Retrofitting of CNC in Conventional Lathe

Project Work

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IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
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CERTIFICATE

This is to certify that the Project Report entitled

RETROFITTING OF CNC IN CONVENTIONAL LATHE

has been submitted by

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in partial fulfilment for the award of the degree of

Bachelor of Engineering in Electrical and Electronics Engineering

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This is to certify that the following final year **ELECTRICAL & ELECTRONICS ENGINEERING** students of **KUMARAGURU COLLEGE OF TECHNOLOGY** have done their project work under the title **"RETROFITTING OF CNC IN CONVENTIONAL LATHE"** in Maintenance & Service Department from **14.07.1995 to 13.10.1995.**

1. C.SIVAKUMAR
2. M.S.VIKRAMAPATHY

During this period their conduct and character were **good**.

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Maintainance & Services

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Senior Manager
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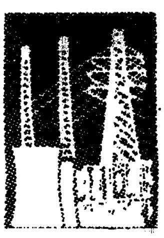
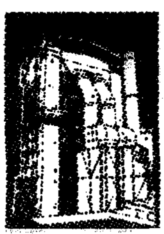
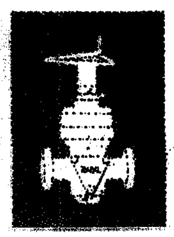

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SYNOPSIS

CNC Retrofit is a via media between conventional Machine tools and full fledged CNC machine Retrofitting is the process of converting an existing conventional Lathe into a CNC Lathe using feedback mechanism.

A typical CNC retrofit package can consist of high precision ball screws, encoders, limit switches, bearings and servomotars. The hallmark of every retrofit package is optimum performance through efficient design and engineering excellence. At a reduced cost we are able to achieve higher accuracy and reduced labour cost which have been the characteristic qualities of full fledged CNC assembly.

Retrofitting can also be carried out for almost all types of Lathes.

CONTENTS

CHAPTER 1

INTRODUCTION

The conventional Lathes that can be used for different types of operations like turning, thread cutting, grinding, milling etc. are all controlled manually.

1.1. Limitations of conventional Lathe

a. The operations carried on are not very accurate.

b. Attention of Labours is much required.

c. Much responsibility rests with the Labour which naturally increases the Labour cost.

d. The causes of error due to Labour fault is more.

e. Time for processing a job is more.

f. Life of the job is less due to the less smooth processing made in the conventional Lathe.

1.2. Advantages of CNC Lathe

a. The Operations are accurate.

b. The responsibilities of labour are much reduced.

c. The Labour cost is reduced.

d. Cause of human errors are reduced.

e. Processing time is less.

f. Life of job is more.

1.3. Disadvantages of CNC Lathe

a. When a CNC Lathe is purchased the existing ordinary Lathe cannot be used since the CNC assembly is available as a whole.

b. The investment required in purchasing a CNC assembly is very high.

1.4. Advantages of Retrofitting

a. With retrofitting the existing conventional Lathe need not be disposed.

b. Cost of the Lathe is saved and hence the overall cost decreases.

c. We can get almost all advantages that are available with the CNC assembly.

d. The ordinary Lathe can be retrofitted according to our necessity.

1.5. Retrofitting

In retrofitting we are automising the X and Z axis movements of the carriage and toolpost by feed mechanism consisting of servomotors, tachogenerators, encoders and ball screws. The tool-changer is also automised using a hydraulic-servo system. The coolant circulation system and the lubrication system are also automised using hydraulic pumps.

CHAPTER 2

CONVENTIONAL LATHE

2.1. Working Principle :

The main function of a lathe is to remove metal in the form of chips from a work piece to give it the required shape and size. This is accomplished by holding the job securely and rigidly on the lathe and then rotating it against a cutting tool. Its basic operations are turning, facing, thread cutting etc.

2.2. The function of Lathe parts

2.2.1. Bed :

It is the base of the lathe. The head stock is mounted on the left end, the carriage in the middle and tailstock at the right end of the bed. The bed has flat or inverted V guide ways.

2.2.2 Head Stock :

It carries a hollow spindle. A live centre can be fitted into the hollow spindle The live centre rotates with the work piece. The spindle is driven by 3 §hase Induction motor. The head stock has a gear box. The power is transmitted to the different parts through gear box.

2.2.3 Tail Stock :

It is mounted on the right end. It is used for supporting the right end of the work piece by means of dead centre. The dead centre does not revolve with work piece. The tail stock is moved along the grooves. The tail stock can be also used for reaming and drilling.

2.2.4 Carriage :

It carries saddle, cross slide, compound rest and toolpost.

a) Saddle : It is a H shaped casting fitted over bed. It moves along guide ways.

b) Cross slide : It carries compound rest and tool post. It can be moved by hand or may be given power feed through apron mechanism.

c) Compound rest : It carries swivel plate (cirular base) which is graduated in degrees.

d) Tool post : The tool is clamped in the tool post.

e) Apron : The lower part of carriage carries gears, clutches and levels for carriage movement.

2.2.5 Feed mechanism :

There are three types of feed namely longitudinal, cross and angular. When the tool moves parallel to the axis of the lathe, the movement is called longitudinal feed When the tool moves perpendicular to the axis of the lathe the movement is called cross feed. When the tool moves at an angle to the axis of the lathe, the movement is called angular feed. The feed rod is used for moving the carriage or cross slide.

CHAPTER 3

RETROFITTING

The CNC unit gives input to a servomotor in the range of (0-10) V. The servomotor starts rotating. The tachogenerator converts the rotary motion into voltages in proportion to the speed. The output of tachogenerator is monitored by the servo processor. It produced differential error. The servoamplifier amplifies the signal and sends to the servomotor. For more accuracy the servo processor also monitors an encoder which produces 250 pulses per revolution. The encoder is coupled with ball screw. The rotary motion is converted into linear motion through the ball screw. Ref. fig. 3.1. The above mechanism is used both for x and z axis movements.

