AUTOMATION OF A PSPR MACHINE

A PROJECT REPORT

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Certificate

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BONAFIDE CERTIFICATE

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PROJECT CERTIFICATE

This is to certify that **Mr.G.Arjunprasad, B.E,** student of **Kumaraguru College of Technology,** has done a Project Work on **"Automation of a PSPR Machine"** **in** our **ROOTS INDUSTRIES LIMITED** from January 2008 to April 2008.

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Abstract

ABSTRACT

This project aims to automate the feed line of the Press Shop Power Press (PSPR) machine. The Power Press is used for making various shapes and materials used for the production of horn. The automation is performed for its process which is used make the pin holder of the horn. Presently, the feeding process is carried out manually. Weighing the advantages of Programmable Logic Controller (PLC) over a micro controller and considering the environment of the industry, PLC emerged as a clear winner to be used as a control device in this project. OMRON Programmable Logic Controller 10C1DRD-D-V2 is used to control the feeding process. The feeder setup is made up of metal and crafted in such a way as to align the feeding strip in the correct manner. The Programmable Logic Controller controls the stepper motor and the Press Shop Power Press machine. When the metal strip that has to be fed is inserted and the signal is given to start the machine, the strip is pulled along using the rollers and from time to time PLC issues the control signal to PSPR so that the ram or slide comes down and makes contact with the metal strip. The required shape is created and slid down in to the basket. When the metal strip is over, sensor detects it and issues signal to load a new one.

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CHAPTER 1
INTRODUCTION

In this global economy and in daily experience, Automation plays an increasingly important role. Engineers strive to combine automated devices with mathematical and organizational tools to create complex systems for a rapidly expanding range of applications and human activities. There are still many jobs which are in no immediate danger of automation. No device has been invented which can match the human eye for accuracy and precision in many tasks; nor the human ear. However, in the scope of industrialization, it is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the physical requirements of work, automation greatly reduces the need for human sensory and mental requirements as well. Processes and systems can also be automated.

In this project, the feeding system of a PSPR machine is automated. The feed line setup basically consists of the Omron PLC 10C1DR-D-V2, stepper motor, driver circuitry, sensor and the feeder setup. The PLC performs the control operation in the feed line setup. It is used to generate control signals for the stepper motor and the PSPR machine. The PLC's output is connected to the driver circuitry. The driver circuitry is responsible for the flux and direction control in the stepper motor. The stepper motor is used for rotating the rollers. The rollers in turn pull the metallic strip forward. The PLC controls the movement of stepper motor and the PSPR machine. When the metallic strip has moved in to the correct position under the ram, the ram slides down and the manufactured part is slid down. The process continues until the strip is used up.

1.1 AIM OF THE PROJECT

To automate the feed line operation of a PSPR machine.

1.2 BLOCK DIAGRAM

The block diagram of the project is shown in Fig 1.1.

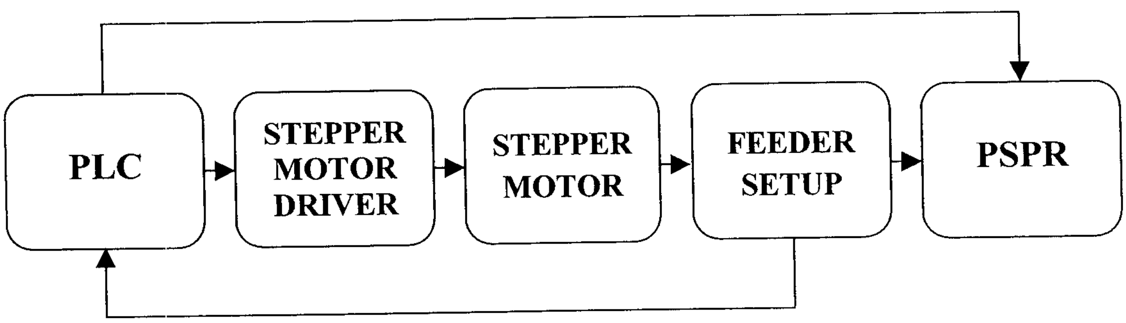


Fig 1.1

The feed line setup basically consists of the PLC, stepper motor, driver circuitry, sensor and the feeder setup. The PLC performs the control operation in the feed line setup. It is used to generate control signals for the stepper motor and the PSPR machine. The PLC's output is connected to the driver circuitry. The driver circuitry is responsible for the flux and direction control in the stepper motor. The stepper motor is used for rotating the rollers. The rollers in turn pull the metallic strip forward. The PLC controls the movement of stepper motor and the PSPR machine. When the metallic strip has moved in to the correct position under the ram, the ram slides down and the manufactured part is slid down. The process continues until the strip is used up.

1.3 PLC

A programmable logic controller (PLC), or programmable controller is a digital computer used for automation of industrial processes, such as control of machinery on factory assembly lines. The details of PLC used is given in the Appendix. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory.

1.4 STEPPER MOTOR DRIVER

The driver circuit of the stepper motor has two major tasks they are

a) To change the current and flux direction in the phase windings.
b) To drive a controllable amount of current through the windings, and enabling as short current rise and fall times as possible for good high speed performance.

Flux direction control

Stepping of the stepper motor requires a change of the flux direction, independently in each phase. The direction change is done by changing the current direction, and may be done in two different ways, using a bipolar or a unipolar drive.

1.5 STEPPER MOTOR

A stepper motor is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps. The motor's position can be controlled precisely, without any feedback mechanism. Stepper motors operate much differently from normal DC motors, which simply spin when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central metal gear, as shown at right. To make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step." In that way, the motor can be turned a precise angle. There are two basic arrangements for the electromagnetic coils: bipolar and unipolar.

1.6 FEEDER SETUP

The feeder setup mainly consists of two rollers. They are held in place by the vertical beams. The upper roller is suspended by the spring and this enables it to hold the metal strip in place.

The rollers are connected to the vertical beam by the ball bearings. The stepper motor is connected to the mechanical setup by means of a gear. Gear ratio used is 1:2. The C section is used to support the metal strip while the feeding operation is performed.

1.7 POWER PRESS

A mechanically powered machine that shears, punches, forms, or assembles metal or other material by means of cutting, shaping, or combination dies attached to slides. A press consists of a stationary bed (or anvil), and a slide (or slides) having a controlled reciprocating motion toward and away from the bed surface, the slide being guided in a definite path by the frame of the press.

1.8 ORGANIZATION OF THE REPORT

Chapter 1 deals with Introduction part. The need for this project and the scope of the project are discussed in detail.

Chapter 2 explains about the Hardware details of the project.

Chapter 3 deals with the design of the Feeder setup.

Chapter 4 deals about the Power Press machine and its configuration.

Chapter 5 offers the Conclusion of the project work.

Chapter 2

CHAPTER 2
HARDWARE DETAILS

2.1 PROGRAMMABLE LOGIC CONTROLLER

A Programmable Logic Controller (PLC), or programmable controller is a digital computer used for automation of industrial processes, such as control of machinery on factory assembly lines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result.

2.1.1 FEATURES

The main difference from other computers is that PLCs are armored for severe condition (dust, moisture, heat, cold, etc) and have the facility for extensive input/output (I/O) arrangements. These connect the PLC to sensors and actuators. PLCs read limit switches, analog process variables (such as temperature and pressure), and the positions of complex positioning systems. Some even use machine vision. On the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays or solenoids, or analog outputs. The input/output arrangements may be built into a simple PLC, or the

PLC may have external I/O modules attached to a computer network that plugs into the PLC.

PLCs were invented as replacements for automated systems that would use hundreds or thousands of relays, cam timers, and drum sequencers. Often, a single PLC can be programmed to replace thousands of relays. Programmable controllers were initially adopted by the automotive manufacturing industry, where software revision replaced the re-wiring of hard-wired control panels when production models changed.

Many of the earliest PLCs expressed all decision making logic in simple ladder logic which appeared similar to electrical schematic diagrams. The electricians were quite able to trace out circuit problems with schematic diagrams using ladder logic. This program notation was chosen to reduce training demands for the existing technicians. Other early PLCs used a form of instruction list programming, based on a stack-based logic solver.

The functionality of the PLC has evolved over the years to include sequential relay control, motion control, process control, distributed control systems and networking. The data handling, storage, processing power and communication capabilities of some modern PLCs are approximately equivalent to desktop computers. PLC-like programming combined with remote I/O hardware, allow a general-purpose desktop computer to overlap some PLCs in certain applications.

Under the IEC 61131-3 standard, PLCs can be programmed using standards-based programming languages. A graphical programming notation called Sequential Function Charts is available on certain programmable controllers.

2.1.2 TRADITIONAL PLC APPLICATIONS

- In automated system, PLC controller is usually the central part of a process control system.
- To run more complex processes it is possible to connect more PLC controllers to a central computer.

2.1.3 ADVANTAGES OF PLC CONTROL

- Rugged and designed to withstand vibrations, temperature, humidity, and noise.
- Have interfacing for inputs and outputs already inside the controller.
- Easily programmed and have an easily understood programming language.

2.2 STEPPER MOTOR

A stepper motor is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps. The motor's position can be controlled precisely, without any feedback mechanism (see open loop control). Stepper motors are similar to switched reluctance motors, which are very large stepping motors with a reduced pole count, and generally are closed-loop commutated.

2.2.1 FUNDAMENTALS OF OPERATION

Stepper motors operate much differently from normal DC motors, which rotate when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step." In that way, the motor can be turned a precise angle.

Theory

A step motor can be viewed as a synchronous AC motor with the number of poles (on both rotor and stator) increased, taking care that they have no common denominator. Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor). Modern steppers are of hybrid design, having both permanent magnets and soft iron cores.

To achieve full rated torque, the coils in a stepper motor must reach their full rated current during each step. Winding inductance and reverse EMF generated by a moving rotor tend to resist changes in drive current, so that as the motor speeds up, less and less time is spent at full current -- thus reducing motor torque. As speeds further increase, the current will not reach the rated value, and eventually the motor will cease to produce torque.

Pull-in torque

This is the measure of the torque produced by a stepper motor when it is operated without an acceleration state. At low speeds the stepper motor can synchronise itself with an applied step frequency, and this Pull-In torque must overcome friction and inertia.

Pull-out torque

The stepper motor Pull-Out torque is measured by accelerating the motor to the desired speed and then increasing the torque loading until the motor stalls or "pulls Out of synchronism" with the step frequency. This measurement is taken across a wide range of speeds and the results are used to generate the stepper motors dynamic performance curve. As noted below this curve is affected by drive voltage, drive current and current switching techniques. It is normally recommended to use a safety factor of between 50% and 100% when comparing your desired torque output to the published "pull-Out" torque performance curve of a step motor.

Detent torque

Synchronous electric motors using permanent magnets have a remnant position holding torque (called *detent torque*, and sometimes included in the specifications) when not driven electrically. Soft iron reluctance cores do not exhibit this behavior.

Stepper motor characteristics

Stepper motors are constant-power devices (power = angular velocity x torque). As motor speed increases, torque decreases. The torque curve may be extended by using current limiting drivers and increasing the driving voltage.

