

# **DEVELOPMENT OF PROGRAM TO CONTROL THE 5<sup>th</sup> AXIS MOVEMENT OF THE TOOL OF A 5-AXIS MACHINING CENTRE**

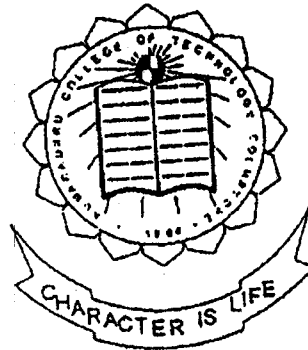
Thesis submitted in partial fulfillment of the requirements for the award of the  
degree of  
**MASTER OF ENGINEERING IN MECHANICAL ENGINEERING  
(INDUSTRIAL ENGINEERING)**  
Of BHARATHIAR UNIVERSITY

By  
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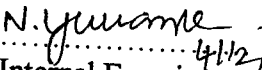
  
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Guide  
**Dr. V.GUNARAJ**

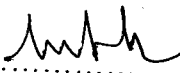
  
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Kumaraguru Colege of Technology on 04.12.2001

  
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Internal Examiner

  
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External Examiner

## CERTIFICATE

This is to certify that this thesis work entitled “**DEVELOPMENT OF PROGRAM TO CONTROL THE 5<sup>TH</sup> -AXIS MOVEMENT OF THE TOOL OF A 5-AXIS CNC MACHINING CENTRE**” being submitted by **C.NITHYANANDAM**

(Reg No.0037H0007) for the award of degree of **MASTER OF ENGINEERING IN MECHANICAL ENGINEERING (INDUSTRIAL ENGINEERING)**, is a bonafide work carried under my guidance. The results embodied in this thesis have not been submitted to any other University or Institute for award of any Degree or Diploma.

.....  
30.11.2009

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## SYNOPSIS

The CNC machining center is widely used in the manufacturing industry for machining the component. CNC machining center are available with different axis of control namely 2 to 5 axis. In 3-axis machining center, the axis like longitudinal, transverse and vertical axis are used. These axes are called as linear axis. The SiTarc 5-axis machining center has five axes. The first three axes are linear axis. The 4<sup>th</sup> - axis is rotary table along z-axis. The 5<sup>th</sup> axis is swivel movement of table. The first 4 axes are easily to run. In 5<sup>th</sup> -axis, the cutting head can operate simultaneously in all of its 5-axes. It is possible to produce 3D machined surfaces. It combines computer software with a 5-axis machining to quickly produce accurate complicated profiles like Globolodial Cam, Automatic tool changer, Turbine blade, Exhaust fan blade etc. in range of materials. In conventional 5-axis CNC Machining center, the 5<sup>th</sup> -axis is located on either in XY Plane or in XZ and YZ Plane. But the SiTarc 5-axis CNC machining center, the 5<sup>th</sup> -axis was difficult to run. Because the 5<sup>th</sup> axis are located in the inclined plane. The inclined plane is neither in XY plane nor in YZ and XZ plane. It is inclined at 45° to XY plane and XZ plane and perpendicular to the YZ plane. The existing software is capable only for generating CNC codes for conventional 5-axis CNC machining center. Hence, we develop the software to translate the existing format of conventional 5-axis CNC machining center in to SiTarc 5-axis CNC Machining center.

To correct the said problem, it is leant that the control of the 5<sup>th</sup> axis no way interfaced and controlled by the post processor. The only solution to rectify the same by developing a control program written in C - language using Mathematical relations between SiTarc and Conventional variables. The program uploaded in SiTarc 5-axis CNC machining center.

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## **1.Introduction to the Company**

### **1.1 SiTarc (SMALL INDUSTRIES TESTING AND RESEARCH CENTER)**

SiTarc is a non-governmental Organization serving small scale industries in and around Coimbatore in the field of calibration of instruments, Pump design and Testing, product development etc. They have undertaken many UNDP projects worth of few crores of rupees. They are the authorized certifying agency by National Board of Accreditation of Laboratory of India (NABC) and internationally approved center for testing of pump. It is located 7 Km from Coimbatore on the Coimbatore-Pollachi Main road, near SIDCO.

### **1.2 General Facilities:**

1. Reliable servo controlled stabilized power supply with standby generators.
2. Computerized operations
3. Reference technical library and database
4. Conference and classrooms
5. Multimedia studio

### **1.3 Major facilities:**

1. State of the art R& D for products and processes
2. Design and reverse engineering by CAD/CAM/CAE
3. Prototyping products and tools in model room
4. Quality testing lab backed by quality assurance system as required by NABL/ISO/IEC guide 25/BIS
5. State of the art metrology lab with temperature, humidity & dust controlled calibration areas
6. Computer based training for HRD
7. Consultancy and technical information

## **2.Introduction to the Project:**

CNC machining center is initially used in the manufacturing Industry for the machining of Box of Prismatic type components which are otherwise difficult to machinise. CNC machining centers are available with difficult axis of control namely, 2 to 5 axis. Now 12 axes CNC machining center is available. In 3axis machining center, the 3axis like longitudinal, transverse and vertical axis are used. In 4axis, similarly for all 3 axes, the 4<sup>th</sup> axis is in rotary movement of the table. In the 5 axis-machining center, the first 3 axis are linear axis. The 4<sup>th</sup> axis is rotary movement about X-axis. The 5<sup>th</sup> axis is rotary movement about Y-axis. This machine is called as conventional CNC 5 axis Machining center.

It combines computer software with a 5axis machining to quickly produce accurate 3 dimensional shapes, both large and small, in range of materials. These shape can be turned and used as the master tooling for Glass, Reinforced plastic parts, vacuum forming tools, foundry patterns and so on. As the cutting head can operate simultaneously in all of its 5 axes, it is possible to produce complex 3D machined surfaces using this technology. Trimming and cutting complex holes accurately on curved and irregularly shaped surfaces has always been difficult. However the 5axis-machining center can quickly trim and out complex holes into plastic parts on a production basis.

But the SiTarc, 5AXIS CNC MACHINING CENTRE is entirely different as compared to the conventional machining center. For all the 3axis are same. The 4<sup>th</sup> axis rotary movement is along Z-axis. The 5<sup>th</sup> axis are swiveling the table. The project, which I have undertaken is this type of machining center.



The 5-axis multi surface milling is to machining the turbine blade makes sense. The powerful tilting options are used to produce a better finish part of turbine; aerospace industry and power plants can be effectively finished with this program. In current version contains gauge checking of tool and shaft.

Say for example, turbine blade, complicated profile shape, impellers, Globodialcam etc. The following products are suitable examples of these 5-axis machining operations.

Axis in a  
Conventional  
5 axis Machining  
Center.

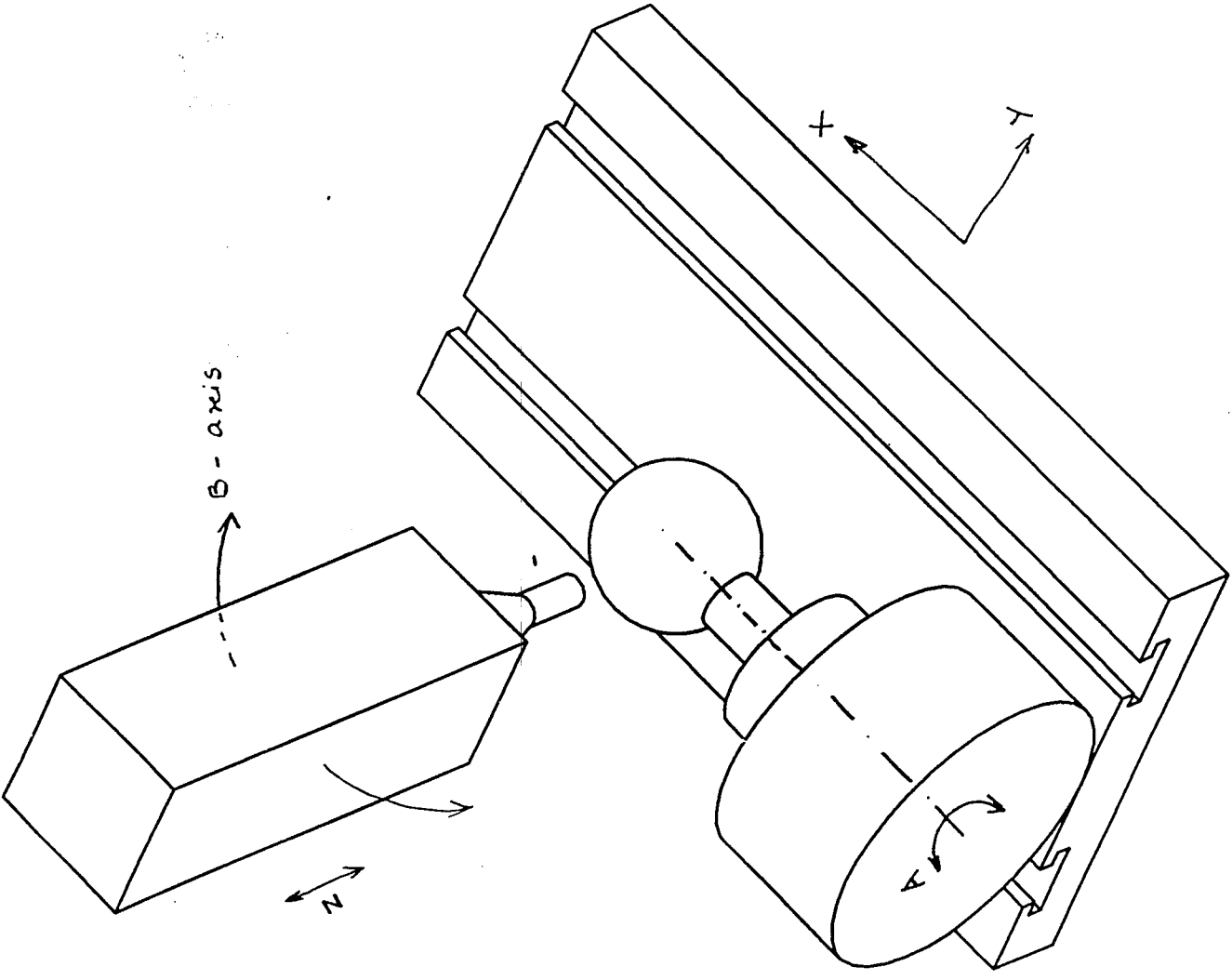
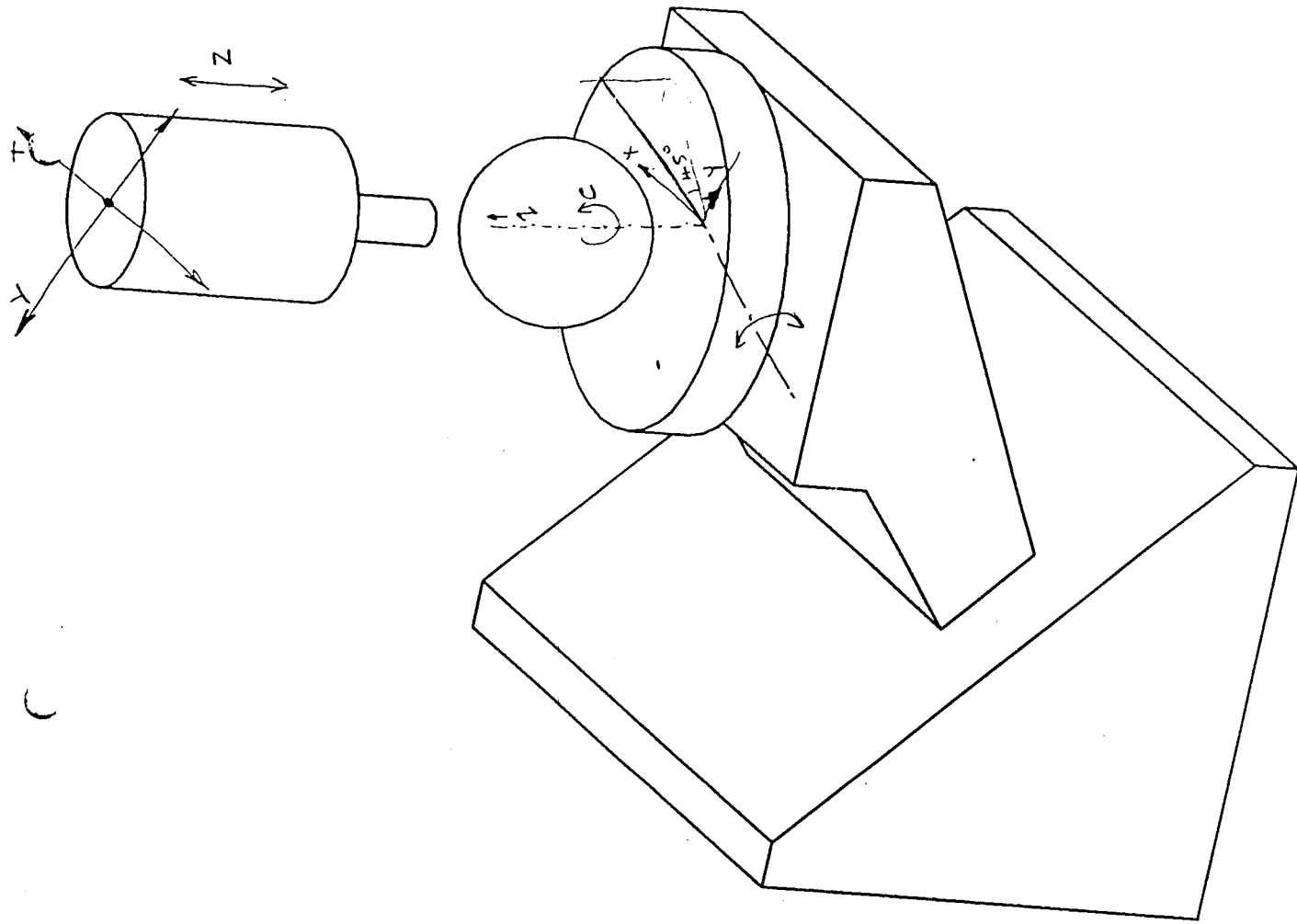
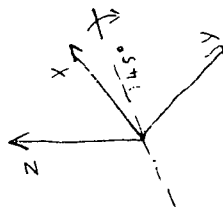


Fig. 1



Axis in a special Purpose  
5 axis Machining center.