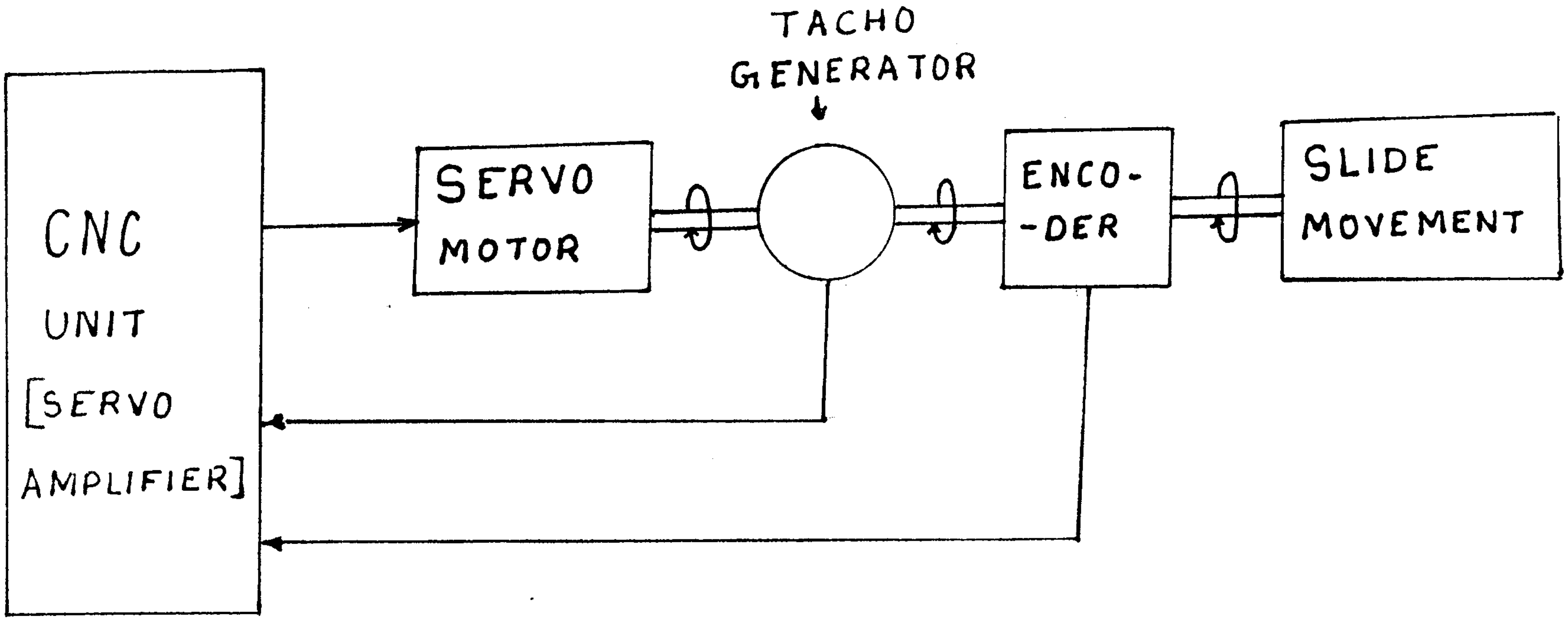

FIG. 3.1 Block diagram for positioning of
tools in Retrofitted CNC lathe
(Both for X and Z axis movements)

CHAPTER 4

CNC UNIT

4.1 Computer Control Concepts :

CNC is a self contained N/C system for a single machine tool, includes a dedicated mini-computer, controlled by stored instruction to perform some or all of the basic numerical control functions.

One of the objectives of CNC system is to replace as much of the conventional N/C hardware with software as possible, to simplify the remaining hardware. There are many ways in which functions can be shared between software and hardware in such system, but all involve some hardware in the controller dedicated to the machine. This controller must contain at least the servo amplifier, the transducer circuits, and intereface components.

The computer output in computer controlled system can be transmitted either as a sequence of reference pulses or as a binary word. With the first technique the computer produces a sequence of reference pulses for each axis-of-motion, each pulse generate a motion of one increment of aixs travel. The number of pulses represents the position and pulse frequency is proportional to required axis feed rate.

These pulses can either actuate a stepper motor in open loop systems or be fed as a reference to a closed loop digital system. This technique is very accurate but results in restrictions on the maximum feed rate. Therefore, it is useful in CNC system.

The control with the binary word technique is closed through the computer itself. The computer contains a control program which compares a reference word with the feedback signal to determine the positional error. This error is supplied at fixed time intervals as an output binary word of the computer. The binary word is fed to a digital to analog converter which in turn supplies a voltage proportional to the required axis feed rate.

A significant advantage of computer control is the avoiding of errors while reading the Numerical Control data tape. In these systems the datatape for producing a part is read only once and stored in the computer memory. When machining the part the program is retrieved thus avoiding one of the biggest sources of error in numerical control systems.

In dealing with errors associated with the part data, the computer controlled systems offer the user an editing feature. Since the part-data is stored in the computer memory it can be easily modified if required, rather than sending the tape for reprocessing - a costly procedure is followed in conventional numerical control systems. Three types of errors can cause the part data-type to be reprocessed; mistakes in the cutting conditions, cutter compoensation or dimensional errors.

Most programmers program the cutting conditions (speed and feed) with safety limits inorder to accomodate for inconsistence in workpiece material and tools. Therefore parts will often be run in production under sub-optimal conditions. When the programmed cutting conditions are too far for achieving even minimum production efficiency, the tape must be sent back to the part - programmer.

Many times the actual size of the tool diameter or length are different from the programmed size. This difference is often too great to be compensated for the appropriate manual devices on the N/C controller. Moreover, the radius compensation available in conventional numerical control system usually compensates only for the distance betweeen the part surface and the cutter center, but small dimensional errors in the cutter directional motional remain.

A third reason for returning a punched data-tape for correction occurs when the tape contains dimensional errors greater than the allowed tolerance. When a tape is returned for correction appropriate changes must be made in the source part-program, i.e., in the APT program of the part. The part program must then be reprocessed and post processed before the tape returns to the shop. This procedure causes a considerable cost interms of both time and money which can be save in NC and CNC systems by using the computer facilities.

