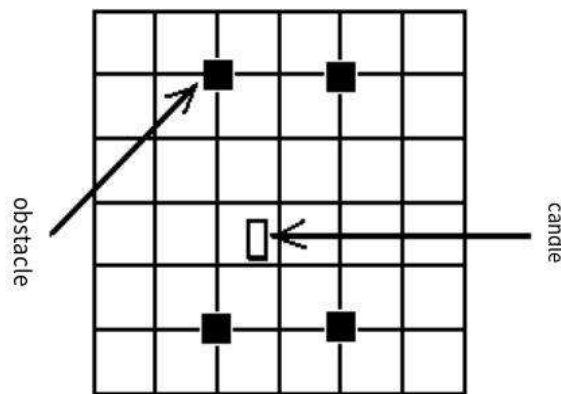
Figure 1. Fire protection area

Simple requirements: (1) Put a candle in any place of the simulated fire site, let the fire engine start from the starting point to look for the fire detection source, and give an alarm when it detects very close to the fire source.(2) The electric fire fighting trolley will carry out fire fighting treatment on the detected fire source. After the treatment is completed, the fire extinguishing alarm will be issued.(3) After extinguishing the fire by electric fire vehicle, safely return to the starting point according to the shortest path.

Complex requirements: (1) Place two candles in the simulated fire site, and the two candles should not be too close to each other. The electric fire engine should start from the starting point to find the fire source according to the principle of proximity, and give an alarm when it detects that it is very close to the first fire source.(2) The first fire source shall be treated with fire extinguishing. After the treatment is completed, the fire extinguishing success alarm shall be issued. Continue to search for and detect the second fire source, and extinguish the second fire source, and issue a successful fire extinguishing alarm after handling.(3) After extinguishing 2 fire sources, the electric fire vehicle should safely return to the starting point according to the shortest path.

Results and discussion

The first is to make electric cars by ourselves. Considering the free steering of the car, we can choose to use a universal wheel to adjust the forward Angle, and then use two DC motors to control the two wheel drive, so as to realize the free rotation of the car, forward and backward. Although the production is a little troublesome, but can be made to meet the requirements of the use of the body. The controller module can use the single chip microcomputer, which is the CPU, RAM, ROM, timer/counter and input/output interface circuit and other main components of the computer integrated on a chip, so that the chip level microcomputer is called the single chip microcomputer, referred to as the single chip microcomputer or single chip microcomputer [4]. STC89C52 microcontroller control force, small size, so low energy consumption. This kind of single chip microcomputer is in the previous long single chip microcomputer on the basis of adding some functions of advanced single chip microcomputer, more suitable for electric fire truck. The power module uses three accumulable lithium batteries and three lithium batteries with voltage change. The DC motor is powered by three rechargeable lithium batteries, other devices such as the MCU are powered by another three lithium batteries after power conversion, and the steering gear is powered by two additional lithium batteries after power conversion. In this way, the DC motor, sensor, MCU and steering gear are powered separately, which can ensure that each part works stably and does not affect each other. The battery volume is not too large, which meets the requirements. The tracking sensor part uses the photoelectric pair detector made by oneself. It is only necessary to observe whether the infrared light can be received. If it is received, the output

