ÇANKAYA UNIVERSITY
MECHANICAL ENGINEERING DEPARTMENT

ME407 PROJECT REPORT

TITLE OF THE PROJECT:	
CNC Hot Wire Foam Cutting Machine	
DATE:	28/06/2020
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ME407 Innovative Engineering Analysis and Design

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STATEMENT OF NON-PLAGIARISM

We hereby declare that all information in this report has been obtained and presented in accordance with academic rules and ethical conduct. We also declare that, as required by these rules and conduct, we have fully cited and referenced all materials and results that are not original to this work.

Date:

Group Member's Name and Surname *Signatures*

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Abstract

This report includes the document that studied within the aim of ME407 project. This report is explained under 3 main headings. These are literature survey, problem definition and design. First of all, literature survey had been done, keywords were identified, and similar projects were searched. In the second part, requirements and constrain were identified. In last part, analytic and numerical calculations were done. The solutions which are analytic and numerical were compared each other.

1. Introduction

Foam material is used in flat-plate collector, automobile, building design, aircraft, sculpture, air conditioning (tornado), advertising (sign board, name plate for firm or factories), art design (wall decoration), producing model and prototype in engineering areas. The characteristics of this material are lightweight. Also cutting process is short time. It can be used at high cutting temperature and it is cheaper than the other materials. This report relates to the production of foam cutting machine. The foam material, which is very high in its usage area, contains all the procedures required to design a machine that can cut 2D and 3D. The programs we use to design this machine are as follows: Autocad Inventor, Ansys, Simulink, Matlab ve UGS. Moreover, we were preferred of the Simens Program Language and codes in terms of infrastructures because Simens Controls are more powerful, faster, and easier to use according to other program languages.

2. Work Planning

- All work had been done together but each parts of work has coordinator these are;
- Literature survey and Problem Definition
- Material selection and Manufacturing
- Program Calculation
- Computer-Aided Control and Codes

3. Literature survey

Key words: EPS types, CNC Hot Wire Cutting, Hot Wire Cutting Types, Numerical Control and Analysis, Computer-Aided Control Mechanism and Codes.

In the literature research, previous projects and where they are used are searched, and then related articles were examined. We then found that the use of EPS, EPP, and XPS materials was convenient, paying attention to the frequency and suitability of the foam material we will use for cutting. We found that the use of NiCr(A) and NiCr(C) is appropriate for the thermal conductivity coefficient and cutting roughness in the selection of wires for foam cutting operation. We have also taken the decision to use the spring to ensure proper tension in the wire section. FANUC code programs from computer-aided programs used for computer-aided control have been our preferred reason for the convenience of the user. We thought of mounting with sigma profiles for the cage in machine design. We will also produce most necessary parts ourselves with the use of 3D printers. This will give us an advantage in making our machine light and portable. Mobility can be controlled with micro control and switch systems.

4. CONCEPTUAL DESIGN

There are many different projects about hot wire cutting. These are ‘’Optimization the Parameters of Hot-wire CNC Machine’’ [11], ‘’CNC Foam Cutting Machine’’ [22], ‘’ Four Axis Hot-Wire Foam Cutter Controlled by Mindstorms EV3” [33], and “Rough Machining Process and Its Simulation for Robot Integrated Surface Sculpturing System Design ’’ [44].

First project is Optimization the Parameters of Hot-wire CNC Machine. This project is designed in two dimensions depending on the diameter, material and temperature of the cutting wire. The intensity of cutting speed and foam was determined by the change of parameters such as optimum temperature, suitable wire diameter.

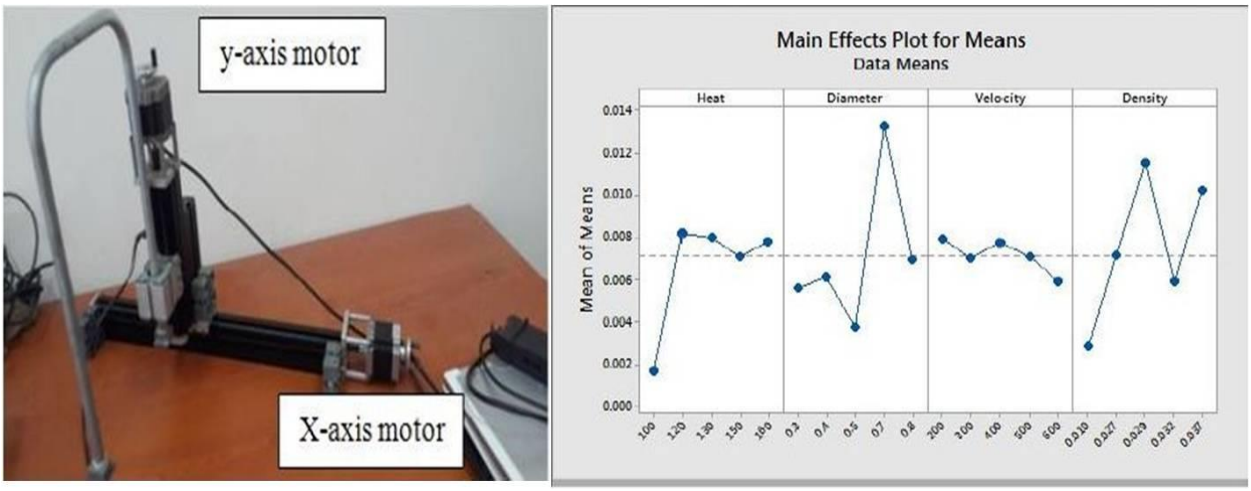


Figure 1 Two Axis of CNC Machine and Main Effects

Second project is CNC Foam Cutting Machine. This machine project is suitable for both 2D and 3D cutting. It allows all kinds of cuts with its wide range of uses. For example, cylindrical and thick plate parts. "Power Machine", which is one of the patented companies in our country, is the machine produced.

Figure 2 Three Axis of CNC Machine

Third project is Four Axis Hot-Wire Foam Cutter Controlled by Mindstorms EV3. The purpose of this project is to create prototypes that will perfect the design with the help of 4-axis numerical control of the designs of flying aircraft. In addition, mixed motifs in 3D models have been the reason for the need. Moreover, the first foam cutting machine made with lego parts in addition.

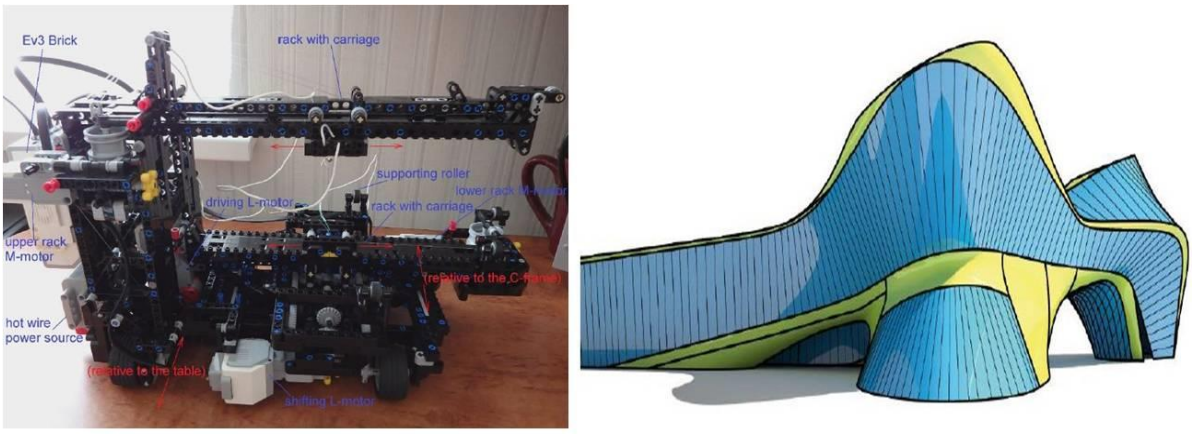


Figure 3 a) Four Axis of CNC machine b) Complex Design

Final project is Rough Machining Process and Its Simulation for Robot Integrated Surface Sculpturing System Design. In the CAM section, it corrects errors that may occur during cutting using offset technique. It has 8-axis. These are 2-axis worktables and 6-axis manipulators.