Steppers exhibit more vibration than other motor types, as the discrete step tends to snap the rotor from one position to another. This vibration can become very bad at some speeds and can cause the motor to lose torque. The effect can be mitigated by accelerating quickly through the problem speed range, physically dampening the system, or using a micro-stepping driver. Motors with greater number of phases also exhibit smoother operation than those with fewer phases.

Open-loop versus closed-loop commutation

Steppers are generally commutated open loop, ie. the driver has no feedback on where the rotor actually is. Stepper motor systems must thus generally be over engineered, especially if the load inertia is high, or there is widely varying load, so that there is no possibility that the motor will lose steps. This has often caused the system designer to consider the trade-offs between a closely sized but expensive servo system and an oversized but relatively cheap stepper.

A new development in stepper control is to incorporate a rotor position feedback (eg. an encoder or resolver), so that the commutation can be made optimal for torque generation according to actual rotor position. This turns the stepper motor into a high pole count brushless servo motor, with exceptional low speed torque and position resolution. An advance on this technique is to normally run the motor in open loop mode, and only enter closed loop mode if the rotor position error becomes too large -- this will allow the system to avoid hunting or oscillating, a common servo problem. There are two basic winding arrangements for the electromagnetic coils in a two phase stepper motor: bipolar and unipolar.

Unipolar motors

An unipolar stepper motor has logically two windings per phase, one for each direction of current. Since in this arrangement a magnetic pole can be reversed without switching the direction of current, the commutation circuit can be made very simple (eg. a single transistor) for each winding. Typically, given a phase, one end of each winding is made common: giving three leads per phase and six leads for a typical two phase motor. Often, these two phase commons are internally joined, so the motor has only five leads.

A microcontroller or stepper motor controller can be used to activate the drive transistors in the right order, and this ease of operation makes unipolar motors popular with hobbyists; they are probably the cheapest way to get precise angular movements.
(For the experimenter, one way to distinguish common wire from a coil-end wire is by measuring the resistance.

Fig 2.1 shows the configuration of unipolar stepper motor coil. Resistance between common wire and coil-end wire is always half of what it is between coil-end and coil-end wires. This is due to the fact that there is actually twice the length of coil between the ends and only half from center (common wire) to the end).

Unipolar stepper motors with six or eight wires may be driven using bipolar drivers by leaving the phase commons disconnected, and driving the two windings of each phase together. It is also possible to use a bipolar driver to drive only one winding of each phase, leaving half of the windings unused.

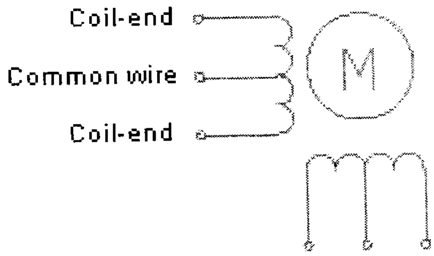


Fig 2.1 Unipolar Stepper motor coil

Bipolar motor

Bipolar motors have logically a single winding per phase. The current in a winding needs to be reversed in order to reverse a magnetic pole, so the driving circuit must be more complicated, typically with an H-bridge arrangement. There are two leads per phase, none are common.Because windings are better utilised, they are more powerful than a unipolar motor of the same weight.

Phase current waveforms

A stepper motor is a polyphase AC synchronous motor (see Theory below), and it is ideally driven by sinusoidal current. A full step waveform is a gross approximation of a sinusoid, and is the reason why the motor exhibits so much vibration. Various drive techniques have been developed to better approximate a sinusoidal drive waveform: these are half stepping and microstepping.

Full step drive (two phases on)

This is the usual method for full step driving the motor. Both phases are always on. The motor will have full rated torque.

Wave drive

In this drive method only a single phase is activated at a time. It has the same number of steps as the full step drive, but the motor will have significantly less than rated torque. It is rarely used.

Half stepping

When half stepping, the drive alternates between two phases on and a single phase on. This increases the angular resolution, but the motor also has less torque at the half step position (where only a single phase is on). This may be mitigated by increasing the current in the active winding to compensate. The advantage of half stepping is that the drive electronics need not change to support it.

Micro stepping

What is commonly referred to as micro stepping is actual "sine cosine micro stepping" in which the winding current approximates a sinusoidal AC waveform. Sine cosine micro stepping is the most common form, but other waveforms are used. Regardless of the waveform used, as the micro steps become smaller, motor operation becomes more smooth. However, the purpose of micro stepping is not usually to achieve smoothness of motion, but to achieve higher position resolution. A microstep driver may split a full step into as many as 256 microsteps. A typical motor may have 200 steps per revolution. Using such a motor with a 256 microstep controller (also referred to as a "divide by 256" controller) results in an angular resolution of 360°/200/256 = 0.00703125° or 51200 discrete positions per revolution. However, it should be noted that such fine resolution is rarely achievable in practice, regardless of the controller, due to mechanical stiction and other sources of error between the specified and actual positions.

Step size repeatability is an important step motor feature and a fundamental reason for their use in positioning. Microstepping can affect the step size repeatability the motor. Example: many modern hybrid step motors are rated such that the travel of every Full step (example 1.8 Degrees per Full step or 200 Full steps per revolution) will be within 3% or 5% of the travel of every other Full step; as long as the motor is operated with in its specified operating ranges. Several manufacturers show that their motors can easily maintain the 3% or 5% equality of step travel size as step size is reduced from Full stepping down to 1/10th stepping. Then, as the microstepping divisor number grows, step size repeatability degrades. At large step size reductions it is possible to issue many microstep commands before any motion occurs at all and then the motion can be a "jump" to a new position.

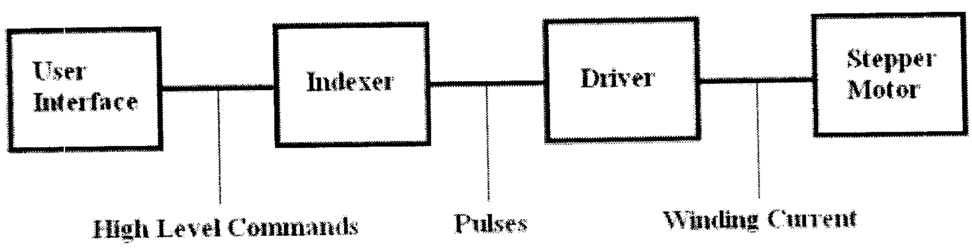
2.2.2 APPLICATIONS

Computer-controlled stepper motors are one of the most versatile forms of positioning systems. They are typically digitally controlled as part of an open loop system, and are simpler and more rugged than closed loop servo systems.

Industrial applications are in high speed pick and place equipment and multi-axis machine CNC machines often directly driving lead screws or ballscrews. In the field of lasers and optics they are frequently used in precision positioning equipment such as linear actuators, linear stages, rotation stages, goniometers, and mirror mounts. Other uses are in packaging machinery, and positioning of valve pilot stages for fluid control systems. Commercially, in floppy disk drives, flatbed scanners, printers, plotters and many more devices.

2.2.3 CONTROL LOGIC

To control a stepper motor, you have to energize each winding individually in a specific and timed order. The energizing is accomplished by a driver circuit (an amplifier). The timing is performed by an indexer circuit and the objective (go forward, go backward, brake, coast, etc.) is controlled by some external user interface, such as a computer or joystick. The figure below shows this process.



2.2.4 DRIVERS

The circuits for driving unipolar and bipolar stepper motors differ because bipolar stepper motors don't have a "center tap." However, it is possible to use bipolar drivers to drive unipolar steppers after some small modifications.

Care must be taken in the driver circuit to protect against voltage spikes. Because the motor windings are inductors, switching off the power to the winding produces a short burst of voltage. To protect against this, always put a diode in parallel with the winding, making sure the diode can handle the winding current. This is shown in Fig 2.2.

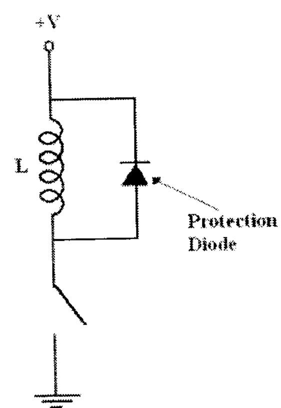


Fig 2.2 Coil Protection Circuit

Bipolar Stepper Driver Circuit

Bipolar stepper drivers use H-bridges to energize the windings of the motor. H-bridges allow you to choose the direction of the current through the winding. Using an H-bridge configuration, there are four transistors for each winding as shown in Fig 2.3 (a). However, most of the time they are prewired together so that only two inputs are needed. This makes generating pulses easier and also serves to protect against short circuits. This Driver circuit is shown in Fig 2.3 (b). Table 2.1 showing the result of each possible control input of Bipolar Stepper Motor Driver Circuit

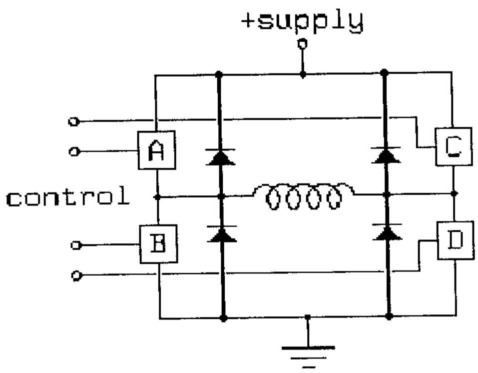


Fig 2.3 (a) H-bridge Configuration

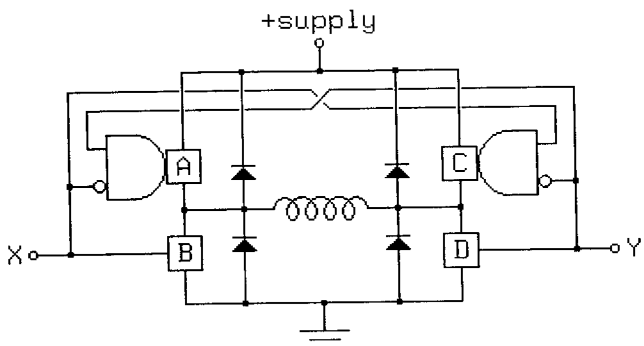


Fig 2.3 (b) Bipolar Stepper Driver Circuit

XY	ABCD	MODE
00	0000	COAST
01	1001	FORWARD
10	0110	BACKWARD
11	1111	BRAKE

Table 2.1: Control Input of Driver Circuit

Chapter 3

CHAPTER 3

FEEDER SETUP

Feeder setup is a mechanical structure that is used to provide the required raw materials to the machine for further processing in a controlled manner. There are different types of Feeding systems available. They are Continuous Manual Feeding, Continuous Automatic Feeding, Single Stroke with Automatic Feed, Continuous on Demand. In ROOTS Industries, they are now using a Continuous Manual Feeding system. In this system, a human operator is always required to feed the system. The Feeder setup system which we have designed is Continuous Automatic Feeding system.

3.1 DESCRIPTION

The assembly drawing of the setup is shown in Fig. The design drawing of each of the parts in the setup are also shown in the figures. The important parts of the setup are the shafts, bearings, gears etc., The bottom shaft is connected to the stand internally and to the 40 teeth gear externally. The bearing is used for the shaft to rotate. The 40 teeth gear is connected to the 20 teeth gear which in turn connected to the motor shaft. The top shaft is connected to the top piece of the stand through a screw rod with a spring. The strip will be fed between these two shafts.