## **2.1 Examples of Products manufacturing using 5-axis machining center.**

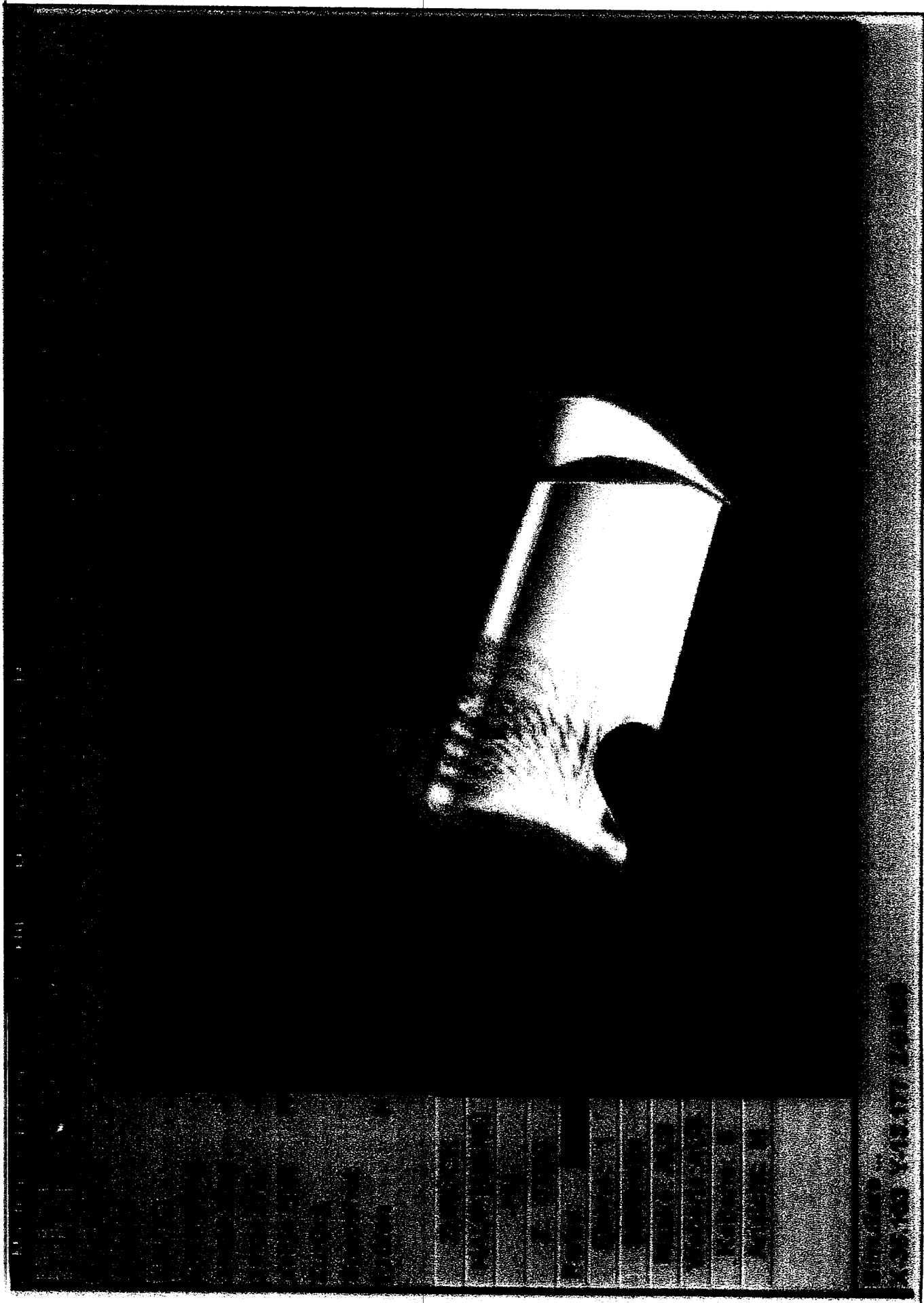


Fig.3

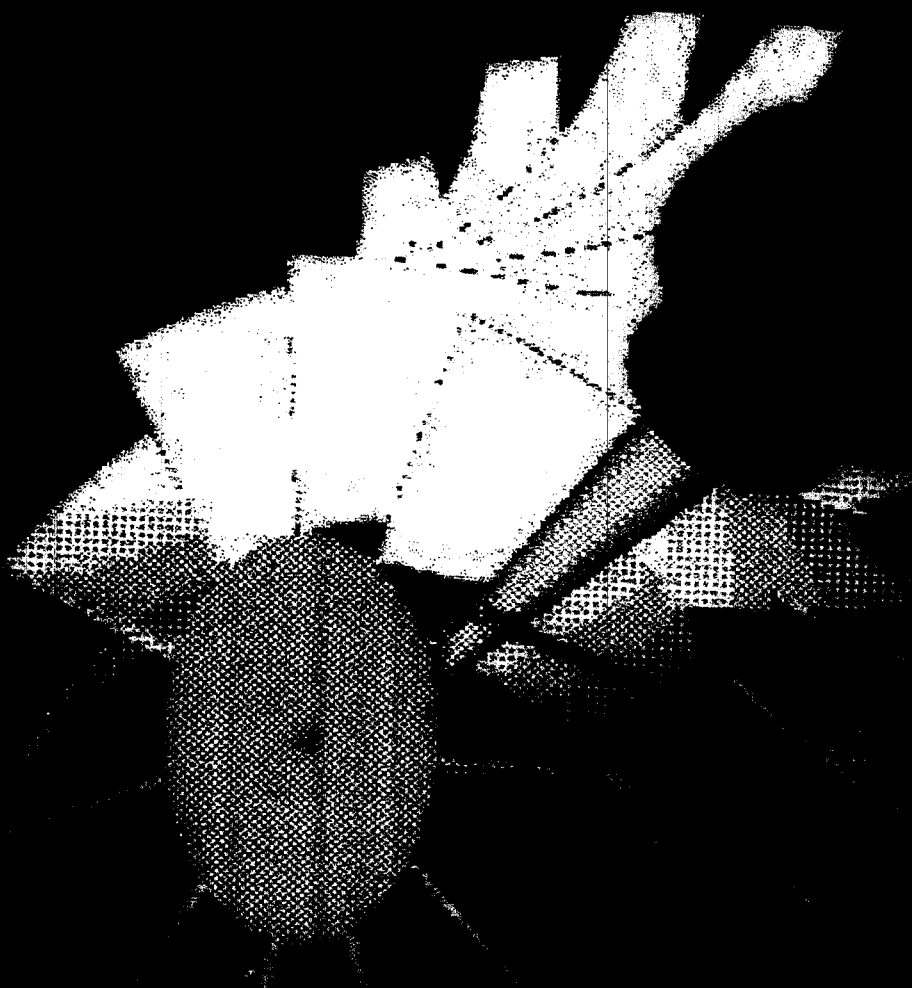


Fig.4 Gear profile

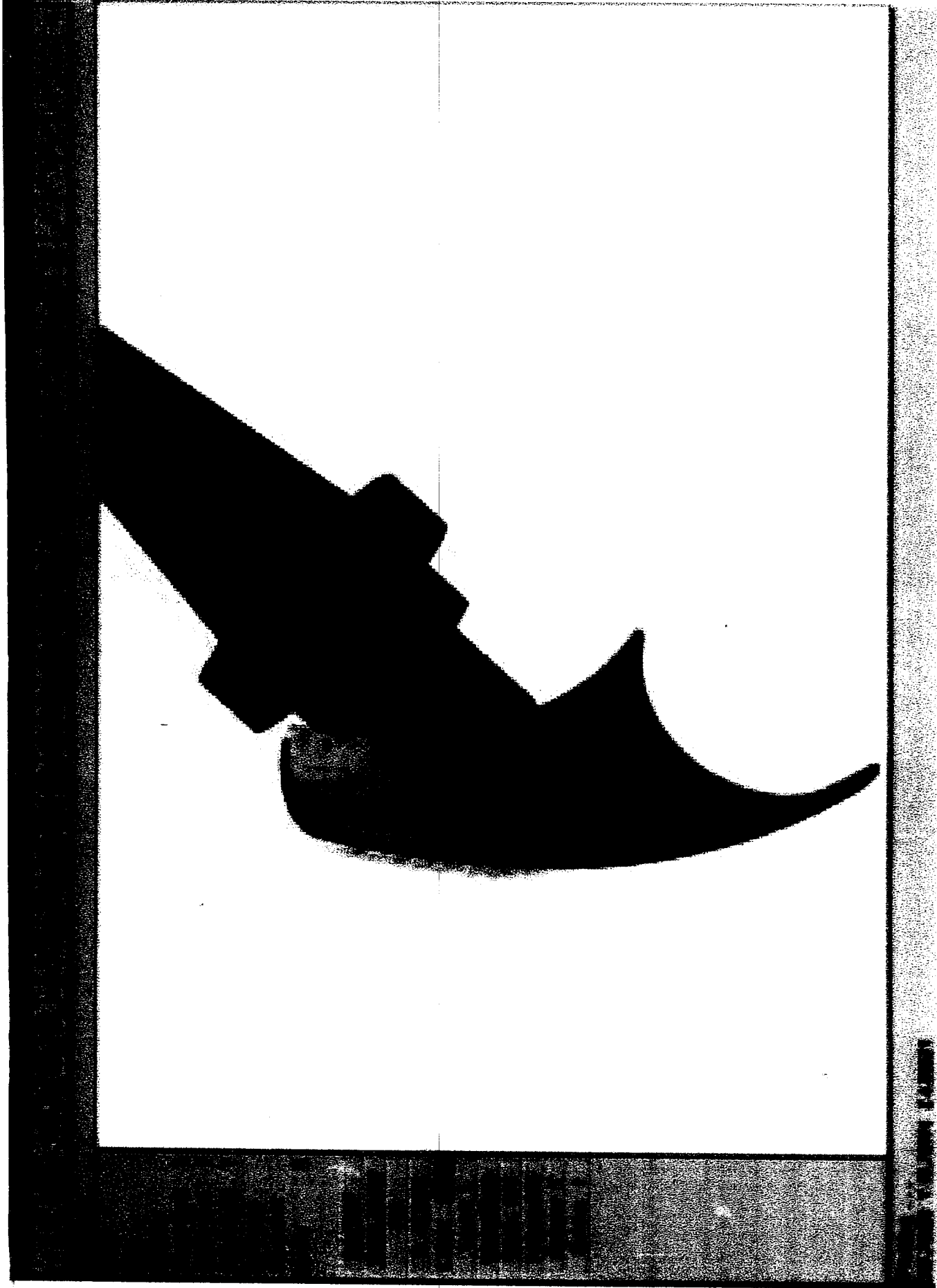


Fig.5 Turbine Blade

## 2.2 Machine details:

Machine : Universal milling and boring machine vertical with NC  
Rotary table with swivel movement.

Make : DECKEL MAHO

Model : DMU 50Y TNC426

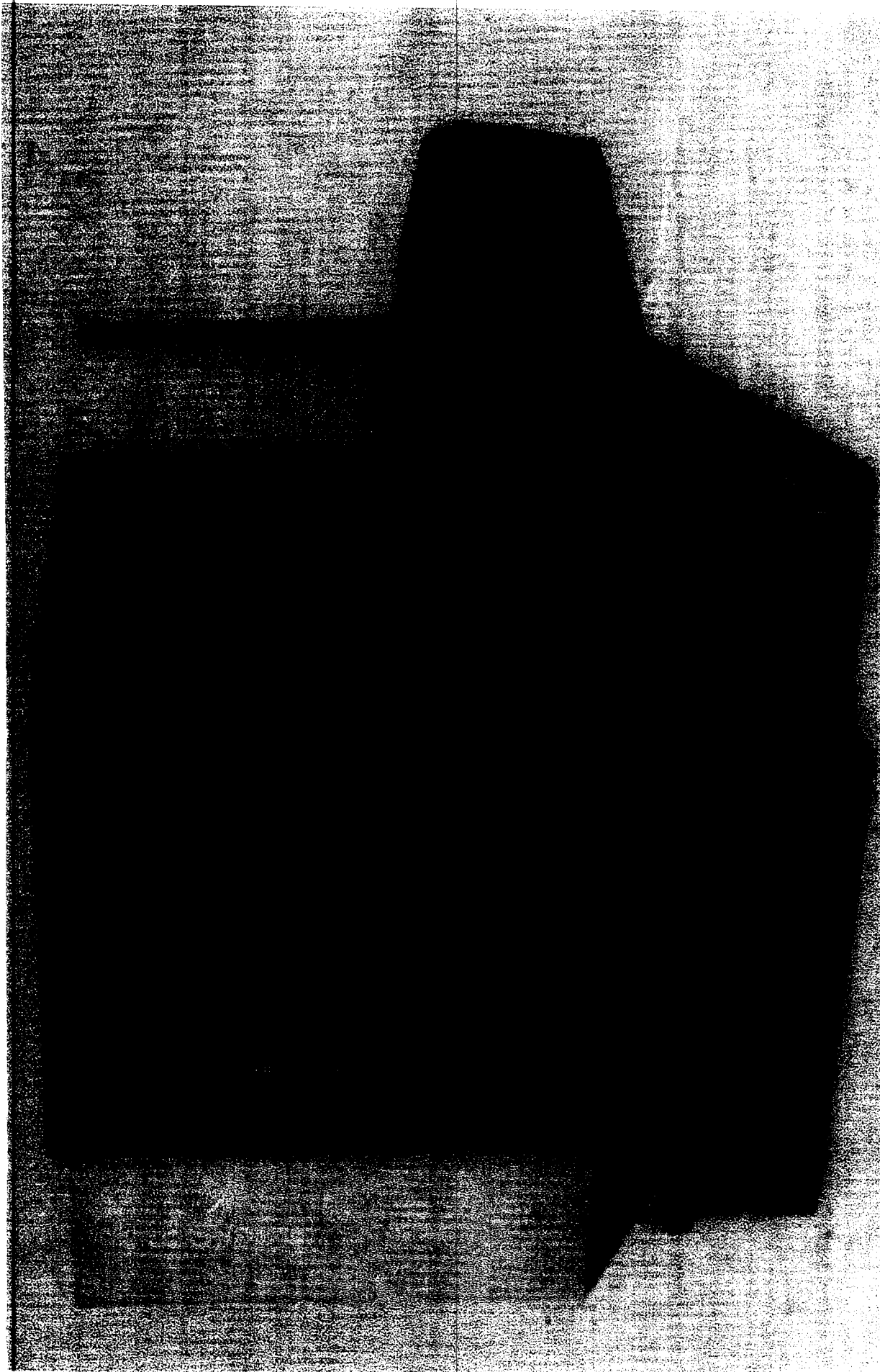
Speed : 3000rpm

Accuracy : <8microns

Axis : X, Y, Z, C, B

Where X, Y, Z are linear axis  
C is the rotary table along Z-axis  
B is swiveling axis





**5 Axis CNC Machining Centro**

**2.3 AXIS OF MOVEMENTS IN THE 5-AXIS CNC MACHINE CENTER  
AVAILABLE AT SiTarc**

**Top View**

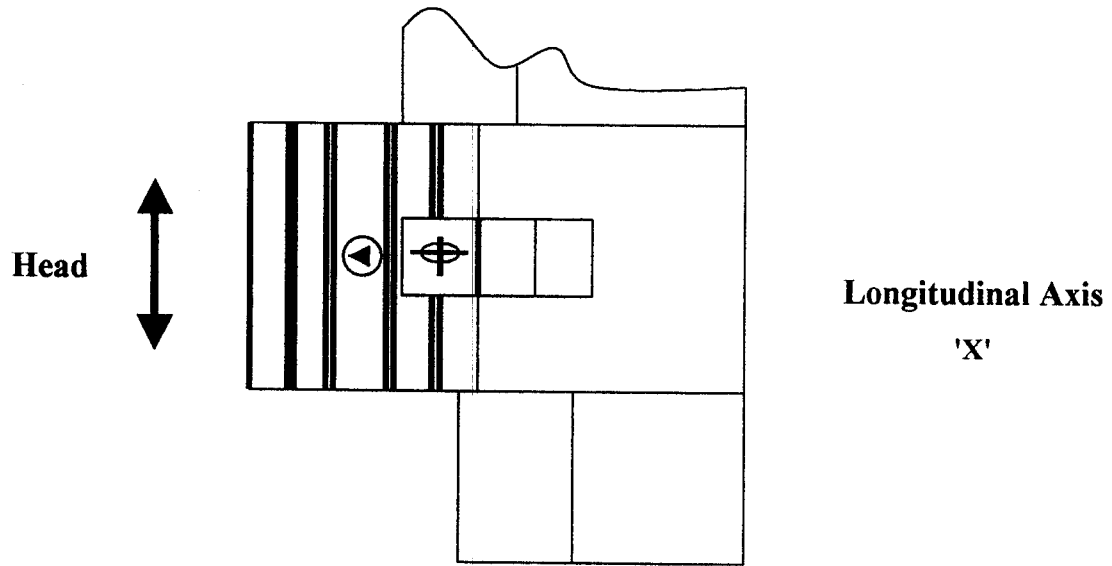
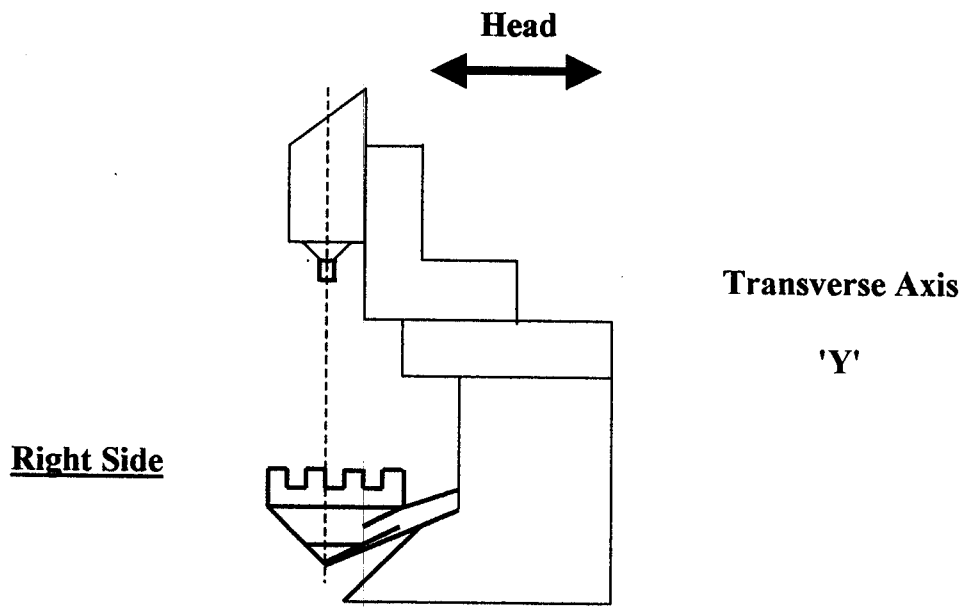


Fig.7



**Right Side**

Fig.8

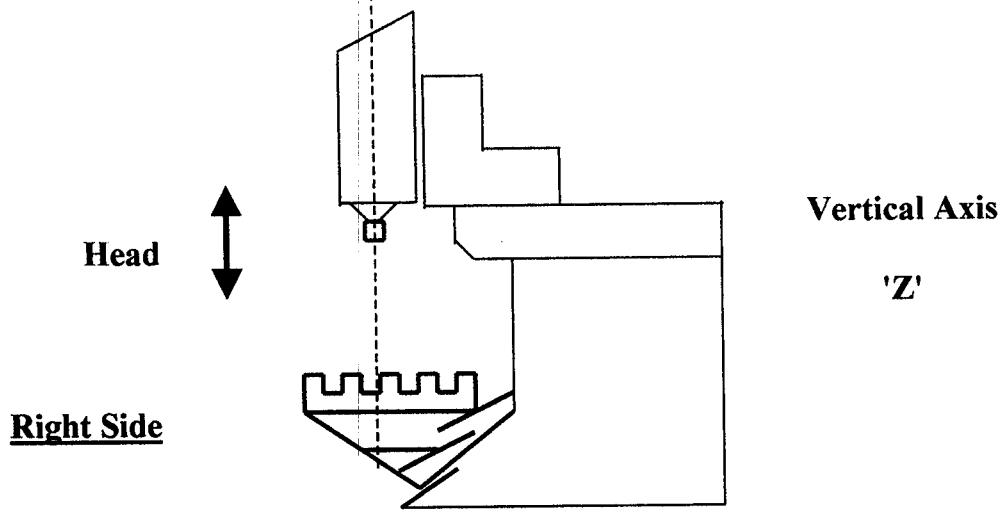


Fig.9

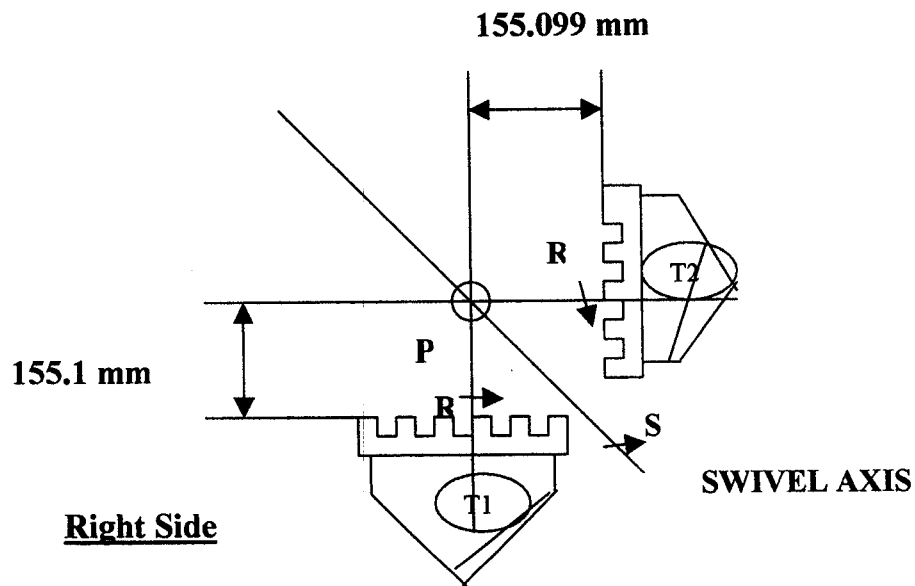


Fig.10

**T1 - Initial Table Position at B = 0**  
**T2 - Final Table Position at B = 180**

**R - The Rotary Axis**  
**S - Swivel Axis**  
**P - Pivot Point**

### 3. Problem definition:

For using 5axis CNC machining center, we can manufacture very complicated jobs like mixed flow impeller, Indexing Cam and Turbine Blades etc. For above-mentioned jobs, the tool movement should take place in the entire 5 axes.

Say for example the indexing cam, in order to get a profile shape in a job; the 5<sup>th</sup> axis is used for swiveling action. Due to this swiveling action the profiles can be obtained in the job. But to perform this swiveling action it was difficult to run the 5<sup>th</sup> axis.

Because the existing software is capable of generating CNC codes for machining a component in conventional 5axis CNC machining center, this CNC codes are with conventional axis namely X, Y, Z, A, B

Where X, Y, Z- Linear axis

A - Rotation about X-axis

B -Rotary movement about Y-axis

Here the rotary movement about Y-axis is either in XY plane or in YZ plane or in XZ plane.

But in SiTarc has a 5-axis machining center which is having axis namely X, Y, Z, C, B

Where X, Y, Z-Linear Axis

C -Rotary movement of table

-Swivel movement of table

Difference between the conventional and special purpose 5-axis CNC machining center:

Conventional 5-axis CNC Machining Center	Special purpose 5-axis CNC machining centre
<p>X,Y,Z – axis is linear axis</p> <p>The 4<sup>th</sup>-axis is rotary table about X-axis, This is called as A-axis</p> <p>The 5<sup>th</sup>-axis is rotary table about Y-axis. This is called as B-axis</p> <p>The 5<sup>th</sup>-axis are either in XY-plane or in YZ or XZ plane</p>	<p>X,Y,Z-axis is linear axis</p> <p>The 4<sup>th</sup>-axis is rotary table along the Z-axis</p> <p>The 5<sup>th</sup>-axis are swivel movement of table about Y-axis. This is called as B-axis.</p> <p>The 5<sup>th</sup> axis is neither in XY-plane nor in YZ or XZ plane. It is inclined at 45° to XY and XZ plane. And also perpendicular to YZ plane.</p>

The inclined plane (OADE) is making 45° to XY plane and inclined at 45° to XZ plane and perpendicular to YZ plane. The B-axis is located in the inclined plane. If the coordinates of cutter center with respect to XY plane is given the corresponding values of the inclined plane is changed with respect to the inclined plane. Hence, the 5<sup>th</sup> axis is difficult to run.

Hence, the developing software to translate the existing 5axis CNC machine language in to the CNC language is suitable for a special purpose 5axis-machining center.

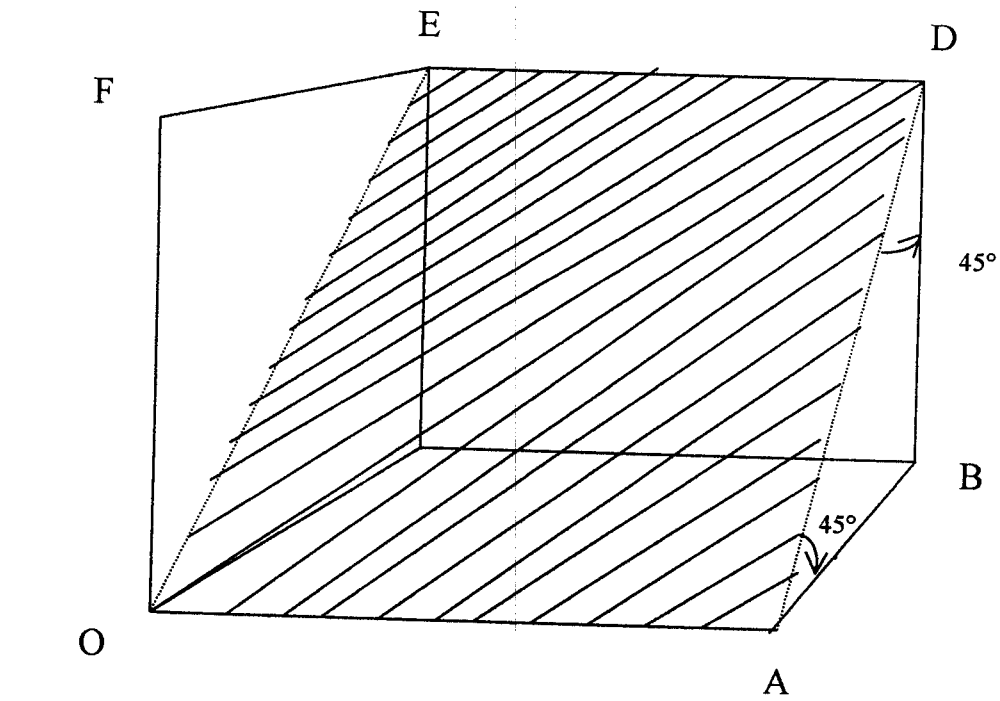
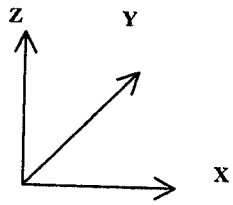


Fig.11



Let  $OABE = XY$  Plane  
 $BCED = XZ$  Plane  
 $OCEF = YZ$  Plane  
 $OADE =$  Inclined Plane

Axis in a  
Conventional  
5 axis Machining  
Center.