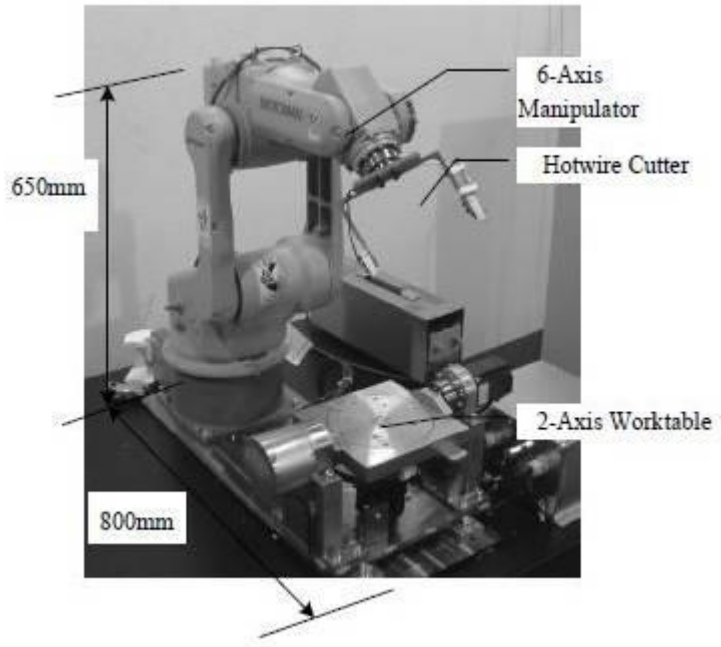


Figure 4 8-Axis CNC Hot Wire Machine

5. Patents

US3757617A- At 1973, John A. Fabbri was invented “Foam Cutting Apparatus” which has 2 axis [X].

US4601224A- At 1986, William T. Clack, III was invented “Hot Wire Cutting System” which has 2 axis [Y].

2007/04961- At 2007, Güç Makine Elektrik Elektronik San. Tic. LTD. ŞTİ. was invented “CNC Foam Cutting Machine” which has 3 axis [W].

EP2402125A1- At Jason Stege was invented “Method of Producing Test Components by a Hot Wire Cutter” which has 3 axis [Z].

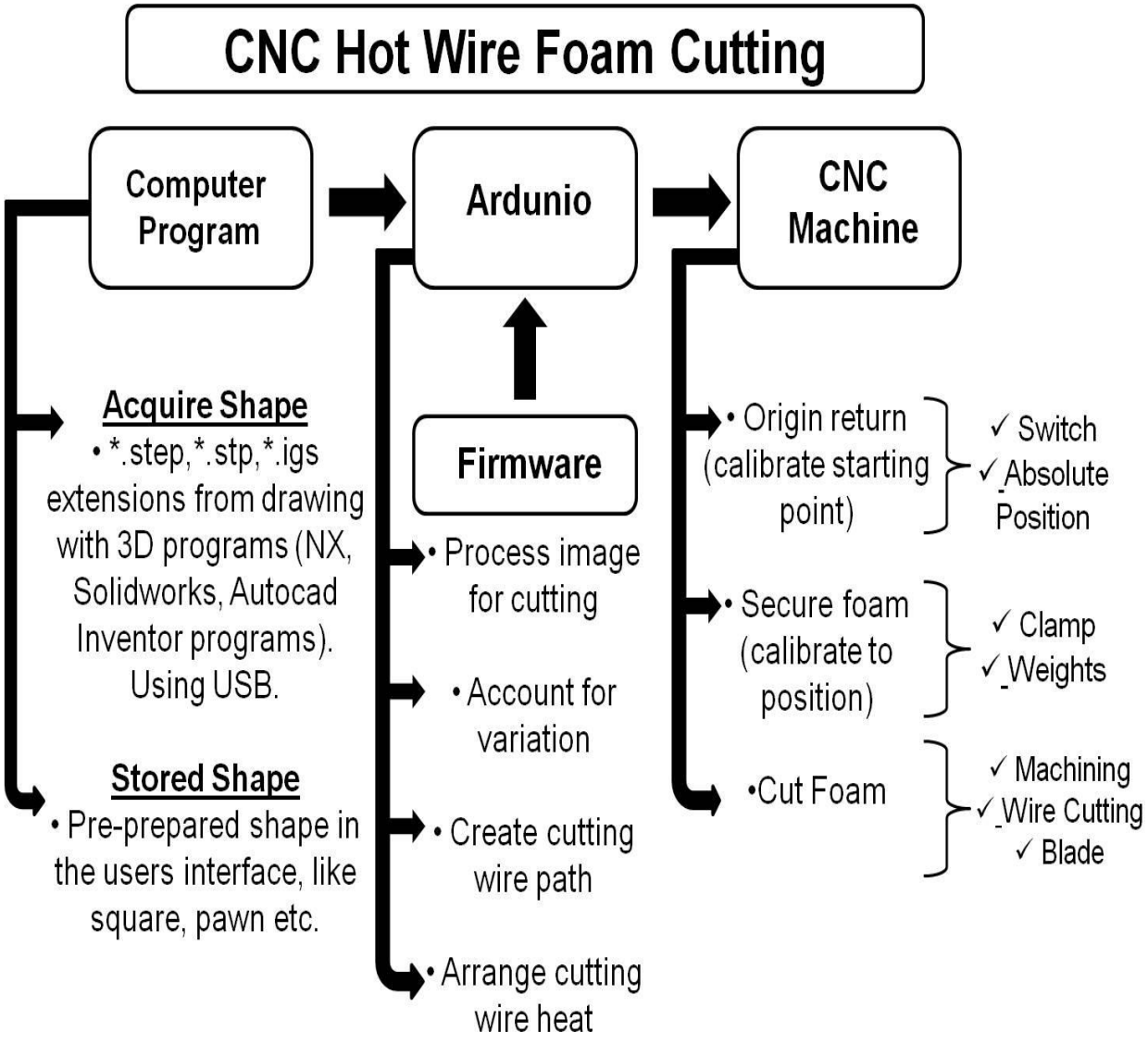
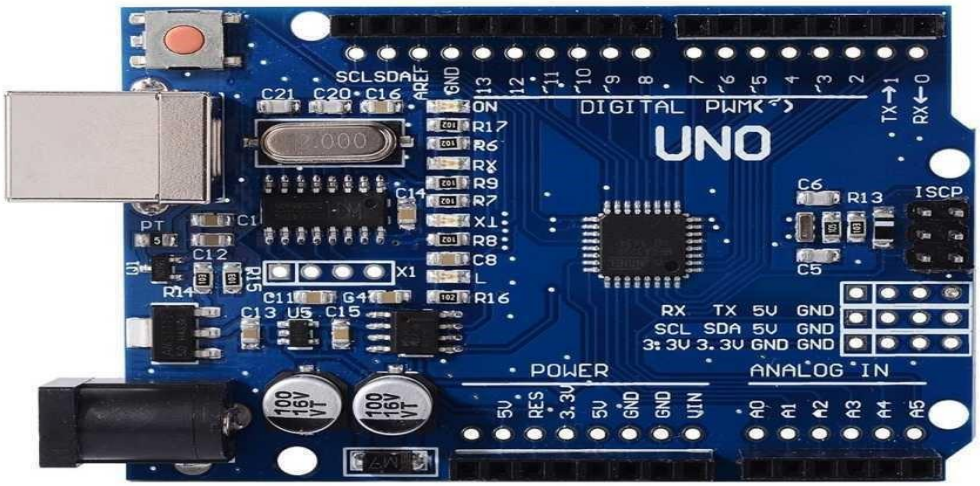