3.1.1 SHAFT

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft. In order to transfer the power from one shaft to another, the various members such as pulleys, gears etc. are mounted on it. These members along with the forces exerted upon them causes the shaft to bending. The material used for ordinary shaft is mild steel. When high strength is required, an alloy steel as nickel, nickel chromium or chrome-vanadium steel is used. The types of shafts are Transmission shafts and Machine shafts. The former transmit power between the source and the machines absorbing power. The counter shafts, line shafts and all factory shafts are Transmission shafts. The latter form an integral part of the machine itself. The crank shaft is an example for this Machine shaft.

3.1.2 BEARINGS

A bearing is a machine element which supports another moving machine element (known as journal). It permits a relative motion between the contact surfaces of the members, while carrying the load. In order to reduce frictional resistance and wear and in some cases to carry away the heat generated, a layer of fluid (known as lubricant) may be provided.

Classification of Bearings

The bearings are classified depending upon the direction of load to be supported and depending on the nature of the contact. Depending upon the direction of load to be supported, it is classified into Radial bearings and Thrust bearings. In Radial bearings, the load acts perpendicular to the direction of motion of the moving element and in Thrust bearings, the load acts along the axis of rotation. Depending on the nature of contact, it is classified into Sliding contact bearings and Rolling contact bearings. In Sliding contact bearings, the sliding takes place along the surfaces of contact between the moving element and the fixed element. The sliding contact bearings are also known as plain bearings. In Rolling contact bearings, the steel balls or rollers, are interposed between the moving and fixed elements. The balls offer rolling friction at two points for each ball or roller.

Advantages of Ball and Roller Bearings

- Friction is low except at high speed.
- These require little lubricant and maintenance.
- Relatively accurate shaft alignment can be maintained.
- These occupy less axial space but larger diametral space than journal bearings.
- Heavy momentary loads can be carried.
- Replacement is easy.
- Selection of bearing from manufacturer's catalogue is relatively simple.

Table 3.1 Applications of different types of bearings

DESIGNATION	APPLICATION
Deep Groove Ball Bearing	Can carry considerable thrust load apart from radial load – high speed
Self Aligning Ball Bearing	Minor singular displacements of shafts will not affect
Single Row Angular Contact Ball Bearing	For heavy axial loads
Double Row Angular Contact Ball Bearing	Can carry radial loads with heavy thrust in both directions
Spherical Roller Bearing	High carrying capacity, self aligning – for heavy radial loads with considerable axial load in both directions
Cylindrical Roller Bearing	For heavy radial loads at high speeds permit slight axial displacement
Taper Roller Bearing	For combined radial and axial loads
Single Thrust Ball Bearing	For axial load in one direction only
Double Thrust Ball Bearing	For axial loads acting on both directions
Spherical Roller Thrust Bearing	For heavy axial loads – high speed –self aligning

Disadvantages of Ball and Roller Bearings

- These are nosier than journal bearings.
- More expensive and suitable provisions are necessary for mounting.
- They have a limited life because the raceways are highly stressed repeatedly as the shaft rotates, resulting in an eventual fatigue failure.
- Failure of bearing can occur without warning and cause damage to machinery.

3.1.3 GEARS

A gear is a component within a transmission device that transmits rotational force to another gear or device. A gear is different from a pulley in that a gear is a round wheel which has linkages ("teeth" or "cogs") that mesh with other gear teeth, allowing force to be fully transferred without slippage. Depending on their construction and arrangement, geared devices can transmit forces at different speeds, torques, or in a different direction, from the power source. Gears are a very useful simple machine. The most common situation is for a gear to mesh with another gear, but a gear can mesh with any device having compatible teeth, such as linear moving racks. A gear's most important feature is that gears of unequal sizes (diameters) can be combined to produce a mechanical advantage, so that the rotational speed and torque of the second gear are different from that of the first.

The smaller gear in a pair is often called the *pinion*; the larger, either the *gear*, or the *wheel.*

Spur gears

Spur gears are the simplest, and probably most common, type of gear. Their general form is a cylinder or disk. The teeth project radially, and with these "*straight-cut gears*", the leading edges of the teeth are aligned parallel to the axis of rotation. These gears can only mesh correctly if they are fitted to parallel axles.

Helical gears

Helical gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. The angled teeth engage more gradually than do spur gear teeth. This causes helical gears to run more smoothly and quietly than spur gears. Helical gears also offer the possibility of using non-parallel shafts. A pair of helical gears can be meshed in two ways: with shafts oriented at either the sum or the difference of the helix angles of the gears. These configurations are referred to as *parallel* or *crossed*, respectively.

With parallel helical gears, each pair of teeth first make contact at a single point at one side of the gear wheel; a moving curve of contact then grows gradually across the tooth face. It may span the entire width of the tooth for a time. Finally, it recedes until the teeth break contact at a single point on the opposite side of the wheel. Thus force is taken up and released gradually. With spur gears, the situation is quite different. When a pair of teeth meet, they immediately make line contact across their entire width. This causes impact stress and noise. Whereas spur gears are used for low speed applications and those situations where noise control is not a problem, the use of helical gears is indicated when the application involves high speeds, large power transmission, or where noise abatement is important. A disadvantage of helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings, and a greater degree of sliding friction between the meshing teeth, often addressed with specific additives in the lubricant.

Double helical gears

Double helical gears, also known as herringbone gears, overcome the problem of axial thrust presented by 'single' helical gears by having teeth that set in a 'V' shape. Each gear in a double helical gear can be thought of as two standard, but mirror image, helical gears stacked. This cancels out the thrust since each half of the gear thrusts in the opposite direction. They can be directly interchanged with spur gears without any need for different bearings.

Bevel gears

Bevel gears are essentially conically shaped, although the actual gear does not extend all the way to the vertex (tip) of the cone that bounds it. With two bevel gears in mesh, the vertices of their two cones lie on a single point, and the shaft axes also intersect at that point. The angle between the shafts can be anything except zero or 180 degrees.

Crown gear

A crown gear or contrate gear is a particular form of bevel gear whose teeth project at right angles to the plane of the wheel; in their orientation the teeth resemble the points on a crown. A crown gear can only mesh accurately with another bevel gear, although crown gears are sometimes seen meshing with spur gears. A crown gear is also sometimes meshed with an escapement such as found in mechanical clocks.

Hypoid gears

Hypoid gears resemble spiral bevel gears, except that the shaft axes are offset, not intersecting. The pitch surfaces appear conical but, to compensate for the offset shaft, are in fact hyperboloids of revolution. Hypoid gears are almost always designed to operate with shafts at 90 degrees. Depending on which side the shaft is offset to, relative to the angling of the teeth, contact between hypoid gear teeth may be even smoother and more gradual than with spiral bevel gear teeth. Also, the pinion can be designed with fewer teeth than a spiral bevel pinion, with the result that gear ratios of 60:1 and higher are "entirely feasible" using a single set of hypoid gears.[5

Worm gear

A worm is a gear that resembles a screw. It is a species of helical gear, but its helix angle is usually somewhat large (ie., somewhat close to 90 degrees) and its body is usually fairly long in the axial direction; and it is these attributes which give it its screw like qualities.

Rack and pinion

A rack is a toothed bar or rod that can be thought of as a sector gear with an infinitely large radius of curvature. Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. Such a mechanism is used in automobiles to convert the rotation of the steering wheel into the left-to-right motion of the tie rod(s). Racks also feature in the theory of gear geometry, where, for instance, the tooth shape of an interchangeable set of gears may be specified for the rack (infinite radius), and the tooth shapes for gears of particular actual radii then derived from that.

Terms Used In Gears

Pitch Circle : It is an imaginary circle which by pure rolling action, would give the same motion as the actual gear.

Pitch Circle Diameter : It is the diameter of the itch circle. The size of the gear is usually specified by the pitch circle diameter.

Pitch point : It is a common point of contact between two pitch circles.

Pitch surface : It is the surface of the rolling discs which the meshing gears have replaced at the pitch circle.

Pressure angle or angle of obliquity: It is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point.