signal is low level; otherwise, it is high level. This kind of self-produced tracking sensor can basically achieve the requirements of electric fire truck production. The flame sensor module uses far infrared. The detection range of the far infrared sensor is relatively large, the remote fire source can also be accurately detected, the sensitivity is particularly good, and the small shape, convenient installation in the car plate, these advantages meet the needs of the electric fire truck. The obstacle avoidance module uses an infrared photoelectric switch. The principle of this kind of switch to avoid obstacles is that the light transmitter emits a light beam, if the speed of light is blocked by the obstacle, the light receiver can not receive, thus judging whether there is an obstacle. The switch can detect more than just metals. It can also detect other objects that block the light beam, by seeing whether the infrared light is blocked or radiated back. The switch is also easy to operate, simply observing whether the beam is reflected or obscured can respond, output low level or high level. Because the electric fire engine only needs to judge the existence of obstacles simply, without solving the problem caused by particularly complex environmental interference factors, the operation and debugging is also easy and convenient. The meter velocimetry module uses the photoelectric tube. RPR220 type photoelectric tube and code plate is more sensitive, so put the optical code plate and the electric fire engine wheel together, you can measure the distance with the rotation of the wheel, in this case, the output signal of RPR220 type photoelectric tube can be changed according to the light irradiation in the white or black area. Finally, the output signal is transmitted to the MCU, and the speed of the wheel can be measured. The motor drive module uses L298N. Its working current and voltage are relatively large, the working cycle is relatively short, the enabling end can also be better controlled, similar to the full bridge in shape, so it is also called the full bridge driver chip, the operation voltage is high, the current is large, the corresponding frequency is high, can control the enabling end, a L298N can control 2 motors, high efficiency, very convenient. The voice module uses the Lingyang 61B board. This board not only makes up for the disadvantages of large size, inconvenient use and not affordable in Scheme 2, but also has a particularly strong speech processing ability, and can broadcast and recognize speech. It contains the advantages of DSP, and the calculation speed is fast, very suitable for electric fire trucks. DF wireless transceiver module is adopted. This module is processed by the MCU, the PT2262 encoding, DF data transmission module to send out the steering data [5], the output waveform is easy to observe, anti-interference, high efficiency, very stable, to meet the transmission of a small amount of data information, and the price is low, it is suitable for electric fire trucks, these excellent characteristics. Display module uses LED tube. The nidigitube works very well in terms of clarity, with a high level of light for remote observation. It also has the ability to display moving images in English and pictures and video to show fire fighting. It is self-luminous, but also particularly strong, not afraid of interference, in low brightness conditions can better reflect the intensity of its light. This kind of semiconductor is mainly composed of diodes, simple structure, easy to use.

As a single chip microcomputer with similar functions to CPU, if you want to achieve these functions, there must be various devices with these functions, such as interface circuits, input devices and storage. The single chip chip needs wiring to work, the smallest system of the single chip is just able to work properly under very simple equipment. Figure 2 shows the minimum system of a single chip microcomputer called STC89C52. L298N drive circuit has some advantages, suitable for electric fire truck drive, it is stable, good performance and easy to operate. L298N is a full-bridge driver chip developed by SGS company. One of its advantages is that it has large current and large voltage. The chip has a driver that can receive logic level signals and has a short working cycle, which can control the enable end and control two motors at the same time, and control the motor steering between the two output ends.

Figure 2. STC89C52 Microcontroller minimum system

When the enable end works, each input port input the corresponding high and low level can make the transistor on or off, so as to achieve positive and negative motor rotation. When the input levels of IN1 and IN2 are the same, the motor stops [6]. Its function table is shown in Table. The circuit diagram of L298N control motor is shown in Figure 3.

Table

L298 FUNCTION TABLE

IN1	IN2	ENA	Motor state
X	X	0	stop
0	0	1	stop
0	1	1	clockwise
1	0	1	counterclockwise
1	1	1	stop

Figure 3. L298N circuit diagram

The L298N can be used for PWM control. If the electric fire engine is required to go straight forward, the No. 5 and No. 7 leading angles are connected to high level, and the No. 10 and No. 12 leading angles are connected to the negative terminal of the power supply, and then the forward, backward, turning and other actions are realized. Input the corresponding signal can complete the control of various motor actions, such as forward and backward. If the capacitor is connected to the motor in parallel, some cost can be saved. D1 ~ D8 are two-stage tubes IN4007, which can protect other devices in the circuit from being burned out due to excessive reverse current of sudden line break, that is, play a role of continuous current protection [7].