Figure 5 Operation Tree

6. WHY ARDUINO UNO?

Arduino Uno is the most basic board available for a beginner, and potentially the best option. It is a good all purpose board with enough features to get a beginner started. Some of its advantageous features are: Its greatest advantage is that we connect the board to the computer via a USB cable which serves a dual purpose of power supply and acts as a Serial port to interface the Arduino and the computer. It can also be powered to DC through a 9V-12V AC adapter. When harmed, which is not possible for other models, the ATmega328 chip can be bought, removed and replaced new.The board works both at 5V, i.e. digital pin output or 5v read, and 0-5V read analog pins.Lots of example code and projects are done with the help of Arduino Uno, so they get good support.The Uno is composed of 14 Digital I / O pins and 6 Analog I / O pins.Created lots of extra hardware add-on for Uno.There's special hardware for Internet, Bluetooth, Motor Control etc.Also It is price performance product.

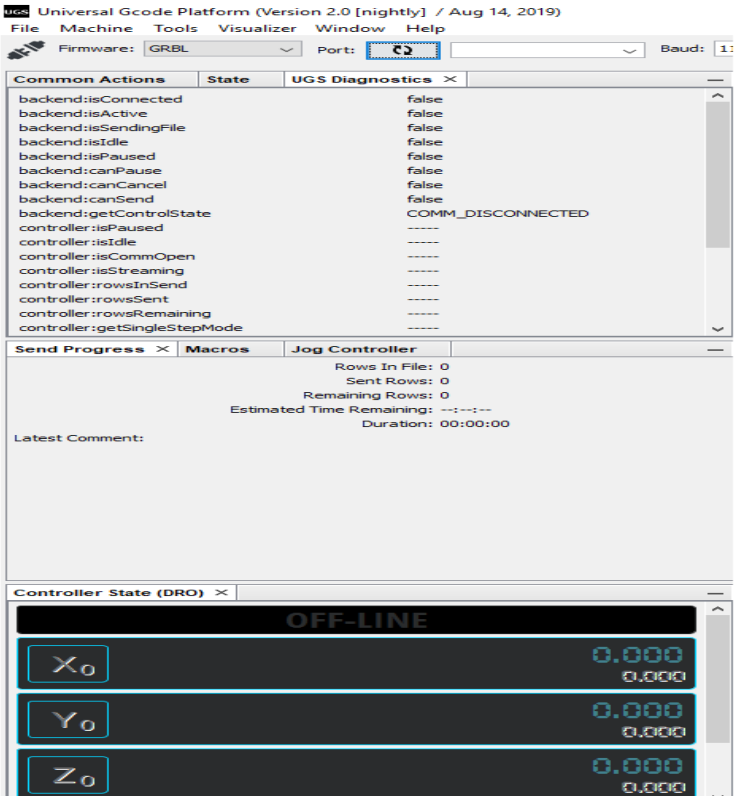


6.1. GRBL ARDUINO LIBRARY

GRBL is a firmware which controls stepper motors and spindles, lasers, for arduino panels (uno, nano etc.). GRBL uses gcode as input andsends out signals using arduino pins. The parallel port controller is used by mostindustrial cnc devices, which includes these broad purple connectors. GRBL simply plugs the arduino boards into a free usb port. We'll upload a firmware that controls motion to the Arduino.Most popular choice for CNC machines is GRBL firmware.

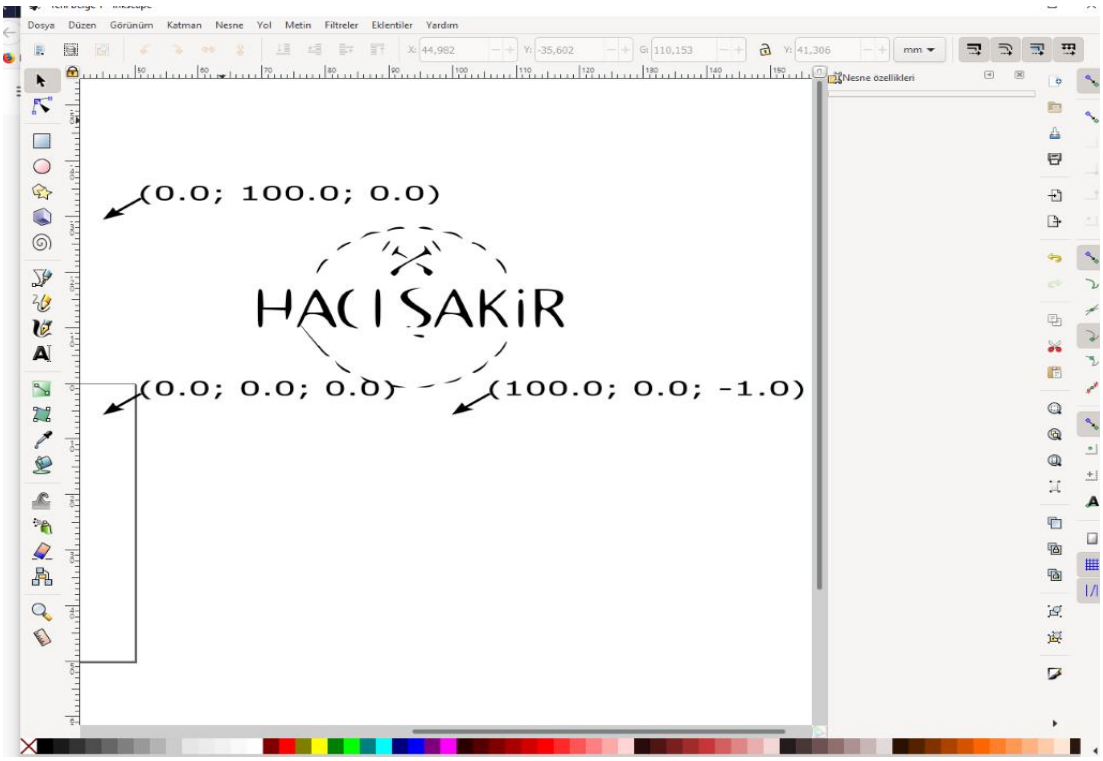
6.2. UNIVERSAL GCODE SENDER

Through this program we will do our calibration process. Also, our management screen will be in this program.



6.3. INKSCAPE GCODE GENERATOR

After all preparation we need to generate and how to plan the drawings so that the CNC machine can carve it out. We need a vector graphics program, and we have chosen an open source platform Inkscape.



We have a lot of option if we use inkscape. Because inkscape has code converter,size adjuster,step counter. In the example above, there is the logo before it was sent to the g code sender.After this part we will work with gcode sender. As a result, movement begins to be provided to us.