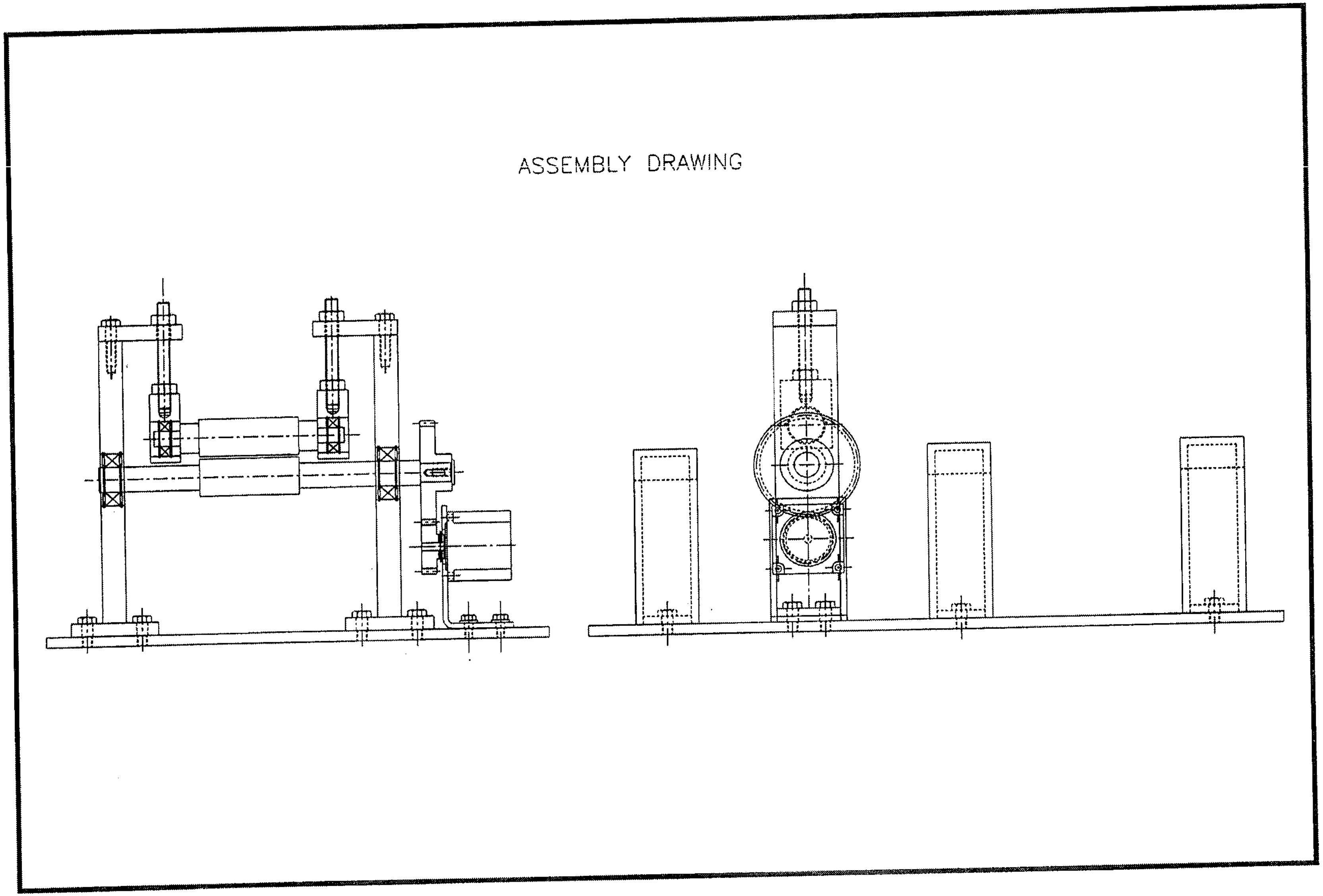


Fig 3.1 Assembly Drawing

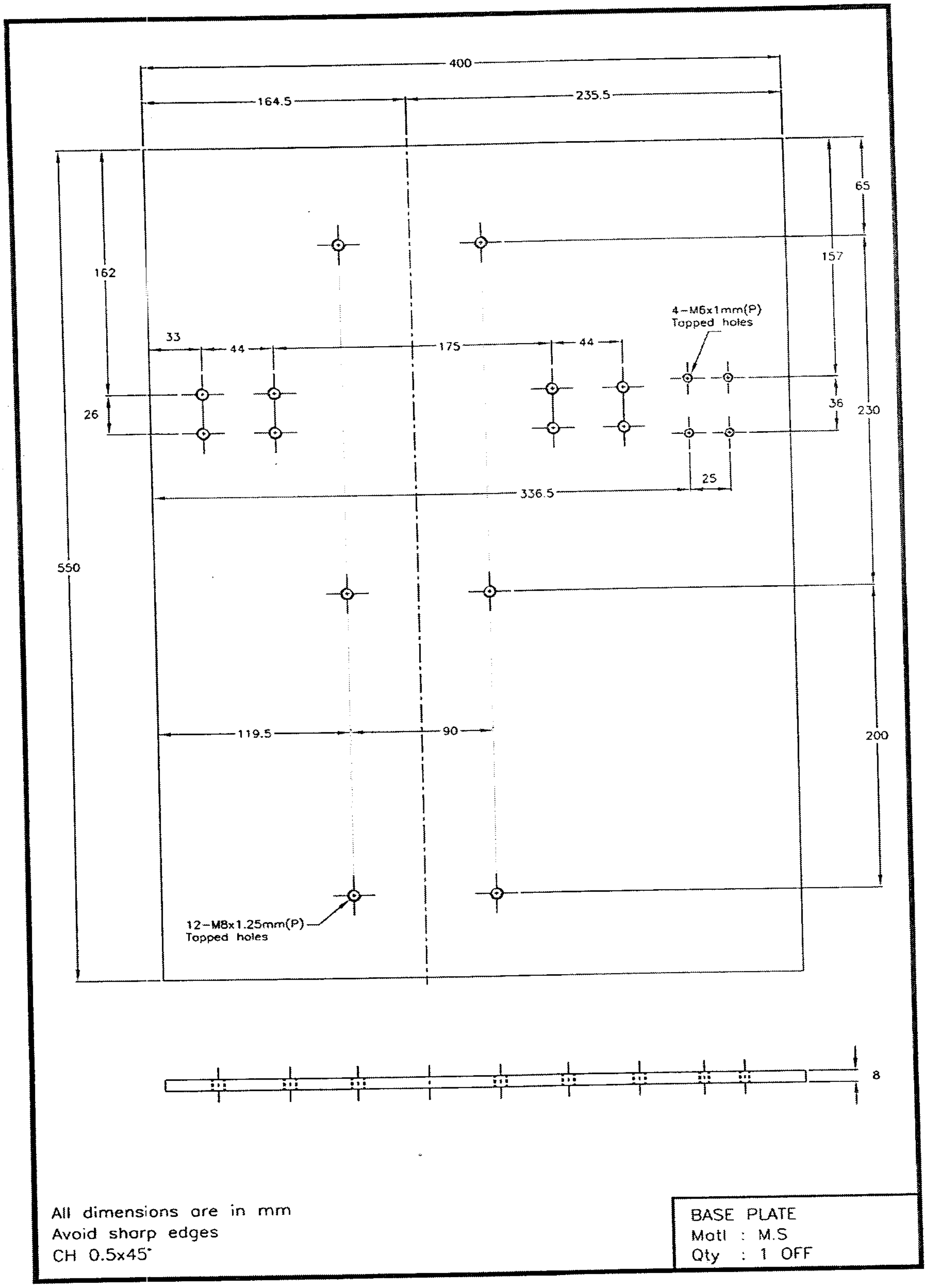


Fig 3.2 Base Plate

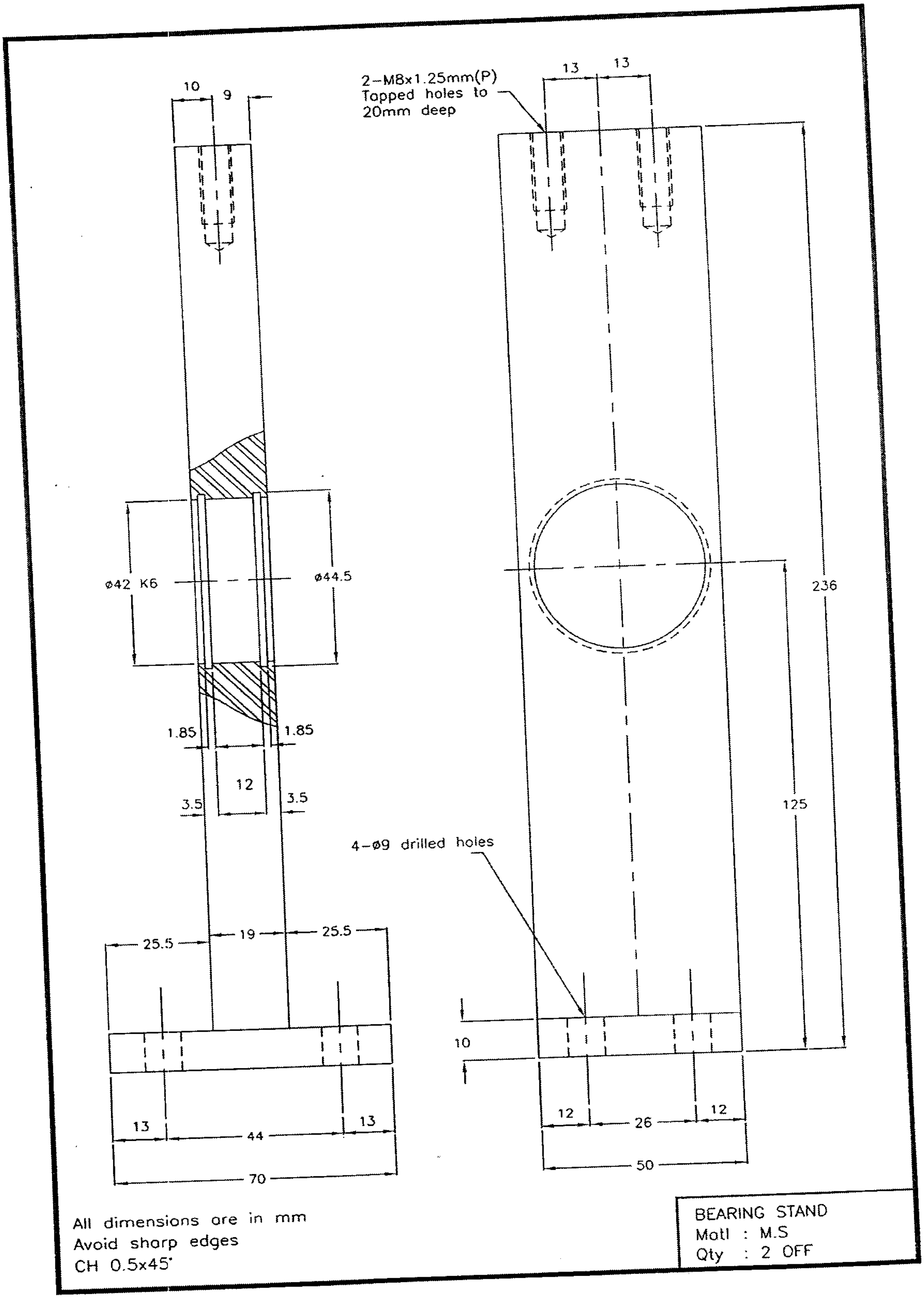


Fig 3.3 Bearing Stand

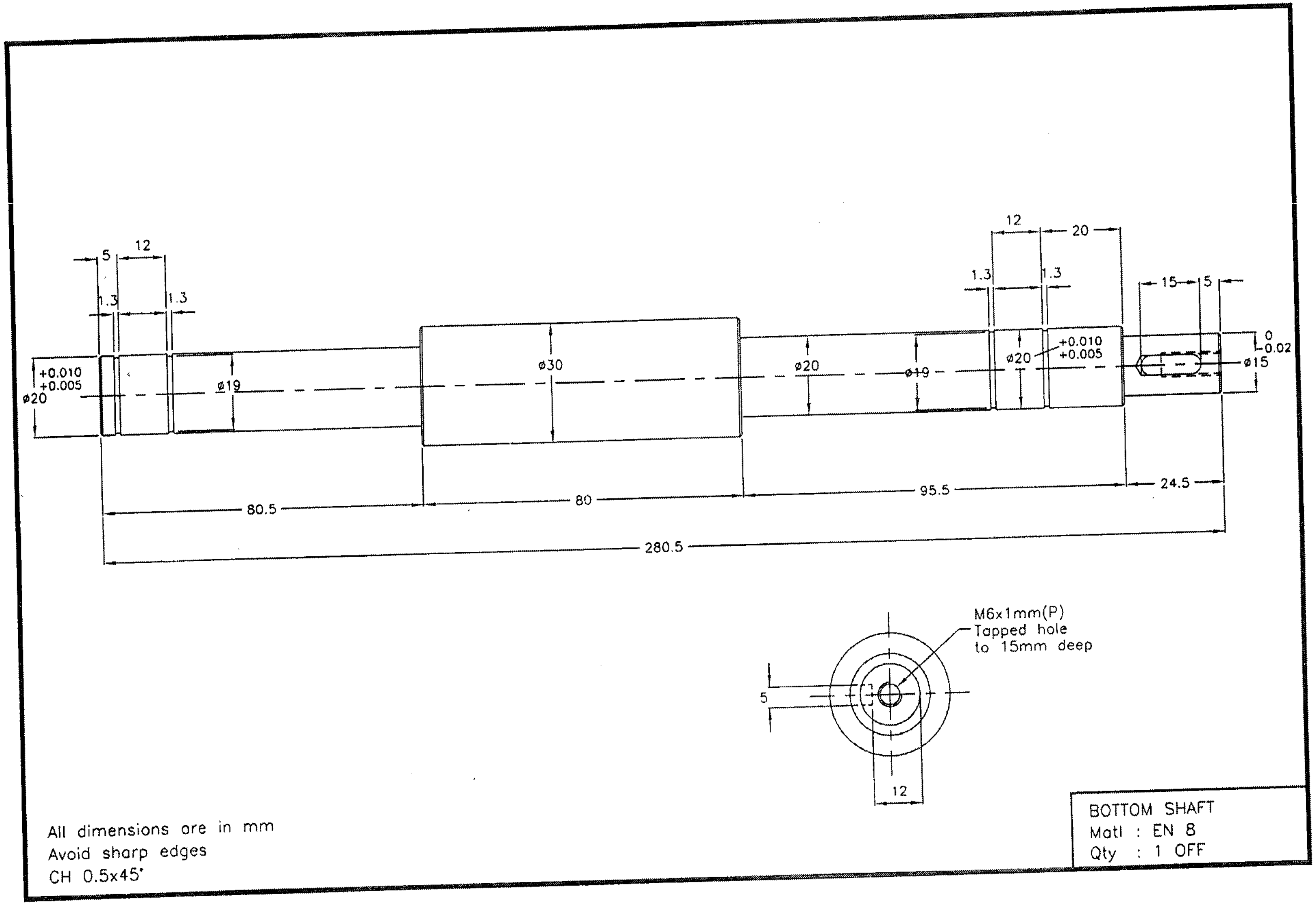


Fig 3.4 Bottom Shaft

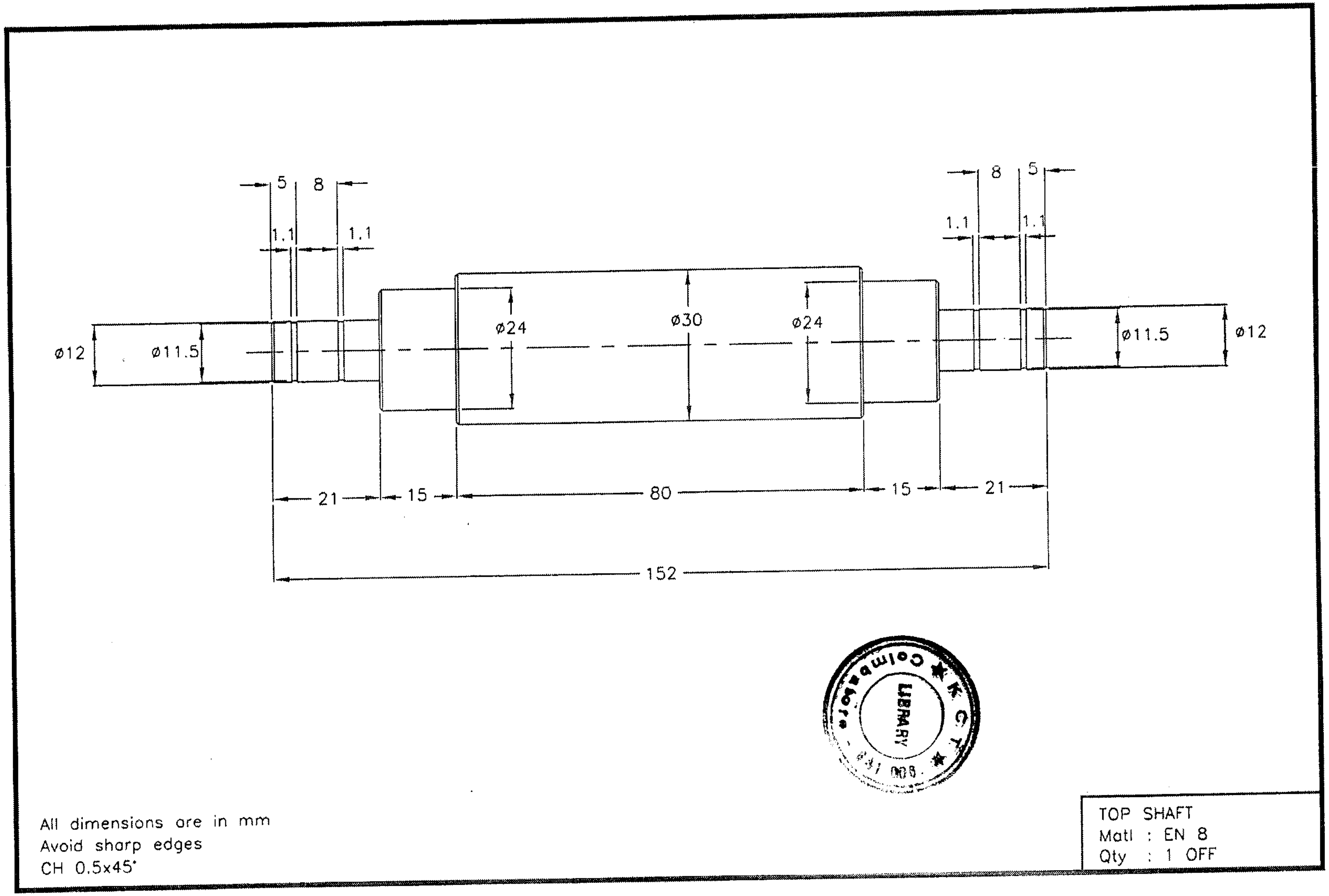


Fig 3.5 Top Shaft

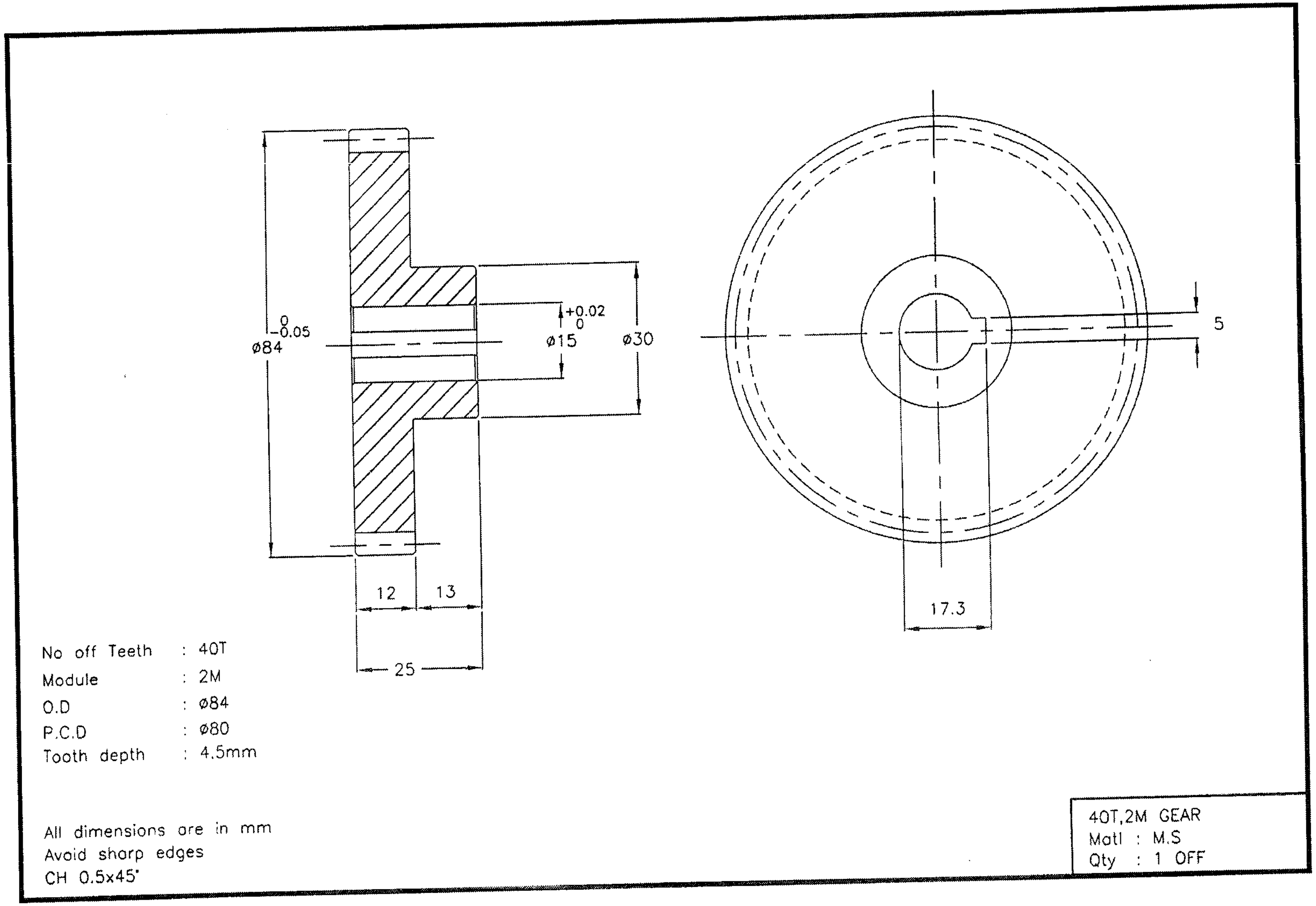


Fig 3.6 40T 2M Gear

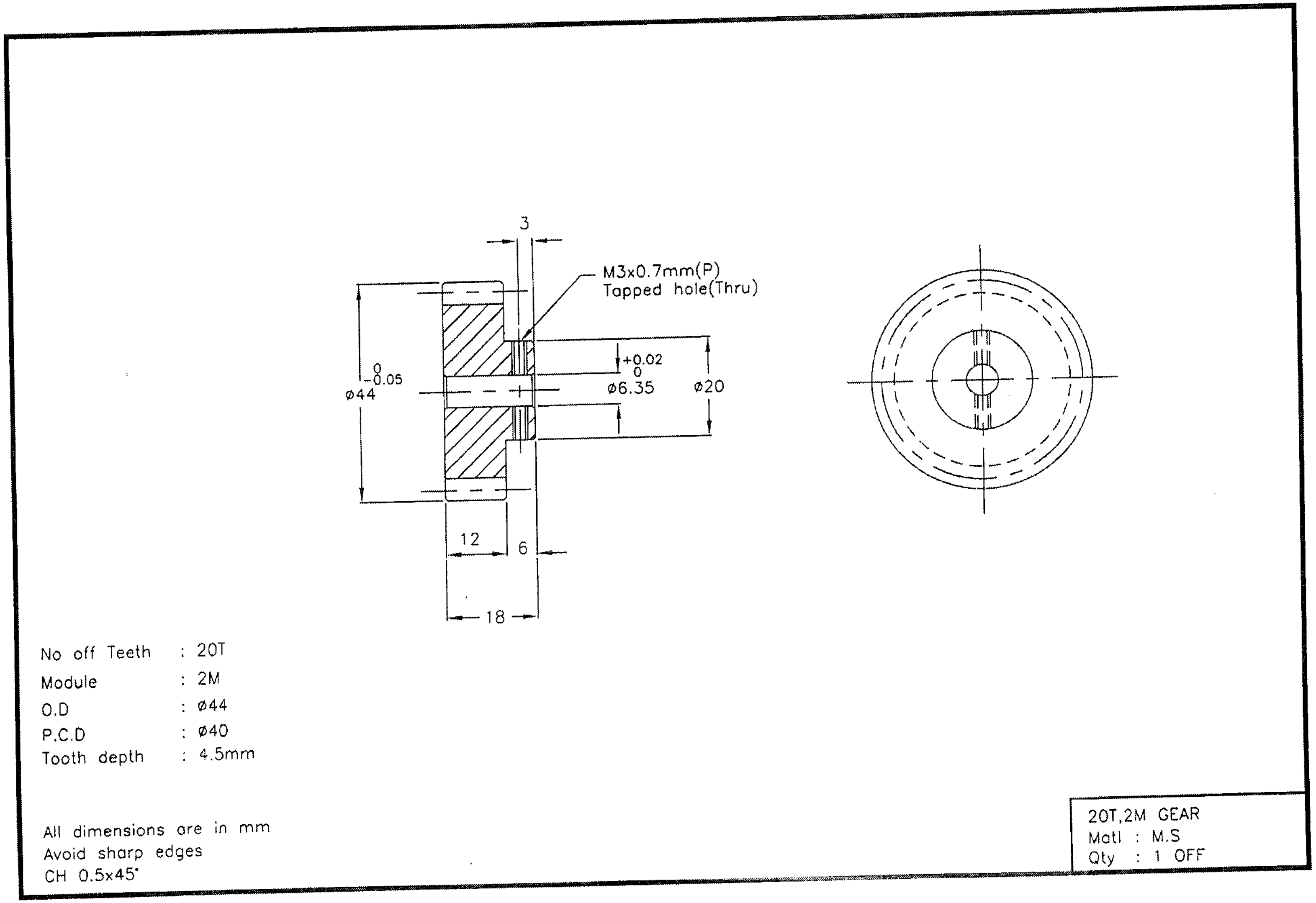


Fig 3.7 20T 2M Gear

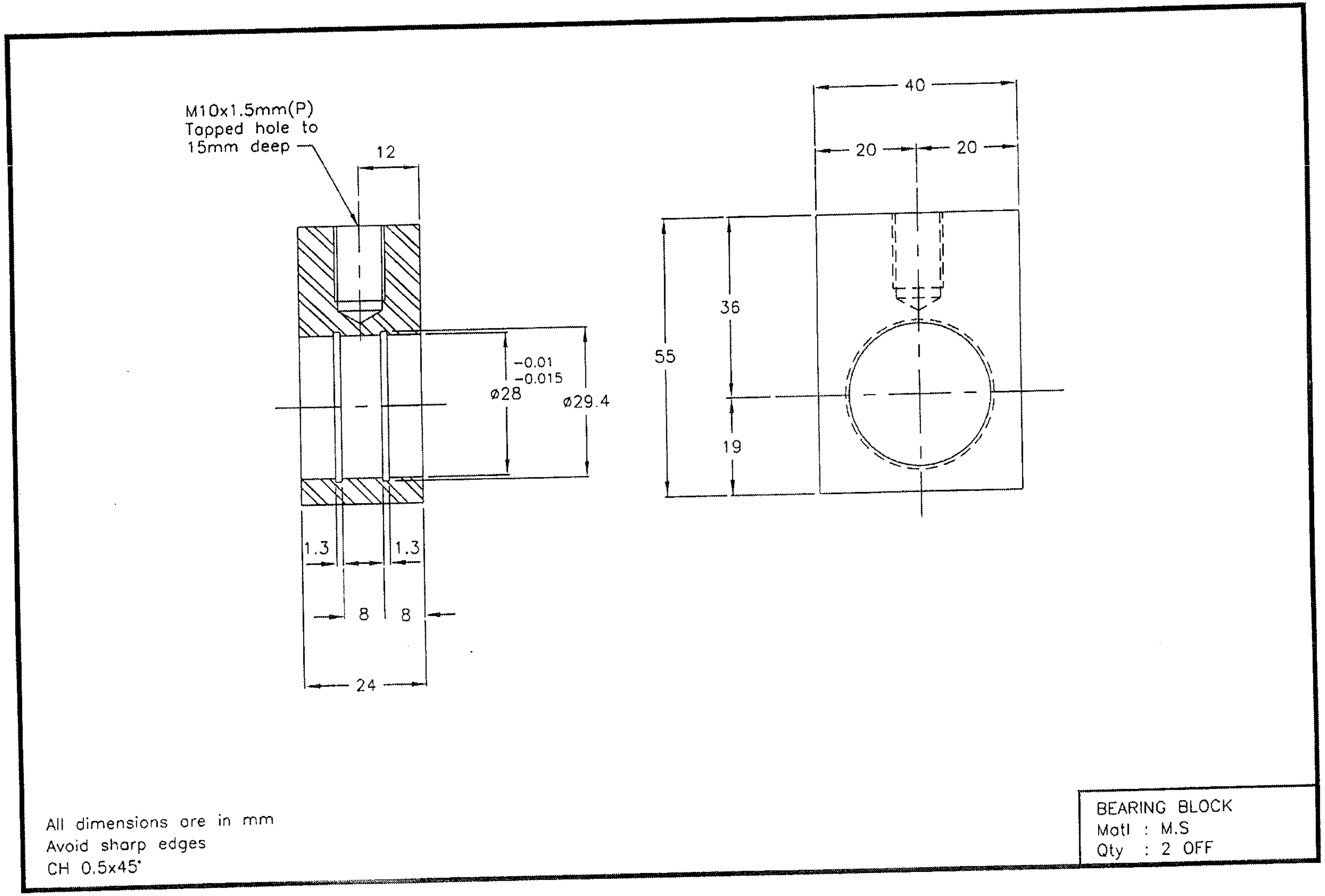


Fig 3.8 Bearing Block

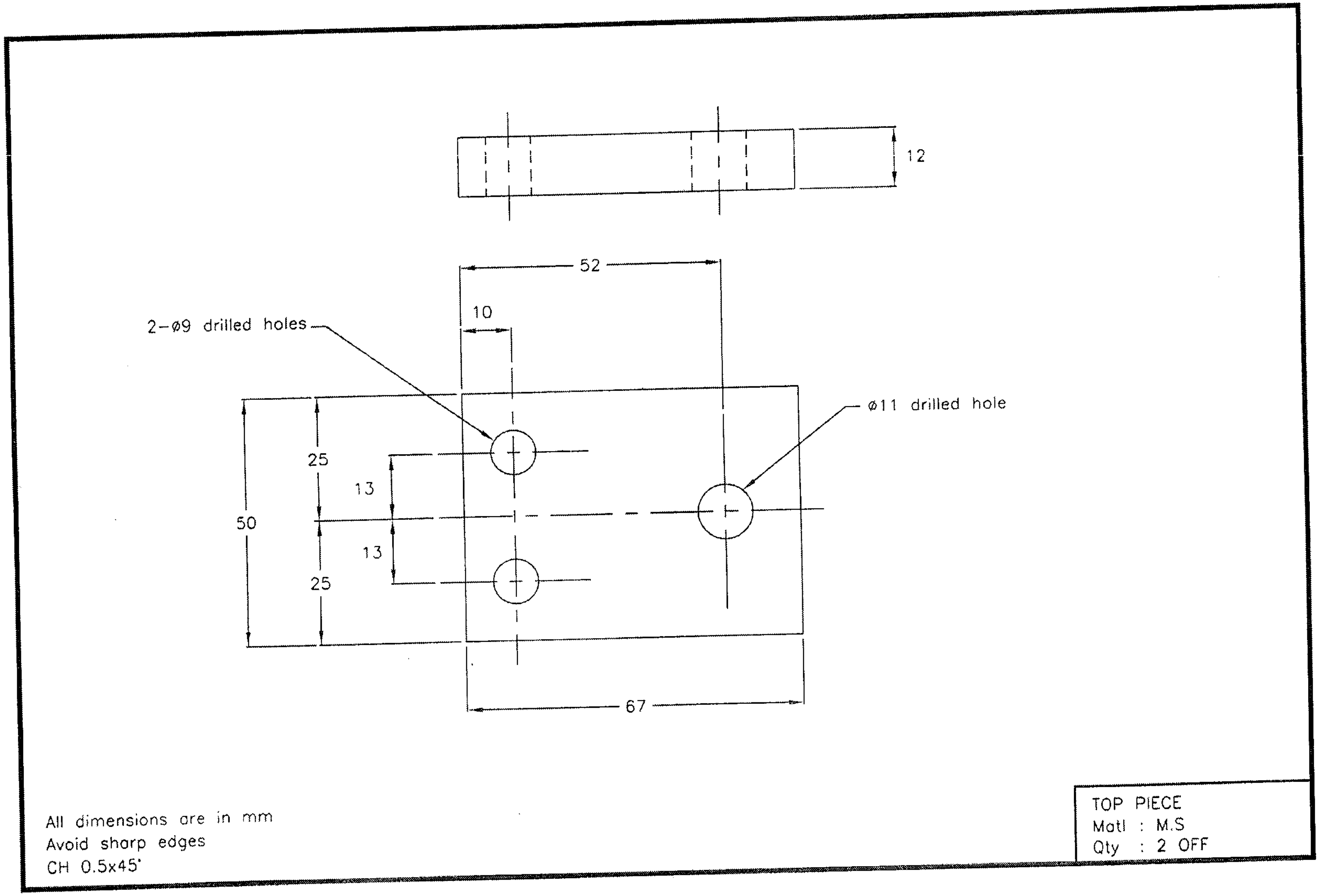


Fig 3.9 Top Piece

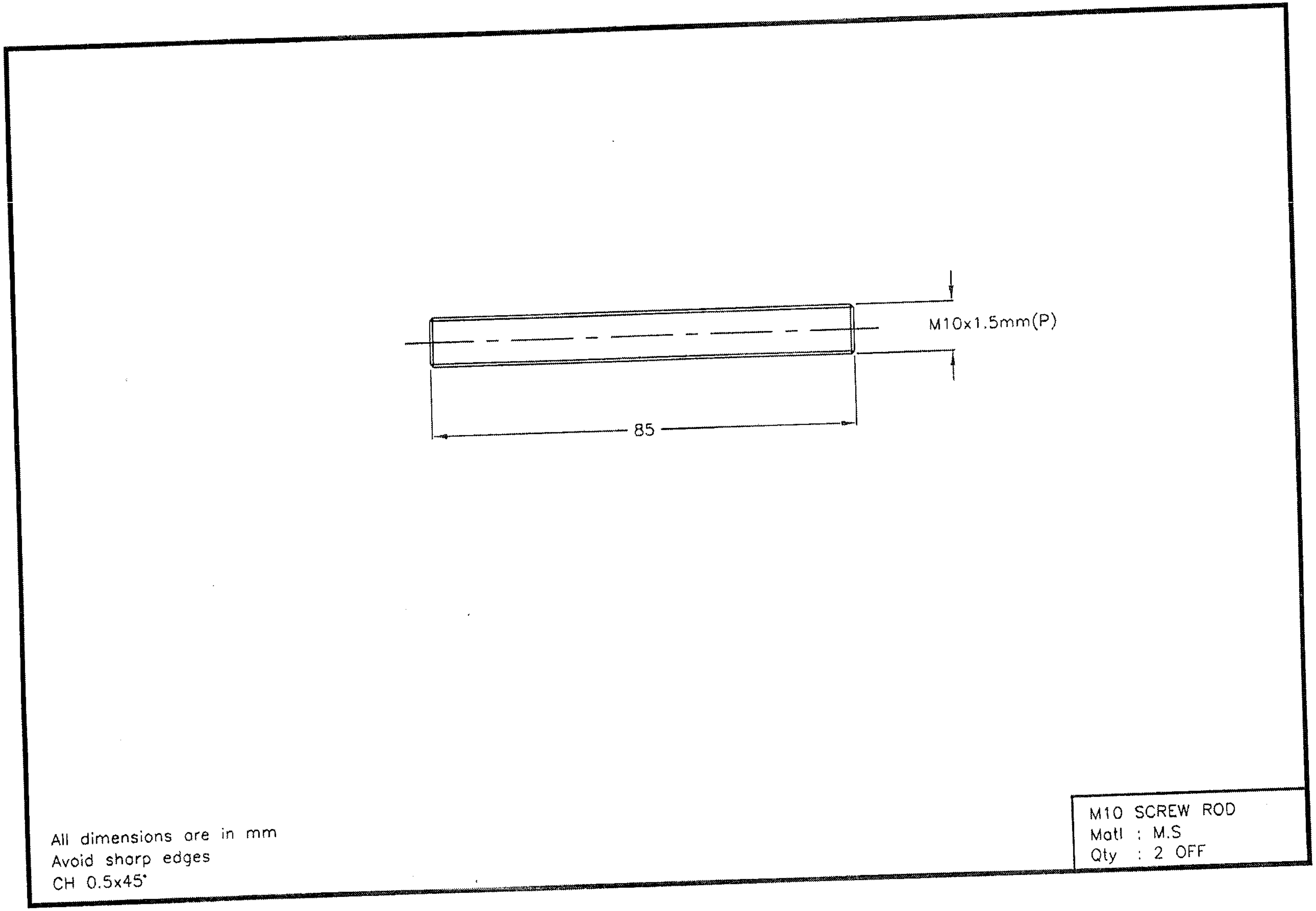


Fig 3.10 M10 Screw Rod

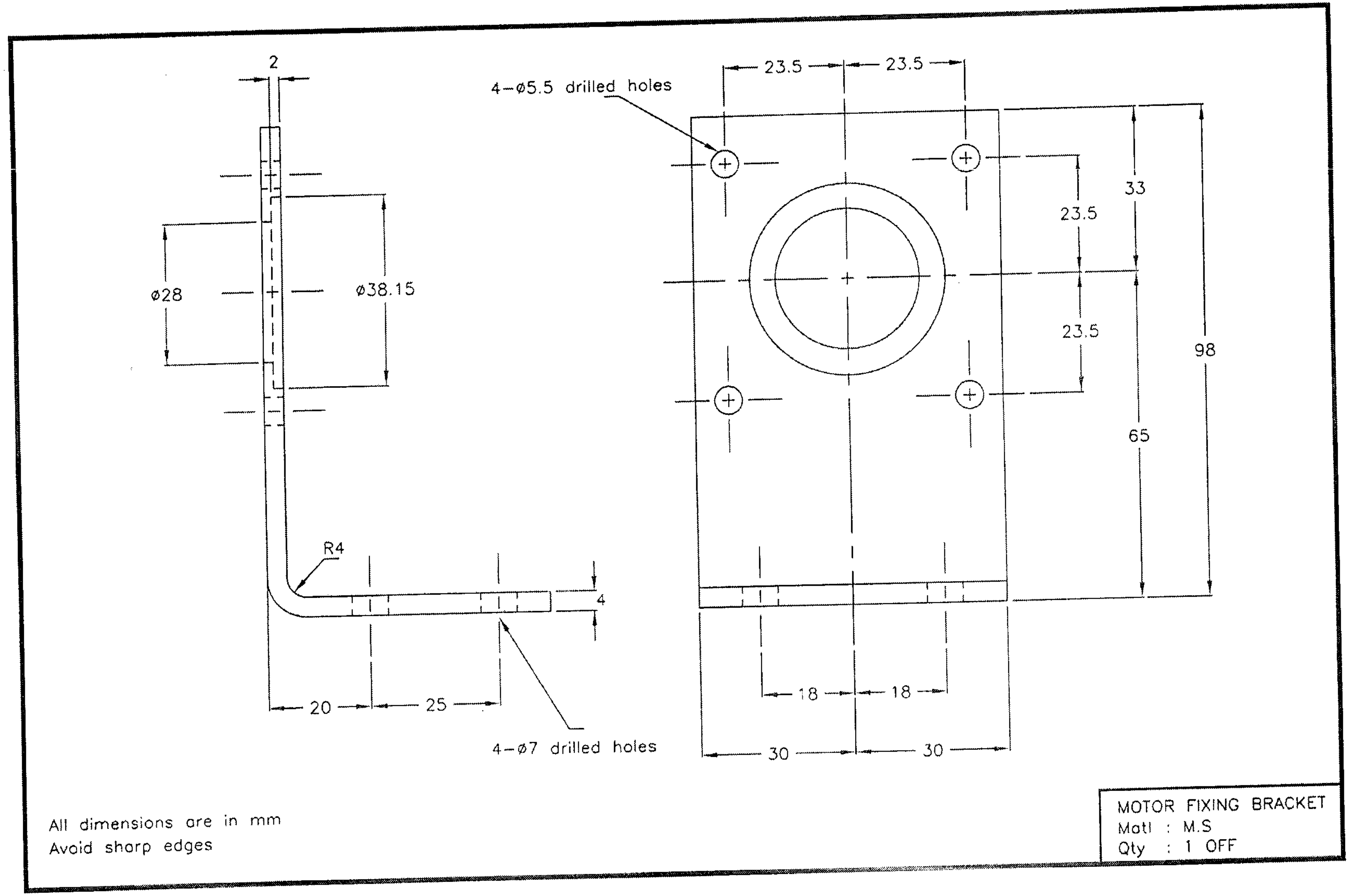


Fig 3.11 Motor Fixing Bracket

Chapter 4

CHAPTER 4
PSPR MACHINE

4.1 POWER PRESS

A mechanically powered machine that shears, punches, forms, or assembles metal or other material by means of cutting, shaping, or combination dies attached to slides. A press consists of a stationary bed (or anvil), and a slide (or slides) having a controlled reciprocating motion toward and away from the bed surface, the slide being guided in a definite path by the frame of the press.

Major components of a mechanical power press are the frame, motor, flywheel, crankshaft, clutch and brake.

The purpose of Crankshafts is to convert circular motion to linear motion and Clutches is to connect the rotating flywheel with the crankshaft causing the press to stroke.