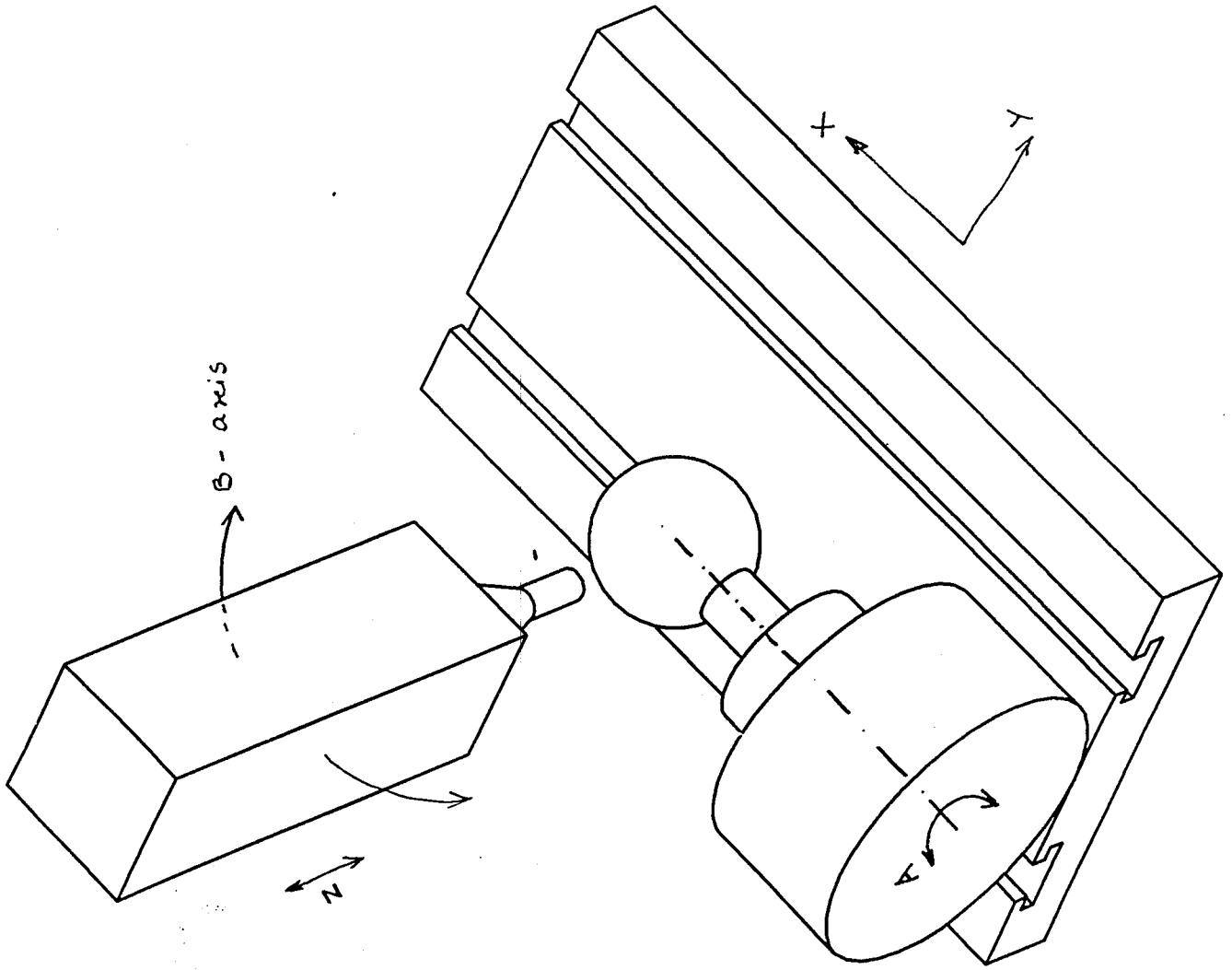


Fig. 1



Axis in a special Purpose  
5 axis Machining center.

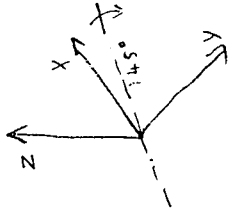
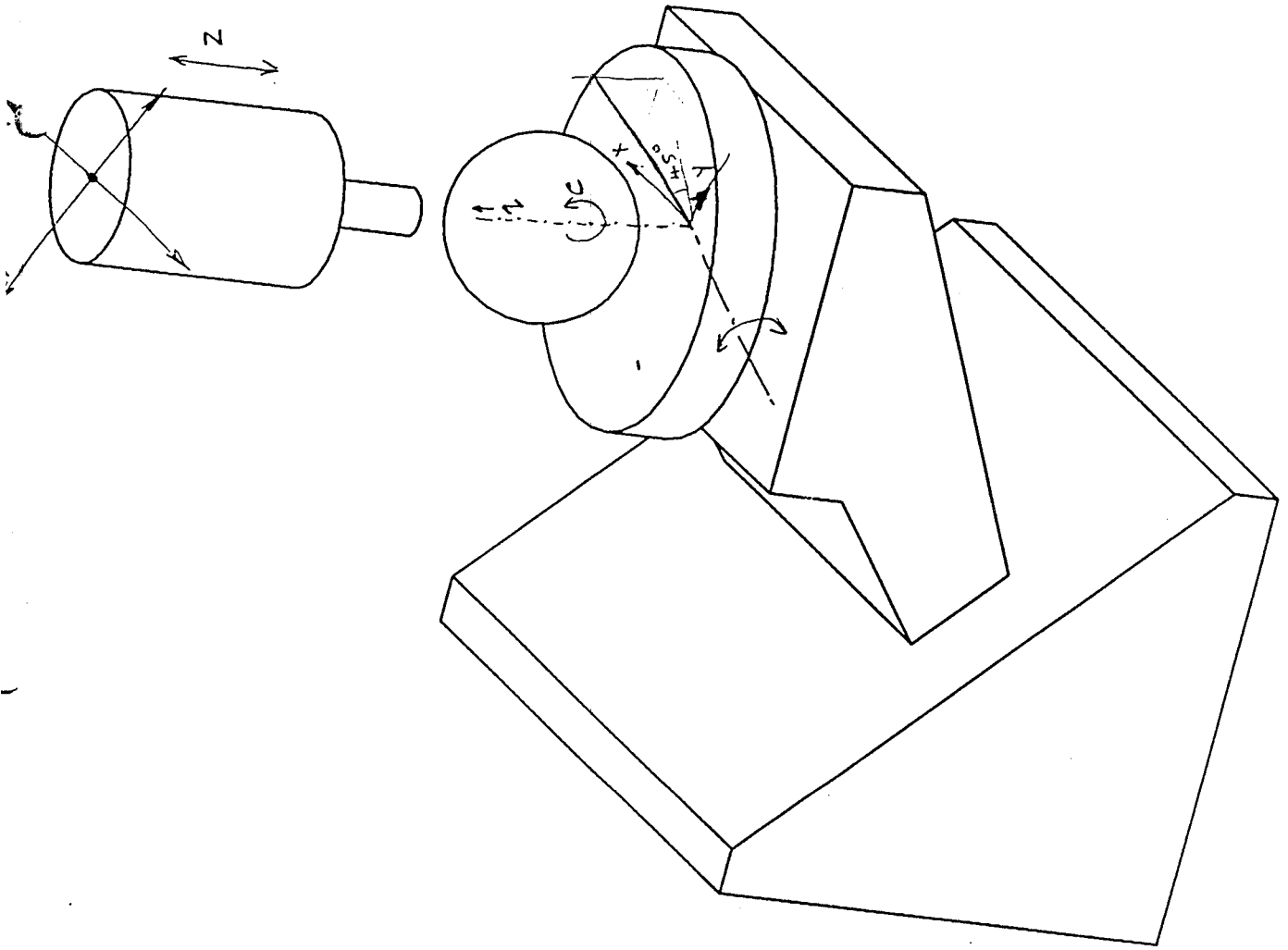


Fig. 2

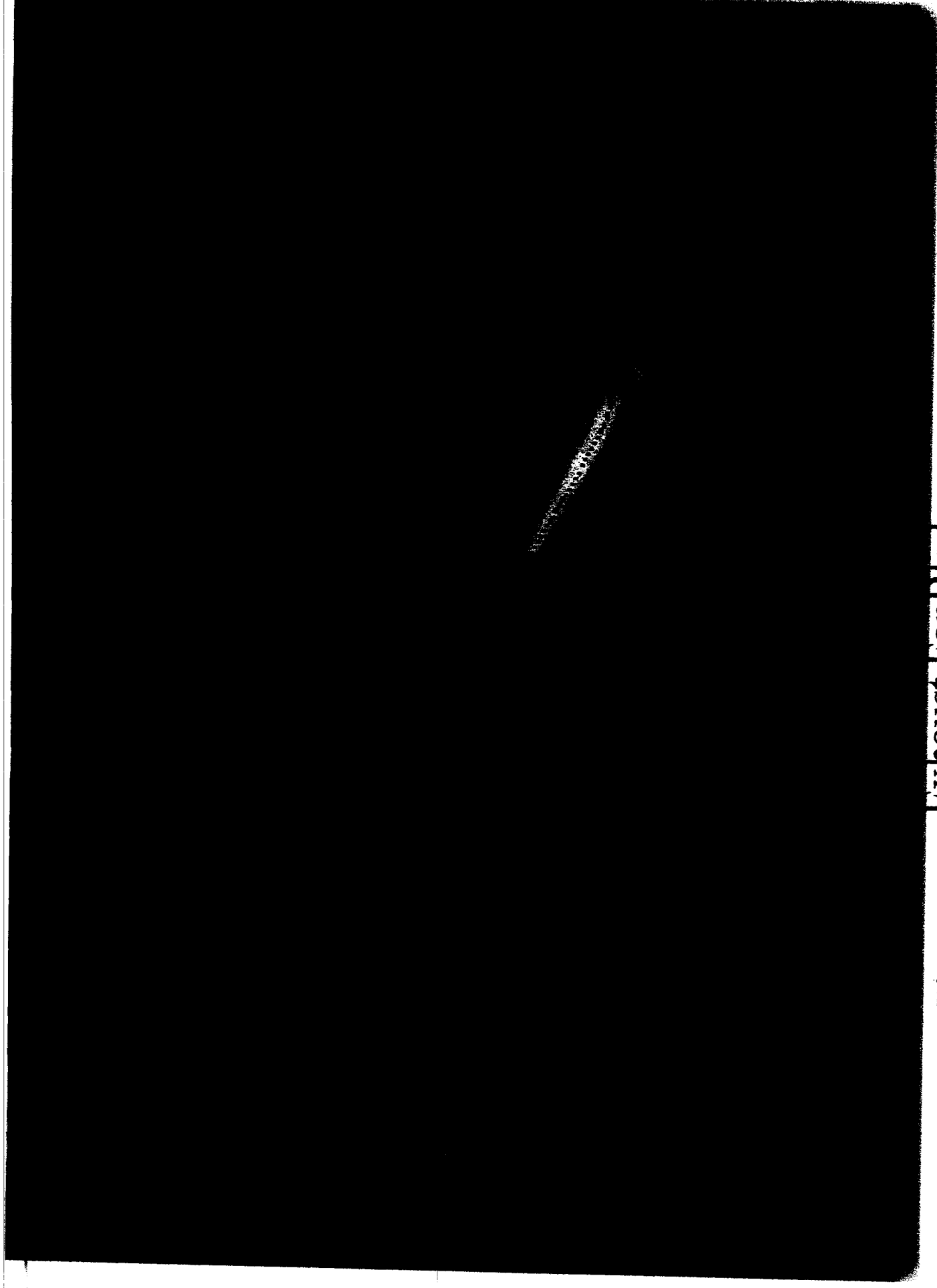


Fig.14

Exhaust FanBlade

Existing format of conventional machine:

```

0 BEGIN PGM 5NAV-ROT1 MM
1 BLK FORM 0.1 Z X-300 Y-300 Z-100
2 BLK FORM 0.2 X+300 Y+300 Z+0
3 TOOL CALL 9 Z S2500
4 X0. Y0. C0. B0. F MAX M03
5 L Z250.0 F MAX
8 L X-44.9239 Y-12.202 Z237.798 C305.345 B42.026 F MAX
9 L X-7.0266 Y45.1387 Z255.0 F MAX
10 L X-3.0197 Y46.227 Z255.0 F MAX
11 G01 L X-3.0196 Z209.4693 F500
12 L X-3.8817 Y44.9912 Z210.1837 C306.593 B43.78
13 L X-4.7215 Y43.8636 Z210.776 C307.538 B45.312
14 L X-5.5158 Y42.8331 Z211.2681 C308.232 B46.643
15 L X-6.2522 Y41.8904 Z211.6774 C308.715 B47.794
16 L X-6.9254 Y41.0278 Z212.0183 C309.016 B48.78
17 L X-7.5335 Y40.2386 Z212.3025 C309.16 B49.619
18 L X-8.0771 Y39.5164 Z212.5396 C309.167 B50.323
19 L X-8.5582 Y38.8559 Z212.7377 C309.054 B50.905
20 L X-8.9792 Y38.2516 Z212.9034 C308.834 B51.377
21 L X-9.3426 Y37.6986 Z213.0428 C308.521 B51.748
22 L X-9.6508 Y37.1917 Z213.1609 C308.126 B52.028
23 L X-9.9059 Y36.726 Z213.2623 C307.661 B52.224
24 L X-10.1095 Y36.2965 Z213.3511 C307.135 B52.344
25 L X-10.2656 Y35.8993 Z213.4301 C306.556 B52.396
26 L X-10.3809 Y35.5317 Z213.5003 C305.928 B52.388
27 L X-10.462 Y35.1913 Z213.5624 C305.255 B52.327
28 L X-10.5153 Y34.8749 Z213.6174 C304.54 B52.222
29 L X-10.5467 Y34.5796 Z213.6659 C303.788 B52.079
30 L X-10.5616 Y34.3019 Z213.7091 C303.003 B51.907
31 L X-10.5653 Y34.0382 Z213.7479 C302.192 B51.713
32 L X-10.5624 Y33.7845 Z213.7835 C301.359 B51.505
33 L X-10.5572 Y33.5367 Z213.8174 C300.513 B51.29
34 L X-10.5535 Y33.2902 Z213.851 C299.66 B51.077
35 L X-10.5547 Y33.0403 Z213.886 C298.808 B50.873
36 L X-10.5634 Y32.7819 Z213.9243 C297.967 B50.685
37 L X-10.5815 Y32.5102 Z213.9677 C297.145 B50.52
38 L X-10.6071 Y32.224 Z214.0173 C296.346 B50.379
39 L X-10.6366 Y31.9238 Z214.0734 C295.571 B50.258
40 L X-10.6669 Y31.6105 Z214.136 C294.817 B50.154
41 L X-10.6946 Y31.2848 Z214.2055 C294.086 B50.063
42 L X-10.7174 Y30.9478 Z214.2816 C293.377 B49.981
43 L X-10.7323 Y30.6008 Z214.3643 C292.686 B49.906
44 L X-10.7371 Y30.2449 Z214.4534 C292.014 B49.834
45 L X-10.7296 Y29.8815 Z214.5486 C291.358 B49.76
46 L X-10.7081 Y29.5121 Z214.6496 C290.715 B49.683
47 L X-10.6707 Y29.1382 Z214.7559 C290.084 B49.599
48 L X-10.6158 Y28.7614 Z214.8672 C289.462 B49.503
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52 L X-10.2452 Y27.2447 Z215.346 C287.01 B49.003
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54 L X-10.0527 Y26.4724 Z215.591 C285.8 B48.753
55 L X-9.9782 Y26.0786 Z215.7115 C285.2 B48.651
56 L X-9.9265 Y25.6778 Z215.8299 C284.604 B48.574
57 L X-9.9038 Y25.2681 Z215.9455 C284.016 B48.528
58 L X-9.9157 Y24.8478 Z216.0578 C283.437 B48.52
59 L X-9.9679 Y24.4146 Z216.1663 C282.869 B48.558
60 L X-10.0651 Y23.9662 Z216.2705 C282.315 B48.647
61 L X-10.2124 Y23.4998 Z216.3699 C281.779 B48.795
62 L X-10.4119 Y23.013 Z216.4641 C281.264 B49.006
63 L X-10.6547 Y22.5064 Z216.5539 C280.771 B49.272
64 L X-10.9275 Y21.9823 Z216.6402 C280.298 B49.579
65 L X-11.218 Y21.4431 Z216.7239 C279.842 B49.915
66 L X-11.5146 Y20.8922 Z216.806 C279.4 B50.265
67 L X-11.8063 Y20.3332 Z216.8874 C278.968 B50.616

```

ROT1

68	L	X-12.0829	Y19.7699	Z216.9689	C278.542	B50.955
69	L	X-12.335	Y19.2068	Z217.0517	C278.116	B51.27
70	L	X-12.5538	Y18.6489	Z217.1366	C277.684	B51.548
71	L	X-12.7307	Y18.1009	Z217.2248	C277.239	B51.776
72	L	X-12.8579	Y17.5685	Z217.3174	C276.775	B51.942
73	L	X-12.9279	Y17.0571	Z217.4153	C276.284	B52.033
74	L	X-12.9338	Y16.5723	Z217.5196	C275.758	B52.037
75	L	X-12.8798	Y16.1149	Z217.6295	C275.194	B51.957
76	L	X-12.781	Y15.6808	Z217.7431	C274.595	B51.81
77	L	X-12.6517	Y15.2653	Z217.8582	C273.966	B51.613
78	L	X-12.5065	Y14.8634	Z217.9728	C273.31	B51.384
79	L	X-12.3592	Y14.4698	Z218.0851	C272.635	B51.14
80	L	X-12.2233	Y14.0787	Z218.1935	C271.946	B50.9
81	L	X-12.1122	Y13.6839	Z218.2962	C271.251	B50.681
82	L	X-12.039	Y13.2789	Z218.3918	C270.56	B50.502
83	L	X-12.0165	Y12.8566	Z218.4789	C269.882	B50.382
84	L	X-12.0565	Y12.4092	Z218.5559	C269.23	B50.339
85	L	X-12.1705	Y11.9284	Z218.6211	C268.614	B50.391
86	L	X-12.3689	Y11.4053	Z218.6725	C268.05	B50.556
87	L	X-12.65	Y10.8356	Z218.7095	C267.543	B50.838
88	L	X-12.9924	Y10.225	Z218.7344	C267.09	B51.21
89	L	X-13.3734	Y9.5814	Z218.7501	C266.68	B51.645
90	L	X-13.7721	Y8.9135	Z218.7593	C266.303	B52.116
91	L	X-14.1692	Y8.2311	Z218.7653	C265.947	B52.595
92	L	X-14.5471	Y7.5448	Z218.7718	C265.598	B53.056
93	L	X-14.8895	Y6.8663	Z218.7827	C265.242	B53.474
94	L	X-15.1814	Y6.2077	Z218.8025	C264.862	B53.823
95	L	X-15.4083	Y5.5821	Z218.8361	C264.441	B54.078
96	L	X-15.5561	Y5.0038	Z218.8887	C263.96	B54.213
97	L	X-15.6099	Y4.4878	Z218.9658	C263.398	B54.201
98	L	X-15.5536	Y4.0508	Z219.0733	C262.73	B54.012
99	L	X-15.379	Y3.7044	Z219.2144	C261.936	B53.629
100	L	X-15.1075	Y3.441	Z219.3851	C261.018	B53.08
101	L	X-14.7664	Y3.2473	Z219.5794	C259.988	B52.405
102	L	X-14.3842	Y3.1085	Z219.791	C258.858	B51.645
103	L	X-13.9917	Y3.0076	Z220.0136	C257.648	B50.846
104	L	X-13.6229	Y2.9245	Z220.241	C256.383	B50.06
105	L	X-13.3151	Y2.8355	Z220.4671	C255.099	B49.342
106	L	X-13.1078	Y2.7125	Z220.6861	C253.841	B48.753
107	L	X-13.0419	Y2.5234	Z220.8921	C252.664	B48.356
108	L	X-13.1571	Y2.2313	Z221.0786	C251.636	B48.215
109	L	X-13.4896	Y1.7959	Z221.2372	C250.828	B48.391
110	L	X-14.0688	Y1.1754	Z221.3566	C250.311	B48.939
111	L	X-14.0684	Y1.1434	Z216.5957	C250.378	B48.956
112	L	X-13.8643	Y1.6749	Z216.4231	C250.928	B48.851
113	L	X-13.7405	Y2.1552	Z216.2438	C251.562	B48.867
114	L	X-13.6871	Y2.594	Z216.0608	C252.264	B48.987
115	L	X-13.6931	Y3.0006	Z215.8766	C253.016	B49.193
116	L	X-13.7473	Y3.384	Z215.6936	C253.802	B49.464
117	L	X-13.838	Y3.7526	Z215.5137	C254.608	B49.783
118	L	X-13.9533	Y4.1142	Z215.3388	C255.42	B50.128
119	L	X-14.0813	Y4.4762	Z215.1708	C256.226	B50.482
120	L	X-14.2103	Y4.8453	Z215.0115	C257.018	B50.825
121	L	X-14.3283	Y5.228	Z214.8627	C257.785	B51.14
122	L	X-14.4234	Y5.6301	Z214.726	C258.521	B51.407
123	L	X-14.4837	Y6.0569	Z214.6033	C259.22	B51.609
124	L	X-14.4991	Y6.5121	Z214.4958	C259.879	B51.733
125	L	X-14.4717	Y6.9926	Z214.4021	C260.504	B51.784
126	L	X-14.4078	Y7.4931	Z214.32	C261.102	B51.774
127	L	X-14.313	Y8.0088	Z214.2473	C261.681	B51.713
128	L	X-14.1937	Y8.5348	Z214.1819	C262.247	B51.614
129	L	X-14.0562	Y9.0668	Z214.1217	C262.806	B51.487
130	L	X-13.9068	Y9.6005	Z214.0648	C263.364	B51.343
131	L	X-13.7524	Y10.1319	Z214.0093	C263.925	B51.194
132	L	X-13.6003	Y10.6573	Z213.9534	C264.494	B51.05
133	L	X-13.4578	Y11.1735	Z213.8953	C265.074	B50.922
134	L	X-13.333	Y11.6774	Z213.8332	C265.669	B50.821
135	L	X-13.234	Y12.1661	Z213.7653	C266.28	B50.759
136	L	X-13.1686	Y12.6374	Z213.6901	C266.91	B50.744
137	L	X-13.1365	Y13.0928	Z213.6076	C267.555	B50.775
138	L	X-13.1324	Y13.5358	Z213.519	C268.21	B50.843