7. Literature survey

Key word: CNC, foam cutter, hot wire foam cutting machines.

1) At 2003, D. Aitchison, R. Sulaiman was found a machine for a hot wire cutting. Before while the machine is cutting 2½ shapes, they were needed 3D shapes. Also, it has been arranged the optimum heat, and feedback control [1].

2) At 2005, S.D. Y. Yang, H.C. Kim, S.H. Lee, S. K. Park was created a machine for a large size shapes which has 4 axis, and it is cutting asymmetric shapes [2].

3) At 2006 Jiang Zhu, Tomohisa Tanaka, Yoshio Saito were fabricated a robotic machine which has 8 axis. If it is separating, it consist of 6 axis robot and 2 axis worktable, and it works according to CNC operation [3].

4) At 2008 Guc Makina (Turkey) was invented a utility model machine by a hot wire cutting tools and CNC control mechanism [4].

5) At 2009 D. Aitchison, H. Brooks, J. Bain was invented a machine which has a 3D axis. Optimum operating conditions are founded on the machine, like kerf width, applying force, and other parameters [5].

6) At 2010 Simens (United States) was founded a patent machine by a hot wire cutting tools and depending offset principle [6].

7) At 2011, D. Pigram, W. McGee was found a robotic machine which has 7- axis. It has a two dimensional which has works reciprocal between each other [7].

8) At 2016, K. Petkov and J. Hattel was invented a one dimensional machine within Ni-Cr20% wire used in hot wire cutting operation. Also, it has relationship between kerf width, and side angle [8].

9) At 2016, A. Abeysinghe, S. Abeysir have found out a 3D and numerically system machine. Especially the cutting parameters are considered on the machine 9].

10) At 2017, Figliolini, P. Rea, C. Cocomello have designed a 4-DOFs hot wire machine for a experimental works. It has four step motors and it is controlling by CAD-CAM systems. Moreover it has working planer surfaces and skew surfaces [10].

11) At 2018, G. Figliolini, P. Rea, C. Cocomello a 4-DOFs hot wire CNC cutter machine, actually it has 3-DOFs cartesian coordinate and holding apparatus like a fork for hot wire while it is cutting [11].
12) At 2018, H. Hua, T. Jia were came with up a CNC hot wire cutter robotic machine which has a 5-axis [12].

8. REFERANCESES

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[3]https://www.researchgate.net/profile/Jiang_Zhu19/publication/266882022_Rough_Machining_Process_and_Its_Simulation_for_Robot_Integrated_Surface_Sculpturing_System/links/5554c2a808aeaaff3bf45334.pdf

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9. APPENDICES

9.1. APPENDIX B: Patent Figures

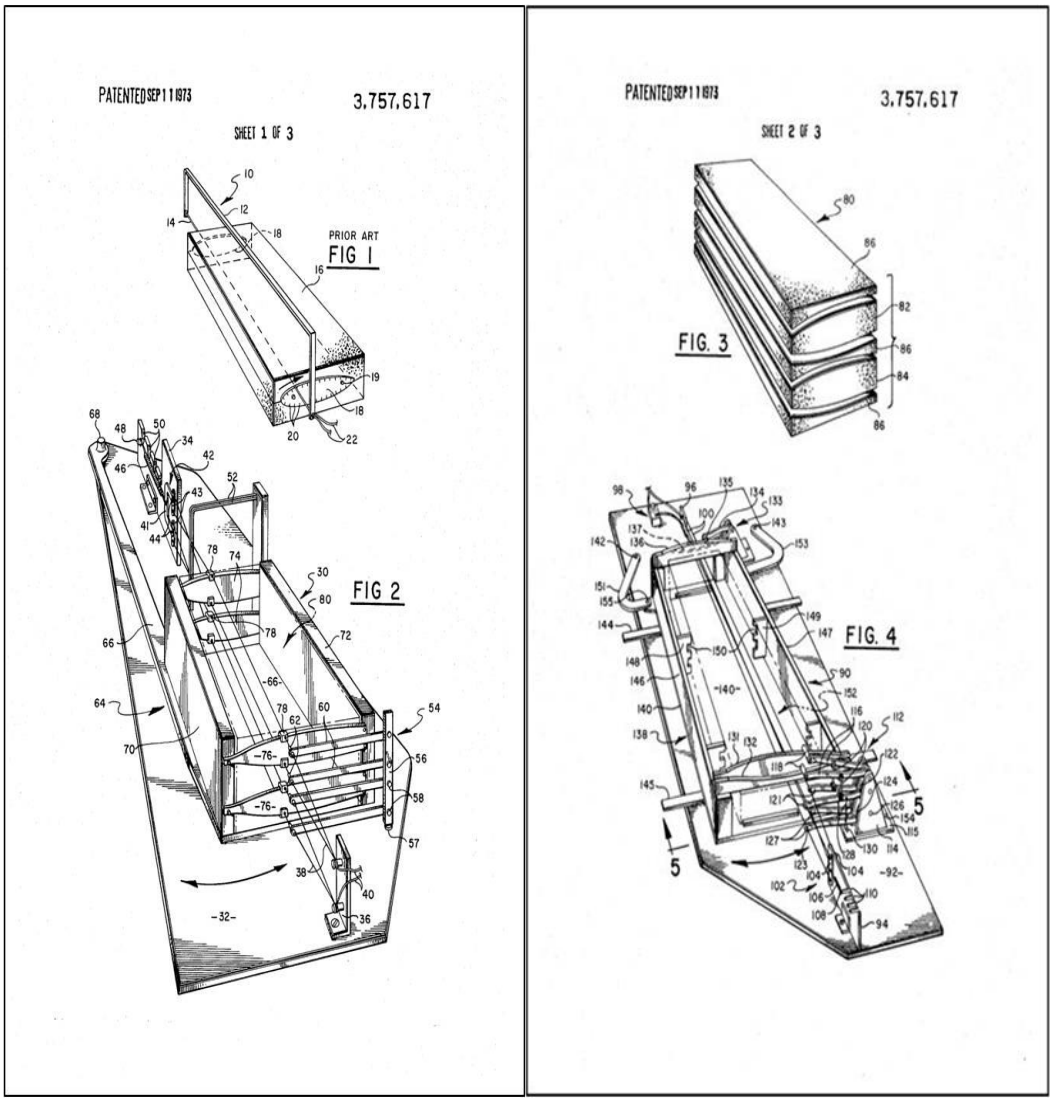

Figure 6 US3757617A'Foam Cutting Apparatus'[X]

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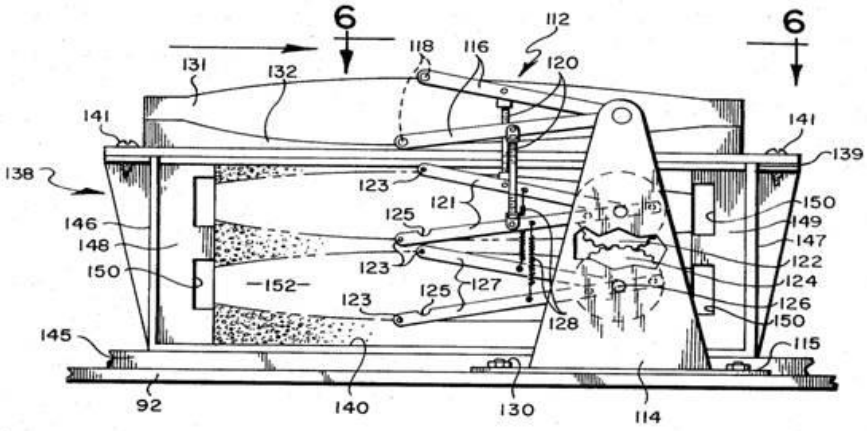