The clutch on a mechanical power press is either a full revolution or a part revolution clutch. The full revolution clutch transfers motion from the flywheel to the ram or slide through a mechanical connection. The connection cannot be broken until one revolution has been completed. A part revolution clutch is also referred to as a friction clutch. Motion is transmitted by two pieces of material being pushed against one another. This type of clutch can be disengaged at any time. Brake is used to stop the motion of the slide or ram.

The brake may be a constant drag type (common on a full revolution clutch machine) or it may be engaged only while the clutch is disengaged (common on a part revolution clutch machine).

1.STRUCTURAL TYPES OF MECHANICAL POWER RESSES

Mechanical power presses range in size from units designed for bench mounting, with work areas of a few square inches, to machines that stand tens of feet high, with work areas tens of feet square. Mechanical power presses may be used to produce parts as small as wire terminals to as large as a truck frame.

Two general frames used for mechanical power presses are the "C" frame and the straight side frame. The "C" frame is similar to a "C" clamp in appearance, with the lowest part of the "C" supporting the bed and the slide mounted in the upper part of the "C".

a. Classes of "C" Frame Presses

i. OBI (Open Back Inclined) - The OBI press has a "foot" or base that supports the main "C" frame member. The base is slotted to allow the main frame to be tilted back so that gravity can assist the "blow off" mechanism in removing the fabricated material or scrap through the open back of the press.

ii. Gap Press - The gap press is a basic "C" frame press, usually with a base and operating frame cast in one piece which cannot be inclined.

iii. Horn Press - The horn press uses a two piece "C" frame structure. The lower part of the "C" frame is adjustable. A separate frame member that can be adjusted up or down to reduce the gap in the "C".