#### 4.1 FLOWCHART:

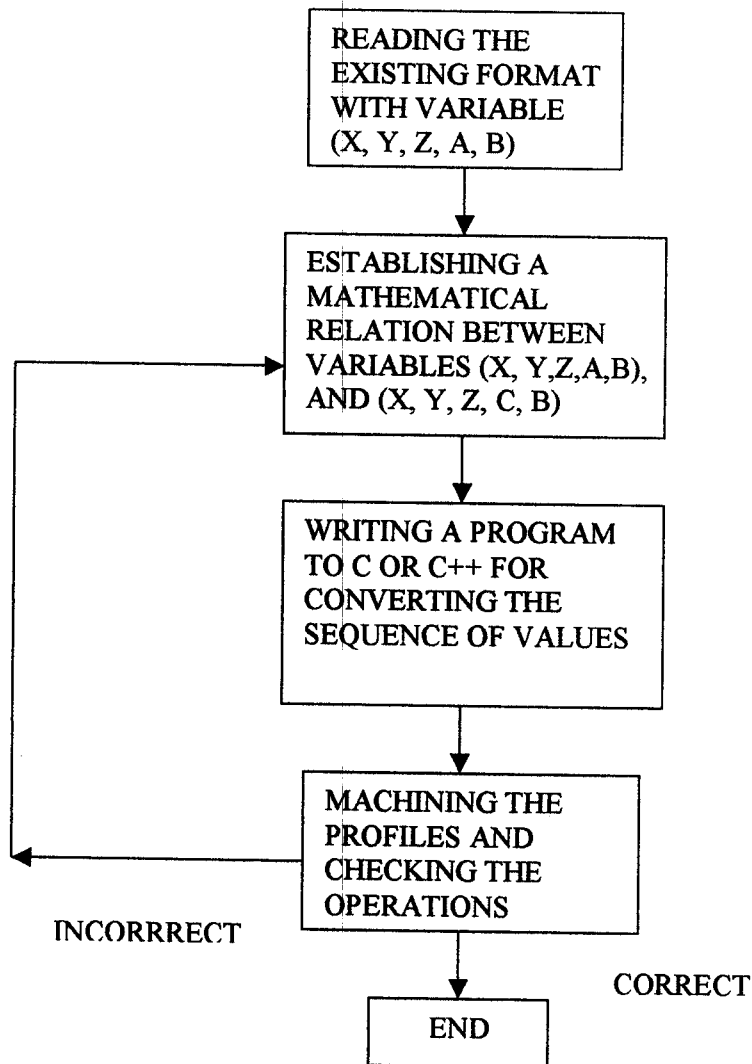


FIG.15

Flowchart showing Solution proposed and activity sequence

## 4.2 Existing format:

The SiTrac 5-axis CNC machining center, the 5<sup>th</sup>-axis is entirely different as compared to the conventional CNC machining center previously. The 5<sup>th</sup>-axis was difficult to run. Because the existing format is capable of generating the CNC codes for machining the component is only in the conventional 5-axis CNC machining center. But this existing format is not suited to the special purpose machine.

Say for example, using the Mastercam software makes the exhaust fan blade operations. This software is automatically produce the postprocessor is nothing but the output of the NC codes. This existing format is connected to the machine. But due to this operation, the special purpose machine is not to run the fifth axis. In fan blade using this 5<sup>th</sup> axis makes the profiles. But it was difficult to run. Because this existing format of this programmed variable as (X, Y, Z, C, B). The exhausting fan blade is created by using Master cam software and also to get the existing format. The models and existing format are given below.

## 4.3 Mathematical relations:

The special purpose CNC-5axis machining center, the 5<sup>th</sup> axis is neither in XY plane nor YZ plane or XZ plane. The 5<sup>th</sup> axis is located in the inclined plane. The inclined is 45 degree to XY plane and XZ plane and perpendicular to the YZ plane. But the conventional plane is neither in XY plane or in XZ plane or in YZ plane.

If the coordinates of the cutter center is given with respect to given XY plane, the corresponding value of the inclined plane are calculated by using this Mathematical model. The mathematical model should create the corresponding values of cutter center in inclined plane.

Hence the mathematical model are created in relation between the conventional CNC machining center variables (X, Y, Z, A, B) and special purpose CNC machining center variables (X, Y, Z, C, B).

## 4.3 C or C++ Programmed:

The C- Programmes are to translate the existing format of the conventional CNC machining center (X, Y, Z, A, B) in to the special purpose CNC machining center (X, Y, Z, C, B). The programmers are prepared manually. The existing format of the file name and mathematical equation are to enter into the program. The output format is converted into the special purpose machine in existing format. These Programmes are entered into the machine. This output will run the 5<sup>th</sup> axis of the special purpose in the CNC machining center.

#### **4.4 Machining and checking process:**

Connect the output of the program to the machine and then check the machining operations. For example, the turbine blade is to finish the operations and to make the complex profiles. This complex profiles are checked. The machining operations should run easily in the 5<sup>th</sup> axis. Because this type of profiles are made easily in the 5<sup>th</sup>-axis. If it is correct, the operations are stopped. If the 5<sup>th</sup> axis is not run easily, we modify the mathematical relations and continue to the same procedures.

## 5. Tools Used to Solve the Problem:

The following tools are to solve the problem.

1. Master Cam
2. Mathematical Model
3. C-Program

### 5.1 Master Cam:

Mastercam is an integrated CAD/CAM Software package that operates in the Microsoft Windows 95 and Windows Nt environments. We can create geometry and preparing engineering details, finished blueprints, graphical tool paths and CNC code. Master Cam offers solutions for 2 through 5 axis machining, turning, wireEDM and 3D design.

Mastercam's full associativity gives you the power to capture your knowledge and build on your experience. Once you program a part - any part - you can modify any element of the job and immediately get updated toolpaths without starting over. And Mastercam's intelligent NC programming lets you build a library of machining strategies done the way you want them. Just choose saved operations and apply them to a part, and Mastercam adapts them to the new model. Fast, easy and productive. The way programming should be.

#### Powerful Part Modeling

- Easy 2D and 3D geometry creation with multiple ways to create entities.
- Fast creation of a wide range of NURBS and parametric surfaces.
- Flexible surface filleting offers constant radius fillets and point-and-click variable radius fillets.
- Automatic parting line calculation for mold making.
- Associative dimensions update as you change your model.
- Quickly translate, mirror, scale, rotate and offset entities.
- Extensive editing tools ensure your model is exact.
- Dynamic rotation, panning, zooming in multiple views.
- AutoCursor™ snaps to commonly used points.
- User-definable drafting grid simplifies detailed construction.
- Measure minimum and maximum curvature radius, and calculate surface area for single or multiple surfaces.
- Analyze single points, between points, angles and entire entities

#### Powerful Roughing

Fast, efficient bulk material removal is essential to efficient NC programming. Mastercam gives you a variety of techniques to rough all of your parts.

- Rough cut multiple surfaces, solid models, or a combination of both.
- Rough cut with constant Z contours or pockets.
- Rough cut by descending parallel or radial cuts, with complete control over plunging with positive and negative Z motion.
- Project 2D toolpaths onto multiple surfaces for specialized rough cuts.



- Plunge roughing enters a part straight from the top (with no XY motion) and removes material.
- Constant Z rough REST milling (remachining) identifies and machines areas that need to be roughed with a smaller tool.

### **Versatile Finishing**

Mastercam's suite of finishing tools lets you choose the best method for a specific project.

- Finish machine multiple surfaces, solid models, or a combination of both.
  - Parallel finishing delivers robust toolpaths for a wide variety of projects.
  - Scallop machining maintains a consistent finish on sloped and flat surfaces alike by using a constant 3D stepover.
  - Create toolpaths radiating outward from a selected point with Radial finishing.
  - Flowline machining cuts single or multiple surfaces using their natural shape to define the cutter path, delivering a smoother finish.
  - Ruled toolpaths include automatic synchronization by entity, branch or node.
- Cutting options are constant Z, zigzag, circular, one way or 5-axis swarf machining.
- Finish machine by projecting a 2D toolpath onto multiple surfaces.

### **Cleanup Machining**

Leftover material causes extra handwork and time. Mastercam automates leftover material removal, leaving you with a finer finish.

- Constant Z REST milling (remachining) identifies and machines areas that need to be cut with a smaller tool.
- Pencil tracing walks a tool along the intersection of surfaces to clean out hard-to-reach areas.
- Steep/Shallow machining cuts only those regions of selected surfaces that have slopes between two specified angles.

### **Efficient Machining Options**

- Restrict roughing and finishing area with containment boundaries and check surfaces.
- For multiple cavities, choose to complete each Z depth in all cavities, or complete an entire cavity before moving on to the next.
- Run multi-surface machining functions immediately or set them all to run overnight with batch processing.
- Trim toolpaths to multiple boundaries.

### **Multiaxis Machining**

Multiaxis machining adds an extra level of flexibility to your machining operations. Mastercam's suite of multiaxis tools lets you program quickly and efficiently.

- Swarf machining over multisurface floors.
- Swarf fanning.
- Tool vector filter adds or removes vectors for gouge prevention.
- 5-axis shank containment for cutting internal areas larger than tool entrance.
- 5-axis single surface flowline machining.

- Machine curves on surfaces in 5-axis including automatic projection of curves onto surfaces. Define side angle and lead/lag angle for the tool as well.
- Perform 5-axis drilling.
- Create 5-axis contour toolpaths around the surface edges of the model for applications such as trimming vacuum-formed parts.

### **Powerful High-Speed Machining (HSM) Motion**

- “Fishtail” corner cleanout for high-speed pocketing.
- Ramp contour finishing provides uninterrupted smooth motion.
- Variable Z-level cuts for smoother Z-level finishing
- Automatically plunge or begin cuts outside the part.
- Constant Z smoothing rounds sharp corners where possible.
- Loop onto and off of Z-level cuts for smooth continuous motion
- High speed channel machining strategy for eliminating tool burial.
- High-speed options for surface rough pocket, surface rough contour, and surface finish contour help automate high-speed motion.

### **Dependable Toolpath Verification**

- Watch your part being cut from a solid block of material with Mastercam's solid-model toolpath verification. The tool and holder are checked and displayed during simulation.
- Step through the program with toolpath backplotting and get an estimate of machining time.
- Verify 2D toolpaths with a pixel paint of the full tool diameter to check the finish.

### **Practical NC Tools**

- Significantly reduce the size of a program with toolpath filtering. The filter automatically turns small, multiple linear moves into single line or arc moves within a specified tolerance.
- Mastercam automatically generates customizable setup sheets.
- Define separate entry and exit vectors for toolpaths to control the tool's approach and retract for cutting.
- Tool plane and tool origin allow programming in different views for tombstone work.
- Replace X or Y with a rotary axis to wrap the toolpath around a diameter with axis substitution.
- Pick from a library of hundreds of post-processors or have one customized.
- Macro recording automates repetitive tasks.
- Subroutine support.

The project which I have used the Mastercam mill is to create the 5-axis movement Animation in the special purpose of 5-axis CNC machining centre and also to create the postprocessor with variable (X, Y, Z, A, B ).