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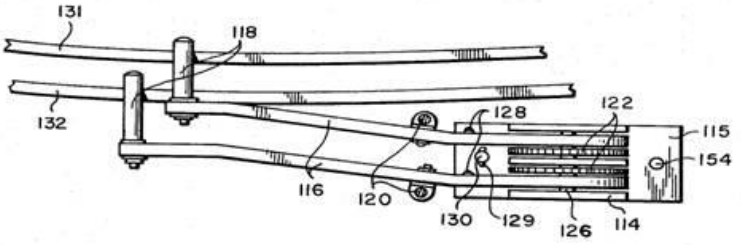
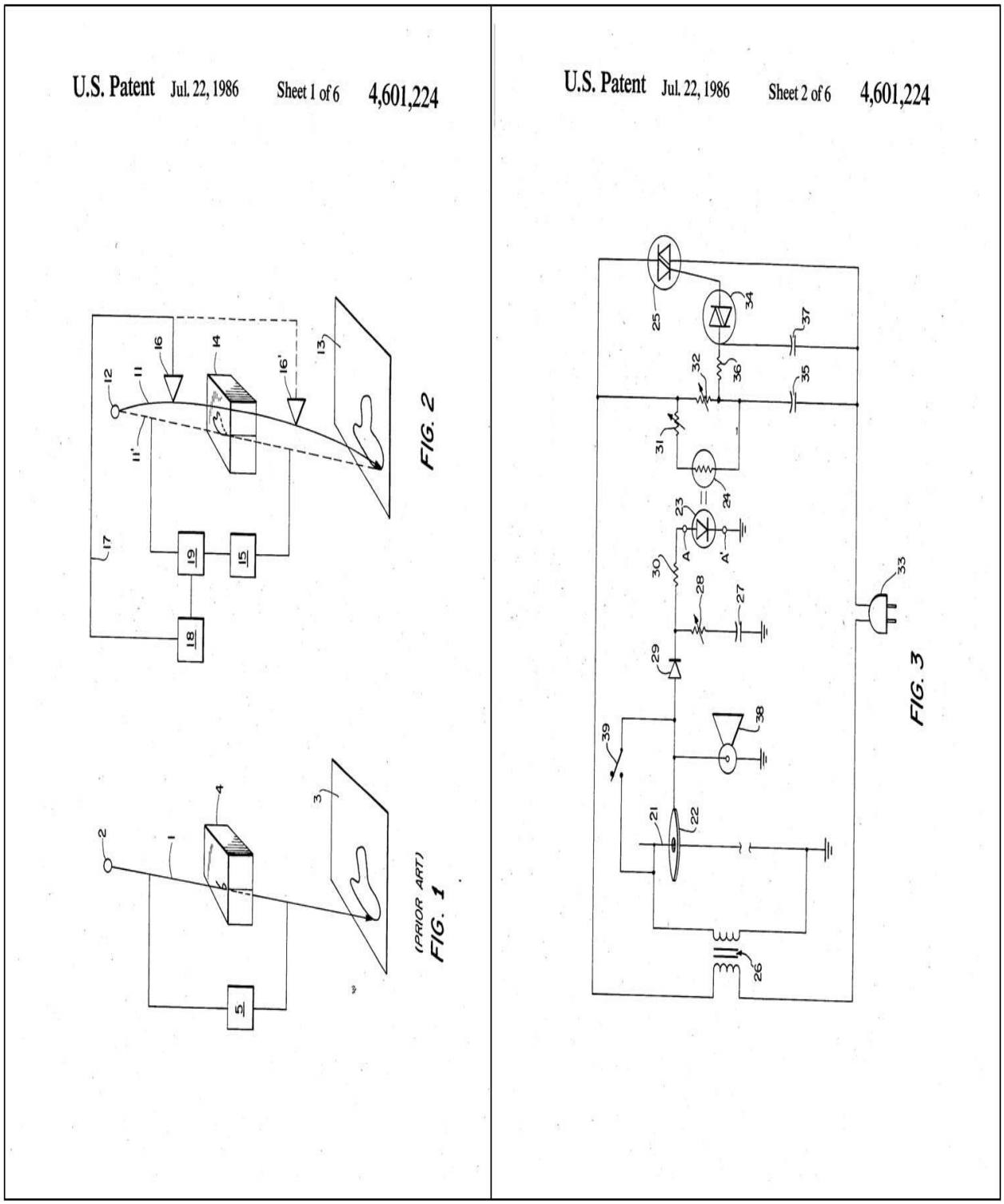
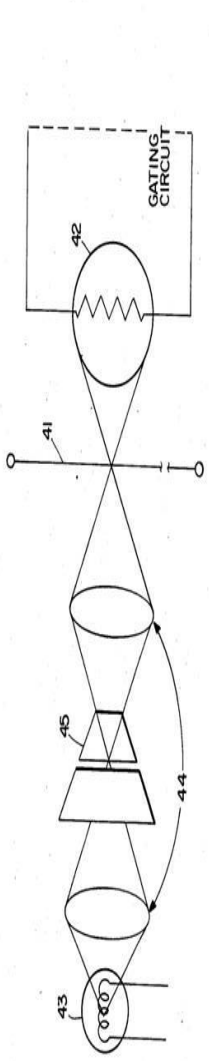


FIG. 6

Figure 7 US4601224A'Hot Wire Cutting System'[Y]





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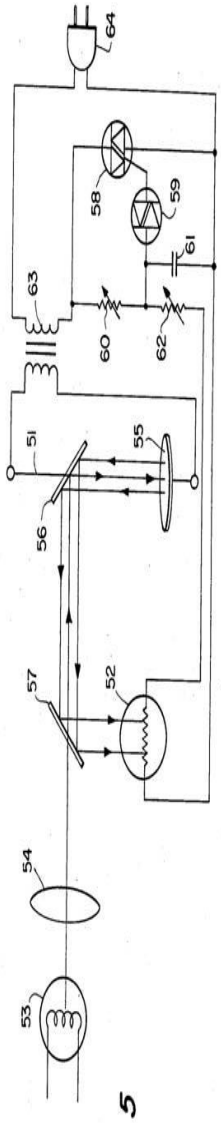

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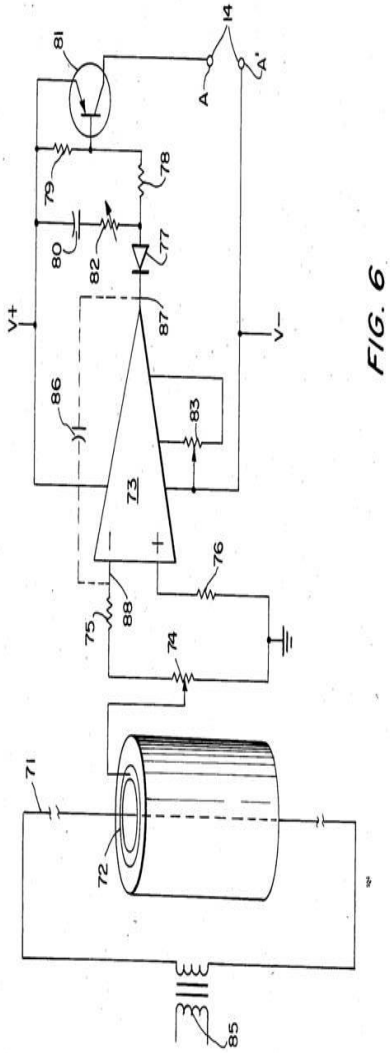