4.2 Features of CNC :

* Storage of more than one part program with improvement in computer technology, many of the newer CNC controllers have a large enough capacity to store more than a single program. This translates into the capability to store whether one very large program or several small and medium-sized programs.
* Use of diskettes : There is growing use of floppy disks for a part of programs in manufacturing. The capacity of a 8-inch disk is the approximate equivalent of 8000 ft punched tape. Because of this more information is stored.

* Program editing at the machine tool site; To deal with the mistakes in part programming, CNC systems permit the program to be edited while it is in computer memory. Hence, the process of testing and correcting the program can be done entirely at the machine site rather than returning to the programming office in the shop to make the tape corrections. In addition to part program corrections, editing can also be done to optimize the cutting conditions of the machining cycle. After correcting and optimizing the program, a tape punch can be connnected to the CNC controller in order to obtain a revised version of the tape for future use.

* Fixed cycles and programming subroutines : The increase memory capacity and the ability to program the control computer in CNC provides the opportunity to store frequently used machining cycles in memory that can be called by the part program. Instead of writing the instructions for the particular cycles into every program, a code is written into the program to indicate cycle should be executed. Some of these cycles require the definition of certain parameters to execute. Refer Fig. 4.1.

4.3 Specification of CNC unit used

TYPE :- VIKING 100T with
12" monochrome CRT
.005 mm resolution
Built in PLC with 32 I/O
Rs. 232 C Interface port
manual pulse generator

4.4 Specification of the Servo Stabilizer used for CNC unit

KRYKARD

3 phase Servo Stabilizer

Input voltage	: 295 - 465 V
Output voltage	: 400 V
Normal rating	: 15 KVA

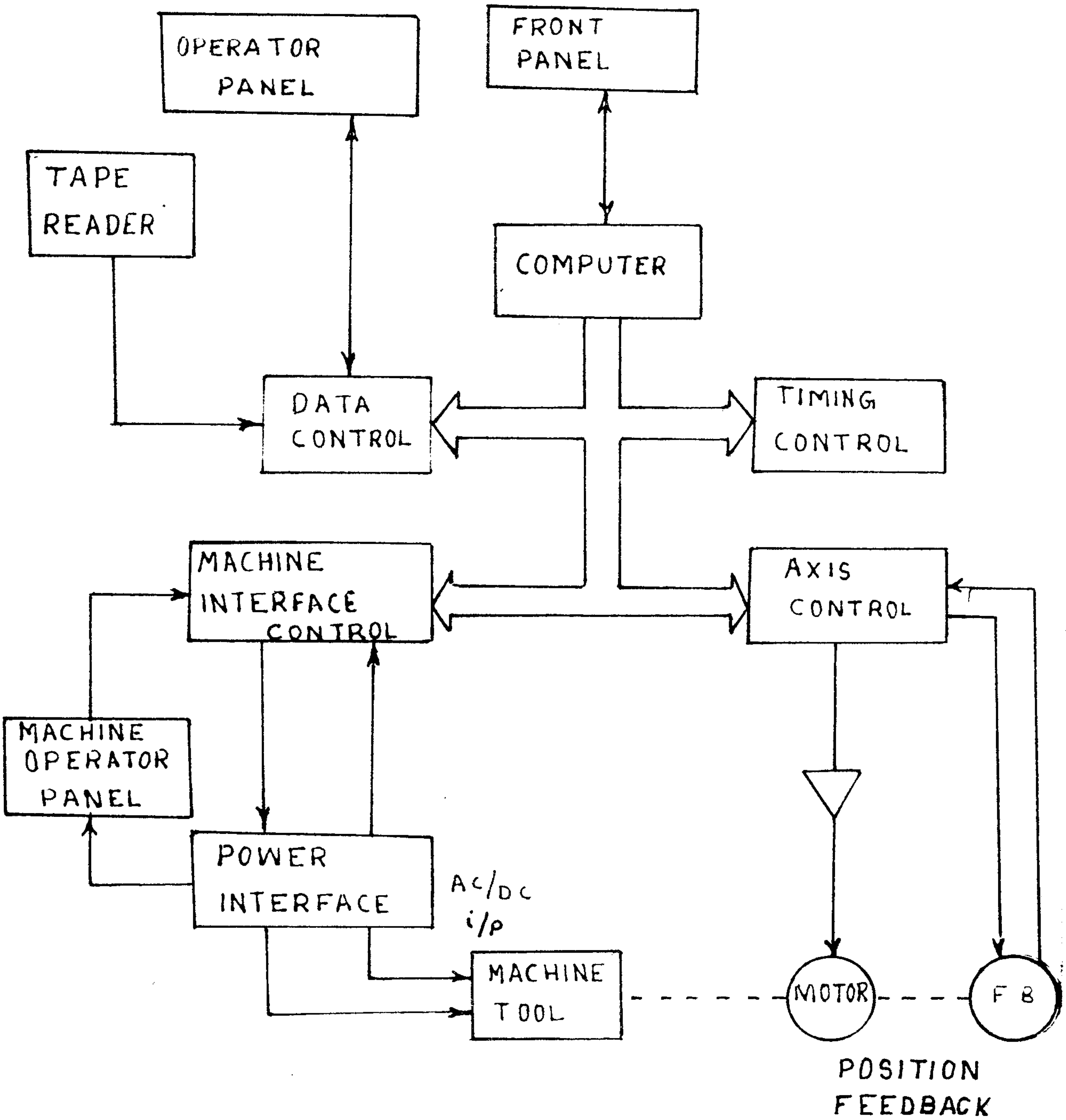

FIG. 4.1 CNC Unit general layout

CHAPTER 5

SERVOMOTOR

5.1 Servomotor

Among the various dc servomotors are the series motor, the shunt (armature or field controlled) motor and permanent magnet fixed excitation shunt motor. These units develop high output power in a given size and in the case of the field controlled shunt motor require little control power. Radio interference generation brush wear and dc amplifier drift are problems. Isolation and matching of dc circuits are difficult as compared with ac circuits.

The series motor has high starting torque and current with poor speed regulation. Reversibility is obtained with a switching system that reverses the field terminals or with a split serious winding, one winding for each direction of rotation. The latter reduces motor efficiency. A typical speed torque curve shows a high stall torque and rapid reduction of torque with increasing speed. This results in good damping but gives a large velocity error.