## **5.2 TRAVERSE AXIS 'Y'**

--	--	--	--	--	--	--	--

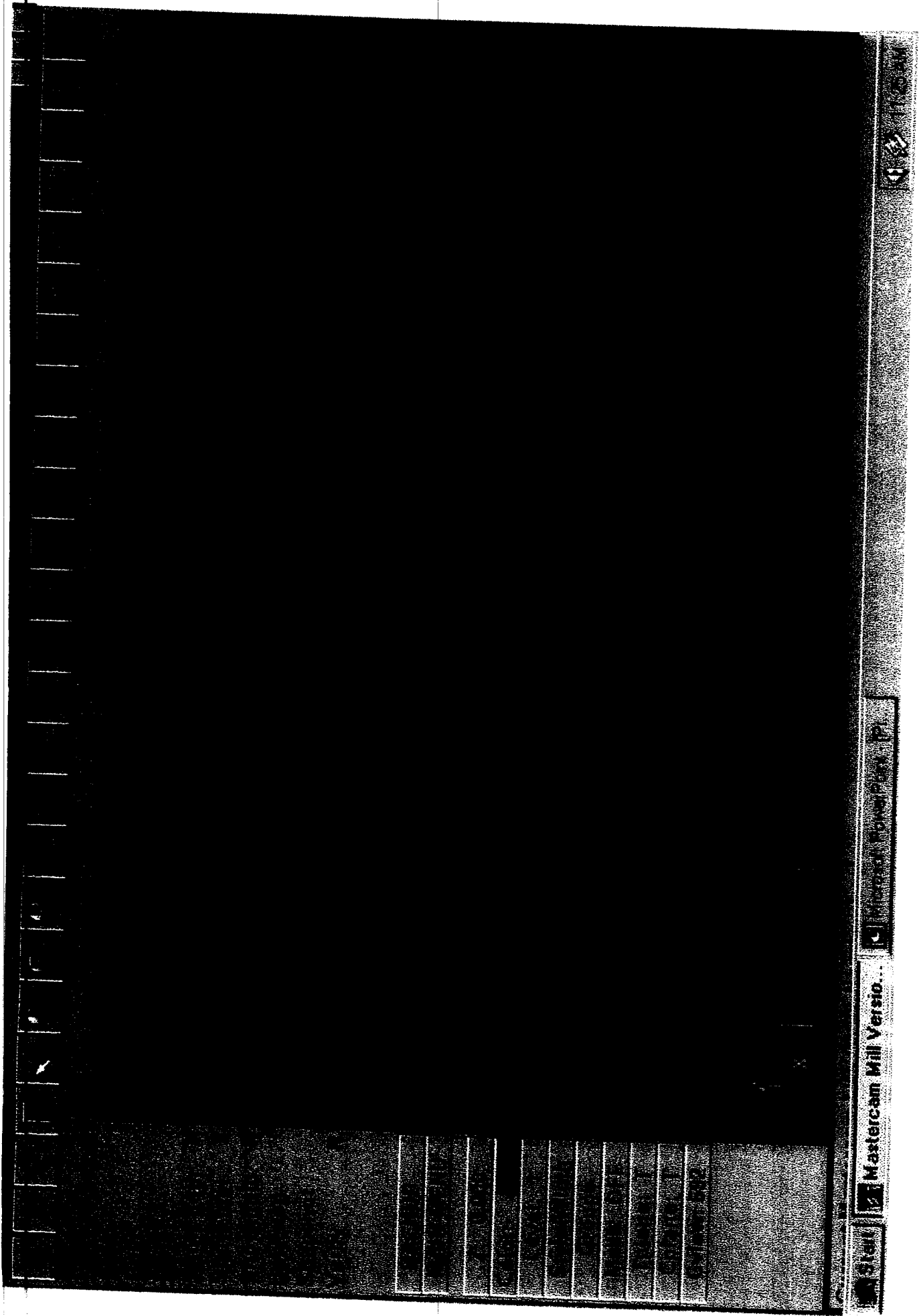


Fig.17

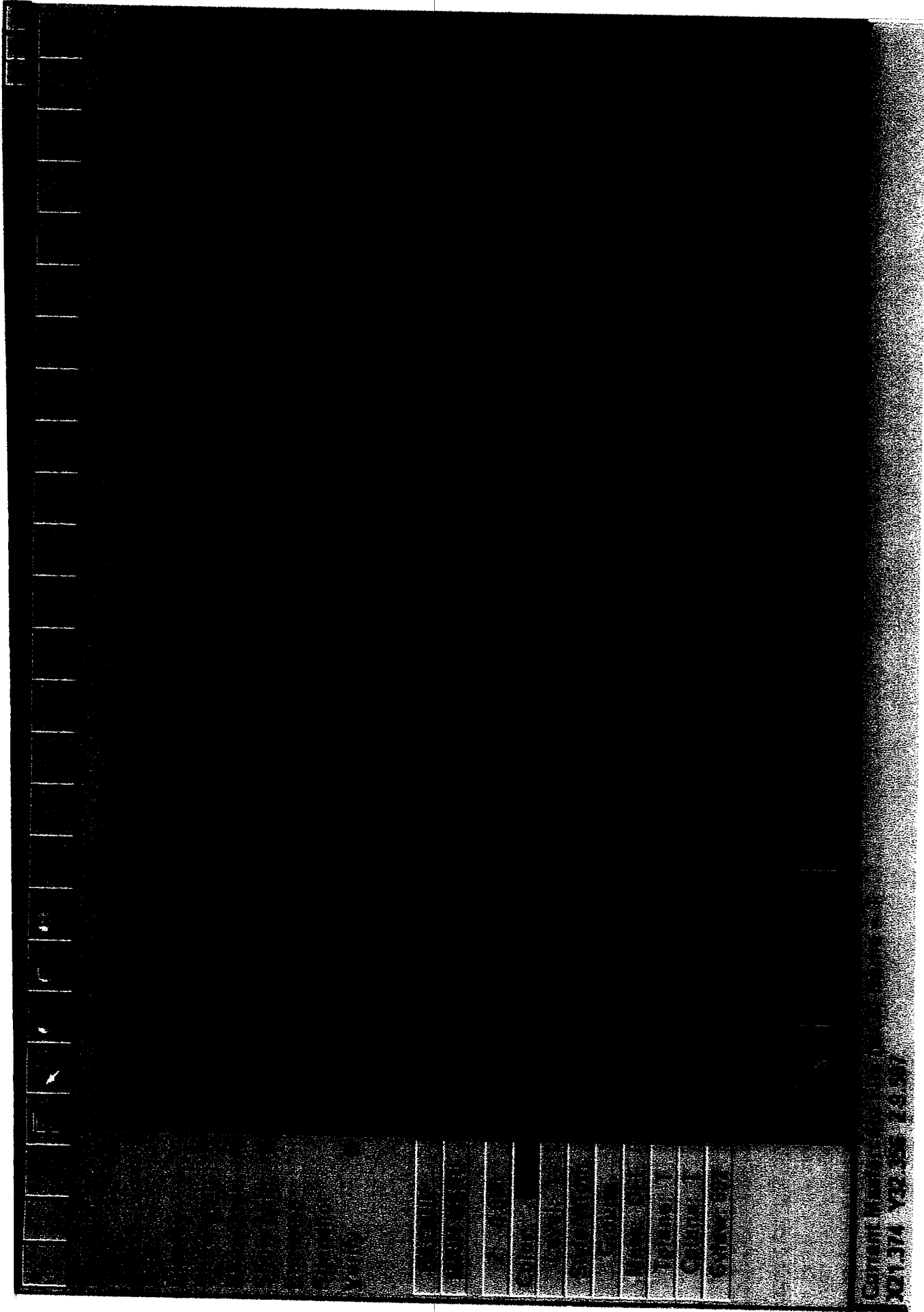


Fig.18

### **5.3 LONGTITUTIONAL AXIS 'X'**



Fig.19



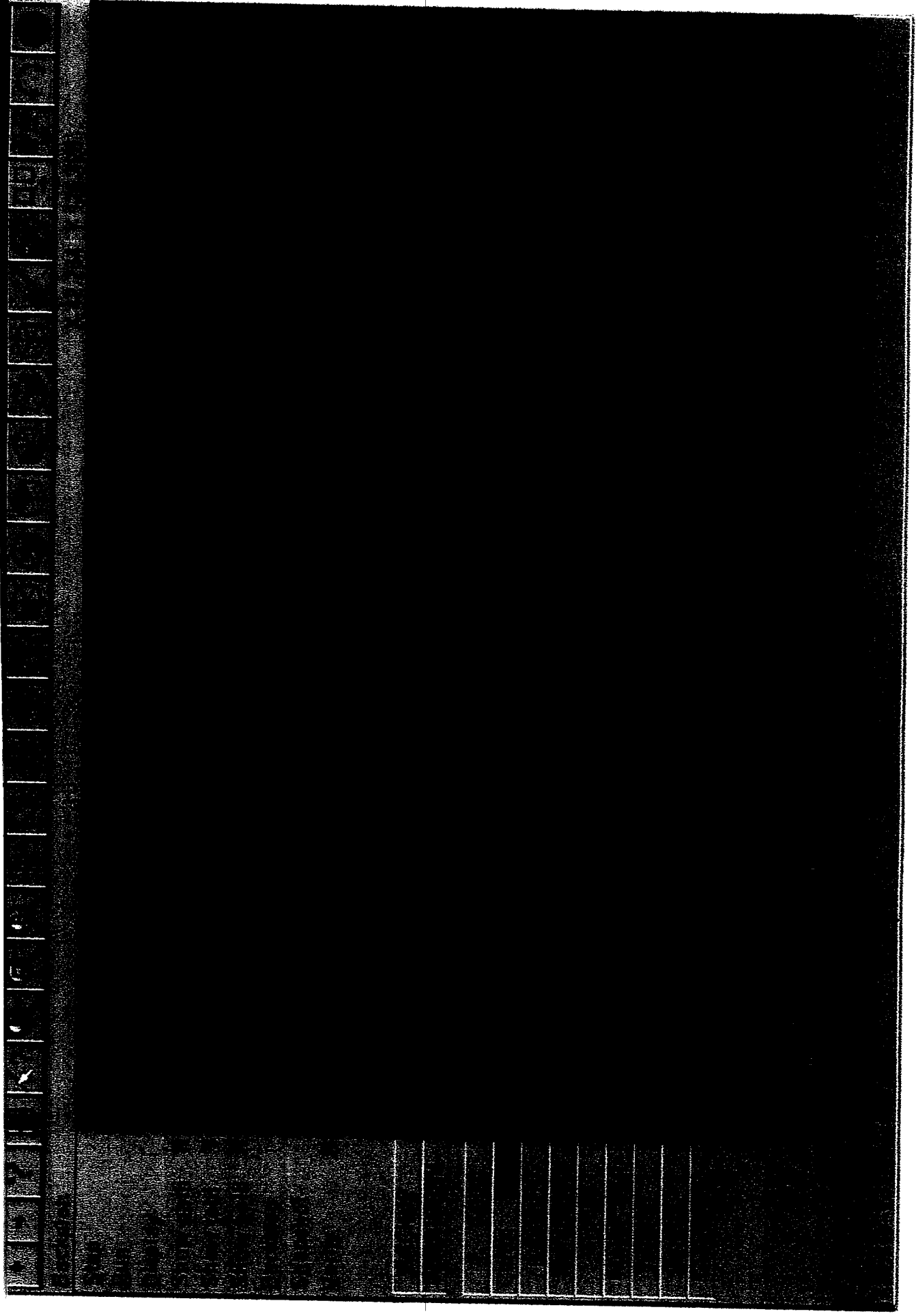


Fig.20

## **5.4 VERTICAL AXIS 'Z'**

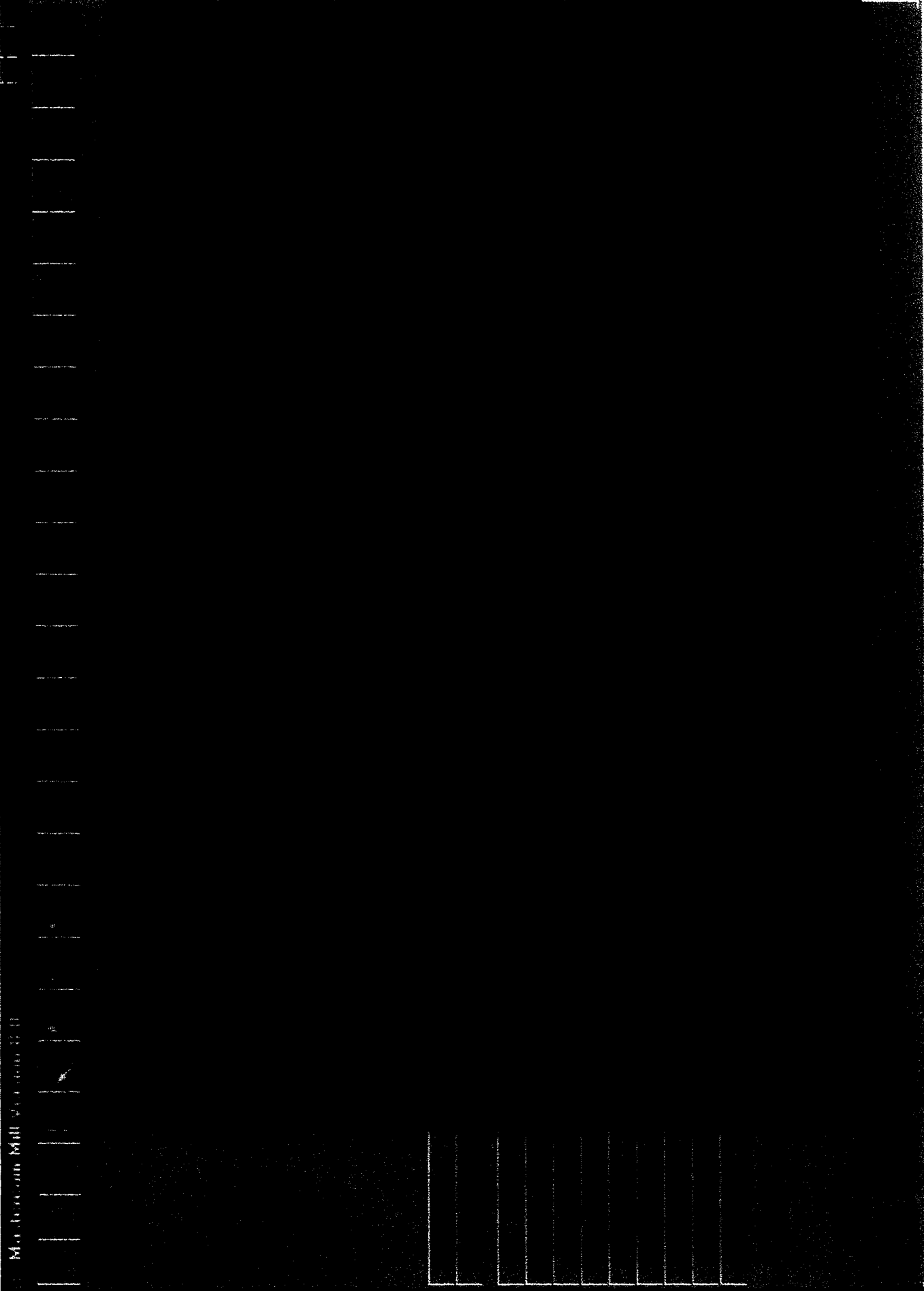
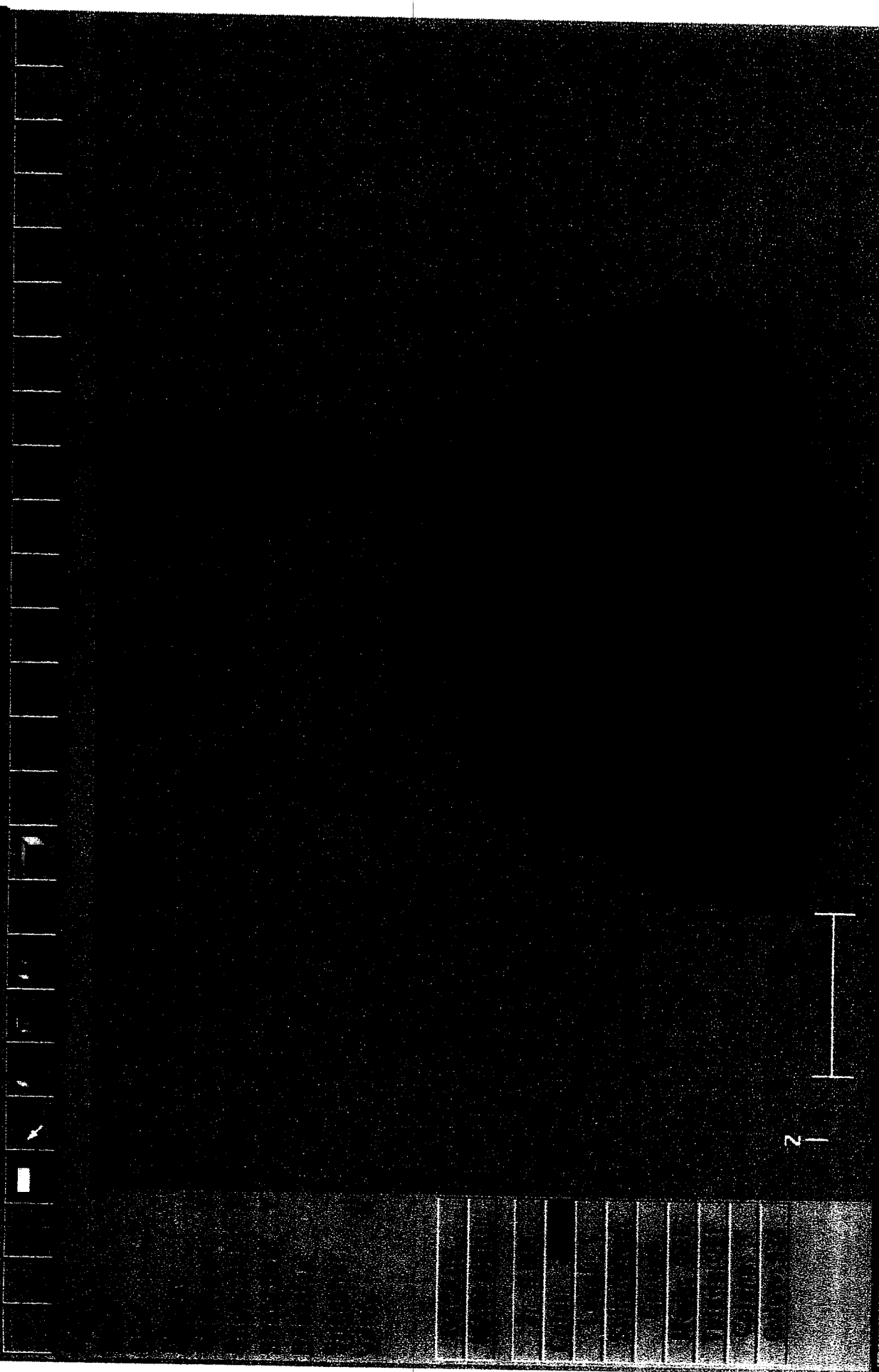


Fig.21



Fig.22

## **5.5 ROTARY TABLE ALONG Z-AXIS**



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Fig.23

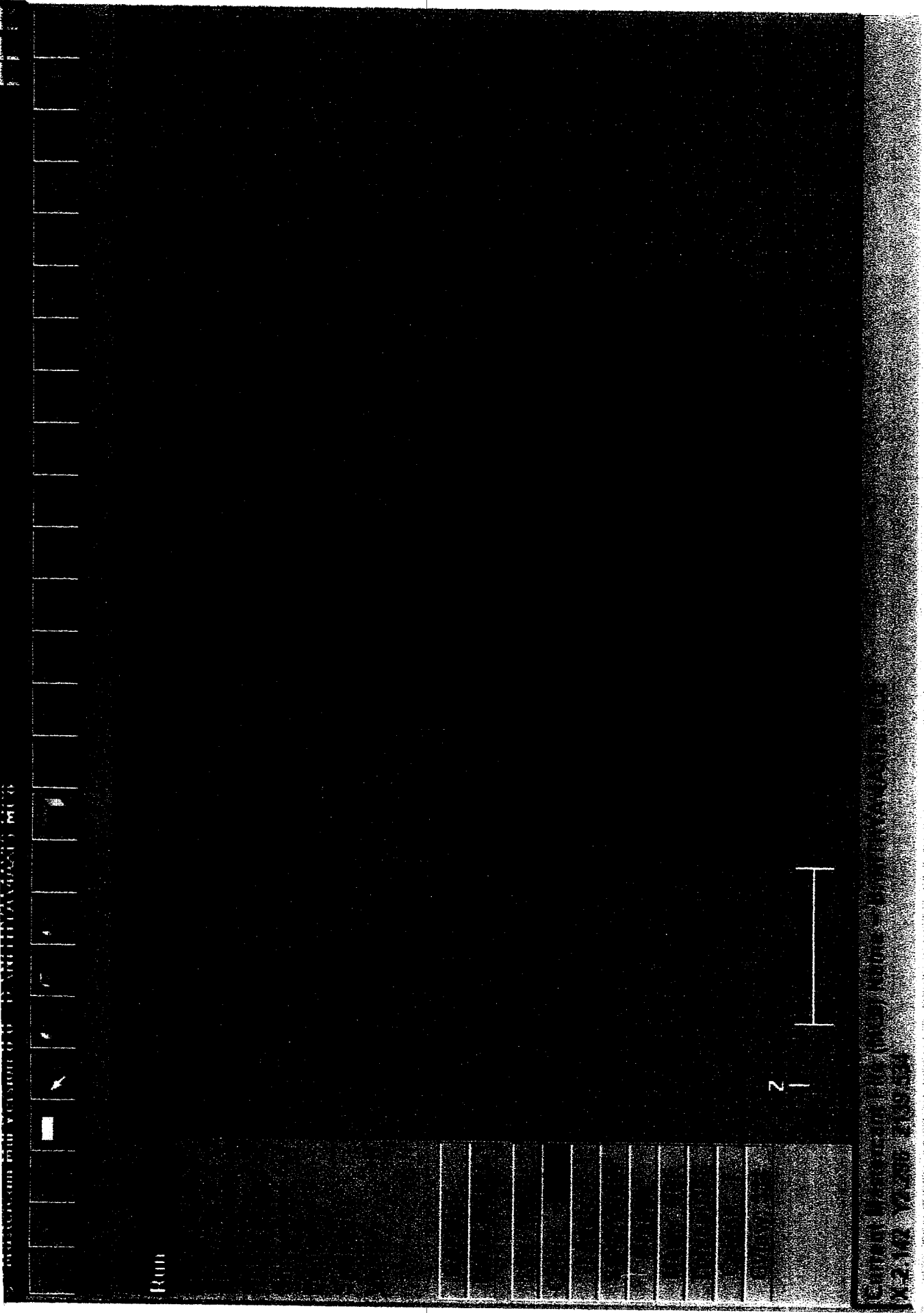
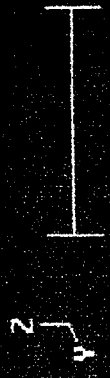
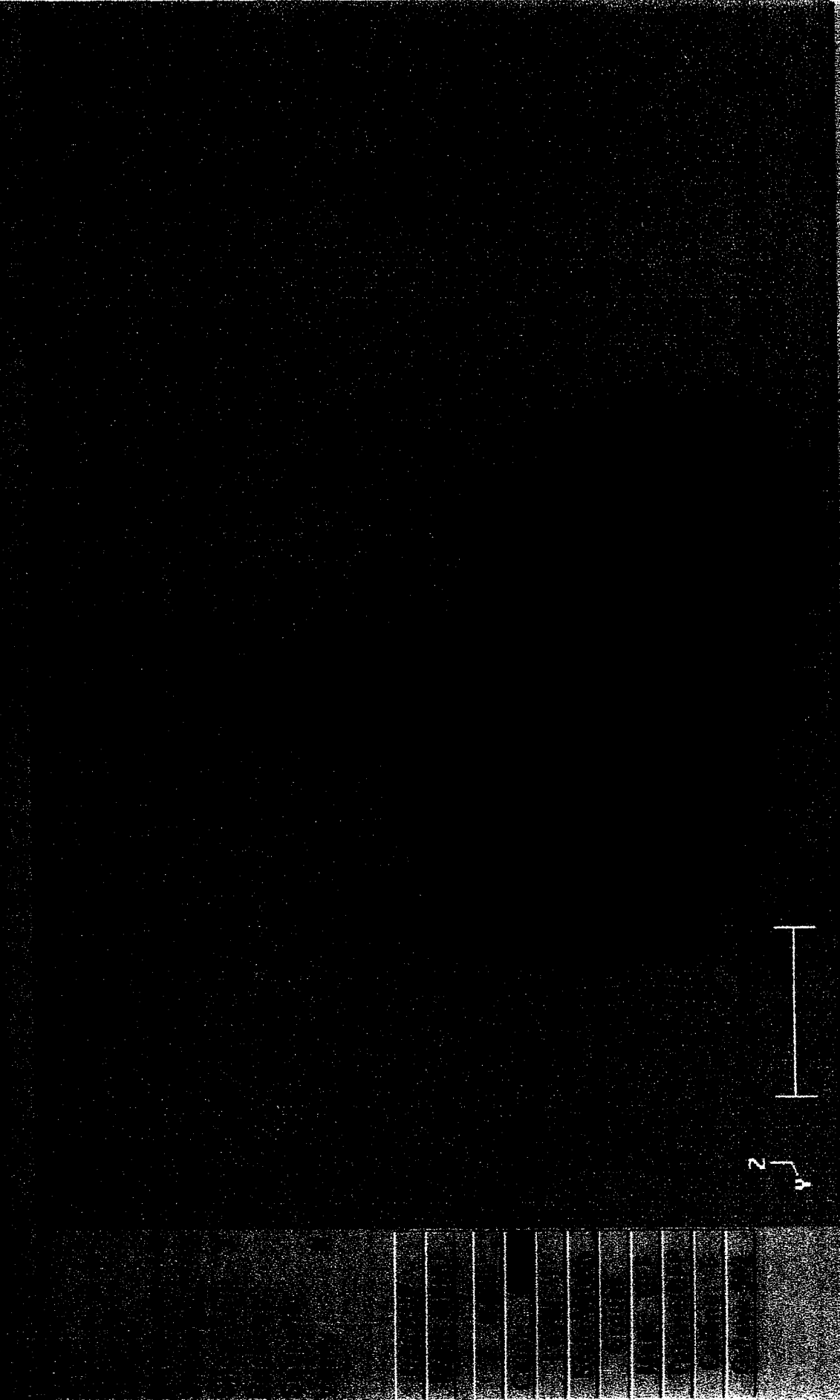
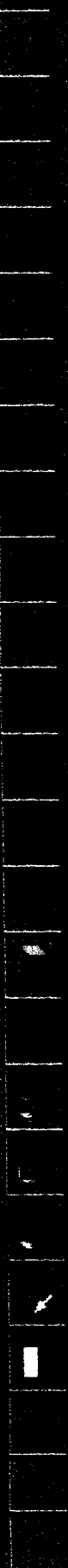