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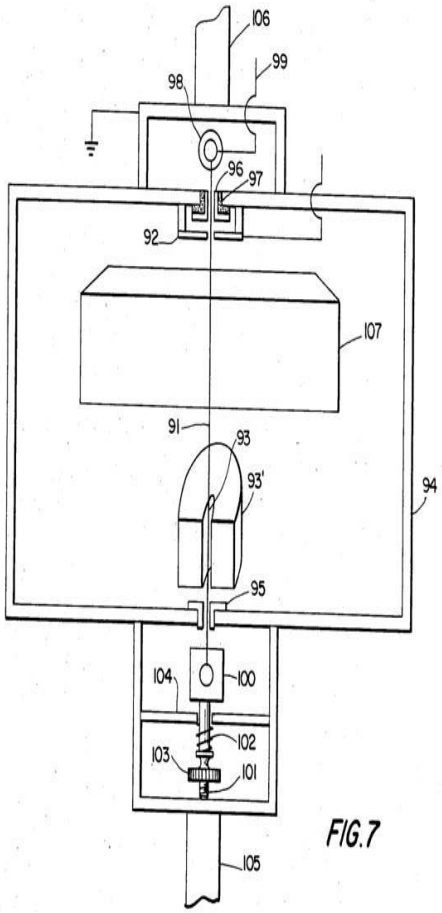

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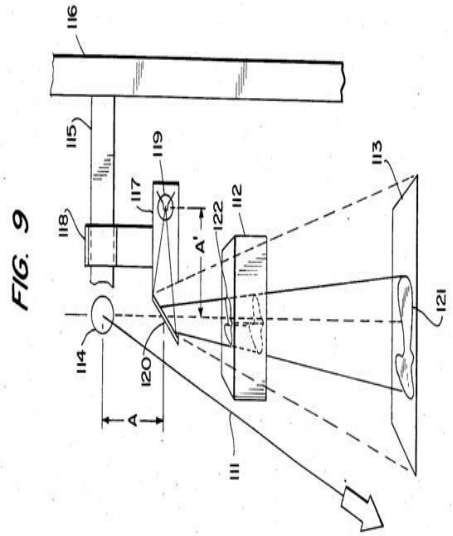

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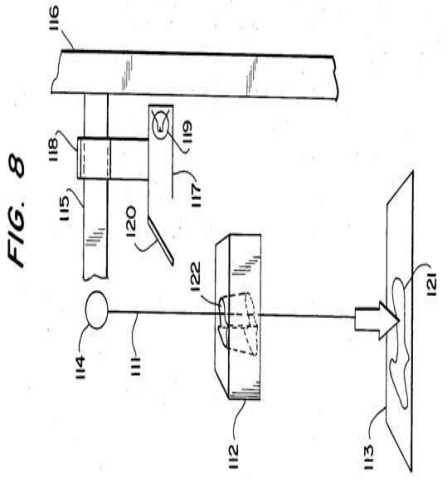
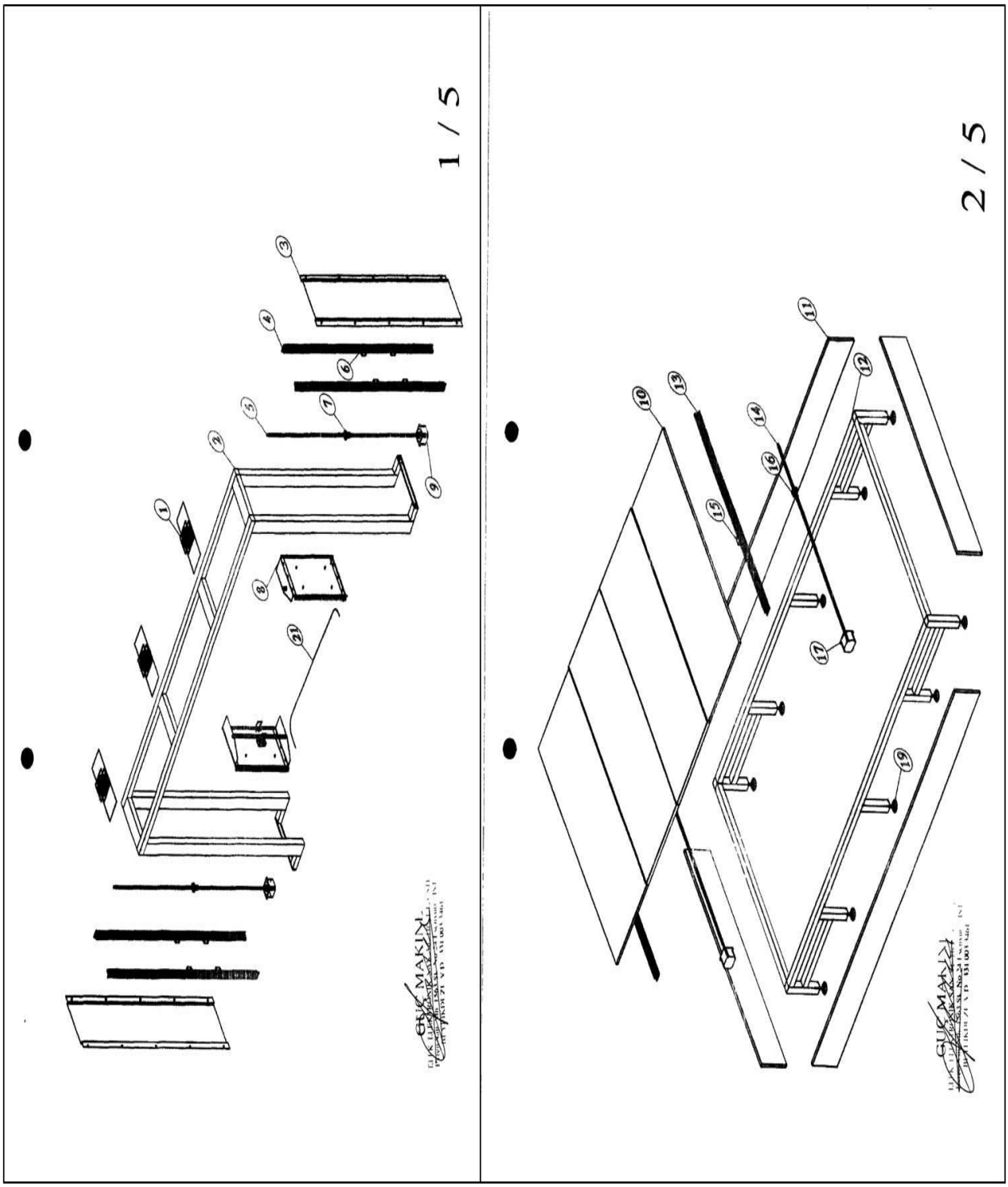
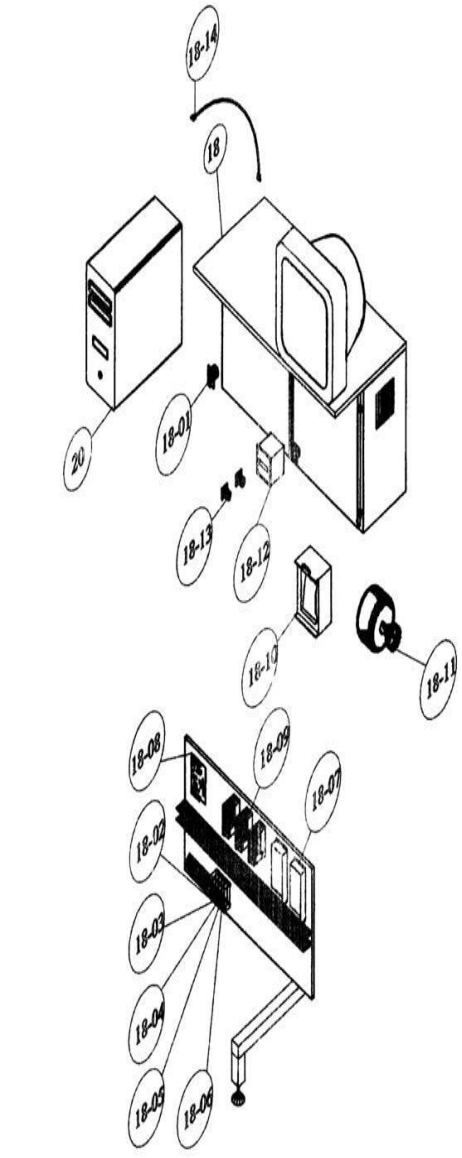