The shunt motor has good speed regulation and starting torque. Reversibility may be obtained with an armature of field polarity-reversal switching system or by using a split shunt winding, one winding for each direction for rotation. The latter reduces motor efficiency. Armature control or field control is available with a shunt motor.

The permanent magnet motor is a fixed excitation shunt motor where the field is actually supplied by a permanent magnet. Performance is similar to the shunt motor with armature control and fixed field.

DC motors can be controlled by using either the current of the field winding or the armature current. The control of field current is less common. Since it is undesirable to supply the large fixed armature current necessary for large dc servomotors. These are also dynamic advantages in armature control. This arises from the fact that the transfer function from the armature voltage to motor shaft angle is idealised to the following expression

$$\frac{\theta}{V_a} = \frac{1}{K_a S(1+T_m S)}$$

Va is the torque of the motor/amp of armature current.

For the field control of dc motors hte idealized transfer function from field voltage to motor shaft angle is

$$\frac{\theta}{V_f} = \frac{K_f}{R_f J S^2 (1+T_f S)}$$

K_f = torque developed per ampere of field current

R_f = field resistance

J = armature intertia

J_f = Lf/Rf= field time constant

5.2. Specification of Servo motor used

Permanent magnet DC servo motor

Cont amps	:	11 A
speed max	:	2000 rpm
Km	:	0.3 Nm/A
Peak volts	:	170 V
Brake holding torque		
Brake voltage	:	24 V
Tacho emf	:	33V/1000 rpm
insulation class	:	F

For lubrication

1 phase induction motor

220 V capacitor start

50 HZ

CHAPTER 6

TACHOGENERATOR

6.1 Principle

The tachogenerator is an electromechanical component which resembles a small motor and which develops an output voltage proportional to shaft speed. The direction of the shaft is indicated by the polarity of the output voltage.

The Ideal characteristics of the tachogenerator are :

1. The output voltage is linear with respect to shaft speed.

2. The magnitude of the output voltage is same for either direction of rotation.

3. The output is relatively free from undesirable voltages such as noise, harmonic and quadrature.

4. At any one speed the output voltages is proportional to input voltage

5. High sensitivity is available i.e. appreciable output voltage with small shoft speed.

6.2 Construction of D.C. Tachogenerator

The d.c. tachogenerator is similar in appearance and operation to the d.c. motor. A fixed field is established with a direct current through a field coil or with a permanent magnet. As the rotor winding cuts the constant magnetic field a voltage that is proportional to angular velocity is generated in the rotor winding. The transfer function can be written

$$\frac{E_o}{\theta} = K_s$$

where K_s is the d.c. generator gradient in volts/rad).

The d.c. tachogenerators are to be carefully constructed. Symmetry of the magnetic material is essential for bi-directional operation. These generators are built in machined aluminium housing that are protected with an anodised finish. Both flange-type and servotype mountings are available.

CHAPTER 7

ENCODER

7.1 Shaft Encoder

The shaft encoder is a type of analog-to-digital converter which directly converts a physical position to a digital value. The shaft encoder is connected to a rotating shaft and reads out the angular position of the shaft in digital form.

7.2 Construction of Photoelectric Encoder

Photoelectric coders are constructed by using a coder disk with bands divided into transparent segment and opaque segments. A light source is put on one side of the disk and a set of photoelectric cells on the other side, arranged so that one cell is behind each band of the coded disk. If a transparent segment is between the light source and light-sensitive cell, a 1 output result and if an opaque area is in front of the photoelcate cell there will be a 0 output. By increasing the number. of bands around the disk, more precision may be added to the coder. The photoelectric type of coder has greater resolution than the brush type, and even greater resolution may be obtained by using gears and several disks. The state of art is about 18 bits or 218 position per shaft revolution but most commercial coders have 14 bits or fewer.

There is one basic difficulty with the coder illustrated. If the disk is in a position where the output number is changing from 011 to 100, or in any position where several bits are changing value, the output signal may become ambiguous. Since the brushes are of first width, they will overlop the change in segments.

DECIMAL	GRAY CODE
0	0000
1	0001
2	0011
3	0011
4	0110
5	0110
6	0101
7	0100
8	1100
9	1101
10	1111
11	1110
12	1010
13	1011
14	1001
15	1000

TABLE 7.1

The scheme for avoiding ambiguity involves the use of a Gray, or unit distance, code to form the coder disk as in Fig.1. In this code, 2 bits never change value in successive coded binary numbers. By using a Gray-coded disk, a 6 may be read for a 7 or a 4 for a 5 but larger errors will not be made.

If the inputs to the machine are from a coder using a Gray code, the code groups must be converted to conventional binary as BCD before use.

The conversion from binary to Gray code is as follows.

1. The leftmost digit of the binary number is also the leftmost digit of the Gray code.

2. The mod 2 sum ($0 \oplus 0$)$=1 \oplus 1 = 0$ and $1 \oplus 0 = 0 \oplus 1 = 1$) of the two leftmost digits in the binary number will give the second leftmost digit in the Gray code.

3. The mode 2 sum of the second and third digits of the binary number gives the third leftmost digit of the Gray code. This rule continues until the mod 2 sum of the two rightmost digits of the binary number give the right most Gray code digit. Ref Fig. 7.1.