b. Straight Side Frame

The frame consists of a bed to which a four corner post arrangement called uprights are attached. The uprights support the final frame member, the crown of the machine. The slide of the machine is attached to a crankshaft in the crown of the press and moves vertically between the uprights.

2. Functional Types of Mechanical Power Presses

All mechanical power presses use an electric motor as the drive source, which stores energy to enable the press to "crunch" through metal or other material at the bottom of the stroke. Although other types of power presses are mechanical in nature, such as hydraulic presses, the term mechanical power press is used to refer to those presses that drive the press slide with a crankshaft. The crankshaft is supported by main bearings, and the slide hangs from the crankshaft through one or more connections called pitmans. The slide is at its highest point when the crankshaft throw is straight up, and at its lowest when the crankshaft is straight down (bottom dead center); therefore, the stroke of the press is twice the crankshaft throw.

The working area of the machine is the space between the slide and the bolster plate that sits on the bed of the press. The shut height is adjustable. The shut height is the distance between the bottom of the slide and the top of the bolster plate, with the crankshaft at bottom dead center.

To stroke the press, the crankshaft is coupled to the flywheel which always turns when the motor is running. This coupling may be accomplished directly or through gears. Gears allow the press to travel slower, exerting more force. Flywheels on a non- geared press are always located on the crankshaft. If bearings freeze up, the press will begin stroking.

A clutch is used to connect the flywheel to the crankshaft. The type of clutch used determines if the press is a part or full revolution clutch mechanical power press.

The full revolution clutches are positive clutches that cannot slip. Once engaged, the full revolution clutch drags the crankshaft through one complete revolution before it can be disengaged by a mechanism that physically pulls the clutch pin, key, or jaw free of the flywheel.

The full revolution clutch has a limited number of engaging points. When the operator trips the clutch mechanism, the pin falls against the surface of the flywheel or gear and "rides" the surface until falling into an engaging point. When the pin falls into an engaging point, the flywheel turns the crankshaft and strokes the slide.

The full revolution mechanical power press uses a friction brake that is always applied to hold the slide stationary when the clutch is not applied. When engaged, the clutch overrides the friction brake. The brake is usually applied directly to the crankshaft.

The part revolution mechanical power press sometimes uses a positive clutch that is forced to engage and disengage by air pressure, springs, etc. Normally, a radial or disk type friction clutch is used for more torque. These types of clutches are where two plates get squeezed together and can be engaged or disengaged. At this point in the slide stroke, the clutch is usually engaged with air pressure and released with a lack of air pressure. The brakes are spring applied air released brakes.