FIG. 8

Figure 8 2007/04961 'CNC Foam Cutting Machine'[W]

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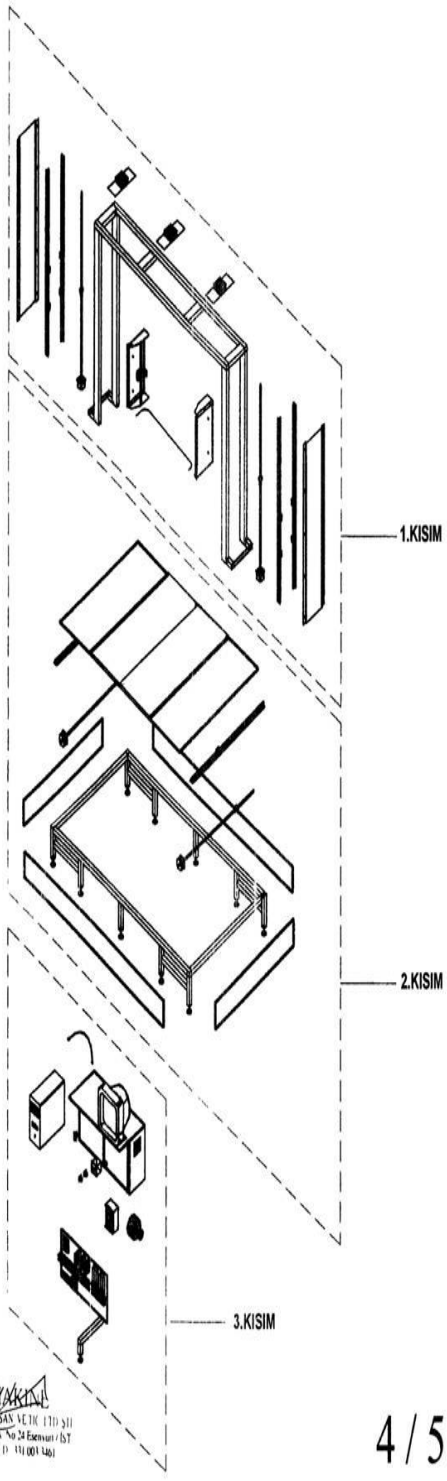
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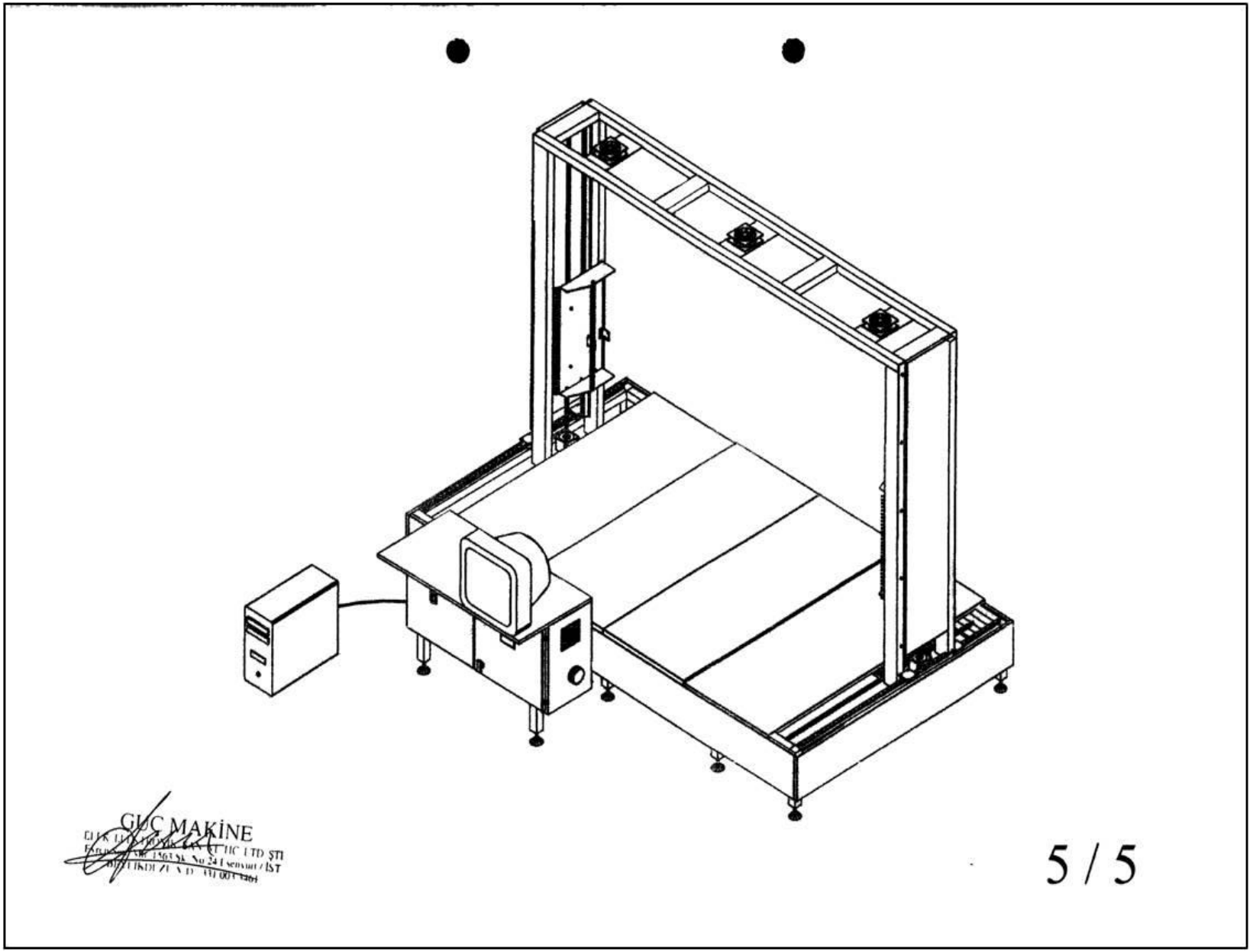
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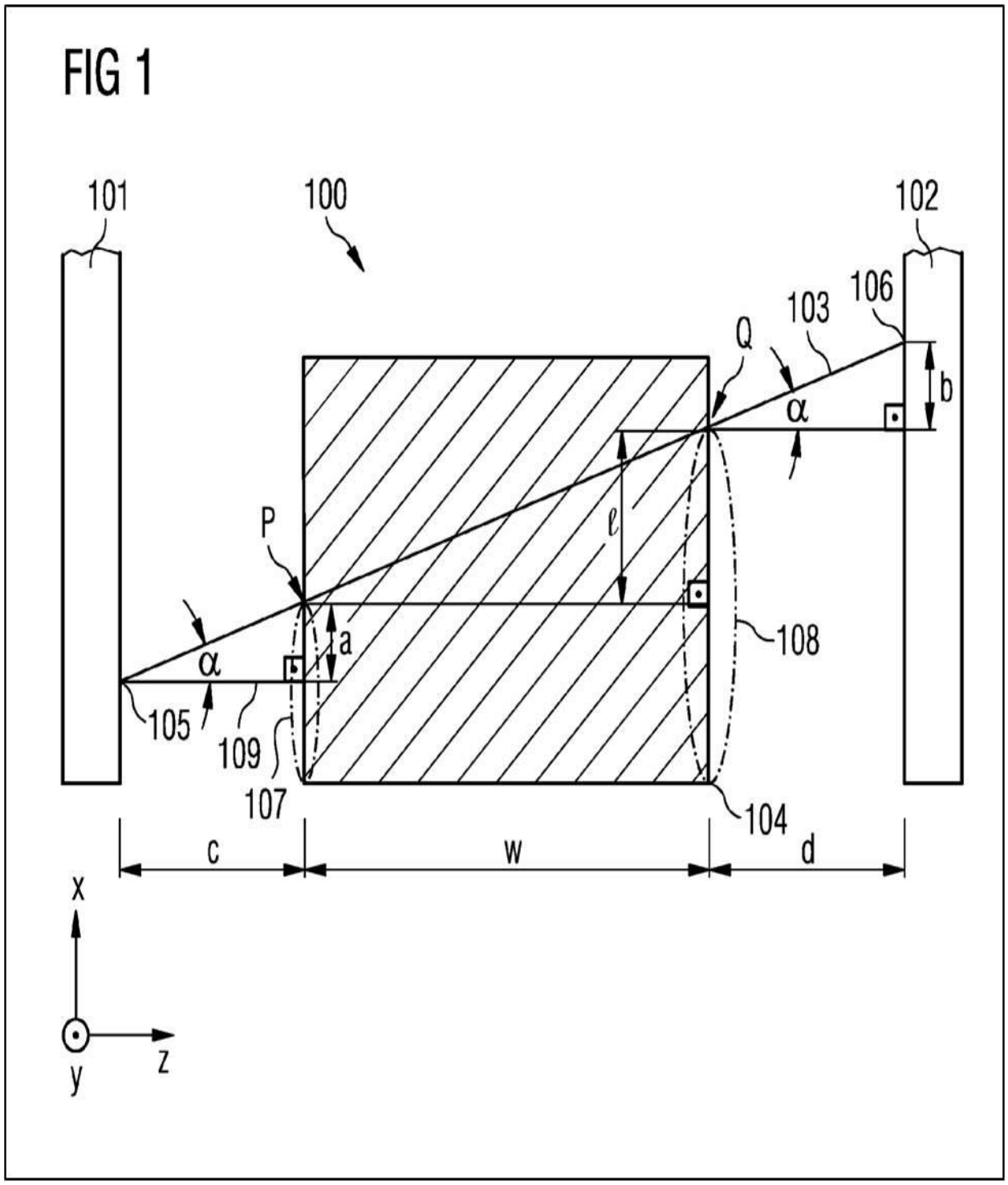
Figure 9 2007/04961 'Method of Producing Test Components by a Hot Wire Cutter'[Z]