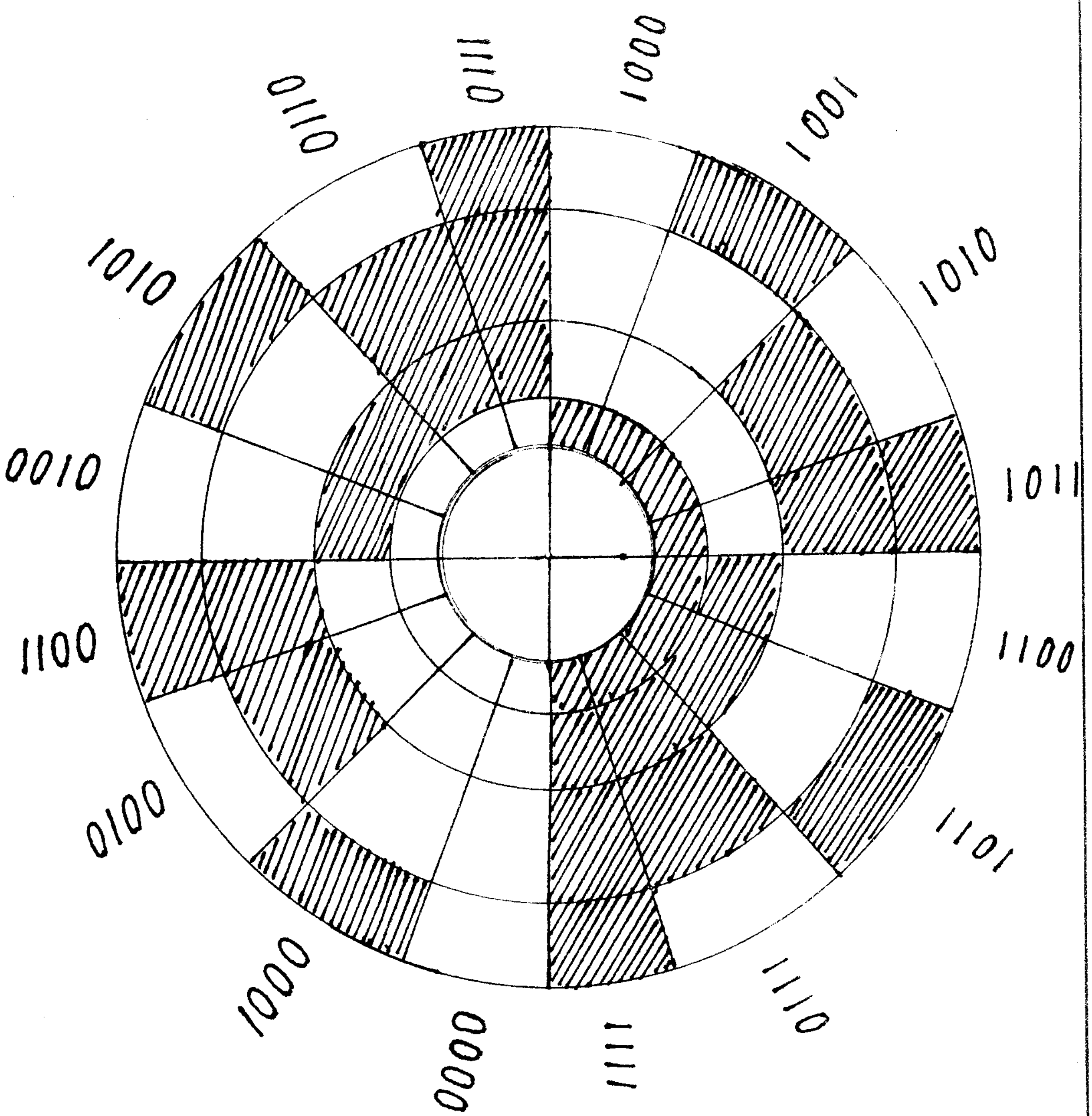

FIG. 7.1 Shaft Position Encoder

CHAPTER 8

TOOL CHANGER

8.1 Automatic tool changer

The concept of the Automatic Tool Changer is that a range of tools shall be available for automatic collection and positioning relative to the job for machining the tank place. It is generally concerned that there shall be sufficient tools in the range on call to complete all machining operations needed for a single setting procedure for tool selection.

(i) The desired tool is selected from the magazine and is placed in a parking position in readness for transfer to the spindle.

ii) The used tool is removed from the spindle and is exchanged with the tools from the parking position.

iii) The magazine is indexed until the position allocated for the used tool is conveniently cited relative to the selector.

iv) The used tool is transferred from the parking position to its allocated position in the magazine.

8.2. Hydraulic system

Hydraulic system is used in automatic tool changers.

8.3. Advantages of Hydraulic System

1. They have greater power-carrying capacity.
2. They are capable of producing many times larger torque than electrical equipment of equivalent size and weight.
3. They can be easily adopted for electrical control.
4. Where continuous operation is necessary, they give a minimum apparatus to horse power ratio.

8.4 Components of Hydraulic Servo Mechanism :

Various components of hydraulic servomechanism are as follows :

1. A source of high pressure oil and a sump to discharge the used oil, which forms the source of fluid for the high pressure supply.

2. A valve, which is the means of controlling the flow of high-pressure oil. The value must be displaced by the actuating signal.

3. An actuator which is the device that actually does the work.This may be a ram type for linear motion as a rotary type for angular motion.

A constant speed electric motor is used to drive a variable delivery pump whose output fluid is used to drive a hydraulic motor which in turn positions the servo controlled shaft. The fluid flow from the pump to the motor is governed in magnitude and direction by the action of a control lever which is generally positioned by a hydraulic preamplifier in which the hydraulic ram output positions the control lever Ref. fig. 8.1.