Fig.27



Learn Mastercam 8.0 Milling  
Start to Finish

Fig.25



## **5.6 SWIVEL MOVEMENT OF TABLE**

Mastercam Mill Generation 10.0

Figure 26

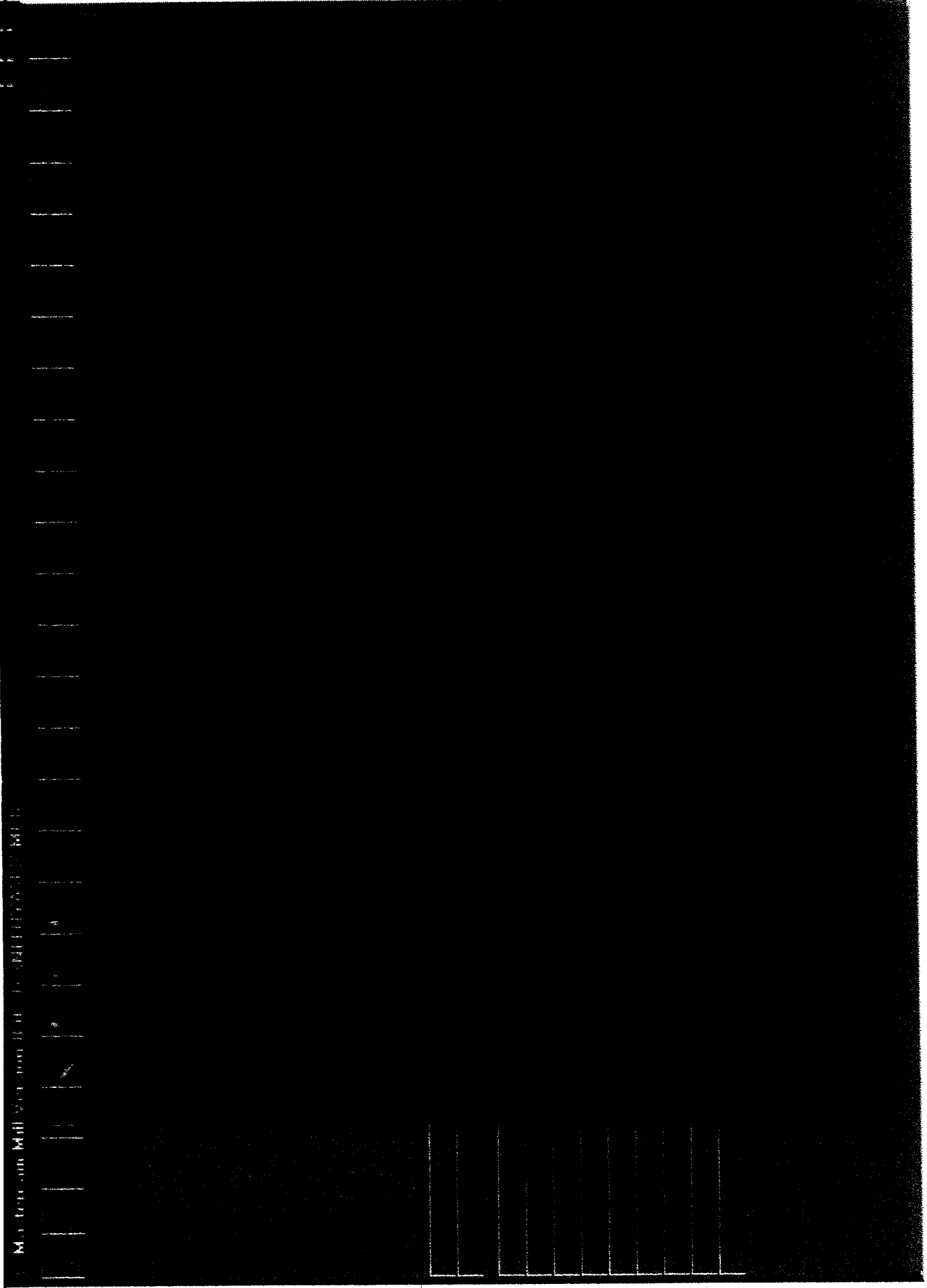


Fig.26

Mastercam Mill Version 8.0 - DANIELTAYLOR MCB

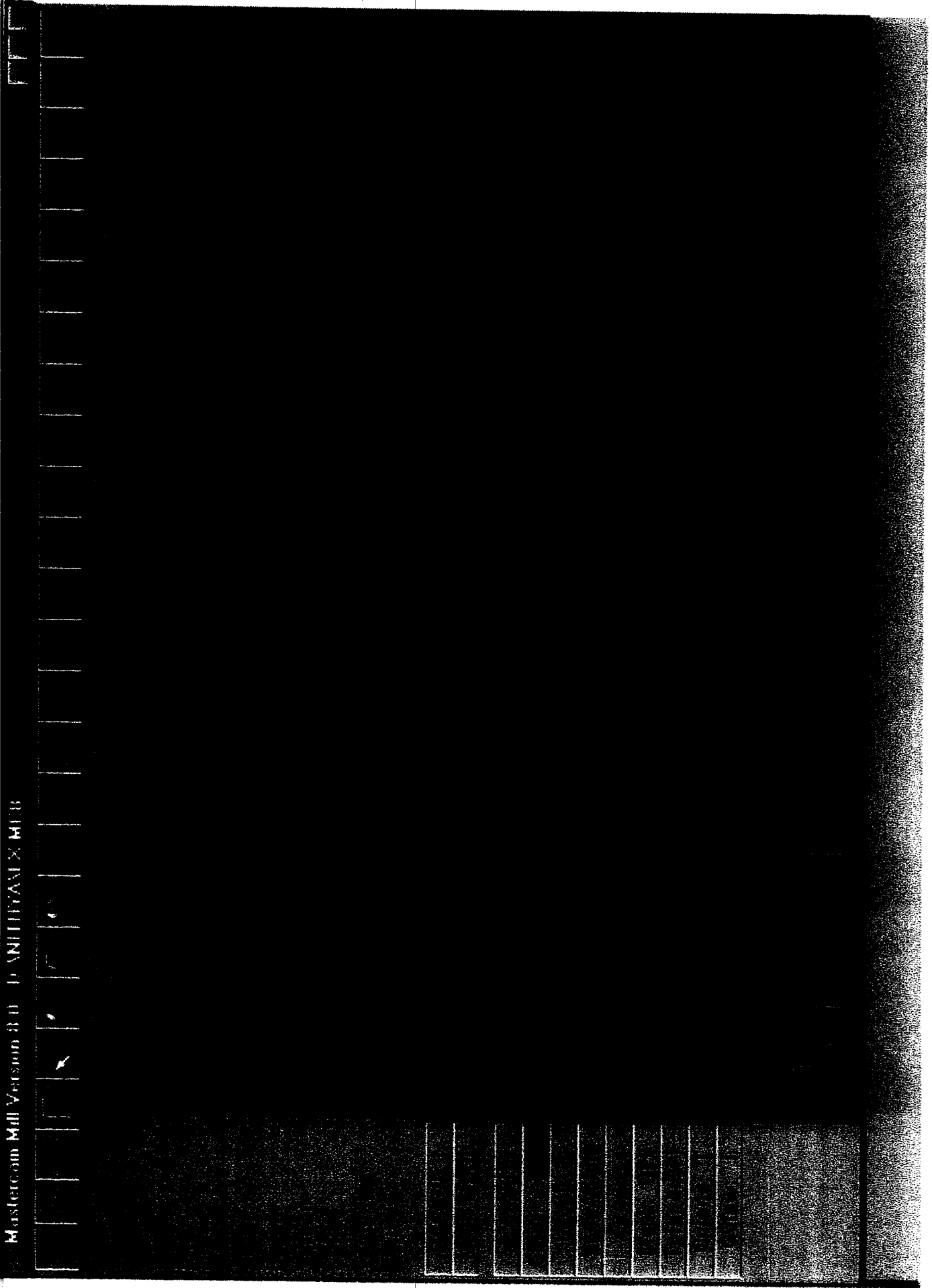


Fig.27

MANAGECADD M10 Version 3.0 - 01/AM0111/AVL X 3 MF 3

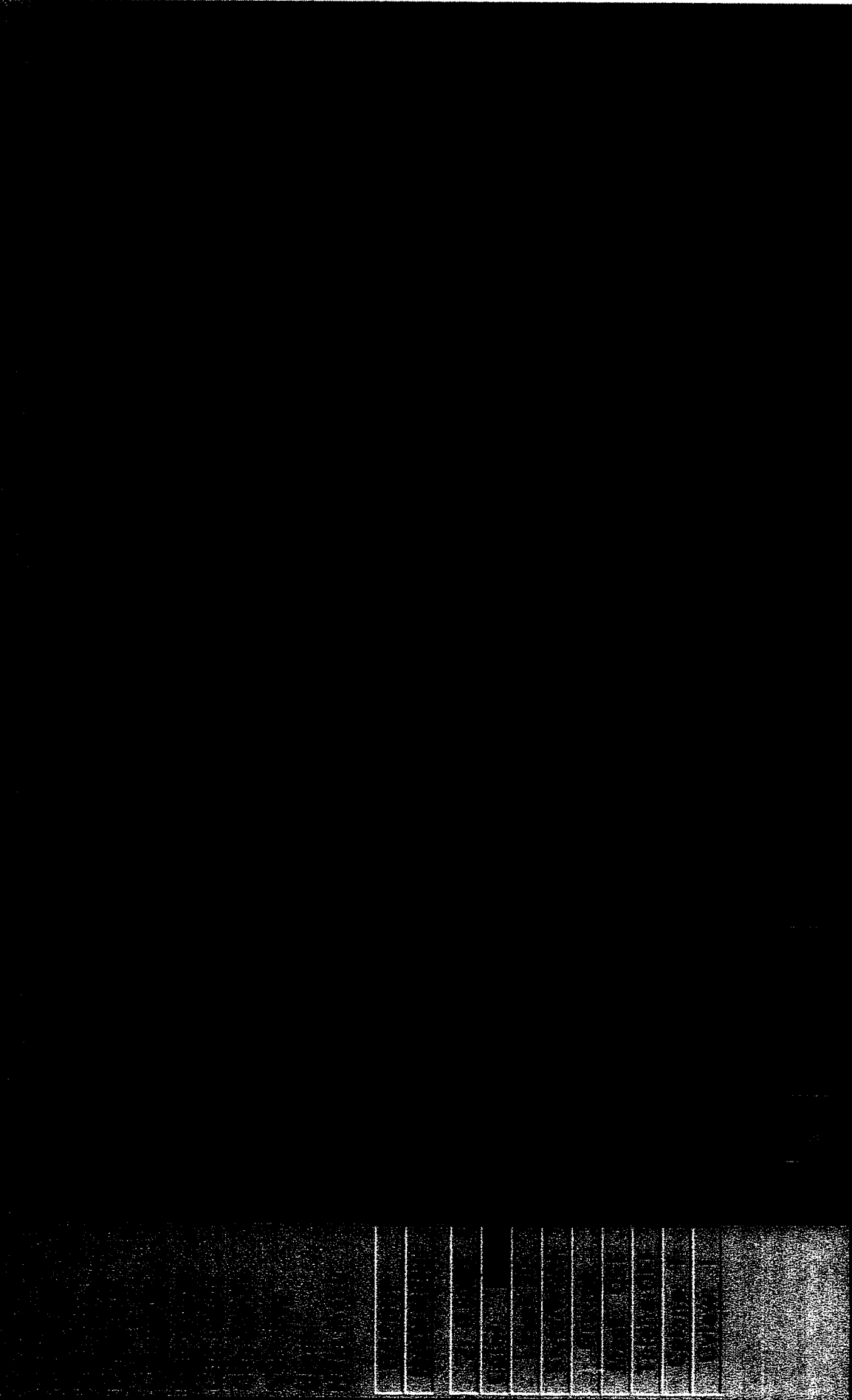


Fig.28

□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



Fig.29

Mastercam Mill Version 8.0 - D:\MILL\TAXI\MCB

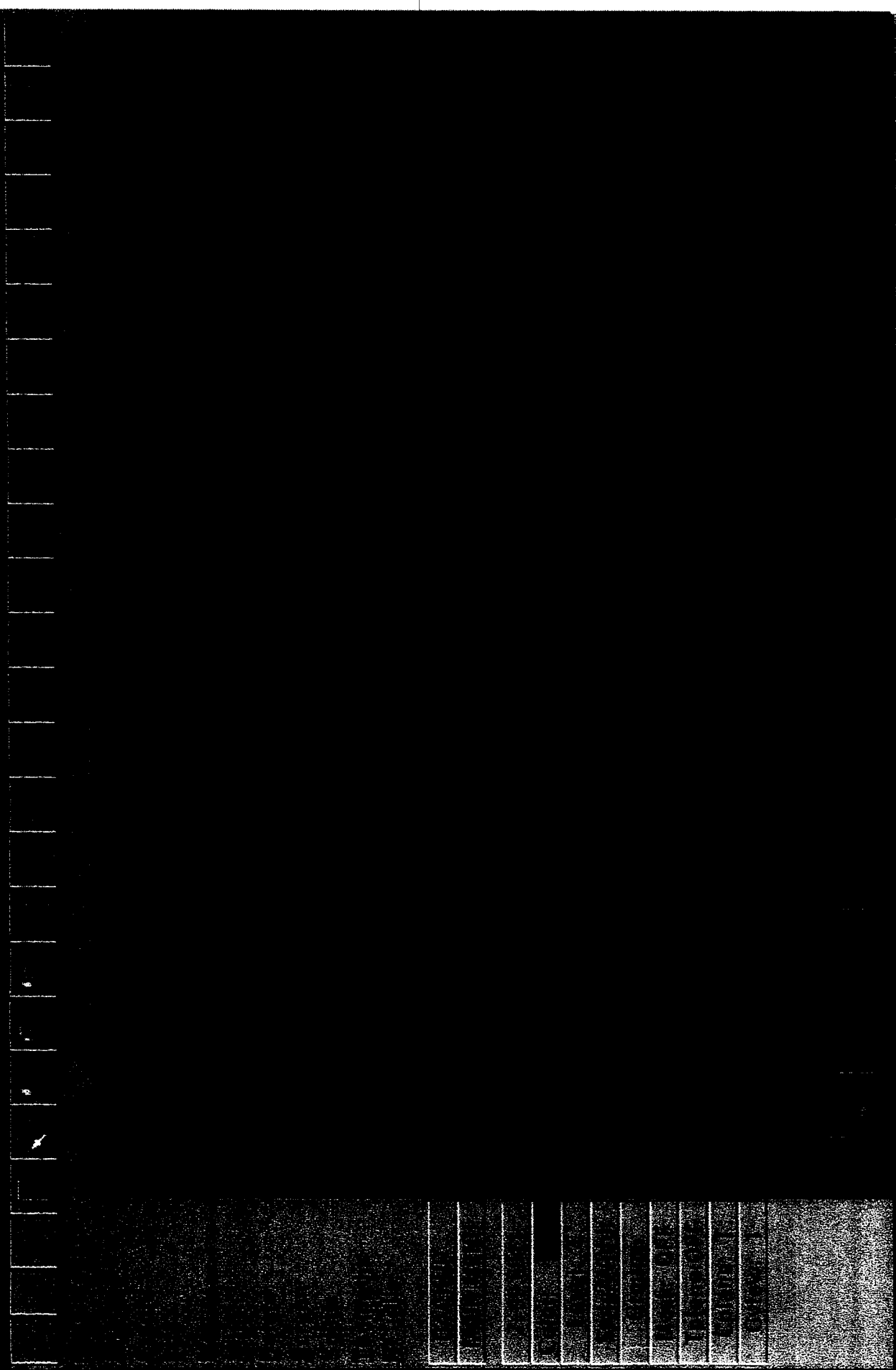
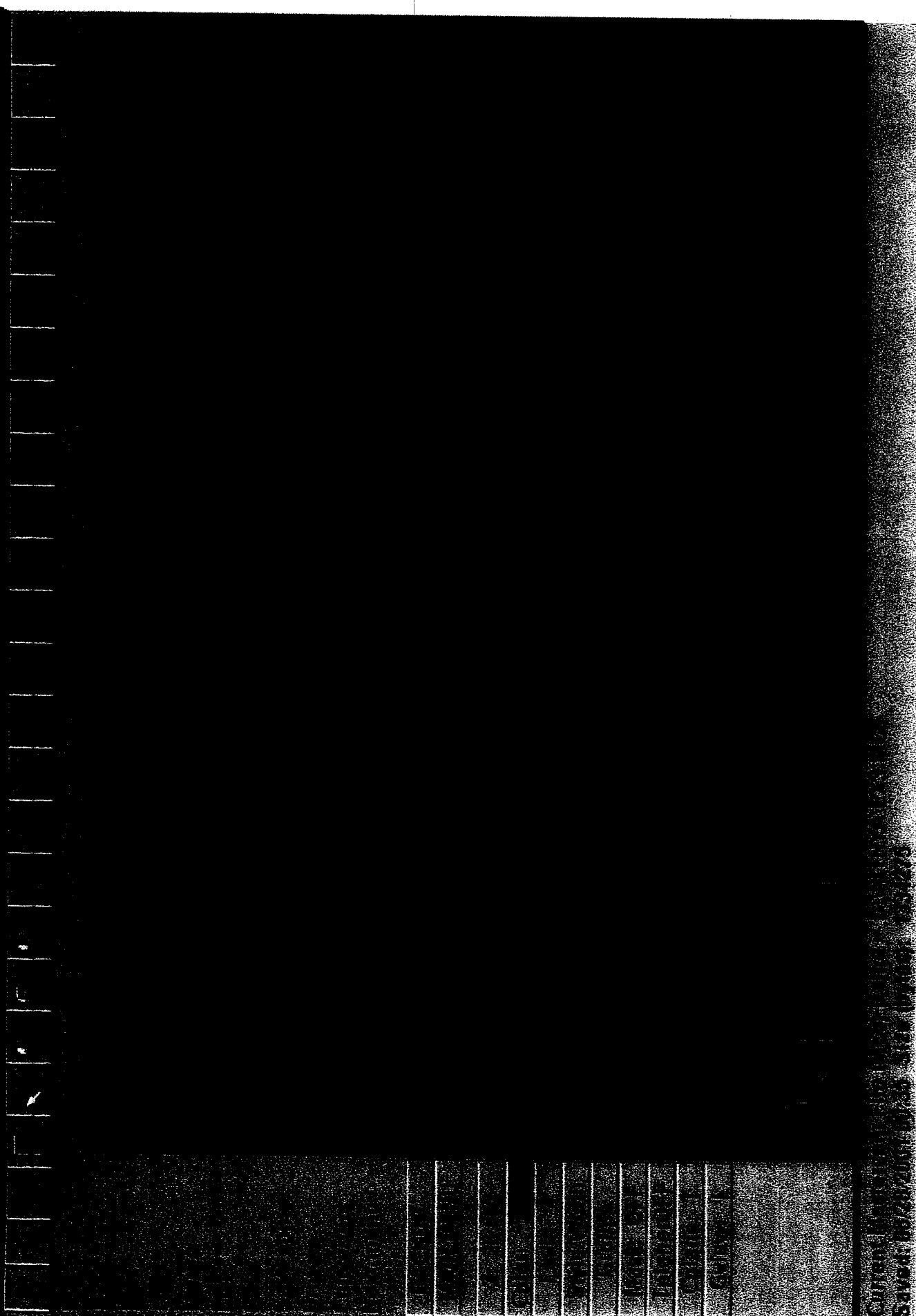


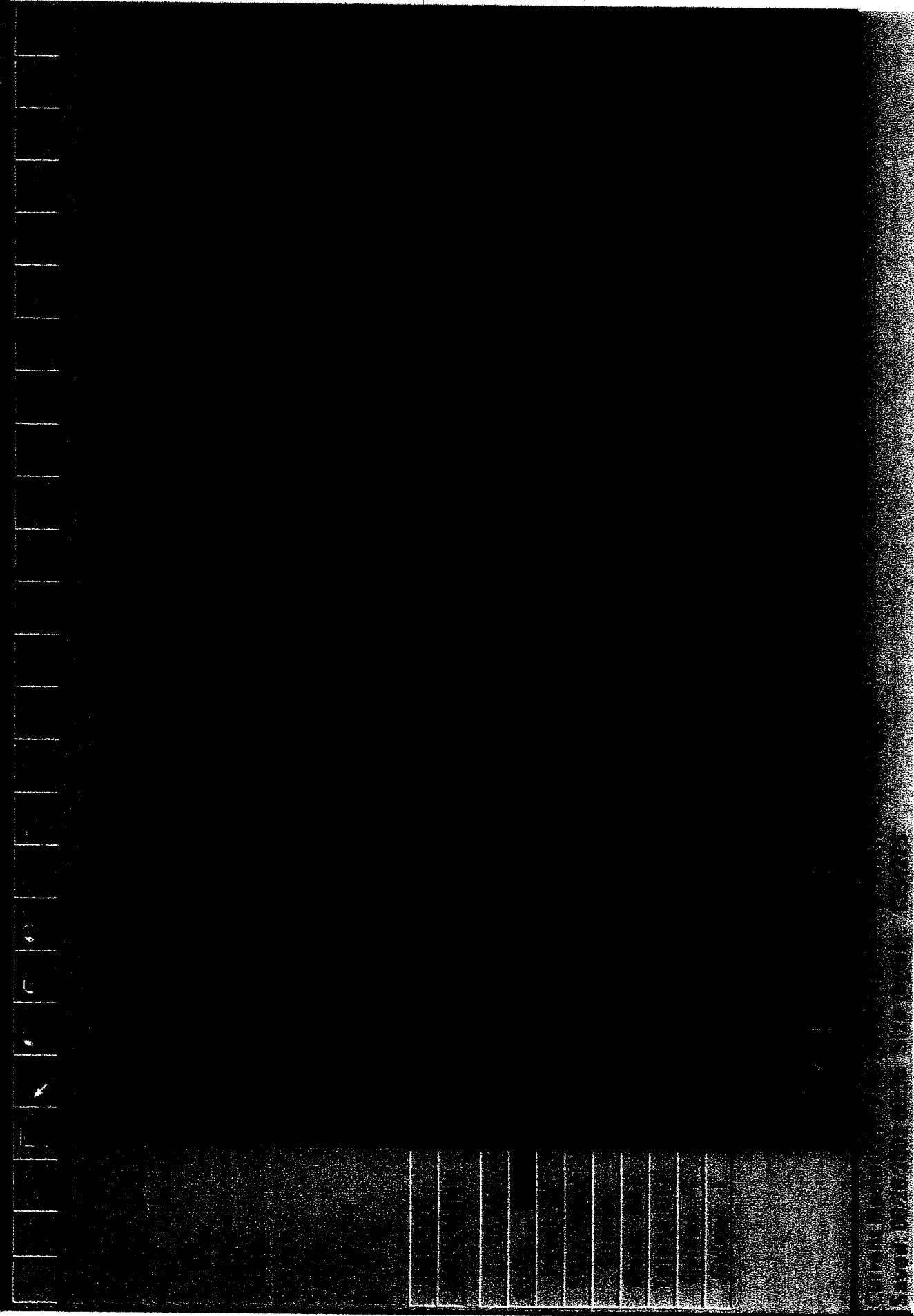
Fig.30

Masterc am Mill Version 8.0 D UNITTYAAYE BMO



Current  
Saved

Mastercam Mill Version 8.01 Part 1114141X31.H18



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Fig.32



Mastercam Mill Version 8.0 D:\PROJECTS\ALX3\MCB

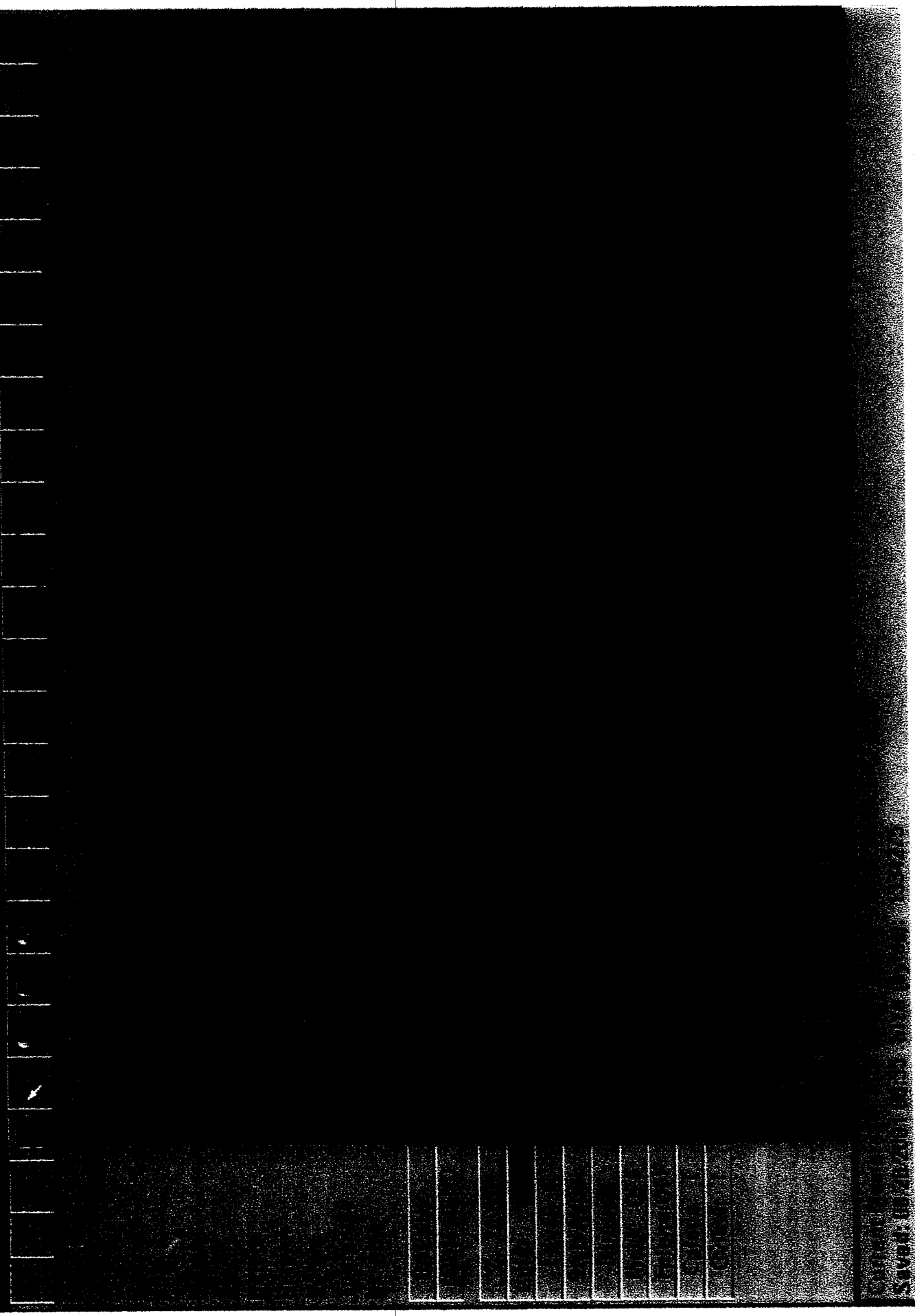


Fig.33

## 5.7. MATHEMATICAL MODEL

In the conventional CNC machining center, the 5<sup>th</sup> axis is either in XY-plane or in XZ plane or in YZ plane. The special purpose CNC machining center, the 5<sup>th</sup> axis is neither in XY plane nor in YZ plane nor in XZ plane. If the coordinates of the cutter center with respect to XY plane is given, the corresponding coordinates of the cutter center with respect to inclined plane value is changed. These changes coordinates values are calculated by using these mathematical relations.