Considering the power consumption of the circuit and the interference of the environment on the system, as well as some limitations of the circuit itself, the comparator type photoelectric tube circuit is finally selected. The circuit diagram is shown in Figure 4. The threshold voltage of the photoelectric tube circuit is adjusted by adjusting the variable resistance.
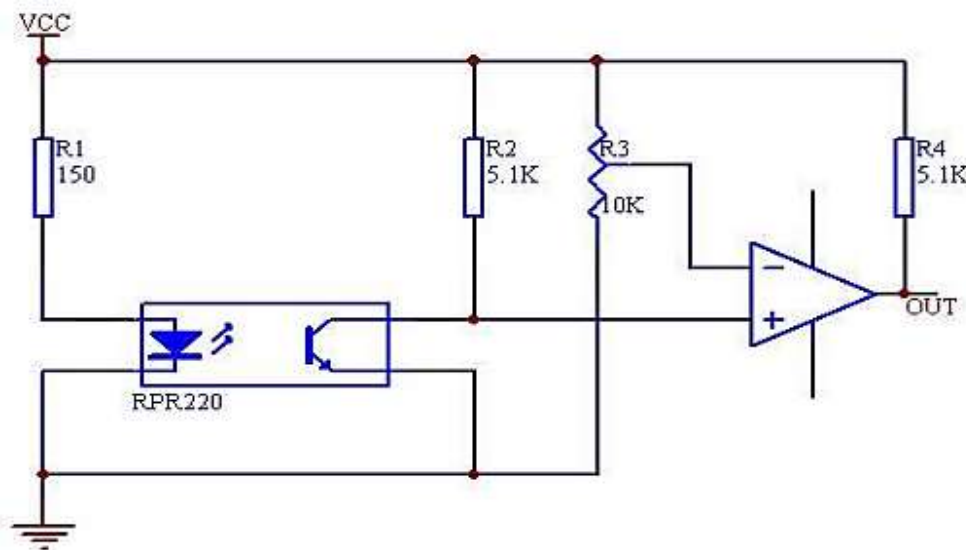

Figure 4. Photoelectric tube matching circuit

In the design of the physical picture, it is considered to install two photoelectric pair tubes symmetrically at the front end of the car. During the movement of the car, the two photoelectric pair tubes will detect the black line (Figure 5).
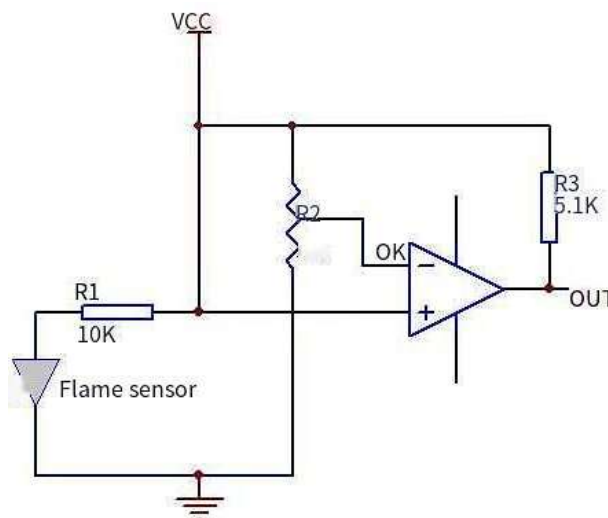

Figure 5. Flame sensor circuit

If the black line is between the two, the car will continue to move forward if it cannot detect the black line. Install the probe down, so that you can accurately detect whether the black line is detected. The flame sensor is the part of the electric fire truck to recognize the flame, and its quality is very key to the realization of the function. When the flame sensor detects the fire source, the sensor will turn on and the comparator will output high level. On the contrary, when there is no fire source, the sensor will not turn on and the comparator will output low level, so as to realize the function of flame identification. Moreover, the performance is very stable and does not consume too much power.

Electric fire truck in the detection of fire, need to grasp the distance between the fire source, can consider the installation of two flame sensors, respectively detect the distant and near fire source, so as to prevent the wrong detection of the car, want to detect the near fire source can turn off the remote flame sensor, on the contrary, want to detect the remote fire source, turn off the near flame sensor, in addition, Short-range sensors can only detect a small part of the location due to their small range, while remote sensors can detect far and wide locations.