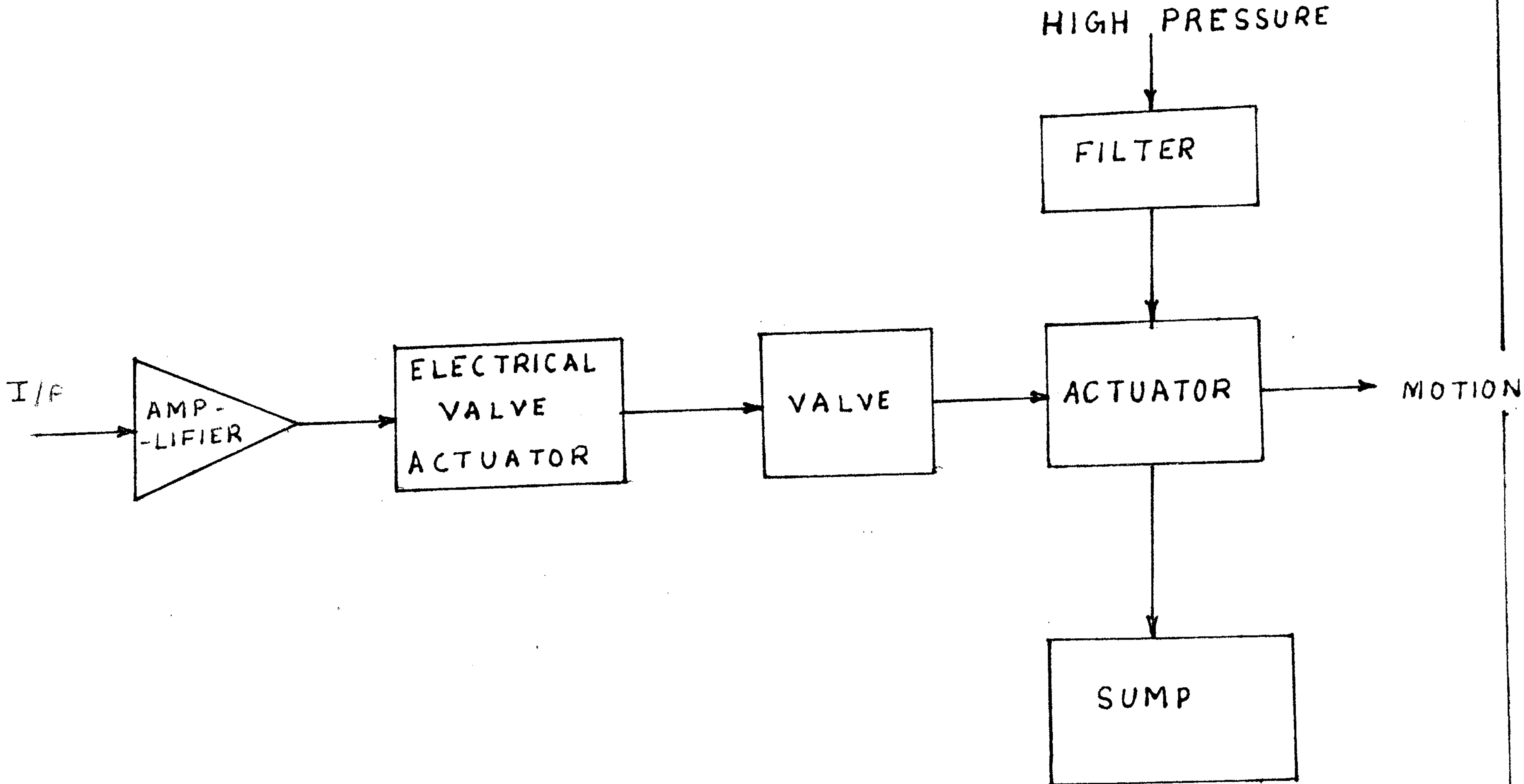

FIG. 8.1 Components of Hydraulic Servomechanism

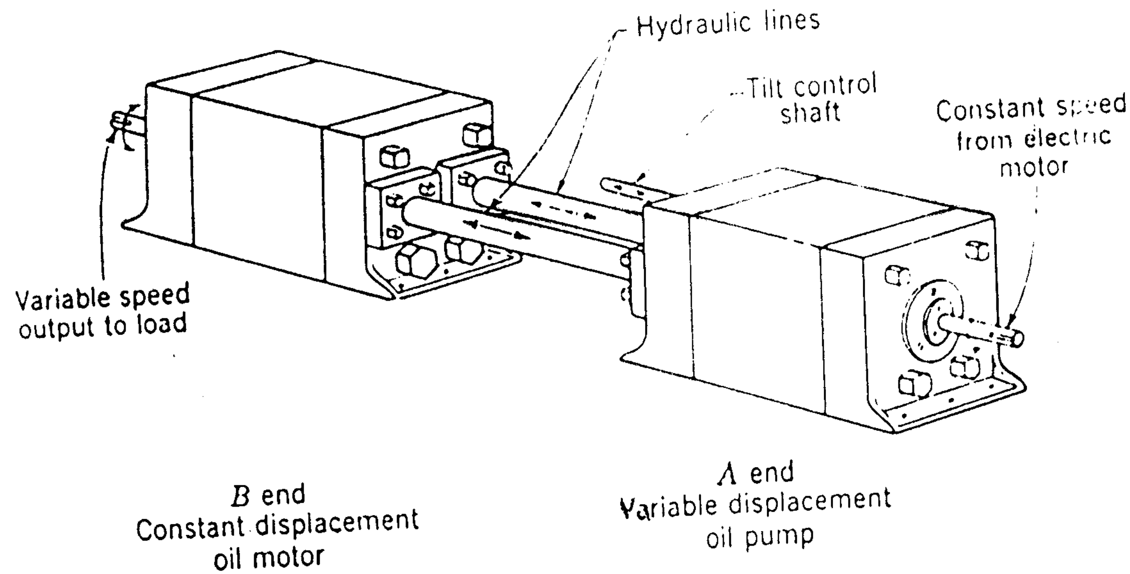

FIG. 8.2 Hydraulic Machine

CHAPTER 9

SLIDE MECHANISM

9.1. Ball Screw

In conventional machine tools usually employ trapezoidal threads. These threads are very inefficient due to high frictional resistance between the flanks of the screw and nut and with the increased diameter of Lead screws used on CNC machines this friction increases the torque requirements. The friction gives rise to local heat and inaccuracies results from this case. Backlash of the magnitude met with an normal screw drives is quite unacceptable for many CNC applications. It can be reduced by backlash eliminator i.e. use of ball Lead screws to eliminate frictional resistance. The thread form in both screw and nut is a female groove of gothic arch form. The efficiency of recirculating ball screw is very high. The use of this type faces another type of inaccuracy (ie.) thrust bearing faces of the screw. By proper good design it can be eliminated. One important characteristic of low friction type screws which must be mentioned is that the imparted motion may be reversible.