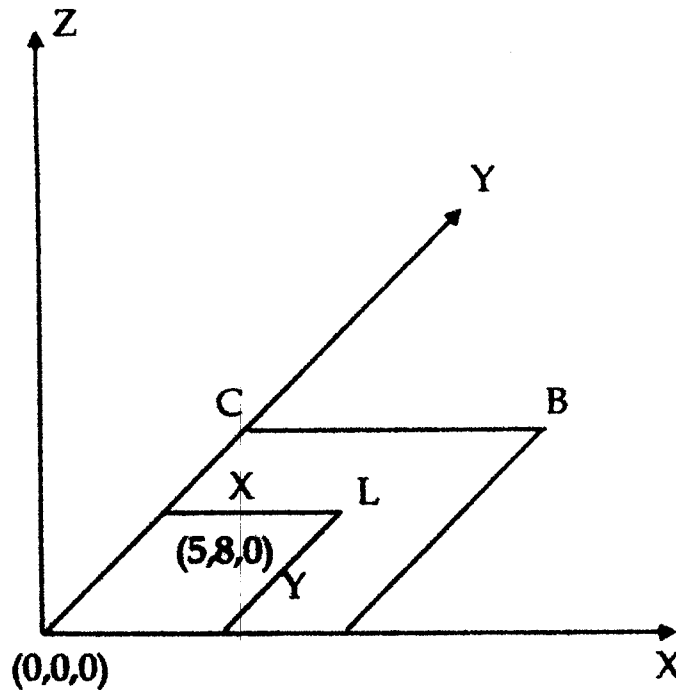


Fig. no.34

Here the coordinates of the cutter center with respect to XY plane are given say like (5,8,0). The corresponding coordinates of the cutter center with respect to inclined plane are measured by following triangles property.

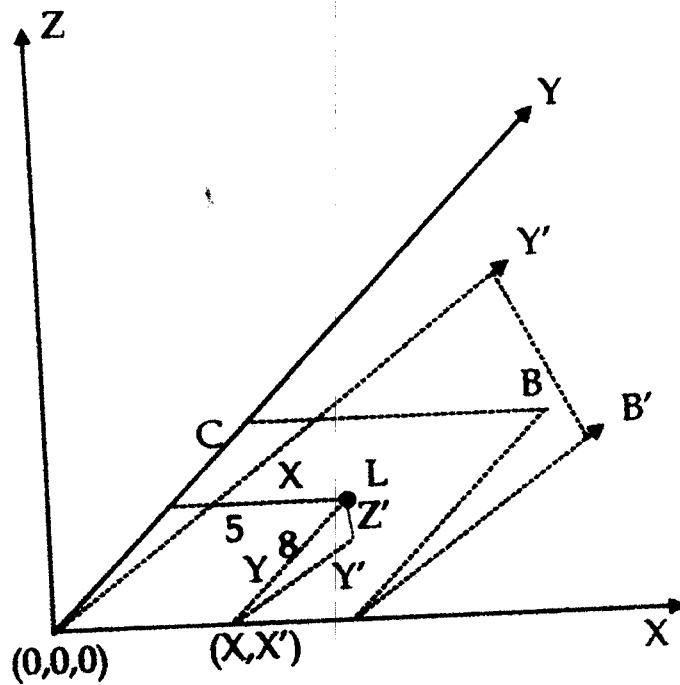


Fig. No. 35

Now consider L,

For applying the trigonometry formulas and we get the 'Y' and 'Z'

For L,  $X=5$ ,  $Y=8$ ,  $Z=0$

For  $L'=5$ ,  $Y'=?$ ,  $Z=?$

Now consider the triangles  $Z'Y'Y$ , we get the  $Y'$  value,

$$\cos\theta = \frac{\text{Adjacent side}}{\text{Hypotenuse}}$$

$$\text{Adjacent side} = \text{Hypotenuse} * \cos\theta$$

$$Y' = 8 \cos\theta, \text{ where } \theta=45 \text{ is the inclined angle}$$

Then we consider the triangles for same manner, we get the  $Z'$  value,

$$\sin\theta = \frac{\text{Opposite side}}{\text{Hypotenuse}}$$

Then opposite side =  $\sin 45 \cdot \text{Hypotenuse}$

$$= 8\sin\theta \text{ where } \theta = 45 \text{ is the inclined angle.}$$

Generally, we can give any coordinates value for  $(X, Y, Z)$  with respect to XY plane, it is converted into inclined plane values for  $X', Y', Z'$ .

Therefore, generally the  $X, Y, Z$  are converted into inclined plane is  $X', Y', Z'$ . These corresponding values are formulated in general.

$$(X, Y, Z) = (X', Y', Z')$$

where  $X = X'$

$$Y = Y' \text{ (since } \theta = 45)$$

$$Z = Z'$$

$$\text{Therefore } (X, Y, Z) = (X, Y \cos\theta, Y \sin\theta)$$

The 4<sup>th</sup> and 5<sup>th</sup> axis of conventional machining center variable is  $(A, B)$ . And also the special purpose machining center 4<sup>th</sup> and 5<sup>th</sup> axis variable is  $(C, B)$ . This mathematical equation is simply modified and finally we get,

$$(X, Y, Z, A, B) = (X, Y \cos\theta, Y \sin\theta, C, B)$$

## 5.8 C- Program:

C-Program are used to convert the existing format of conventional 5<sup>th</sup>-axis into the special purpose 5<sup>th</sup>-axis. The existing format is prepared by using the Master cam software. The existing format is entered with the program input. The file names are given. The program is a copy into a folder and compile and run it. It will prompt you to enter the input file name; enter the file to encode with extension. Similarly enter the output file name we want. It is customary that the files be in the same directory as the program. Inside the program I have commented the area where we can write the code for conversion. There are two variables are involved, one for the parameter i.e 'n', 'r', 'a', etc. and the other for the actual value.

Also the conversion of the mathematical equation is to enter the program. This equation is to modify the coordinates of the cutter center with respect to XY plane into the inclined plane. Finally, the input value of the existing format is converted into the special purpose CNC 5-axis machining center in existing format. These existing formats are interfacing the SiTarc 5AXIS CNC MACHINING CENTRE. Then 5<sup>th</sup> axis is easily run and it will produce the turbine blade with short time and high quality.

Compiled

C-Program

```
#include<stdio.h>
#include<conio.h>
int main()
{
FILE *in,*out;
char fn[15];
char i;
float d;
/*clrscr();*/
printf("Enter the input file name with extension\n");
scanf("%s",fn);
/* OPEN THE INPUT FILE IN READ MODE */
if ((in = fopen(fn, "rt"))
    == NULL)
{
    fprintf(stderr, "Cannot open input file.\n");
    getch();
    return 1;
}
}1:
printf("Enter the OUTPUT file name with extension\n");
scanf("%s", fn);
/* OPEN THE OUTPUT FILE IN WRITE MODE */
if ((out = fopen(fn, "rt")) != NULL)
{
    fclose(out);
    fprintf(stderr, "File already exists do you want to overwrite file(Y/N).\n");
    i = getch();
    if (i == 'y')
    {
        if ((out = fopen(fn, "wt")) == NULL)
        {
            fprintf(stderr, "Cannot open output file.\n");
            getch();
            return 1;
        }
    }
    else
    {
        goto 1;
    }
    i = ' ';
}
else
{
    if ((out = fopen(fn, "wt")) == NULL)
    {
        fprintf(stderr, "Cannot open output file.\n");
        getch();
        return 1;
    }
}
printf("the no is %c",fgetc(in));
/*clrscr();*/
do{
if(fscanf(in,"%c",&i))
{
if(i>=65 || i == 10)
{
if (i>=65)
fscanf(in,"%f",&d); /* SCAN FROM THE INPUT FILE */
printf("The value of %c is %f",i,d);
/* ----- MAKE THE NECESSARY CONVERSIONS HERE
-----i is the
```

Page 1

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Compiled

```
character n,m,r,t and d is the numeric value */
/*x1 = x
y1 = y cos(45)
z1 = y sin(45)
c = a
b = b*/
if (i == 'N')
{
fprintf(out,"%c %c %f",10,i,d);
}
else
{
fprintf(out,"%c %f",i,d);/* WRITE TO THE OUTPUT FILE
*/
}
d=0.0;
}
else
{
printf("the no is %c",i);
}
}while (!feof(in));
fclose(in);
fclose(out);
getch();
return 1;
}
```

## 6. Results and Analysis:

The existing format of conventional machining centre is to modify the SiTarc 5-Axis machining centre. The mathematical relations like  $X1=X$ ,  $Y1=Y\cos\theta$   $Z1=Y\sin\theta$   $C=A$ ,  $B=B$  are enter to the C-Program. Also the existing format was saved in the same directory. The file name is given. Now the C-program is compile and run it. Also the output file name is given. This output is connect to the SiTarc CNC Machining centre. Now the machine is easily to run the 5th -axis and to produce the complex profiles with quality.

Now, the Turbine blade Model is created by using the Master Cam Software. This software should create the model and also to genearte the CNC codes. The CNC code is connecting to the C-program. This input codes are saved in the same directory. The general Mathematical equations are also to enter the C-Program. Now the C-Program is compile and run it. The output file name is given. This output format is convert from the conventional CNC machining centre existing format. The conversion of this output format is connecting to the SiTarc 5-Axis CNC machining centre. Now, the Machine is easily to run the 5th -axis. The Turbine Blade profiles are easily to produced with higher quality.