The fire extinguishing device used in this design is the electric fan [8] with a working voltage of 5v. In order to ensure the driving power, transistor 8550 is used as the driving circuit to increase the driving current. The fan input is connected with the MCU input port, which outputs high and low level to control the operation and stop of the fire extinguishing fan.

Photoelectric code disc and speed measurement tube to achieve speed measurement function, the photoelectric code disc is divided into 16 parts of the black and white disk, and then placed on the wheel side, and then on the frame to make a small hole, so that RPR220 type photoelectric tube through the hole can detect the photoelectric code disc to calculate the number of turns of the wheel rotation, calculate the speed. [9] The diameter of the wheel is 4cm and the circumference of the wheel is:

$$L = 2*\pi*R = 2*3.14*0.03 \text{ m} = 18.85 \text{ cm}$$

The optical code disk is divided into 16 pieces, each arc length is:

$$L = L / 16 \text{ '} = 18.85 \text{ cm} / 16 = 1.04 \text{ cm}$$

If the change frequency of the detected black and white signal is m, then the distance of the car is:

$$S = m*0.52 \text{ cm}$$

The main flow diagram of the system is a very important part of the electric fire truck to achieve the function, determines what kind of car to achieve the function and how to achieve these functions, is the core part of the design. Design the main flow diagram, you can make the car to achieve the required function. In the design of system software, we embed all module programs into the remote control, which is mainly for the convenience of control [10].

In order to ensure that this design is in line with the function required by the subject, it is necessary to debug several important parts of the system. To ensure the correctness and practicality of the design. System debugging is divided into two modules [11]: the car to achieve forward and backward and the fire extinguishing fan induction flame extinguishing. During the test, some problems were also found [12].

Conclusions

This design is a car for the purpose of fire extinguishing, first of all to ensure that the car to achieve the basic functions of forward and backward, left and right turn, but also add automatic tracking and fire detection functions, after asking the teacher some information about this topic,

access to data, browse a variety of papers related to this topic, determine the electric fire truck modules, such as motor module, tracking module, Obstacle avoidance module, wireless transceiver module, etc. The car body consists of two wheels controlled by DC motors and a universal wheel mounted on a circular chassis, which allows the car to rotate at a free Angle. Due to the need for power supply of more systems, so choose multiple rechargeable lithium battery for single-chip microcomputer, DC motor, sensors and other power supply. Wireless transceiver module adopts DF wireless transceiver, which is more affordable and strong anti-interference ability. The key motor drive is L298N, because its working current and voltage are relatively large, the working cycle is relatively short, the enabling end can also be better controlled, similar to the full bridge in shape, so it is also known as the full bridge driver chip, the operation voltage is high, the current is large, the corresponding frequency is high, a L298N can control 2 motors, high efficiency. The voltage used by the fire extinguishing fan is 5v. In order to ensure the driving power, the transistor 8550 is used to increase the driving current.

When detecting the fire source, there may be several fire sources with different distances, which will bring errors. In this case, we can consider using two different distance flame sensors, so as to detect the fire source more accurately. After selecting each module and designing the overall scheme, there are still some problems to be solved, and there is still room for optimization:

(1) The electric fire engine needs a remote control to control it. Make the remote control and set the function buttons.

(2) Obstacle avoidance module to reduce interference, so consider the use of infrared photoelectric switch, which relies on detection light beam to avoid obstacles switch operation is very convenient.

(3) If the fire extinguishing fan wants to put out the fire flexibly, it needs to rotate at its own Angle, which can be considered to install it on the steering gear.

References:

1. Wu, Xingbo, Li, Ming, Hu, Yuan, & Jia, Binbin (2011). Design of Intelligent Fire Truck Based on MSP430. *Journal of Jilin University of Chemical Technology,* 52-57.

2. Fan, Qiangqiang (1994). Design and Development of Fire Truck. *Fire Technology & Product Information,* 34-37.

3. Sun, Yumei (1995). Discussion on the present situation and development direction of Foreign fire Trucks. *Fire Science and Technology,* 40-42.