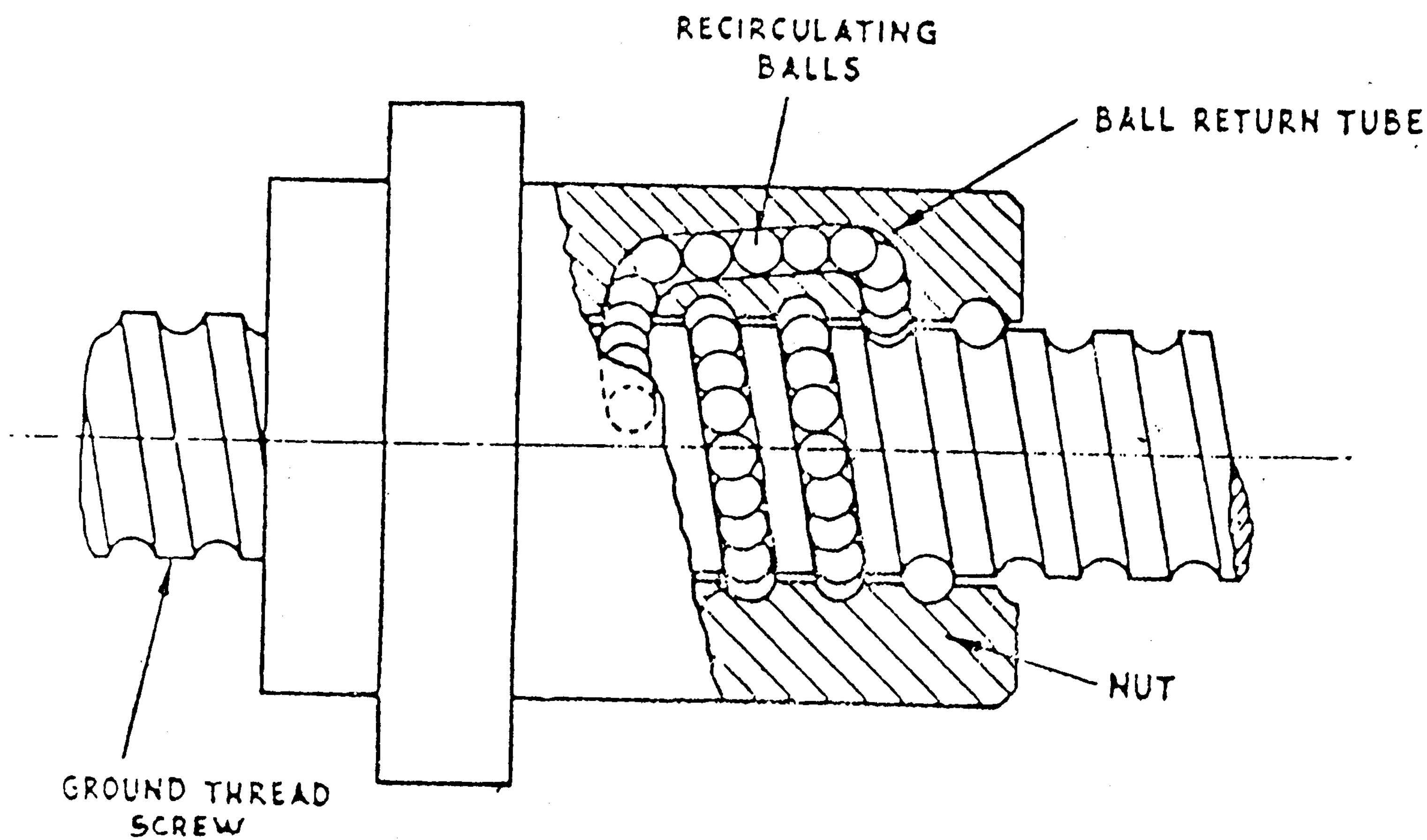

FIG. 9.1 Recirculating Ball Screw

CHAPTER 10

CONCLUSION

The limitations of using the conventional Lathe are its less efficiency, sluggishness and its need more human effort.

The CNC assembly lathe has been found to give results with higher accuracy and less labour effort. The disadvantage of the CNC assembly is its comparatively higher cost.

Retrofitting has been done in a conventional Lathe and found that it shows almost all the salient features that can be found in a CNC assembly Lathe at a reduced cost.

The retrofitting of CNC in conventional Lathe can be made use of in big industries where it is highly imperative to get highly accurate, quicker, least cost results in the various types of machining of jobs.

REFERENCES

1. KATSUHIKO OGATO, "MODERN CONTROL ENGINEERING", Prentic Hall of India Pvt. Ltd.,New Delhi,1991.

2. DR. R. BALASUBRAMANIAM, "BASIS OF MECHANICAL ENGINEERING", Palaniandavar Printers, Coimbatore, 1990.

3. I.J. NAGARATH & GOPAL, "CONTROL SYSTEM ENGINEERING", Wiley Eastern Limited, New Delhi, 1991.

4. M. MORRIS MANO, "DIGITAL LOGIC AND COMPUTER DESIGN", Prentice Hall of India, 1989.

5. E.V. ARMENSKY AND G.B. FALK, "FRACTIONAL HORSE POWER ELECTRICAL MACHINES", MIR Publishers, Moscow, 1985.

APPENDIX 1

SUMMARY SHEET FOR CNC CONTROL

(4 Digits) Programme Number

*N	(4 Digits) Tape Block Number
*G	(2 Digits) Preparatory Command
GO	Positioning
G1	Straight/Line
G2	Clockwise Arc
G3	Counter clockwise Arc
G4	Dwell
G20	Cutting Cycle A
G21	Thread Cutting Cycle
G22	Stored Stroke Limit ON
G23	Stored Stroke Limit OFF
G24	Cutting Cycle B
G28	Return to Reference point
G29	Return from Reference point
G33	Constant Lead Threading
G40	Tool Nose Radius Comp CANCEL
G41	Tool Nose Radius Comp RIGHT
G70	Inch Programming
G71	Metric Programming
G72	Finishing Cycle

G73	Stock Removal in Turning
G74	Stock Removal in Facing
G75	Pattern Repeating
G76	Peck Drilling in Z Axis
G77	Growing in X Axis
G78	Thread Cutting Cycle
G90	Absolute Programming
G91	Incremental Programming
G92	Position Preset
G94	Per Minute Feed
G95	Per Revolution Feed
G96	Constant Surface Speed
G97	Direct RPM Programming
*T	(4 Digits)
	First Two Digits = Turret Face
	Last Two Digits = Offset Number
R	(8 Digits) 00000.000) ARC Centre Distance
*M	(2 Digits) Miscellaneous Functions
M0	Programme Stop
M1	Optional Stop
M2	End of Programme
M3	Spindle Counterclockwise
M4	Spindle Clockwise
M5	Spindle Stop
M8	Coolant ON