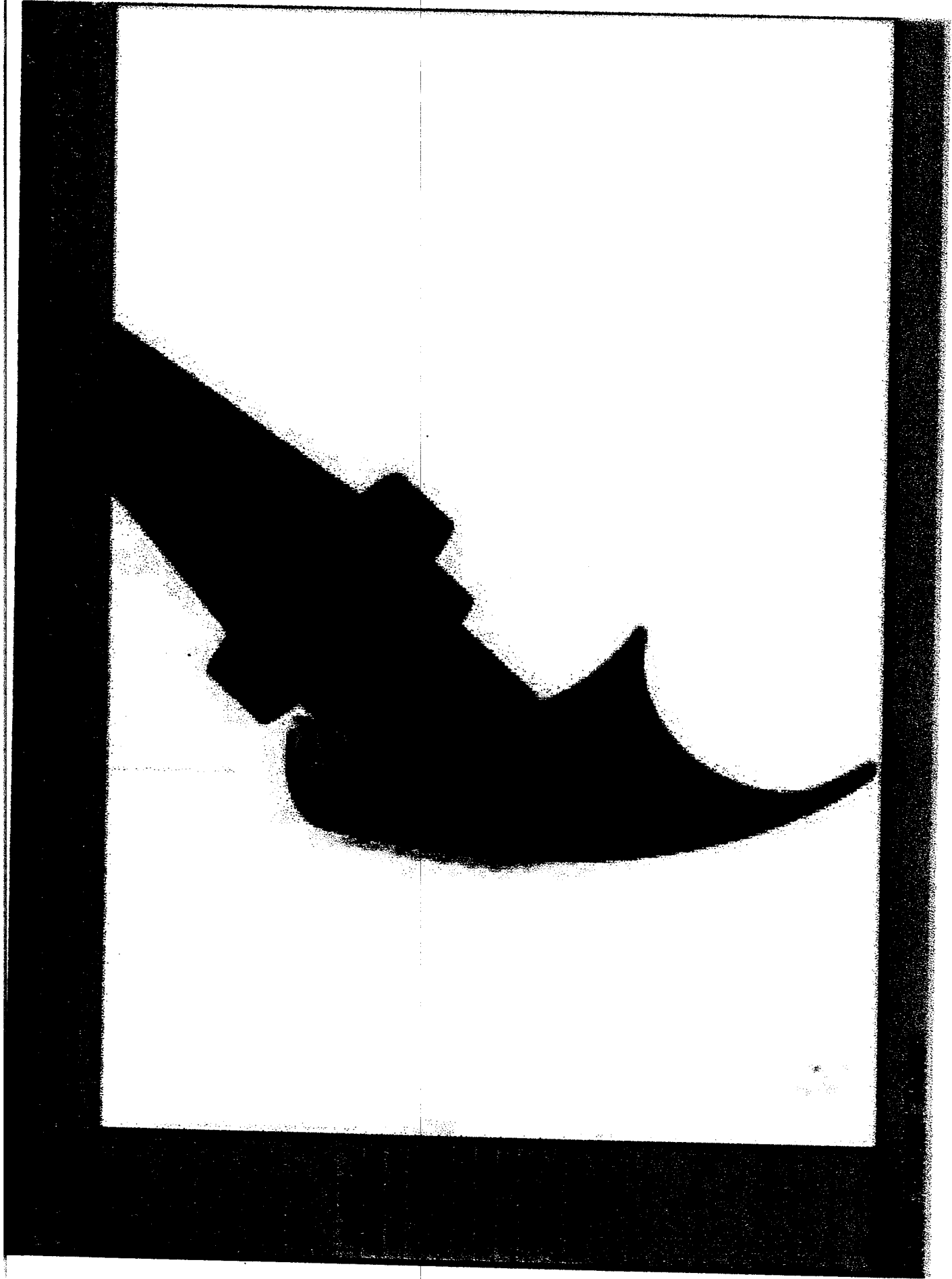


Fig.36

TURBINE BLADE

Existing format of conventional machine:

```

0 BEGIN PGM SNAV-ROT1 MM
1 BLK FORM 0.1 Z X-300 Y-300 Z-100
2 BLK FORM 0.2 X+300 Y+300 Z+0
3 TOOL CALL 9 Z S2500
4 X0. Y0. C0. B0. F MAX M03
5 L Z250.0 F MAX
8 L X-44.9239 Y-12.202 Z237.798 C305.345 B42.026 F MAX
9 L X-7.0266 Y45.1387 Z255.0 F MAX
10 L X-3.0197 Y46.227 Z255.0 F MAX
11 G01 L X-3.0196 Z209.4693 F500
12 L X-3.8817 Y44.9912 Z210.1837 C306.593 B43.78
13 L X-4.7215 Y43.8636 Z210.776 C307.538 B45.312
14 L X-5.5158 Y42.8331 Z211.2681 C308.232 B46.643
15 L X-6.2522 Y41.8904 Z211.6774 C308.715 B47.794
16 L X-6.9254 Y41.0278 Z212.0183 C309.016 B48.78
17 L X-7.5335 Y40.2386 Z212.3025 C309.16 B49.619
18 L X-8.0771 Y39.5164 Z212.5396 C309.167 B50.323
19 L X-8.5582 Y38.8559 Z212.7377 C309.054 B50.905
20 L X-8.9792 Y38.2516 Z212.9034 C308.834 B51.377
21 L X-9.3426 Y37.6986 Z213.0428 C308.521 B51.748
22 L X-9.6508 Y37.1917 Z213.1609 C308.126 B52.028
23 L X-9.9059 Y36.726 Z213.2623 C307.661 B52.224
24 L X-10.1095 Y36.2965 Z213.3511 C307.135 B52.344
25 L X-10.2656 Y35.8993 Z213.4301 C306.556 B52.396
26 L X-10.3809 Y35.5317 Z213.5003 C305.928 B52.388
27 L X-10.462 Y35.1913 Z213.5624 C305.255 B52.327
28 L X-10.5153 Y34.8749 Z213.6174 C304.54 B52.222
29 L X-10.5467 Y34.5796 Z213.6659 C303.788 B52.079
30 L X-10.5616 Y34.3019 Z213.7091 C303.003 B51.907
31 L X-10.5653 Y34.0382 Z213.7479 C302.192 B51.713
32 L X-10.5624 Y33.7845 Z213.7835 C301.359 B51.505
33 L X-10.5572 Y33.5367 Z213.8174 C300.513 B51.29
34 L X-10.5535 Y33.2902 Z213.851 C299.66 B51.077
35 L X-10.5547 Y33.0403 Z213.886 C298.808 B50.873
36 L X-10.5634 Y32.7819 Z213.9243 C297.967 B50.685
37 L X-10.5815 Y32.5102 Z213.9677 C297.145 B50.52
38 L X-10.6071 Y32.224 Z214.0173 C296.346 B50.379
39 L X-10.6366 Y31.9238 Z214.0734 C295.571 B50.258
40 L X-10.6669 Y31.6105 Z214.136 C294.817 B50.154
41 L X-10.6946 Y31.2848 Z214.2055 C294.086 B50.063
42 L X-10.7174 Y30.9478 Z214.2816 C293.377 B49.981
43 L X-10.7323 Y30.6008 Z214.3643 C292.686 B49.906
44 L X-10.7371 Y30.2449 Z214.4534 C292.014 B49.834
45 L X-10.7296 Y29.8815 Z214.5486 C291.358 B49.76
46 L X-10.7081 Y29.5121 Z214.6496 C290.715 B49.683
47 L X-10.6707 Y29.1382 Z214.7559 C290.084 B49.599
48 L X-10.6158 Y28.7614 Z214.8672 C289.462 B49.503
49 L X-10.5422 Y28.3834 Z214.9828 C288.845 B49.394
50 L X-10.4513 Y28.0051 Z215.1019 C288.231 B49.27
51 L X-10.3499 Y27.6258 Z215.2234 C287.62 B49.137
52 L X-10.2452 Y27.2447 Z215.346 C287.01 B49.003
53 L X-10.1439 Y26.8606 Z215.4689 C286.404 B48.872
54 L X-10.0527 Y26.4724 Z215.591 C285.8 B48.753
55 L X-9.9782 Y26.0786 Z215.7115 C285.2 B48.651
56 L X-9.9265 Y25.6778 Z215.8299 C284.604 B48.574
57 L X-9.9038 Y25.2681 Z215.9455 C284.016 B48.528
58 L X-9.9157 Y24.8478 Z216.0578 C283.437 B48.52
59 L X-9.9679 Y24.4146 Z216.1663 C282.869 B48.558
60 L X-10.0651 Y23.9662 Z216.2705 C282.315 B48.647
61 L X-10.2124 Y23.4998 Z216.3699 C281.779 B48.795
62 L X-10.4119 Y23.013 Z216.4641 C281.264 B49.006
63 L X-10.6547 Y22.5064 Z216.5539 C280.771 B49.272
64 L X-10.9275 Y21.9823 Z216.6402 C280.298 B49.579
65 L X-11.218 Y21.4431 Z216.7239 C279.842 B49.915
66 L X-11.5146 Y20.8922 Z216.806 C279.4 B50.265
67 L X-11.8063 Y20.3332 Z216.8874 C278.968 B50.616

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ROT1

68	L	X-12.0829	Y19.7699	Z216.9689	C278.542	B50.955
69	L	X-12.335	Y19.2068	Z217.0517	C278.116	B51.27
70	L	X-12.5538	Y18.6489	Z217.1366	C277.684	B51.548
71	L	X-12.7307	Y18.1009	Z217.2248	C277.239	B51.776
72	L	X-12.8579	Y17.5685	Z217.3174	C276.775	B51.942
73	L	X-12.9279	Y17.0571	Z217.4153	C276.284	B52.033
74	L	X-12.9338	Y16.5723	Z217.5196	C275.758	B52.037
75	L	X-12.8798	Y16.1149	Z217.6295	C275.194	B51.957
76	L	X-12.781	Y15.6808	Z217.7431	C274.595	B51.81
77	L	X-12.6517	Y15.2653	Z217.8582	C273.966	B51.613
78	L	X-12.5065	Y14.8634	Z217.9728	C273.31	B51.384
79	L	X-12.3592	Y14.4698	Z218.0851	C272.635	B51.14
80	L	X-12.2233	Y14.0787	Z218.1935	C271.946	B50.9
81	L	X-12.1122	Y13.6839	Z218.2962	C271.251	B50.681
82	L	X-12.039	Y13.2789	Z218.3918	C270.56	B50.502
83	L	X-12.0165	Y12.8566	Z218.4789	C269.882	B50.382
84	L	X-12.0565	Y12.4092	Z218.5559	C269.23	B50.339
85	L	X-12.1705	Y11.9284	Z218.6211	C268.614	B50.391
86	L	X-12.3689	Y11.4053	Z218.6725	C268.05	B50.556
87	L	X-12.65	Y10.8356	Z218.7095	C267.543	B50.838
88	L	X-12.9924	Y10.225	Z218.7344	C267.09	B51.21
89	L	X-13.3734	Y9.5814	Z218.7501	C266.68	B51.645
90	L	X-13.7721	Y8.9135	Z218.7593	C266.303	B52.116
91	L	X-14.1692	Y8.2311	Z218.7653	C265.947	B52.595
92	L	X-14.5471	Y7.5448	Z218.7718	C265.598	B53.056
93	L	X-14.8895	Y6.8663	Z218.7827	C265.242	B53.474
94	L	X-15.1814	Y6.2077	Z218.8025	C264.862	B53.823
95	L	X-15.4083	Y5.5821	Z218.8361	C264.441	B54.078
96	L	X-15.5561	Y5.0038	Z218.8887	C263.96	B54.213
97	L	X-15.6099	Y4.4878	Z218.9658	C263.398	B54.201
98	L	X-15.5536	Y4.0508	Z219.0733	C262.73	B54.012
99	L	X-15.379	Y3.7044	Z219.2144	C261.936	B53.629
100	L	X-15.1075	Y3.441	Z219.3851	C261.018	B53.08
101	L	X-14.7664	Y3.2473	Z219.5794	C259.988	B52.405
102	L	X-14.3842	Y3.1085	Z219.791	C258.858	B51.645
103	L	X-13.9917	Y3.0076	Z220.0136	C257.648	B50.846
104	L	X-13.6229	Y2.9245	Z220.241	C256.383	B50.06
105	L	X-13.3151	Y2.8355	Z220.4671	C255.099	B49.342
106	L	X-13.1078	Y2.7125	Z220.6861	C253.841	B48.753
107	L	X-13.0419	Y2.5234	Z220.8921	C252.664	B48.356
108	L	X-13.1571	Y2.2313	Z221.0786	C251.636	B48.215
109	L	X-13.4896	Y1.7959	Z221.2372	C250.828	B48.391
110	L	X-14.0688	Y1.1754	Z221.3566	C250.311	B48.939
111	L	X-14.0684	Y1.1434	Z216.5957	C250.378	B48.956
112	L	X-13.8643	Y1.6749	Z216.4231	C250.928	B48.851
113	L	X-13.7405	Y2.1552	Z216.2438	C251.562	B48.867
114	L	X-13.6871	Y2.594	Z216.0608	C252.264	B48.987
115	L	X-13.6931	Y3.0006	Z215.8766	C253.016	B49.193
116	L	X-13.7473	Y3.384	Z215.6936	C253.802	B49.464
117	L	X-13.838	Y3.7526	Z215.5137	C254.608	B49.783
118	L	X-13.9533	Y4.1142	Z215.3388	C255.42	B50.128
119	L	X-14.0813	Y4.4762	Z215.1708	C256.226	B50.482
120	L	X-14.2103	Y4.8453	Z215.0115	C257.018	B50.825
121	L	X-14.3283	Y5.228	Z214.8627	C257.785	B51.14
122	L	X-14.4234	Y5.6301	Z214.726	C258.521	B51.407
123	L	X-14.4837	Y6.0569	Z214.6033	C259.22	B51.609
124	L	X-14.4991	Y6.5121	Z214.4958	C259.879	B51.733
125	L	X-14.4717	Y6.9926	Z214.4021	C260.504	B51.784
126	L	X-14.4078	Y7.4931	Z214.32	C261.102	B51.774
127	L	X-14.313	Y8.0088	Z214.2473	C261.681	B51.713
128	L	X-14.1937	Y8.5348	Z214.1819	C262.247	B51.614
129	L	X-14.0562	Y9.0668	Z214.1217	C262.806	B51.487
130	L	X-13.9068	Y9.6005	Z214.0648	C263.364	B51.343
131	L	X-13.7524	Y10.1319	Z214.0093	C263.925	B51.194
132	L	X-13.6003	Y10.6573	Z213.9534	C264.494	B51.05
133	L	X-13.4578	Y11.1735	Z213.8953	C265.074	B50.922
134	L	X-13.333	Y11.6774	Z213.8332	C265.669	B50.821
135	L	X-13.234	Y12.1661	Z213.7653	C266.28	B50.759
136	L	X-13.1686	Y12.6374	Z213.6901	C266.91	B50.744
137	L	X-13.1365	Y13.0928	Z213.6076	C267.555	B50.775
138	L	X-13.1324	Y13.5358	Z213.519	C268.21	B50.843

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139	L	X-13.1513	Y13.9692	Z213.425	C268.871	B50.94
140	L	X-13.1877	Y14.396	Z213.3268	C269.534	B51.056
141	L	X-13.2358	Y14.8189	Z213.2252	C270.196	B51.185
142	L	X-13.2896	Y15.2406	Z213.1212	C270.853	B51.316
143	L	X-13.3433	Y15.6635	Z213.0158	C271.502	B51.442
144	L	X-13.3905	Y16.0899	Z212.9099	C272.142	B51.554
145	L	X-13.4247	Y16.5221	Z212.8048	C272.77	B51.644
146	L	X-13.4394	Y16.9621	Z212.7016	C273.384	B51.704
147	L	X-13.4276	Y17.4118	Z212.6013	C273.984	B51.724
148	L	X-13.3824	Y17.873	Z212.5051	C274.568	B51.698
149	L	X-13.3019	Y18.345	Z212.4133	C275.139	B51.625
150	L	X-13.1902	Y18.8255	Z212.3254	C275.698	B51.51
151	L	X-13.0512	Y19.3118	Z212.2406	C276.251	B51.362
152	L	X-12.8895	Y19.8016	Z212.1584	C276.799	B51.186
153	L	X-12.7098	Y20.2926	Z212.0779	C277.345	B50.991
154	L	X-12.5167	Y20.7825	Z211.9986	C277.893	B50.782
155	L	X-12.3155	Y21.2696	Z211.9197	C278.443	B50.567
156	L	X-12.1115	Y21.7519	Z211.8406	C278.998	B50.352
157	L	X-11.9102	Y22.2278	Z211.7606	C279.56	B50.145
158	L	X-11.7175	Y22.6959	Z211.679	C280.128	B49.953
159	L	X-11.5395	Y23.155	Z211.5951	C280.704	B49.781
160	L	X-11.3826	Y23.6039	Z211.508	C281.288	B49.637
161	L	X-11.2513	Y24.0425	Z211.4173	C281.879	B49.526
162	L	X-11.1443	Y24.4715	Z211.3233	C282.477	B49.444
163	L	X-11.0597	Y24.892	Z211.2264	C283.08	B49.389
164	L	X-10.9949	Y25.3048	Z211.1271	C283.689	B49.359
165	L	X-10.9479	Y25.7109	Z211.0258	C284.301	B49.349
166	L	X-10.9158	Y26.1109	Z210.9231	C284.918	B49.357
167	L	X-10.8964	Y26.5055	Z210.8193	C285.538	B49.381
168	L	X-10.8868	Y26.8954	Z210.715	C286.162	B49.416
169	L	X-10.8841	Y27.2809	Z210.6109	C286.79	B49.462
170	L	X-10.8857	Y27.6625	Z210.5075	C287.421	B49.513
171	L	X-10.8885	Y28.0407	Z210.4054	C288.058	B49.569
172	L	X-10.8894	Y28.4158	Z210.3054	C288.699	B49.625
173	L	X-10.8855	Y28.7879	Z210.2082	C289.346	B49.681
174	L	X-10.876	Y29.1565	Z210.1142	C290.	B49.735
175	L	X-10.8614	Y29.5207	Z210.0237	C290.662	B49.79
176	L	X-10.8423	Y29.8796	Z209.9368	C291.335	B49.848
177	L	X-10.8192	Y30.2322	Z209.854	C292.02	B49.909
178	L	X-10.7931	Y30.578	Z209.7751	C292.717	B49.976
179	L	X-10.7649	Y30.9159	Z209.7005	C293.429	B50.052
180	L	X-10.7356	Y31.2454	Z209.6302	C294.155	B50.137
181	L	X-10.7062	Y31.5657	Z209.5643	C294.897	B50.233
182	L	X-10.6783	Y31.8761	Z209.5027	C295.655	B50.342
183	L	X-10.653	Y32.1762	Z209.4454	C296.43	B50.466
184	L	X-10.6319	Y32.4653	Z209.3924	C297.222	B50.608
185	L	X-10.6166	Y32.743	Z209.3433	C298.031	B50.767
186	L	X-10.6082	Y33.0098	Z209.2979	C298.855	B50.946
187	L	X-10.6056	Y33.2681	Z209.2553	C299.691	B51.14
188	L	X-10.6076	Y33.5203	Z209.2149	C300.534	B51.345
189	L	X-10.6127	Y33.7688	Z209.1761	C301.379	B51.559
190	L	X-10.6188	Y34.0159	Z209.1382	C302.223	B51.777
191	L	X-10.6241	Y34.2636	Z209.1008	C303.063	B51.995
192	L	X-10.6262	Y34.5141	Z209.0634	C303.896	B52.21
193	L	X-10.6226	Y34.7692	Z209.0258	C304.718	B52.417
194	L	X-10.6107	Y35.0308	Z208.9876	C305.528	B52.614
195	L	X-10.5875	Y35.3004	Z208.9488	C306.323	B52.795
196	L	X-10.5499	Y35.5798	Z208.9092	C307.1	B52.958
197	L	X-10.4946	Y35.8702	Z208.8687	C307.86	B53.098
198	L	X-10.4183	Y36.1731	Z208.8274	C308.599	B53.212
199	L	X-10.32	Y36.49	Z208.7846	C309.316	B53.297
200	L	X-10.2001	Y36.8227	Z208.7391	C310.006	B53.352
201	L	X-10.0587	Y37.1728	Z208.6898	C310.667	B53.376
202	L	X-9.8958	Y37.5419	Z208.6355	C311.295	B53.365
203	L	X-9.7112	Y37.9317	Z208.5751	C311.887	B53.318
204	L	X-9.5046	Y38.3436	Z208.5072	C312.439	B53.234
205	L	X-9.2753	Y38.7793	Z208.4305	C312.949	B53.108
206	L	X-9.0227	Y39.2403	Z208.3436	C313.413	B52.94
207	L	X-8.7458	Y39.7281	Z208.245	C313.827	B52.726
208	L	X-8.4439	Y40.2443	Z208.1327	C314.188	B52.463
209	L	X-8.1158	Y40.7905	Z208.0049	C314.492	B52.147

## ROT1

210 L X-7.7604 Y41.3684 Z207.8594 C314.735 B51.775  
 211 L X-8.33 Y39.9942 Z203.9401 C317.178 B53.754  
 212 L X-8.5427 Y39.5492 Z204.0097 C316.704 B53.863  
 213 L X-8.743 Y39.1228 Z204.0731 C316.194 B53.944  
 214 L X-8.9312 Y38.7141 Z204.1309 C315.651 B53.999  
 215 L X-9.1072 Y38.3224 Z204.1839 C315.076 B54.03  
 216 L X-9.2711 Y37.947 Z204.2326 C314.471 B54.036  
 217 L X-9.4228 Y37.5871 Z204.2776 C313.837 B54.018  
 218 L X-9.5621 Y37.2419 Z204.3196 C313.176 B53.979  
 219 L X-9.6888 Y36.9108 Z204.3589 C312.49 B53.918  
 220 L X-9.8024 Y36.5929 Z204.3962 C311.78 B53.835  
 221 L X-9.9027 Y36.2874 Z204.4319 C311.048 B53.733  
 222 L X-9.989 Y35.9935 Z204.4666 C310.297 B53.61  
 223 L X-10.0604 Y35.7104 Z204.5007 C309.526 B53.467  
 224 L X-10.1165 Y35.4371 Z204.5348 C308.739 B53.305  
 225 L X-10.1574 Y35.1727 Z204.5691 C307.938 B53.126  
 226 L X-10.186 Y34.9161 Z204.6036 C307.123 B52.931  
 227 L X-10.2045 Y34.666 Z204.6381 C306.296 B52.724  
 228 L X-10.2154 Y34.4211 Z204.6728 C305.458 B52.508  
 229 L X-10.2207 Y34.1801 Z204.7077 C304.612 B52.285  
 230 L X-10.2226 Y33.9413 Z204.7429 C303.759 B52.06  
 231 L X-10.2228 Y33.7031 Z204.7786 C302.903 B51.835  
 232 L X-10.223 Y33.464 Z204.8151 C302.045 B51.612  
 233 L X-10.2247 Y33.2221 Z204.8527 C301.188 B51.396  
 234 L X-10.2293 Y32.9756 Z204.8919 C300.336 B51.188  
 235 L X-10.2377 Y32.7225 Z204.9331 C299.492 B50.992  
 236 L X-10.251 Y32.4608 Z204.9767 C298.659 B50.81  
 237 L X-10.2696 Y32.1887 Z205.0233 C297.841 B50.646  
 238 L X-10.2931 Y31.9058 Z205.0732 C297.038 B50.499  
 239 L X-10.3201 Y31.6126 Z205.1265 C296.251 B50.367  
 240 L X-10.35 Y31.3094 Z205.1833 C295.48 B50.25  
 241 L X-10.3815 Y30.9969 Z205.2438 C294.724 B50.145  
 242 L X-10.414 Y30.6755 Z205.3079 C293.982 B50.052  
 243 L X-10.4466 Y30.3458 Z205.3755 C293.255 B49.969  
 244 L X-10.479 Y30.0086 Z205.4466 C292.54 B49.896  
 245 L X-10.5103 Y29.6642 Z205.5211 C291.838 B49.83  
 246 L X-10.5403 Y29.3135 Z205.5989 C291.147 B49.77  
 247 L X-10.5685 Y28.9572 Z205.6797 C290.466 B49.715  
 248 L X-10.5947 Y28.5958 Z205.7636 C289.794 B49.664  
 249 L X-10.6188 Y28.2302 Z205.8502 C289.13 B49.615  
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 251 L X-10.6643 Y27.4875 Z206.0301 C287.821 B49.526  
 252 L X-10.6899 Y27.11 Z206.1224 C287.175 B49.489  
 253 L X-10.7201 Y26.7282 Z206.2157 C286.533 B49.46  
 254 L X-10.7572 Y26.3419 Z206.3094 C285.896 B49.44  
 255 L X-10.8029 Y25.9506 Z206.4032 C285.263 B49.433  
 256 L X-10.8592 Y25.5541 Z206.4965 C284.634 B49.438  
 257 L X-10.9279 Y25.1519 Z206.5891 C284.008 B49.46  
 258 L X-11.0108 Y24.7436 Z206.6806 C283.386 B49.499  
 259 L X-11.1096 Y24.3288 Z206.7705 C282.768 B49.558  
 260 L X-11.2262 Y23.9067 Z206.8584 C282.154 B49.64  
 261 L X-11.3618 Y23.4769 Z206.9442 C281.544 B49.745  
 262 L X-11.5174 Y23.0387 Z207.0274 C280.939 B49.877  
 263 L X-11.6897 Y22.5925 Z207.1085 C280.339 B50.03  
 264 L X-11.8736 Y22.139 Z207.1879 C279.745 B50.201  
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 266 L X-12.257 Y21.214 Z207.3438 C278.569 B50.572  
 267 L X-12.4476 Y20.7446 Z207.4214 C277.987 B50.761  
 268 L X-12.6316 Y20.2724 Z207.4993 C277.408 B50.945  
 269 L X-12.805 Y19.7988 Z207.5782 C276.829 B51.119  
 270 L X-12.9638 Y19.3254 Z207.6584 C276.25 B51.277  
 271 L X-13.1043 Y18.8538 Z207.7405 C275.669 B51.413  
 272 L X-13.2228 Y18.3857 Z207.825 C275.084 B51.522  
 273 L X-13.3158 Y17.9231 Z207.9123 C274.492 B51.598  
 274 L X-13.3801 Y17.4677 Z208.003 C273.89 B51.635  
 275 L X-13.4168 Y17.02 Z208.0969 C273.279 B51.634  
 276 L X-13.431 Y16.5788 Z208.1932 C272.657 B51.6  
 277 L X-13.4277 Y16.1432 Z208.2911 C272.026 B51.54  
 278 L X-13.4118 Y15.7115 Z208.3899 C271.386 B51.46  
 279 L X-13.3879 Y15.2825 Z208.4888 C270.739 B51.365  
 280 L X-13.3608 Y14.8548 Z208.5872 C270.085 B51.263

ROT1

281 L X-13.3347 Y14.4266 Z208.6842 C269.426 B51.16  
 282 L X-13.314 Y13.9965 Z208.7794 C268.764 B51.06  
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 284 L X-13.3054 Y13.1232 Z208.9612 C267.439 B50.901  
 285 L X-13.3254 Y12.6765 Z209.0465 C266.78 B50.854  
 286 L X-13.3667 Y12.2205 Z209.1272 C266.128 B50.836  
 287 L X-13.43 Y11.7541 Z209.2033 C265.484 B50.849  
 288 L X-13.5104 Y11.2787 Z209.2758 C264.848 B50.889  
 289 L X-13.6031 Y10.7957 Z209.3458 C264.219 B50.947  
 290 L X-13.7029 Y10.3068 Z209.4146 C263.596 B51.016  
 291 L X-13.8052 Y9.8139 Z209.4833 C262.978 B51.089  
 292 L X-13.9053 Y9.3189 Z209.5531 C262.362 B51.159  
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 296 L X-14.1979 Y7.3617 Z209.868 C259.875 B51.261  
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 314 L X-13.849 Y2.6475 Z208.6406 C252.087 B49.124  
 315 L X-13.8446 Y3.1276 Z208.5144 C252.692 B49.274  
 316 L X-13.8656 Y3.5942 Z208.388 C253.321 B49.458  
 317 L X-13.9062 Y4.0506 Z208.2627 C253.968 B49.668  
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 325 L X-14.2159 Y7.6791 Z207.4059 C259.232 B51.053  
 326 L X-14.1809 Y8.1576 Z207.3254 C259.865 B51.081  
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 337 L X-13.5234 Y13.3426 Z206.5093 C266.932 B50.917  
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 342 L X-13.596 Y15.4917 Z206.0333 C270.26 B51.367  
 343 L X-13.6107 Y15.9183 Z205.9341 C270.916 B51.453  
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 349 L X-13.3463 Y18.5456 Z205.3726 C274.733 B51.48  
 350 L X-13.2154 Y18.9985 Z205.2896 C275.352 B51.373  
 351 L X-13.0634 Y19.4516 Z205.2093 C275.969 B51.241

ROT1  
352 L X-12.8944 Y19.9096 Z205.131 C276.586 B51.09  
353 L X-12.8135 Y20.1141 Z205.0957 C276.862 B51.015  
354 L Z255.0956 F MAX  
355 L X-12.5504 Y-25.3724 Z255.0 C322.626 B59.747 F MAX  
356 L X-26.0927 Y30.5897 Z255.0 F MAX  
357 L X-11.5723 Y36.4874 Z252.3344 F MAX  
358 L X-11.5724 Z207.4143 F MAX  
359 L Z202.3344  
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362 M05 END PGM 5NAV-ROT1 MM

OUTPUT

Existing format of SiTarc Machining centre:

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 N 0.00000P 0.00000Q 0.00000R 5.00000  
 N 0.00000A 0.00000V 0.00000O 0.00000T 1.00000M 0.00000M 1.00000B 0.00000L  
 0.00000K 0.00000F 0.00000O 0.00000R 0.00000M 0.10000Z 0.00000X -300.00000Y  
 -300.00000Z -100.00000B 0.00000L 0.00000K 0.00000F 0.00000O 0.00000R 0.00000M  
 0.20000X 300.00000Y 300.00000Z 0.00000T 0.00000O 0.00000O 0.00000L 0.00000C 0.00000A  
 0.00000L 0.00000L 9.00000Z 0.00000S 2500.00000X 0.00000Y 0.00000C 0.00000B 0.00000F  
 0.00000M 0.00000A 0.00000X 0.00000O 3.00000L 0.00000Z 250.00000F 0.00000M 0.00000A  
 0.00000X 8.00000L 0.00000X -44.923901Y -12.20200Z 237.79800C 305.34500B 42.02600F  
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 0.00000A 0.00000X 10.00000L 0.00000X -3.019700Y 46.22700Z 255.00000F 0.00000M 0.00000A  
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OUTPUT

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OUTPUT

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## **7. Conclusion:**

The program written in C-language to translate existing software to control the post processor of Special Purpose CNC machining center. This developed C-program is to control the 5<sup>th</sup> – axis swivel movement of the tool of Sitrac 5-axis CNC machining center. Now, any complicated profiles can be machined in single operation with high quality.

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