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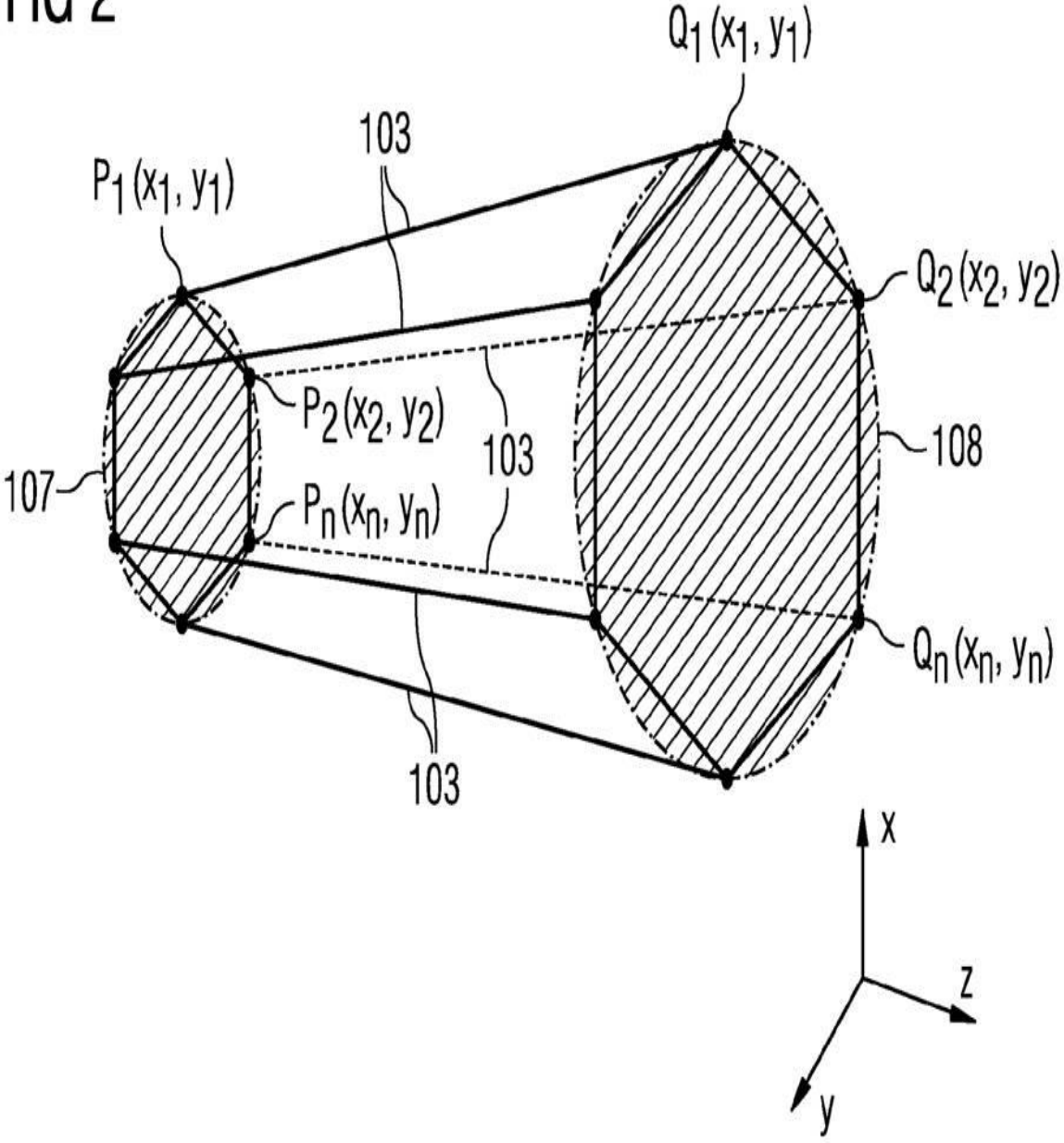
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