4. Zhong Weidong (2015). Solar Smart Car Controlled by single Chip Microcomputer. *Journal of Taiyuan City Vocational and Technical College,* 191-193.

5. Chen, Yunsheng, Xie, Guoyong, & Chen, Haiyun (2010). Application of Wireless Communication Technology in DC Motor Control. *Scientific Instrument Household,* 36-37.

6. Hu, Shousong (2008). Concise Course of Automatic Control. *Science Press,* 41-43.

7. Hu, Qiansheng, & Hu, Minqiang (2009). Electrical Machinery. *China Electric Power Press,* 39-44.

8. Wu, Ran, & Huang, Qirui (2017). Design and implementation of Intelligent fire extinguishing Vehicle based on Single Chip Microcomputer. *Journal of Nanyang University of Technology,* 61-64.

9. Wang, Yong, & Wang, Liying (2018). Intelligent Car Controlled by MSP430 Series single-chip microcomputer. *Electronic World,* 144-147.

10. Zhang, Haijun, Song, Xingwen, Zhao, Ruipeng, & Liu, Yang (2020). Design of Intelligent Car based on C51 Microcontroller. *Rural Staff,* 187-188.

11. Tao, Ye, & Li, Chixin (2019). Intelligent Car Based on Arduino. *Computer Knowledge and Technology,* 222-223.

12. Huang, Jiabin, & Huang, Haipeng (2018). Design of Multi-function All-terrain intelligent Car. *China Electrotechnical Engineering,* 88-90.

Список литературы:

1. Wu, Xingbo, Li, Ming, Hu, Yuan, & Jia, Binbin (2011). Design of Intelligent Fire Truck Based on MSP430. *Journal of Jilin University of Chemical Technology,* 52-57.

2. Fan, Qiangqiang (1994). Design and Development of Fire Truck. *Fire Technology & Product Information,* 34-37.

3. Sun, Yumei (1995). Discussion on the present situation and development direction of Foreign fire Trucks. *Fire Science and Technology,* 40-42.

4. Zhong Weidong (2015). Solar Smart Car Controlled by single Chip Microcomputer. *Journal of Taiyuan City Vocational and Technical College,* 191-193.

5. Chen, Yunsheng, Xie, Guoyong, & Chen, Haiyun (2010). Application of Wireless Communication Technology in DC Motor Control. *Scientific Instrument Household,* 36-37.

6. Hu, Shousong (2008). Concise Course of Automatic Control. *Science Press,* 41-43.

7. Hu, Qiansheng, & Hu, Minqiang (2009). Electrical Machinery. *China Electric Power Press,* 39-44.

8. Wu, Ran, & Huang, Qirui (2017). Design and implementation of Intelligent fire extinguishing Vehicle based on Single Chip Microcomputer. *Journal of Nanyang University of Technology,* 61-64.

9. Wang, Yong, & Wang, Liying (2018). Intelligent Car Controlled by MSP430 Series single-chip microcomputer. *Electronic World,* 144-147.

10. Zhang, Haijun, Song, Xingwen, Zhao, Ruipeng, & Liu, Yang (2020). Design of Intelligent Car based on C51 Microcontroller. *Rural Staff,* 187-188.

11. Tao, Ye, & Li, Chixin (2019). Intelligent Car Based on Arduino. *Computer Knowledge and Technology,* 222-223.

12. Huang, Jiabin, & Huang, Haipeng (2018). Design of Multi-function All-terrain intelligent Car. *China Electrotechnical Engineering,* 88-90.

Ссылка для цитирования:
Yao Yi, Bai Yike, Zheng Shouqing The Design of Electric Fire Engine // Бюллетень науки и практики. 2023. Т. 9. №6. С. 388-396. https://doi.org/10.33619/2414-2948/91/46

Cite as (APA):
Yao, Yi, Bai, Yike, & Zheng, Shouqing (2023). The Design of Electric Fire Engine. *Bulletin of Science and Practice, 9*(6), 388-396. https://doi.org/10.33619/2414-2948/91/46