M9	Coolant OFF
M10	Collet of Chuck Close
M11	Collet or Chuck Open
M18	Tailstock IN
M19	Tailstock OUT
M20	Quill LEFT
M21	Quill RIGHT
M22	Reverse Index
M23	Forward Index
M24	Steady Rest (#1) Open
M25	Steady Rest (#1) Close
M26	Steady Rest (#2) Open
M27	Steady Rest (#2) Close
M28	Parts Catcher Open
M29	Parts Catcher Close
M30	Programme Rewind
M36	Cancel M37
M37	Ignore Up to Speed Feed Hold Signal
M40	Dry Run WITHOUT Spindle Running
M41	Dry Run WITH Spindle Running
M42	Normal Mode (Dry Run Off)
M48	Cancel M49
M49	Feedrate and Spindle Speed Overrides Inactive

M90	In Position Check - ON
M91	In Position Check - OFF
M92	Soft Jaw Boring
M96	Pull Out in Lead Enabled
M97	Pull Out in Lead Disabled
M98	Sub-Programme Call
M99	Sub-programme End

NOTES :

1. Decimal Point Programming Otherwise Leading Zero Suppression.

2. Model Registers

3. The First Tape Block Must Contain an EOB

4. Only One M Code Per Block of Tape.

5. Default Mode.

X (8 Digits ± 00000.000)

Radial Incremental Distance With G91
Radial Absolute Position With G90
Dwell In Seconds with G04

Z (8 Digits ± 00000.000)
Longitudinal Incremental Distance With G91
Longitudinal Absolute Position

U (8 Digits ± 00000.000)
Radial Incremental Distance

W (8 Digits ± 00000.000)
Longitudinal Incremental Distance

I (8 Digits ± 00000.000) ARC Centre Distance in X-Axis

K (8 Digits ± 00000.000)ARC Centre Distance In Z-Axis

*F	(6 Digits 000.000) Feedrate In IPR (5 Digits 000.000) Feedrate In IPM	
E	(7 Digits 000.000) Thread Lead In IPh	
*S	(4 Digits) RPM (SFM With CSS)	

APPENDIX - 2

CNC RETROFIT PACKAGE

SL. NO.	QTY NOS	DESCRIPTION
1.		CNC PACKAGE CONSISTING OF :
	ONE	KEC's CNC system Type VIKING 100 T with: * 12" monochrome CRT * 0.005mm resolution * Built in PLC with 32 I/Os * RS 232 C Interface port * Manual pulse generator
1.2.	ONE	All necessary interface cables of 8 metres * Between cardcage and CRT * RS232C cable
2.	ONE	DATA LOADER
3.		FEED BACK TRANSDUCER :
3.1.		ROTARY ENCODERS :
3.1.1.	ONE	250 Pulses/revolution for X Axis
3.1.2.	ONE	250 Pulses/revolution for Z Axis
4.	TWO SETS	EUCHNER LIMIT SWITCH KITS
4.1.		Limit switch sets
4.2.		Small size vector dogs

4.3. Big size vector dogs

4.4. Race way for vector dogs

5. SERVO FEED DRIVE PACKAGE CONSISTING OF :

5.1.	ONE	Permanent Magnet DC Servo Motor for X Axis Type MDC/10.10H/MSA-0/SO2 equipped with tacho generator of 33 volts/1000 rpm. Temperature Sensor connector Key way of 3.5 x 6.0 x 40 mm Maximum speed 2000 rpm Continuous stall torque at 45^{o} ambient 2.5Nm
5.2.	ONE	Permanent Magnet DC Servo Motor for Z Axis Type DC/10.20F/MSA-0/SO2 equipped with tacho generator of 33 volts/1000 rpm. Temperature Sensor connector Keyway of 3.5 x 6.0 x 40 mm Maximum speed 2000 rpm Continuous stall torque at 45^{o}C ambient 3.7Nm
5.3.	ONE	Thyristor Control Amlifier Type 3TRM2/G11-WO/TSS4/092/082 equipped with axes modules TSS4/092/082 for motor of X and Z axes.
5.4.	ONE	Isolation Transformer single phase 50 Hz Type ETT5/S-380, 415, 440/2x140V Primary voltage 380, 415, 440 Secondary voltage 2 x 140V Power rating 5KVA for Amplifier 3TRM2
5.5.	TWO	Smoothing Choke for Motor X Axis type GLD-2
5.6.	ONE	Smoothing Choke for Motor Z Axis Type GLD-2

6. ONE Auto Lubrication Unit

7. ONE High Precision Ground Ball Lead Screws

7.1 ONE For X axis
Dia to suit mm
Pitch to suit
Thread length to suit mm
Overall length to suit mm

7.2. ONE For X axis
Dia to suit mm
Pitch to suit
Thread length to suit mm
Overall length to suit mm

8. ONE SET Mechanical retrofit kit for X axis consisting of :

8.1. High Precision bearings for mounting the ball screws, servo motors and encoders.

8.2. Mechanical brackets for mounting the ball screws, servo motors and encoders.

8.3. Timer belts and pulleys with taper lock bushes.

9. ONE SET Mechanical retrofit kit for Z Axis consisting of :

9.1. High Precision bearings for mounting the ball screws.

9.2. Mechanical brackets for mounting the ball screws, servo motors and encoders.

9.3. Timer belts and pulleys with taper lock bushes.

10.	ONE	Air conditioned Electrical Interface Panel suitable for viking 100T and consisting of electricals for axes control interlocks, etc. All cabling for servo motors, encoders, limit switches and actuating dogs.
10.1.	ONE	Ultra Isolation Transformer for CNC system
11.		RETROFITTING WORK :
11.1.		Modification of cross slide and saddle to incorporate the ball screws and centralised lubrication.
11.2.		Electrical wiring and mounting.
11.3.		Machine proveout with CNC system.
12.0	ONE	8 Station automatic tool turret Type BTP63/BTR80
13.0	ONE	3 Ph. stabiliser of 15 KVA rating.
14.0	THREE SETS	Programming manual.