4.2 PSPR MACHINE CONFIGURATION

1	Force exerted ay bottom of stroke	50 T
2	Adjustability of Stroke	8 to 88 mm
3	Adjustability of RAM	63 mm
4	Hole in RAM for Tools	50 mm dia
5	Hole in RAM for Tools (depth)	85 mm
6	Depth of Threat	240 mm
7	Maximum. distance between bed for RAM at maximum stroke up	280
8	Length of Bed	700 mm
9	Width of Bed	450 mm
10	Opening in Bed	250 mm dia
11	Thickness of Bolster	75 mm
12	Opening through Bolster	250 mm dia
13	Width of Opening in back	440 mm
14	Size of Fly wheel (dia x face)	675 x 200 mm
15	Floor to top of bed	790 mm
16	Overall Height	2560 mm
17	Left to Right	1130 mm
18	Front to Back	1510 mm
19	No. of Stroke / min	60
20	Vee belts	A91 (3 Nos)
21	Electric Motor NGEF	5 HP 3 Phase Induction Motor
22	Parallelity	0.2 mm (max)
23	Motor current	4.5A (max)

Chapter 5

CHAPTER 5
CONCLUSION

This project has automated the feeding mechanism of the PSPR and thereby eliminating the need to feed the metal strip manually and reducing the cost involved for manual labour and supervision.

The metal strip of various sizes can be fed in by varying the width of the feed way. The strip being fed in with increased precision can go a long way in increasing the productivity and profit.

FUTURE EXPANSION

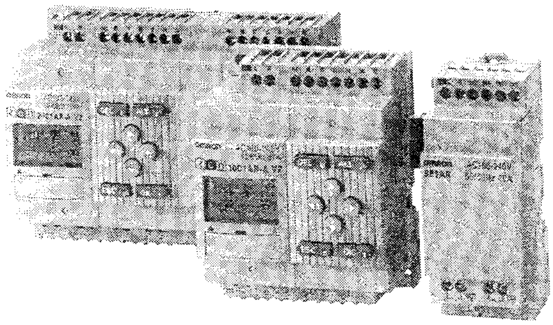
This setup can be enhanced further by the usage of the pick and place robots. The robotic arm will consist of a flat circular shaped electromagnet. When the feeding operation is started, the arm will position itself above the stack holding the metal strips. The electromagnet will be energized, which will attract the strip towards it and the arm will move forward and position the strip under the ram. The electromagnet is de-energized and the metal strip is molded to required shape. The only operation that will be manually performed will be the loading of the metal strips inside the container.

Appendix

OMRON

Programmable Relay
ZEN V2 Units

Please read and understand this catalog before purchasing the products. Please consult your OMRON representative if you have any questions or comments. Refer to *"Warranty and Application Considerations"* on page 36, and *"Precautions for Safe Use"* on page 34.



NEW

The information in this document applies to V2 Units. Refer to page 28 for details on differences with previous products.

Even Broader Applications with Increased Functionality and Higher Precision

- Increased functionality in a compact body (70 mm wide × 90 mm high).
- Easy programming is available using the LCD and operation buttons. (See note 1.)
- This single Unit easily provides relay, timer, counter, and time switch functions.
- Expansion is easy with Expansion I/O Units, allowing up to 44 I/O points. (See note 2.)
- Economy-type and Communications-type CPU Units have been added to series.
- Improved Weekly Timers (See note 1.) Increased timing accuracy with a monthly deviation of ±15 s max. Multiple-day operation and pulse output operation have been added.
- Select from two power supply options: 100 to 240 VAC or 12 to 24 VDC.

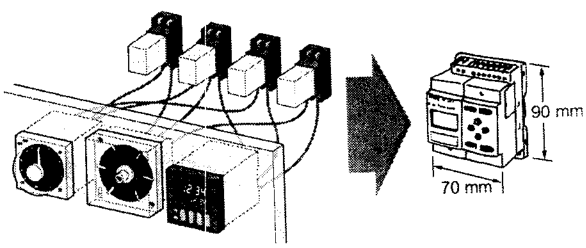
Note: 1. Not supported for ZEN-□C2□□-□-V2 models.
2. When using CPU Units with 20 I/O points.

Features

■ Easy and Simple Programming for Automatic Small-scale Control

Saves Space, Wiring, and Installation Steps

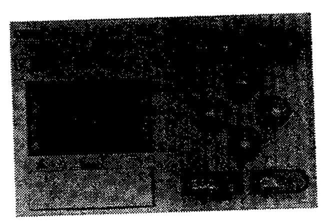
- Versatile functionality in a compact body (70 mm wide × 90 mm high).
- This single Unit easily provides relay, timer, counter, and time switch functions. Wiring work is greatly reduced because separate wiring is not required for devices such as timers and counters.



Easy Programming

The LCD screen comes with 8 operation buttons on the front panel to enable programming in ladder view format. The LCD screen also has a backlight, making it easier to see when the ZEN is used in dark locations.

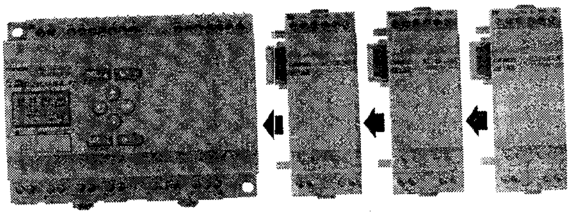
Note: Not supported for ZEN-□C2□□-□-V2 models.



Flexible Expansion Enables Up to 44 I/O Points

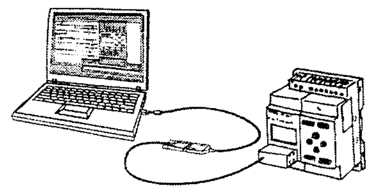
Up to three Expansion I/O Units can be connected if there are not enough I/O points. Expansion I/O Units are only 35 mm wide.

Note: CPU Units with 10 I/O points can be expanded to 34 I/O points. Expansion I/O Units cannot be connected to Economy-type CPU Units.



Support Software with Simulation Function

- Programs can be easily written, saved, and monitored by personal computer.
- Programs can be simulated on the personal computer without connecting to the ZEN.



Note: For notebook computers that do not have an RS-232C serial port, connect the computer to the ZEN by connecting an OMRON CS1W-CIF31 USB-Serial Conversion Cable to the ZEN-CIF01 Connecting Cable.

Other Versatile Functions

- Use of a Memory Cassette makes it easy to copy and save programs.
- Equipped with two analog input channels (CPU Units with DC power supply only).
- Password function ensures security. (See note.)
- Multi-language display in six languages (English, Japanese, German, French, Spanish, Italian). (See note.)
- Display user-set messages or analog-converted values. (See note.)

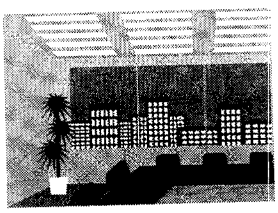
Note: Not supported for ZEN-□C2□□-□-V2 models.

■ Enhanced Features of V2 CPU Units

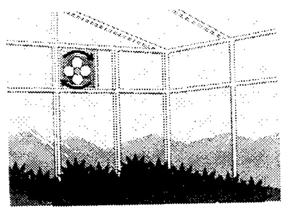
Improved Weekly Timer and Calendar Timer Functions

Note: Not supported for ZEN-□C2□□-□-V2 models.

- The time precision has been increased.
  Conventional model: 2-min difference/month
  ↓
  -V2 models: ±15-s difference/month (at 25°C)
- Multiple-day operation and pulse-output operation are now possible.
- These improved functions are convenient for time-controlled applications such as lighting and air conditioning control.



Lighting control



Air conditioning control

Economy-type Added to the Series

- Economy-type CPU Units with a more affordable price have been added to the series, although Expansion I/O Units cannot be added.

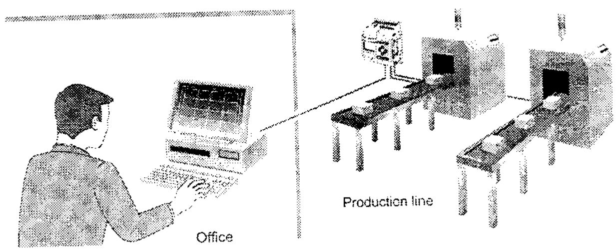
12 to 24 VDC Line Voltage Operation

Operation is now possible with 12 VDC.

Expansion I/O Units have been reduced to half-size (35 mm wide).

RS-485 Communications Model Added to Series

Production line conditions can be remotely monitored by monitoring the ZEN control status.



More Precise Analog Input

Conventional model: ± 10% FS → -V2 models: ± 1.5% FS
DC power supply models are equipped with two analog inputs (0 to 10 V). There are four analog comparators. The increased precision makes it even easier to use the Unit in simple control applications with voltage, current, temperature, and other analog values.

8-digit Counter, 150-Hz Counter

- An 8-digit counter and 8-digit comparator have been added.
- The maximum count for DC power supply models is 150 Hz.

Twin-timer Operation Added

Twin-timer operation allows you to set ON and OFF times separately, greatly simplifying intermittent operation.

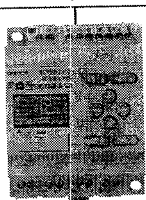
■ Series Configuration

CPU Units

Power supply voltage: 100 to 240 VAC, 12 to 24 VDC, Output: Relay, transistor output

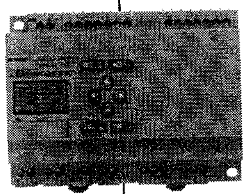
With LCD display, operation buttons, and calendar/clock function

10 I/O points



- Standard LCD type: ZEN-10C1□
- Economy type: ZEN-10C3□
  Expansion I/O Units cannot be connected.
- Communications type: ZEN-10C4□
  RS-485 communications type.

20 I/O points

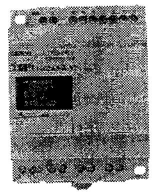


- Standard LCD type: ZEN-20C1□
- Economy type: ZEN-20C3□
  Expansion I/O Units cannot be connected.

LED type

- 10 I/O points: ZEN-10C2□
- 20 I/O points: ZEN-20C2□

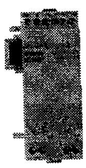
This CPU Unit has no LCD, operation buttons, or calendar/clock function.



(10 I/O points)

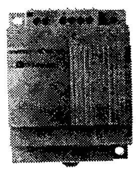
Expansion I/O Units

Only 35-mm wide.
4 input, 4 output points



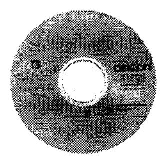
Power Supply Unit

Same shape and design as ZEN.
24 VDC, 30 W



Support Software

Allows easy programming and operation simulation.



Model Number Structure

■ Model Number Legend

Note: This model number legend includes combinations that are not available.
Please check *"List of Models"* for availability.

CPU Units

ZEN-□C□□□-□-V2
1 2 3 4 5

1. **Number of I/O points**
   10: 6 inputs and 4 outputs (See note.)
   20: 12 inputs and 8 outputs
2. **Type classifier**
   1: Standard LCD type with display
   2: LED type without display
   3: Economy type with display
   (Expansion I/O Units cannot be connected.)
   4: Communications type with display
3. **Input type**
   A: AC input
   D: DC input
4. **Output type**
   R: Relay
   T: Transistor
5. **Supply voltage**
   A: AC power supply
   D: DC power supply

Note: The Communications-type CPU Unit has 6 inputs and 3 outputs.

Expansion I/O Units

ZEN-8E1□□
1 2 3 4

1. **Number of I/O points**
   8: 4 inputs and 4 outputs
2. **Unit version classifier**
   E1: Can connect to V2 CPU Units (See note.)
3. **Input type**
   A: AC input
   D: DC input
4. **Output type**
   R: Relay
   T: Transistor

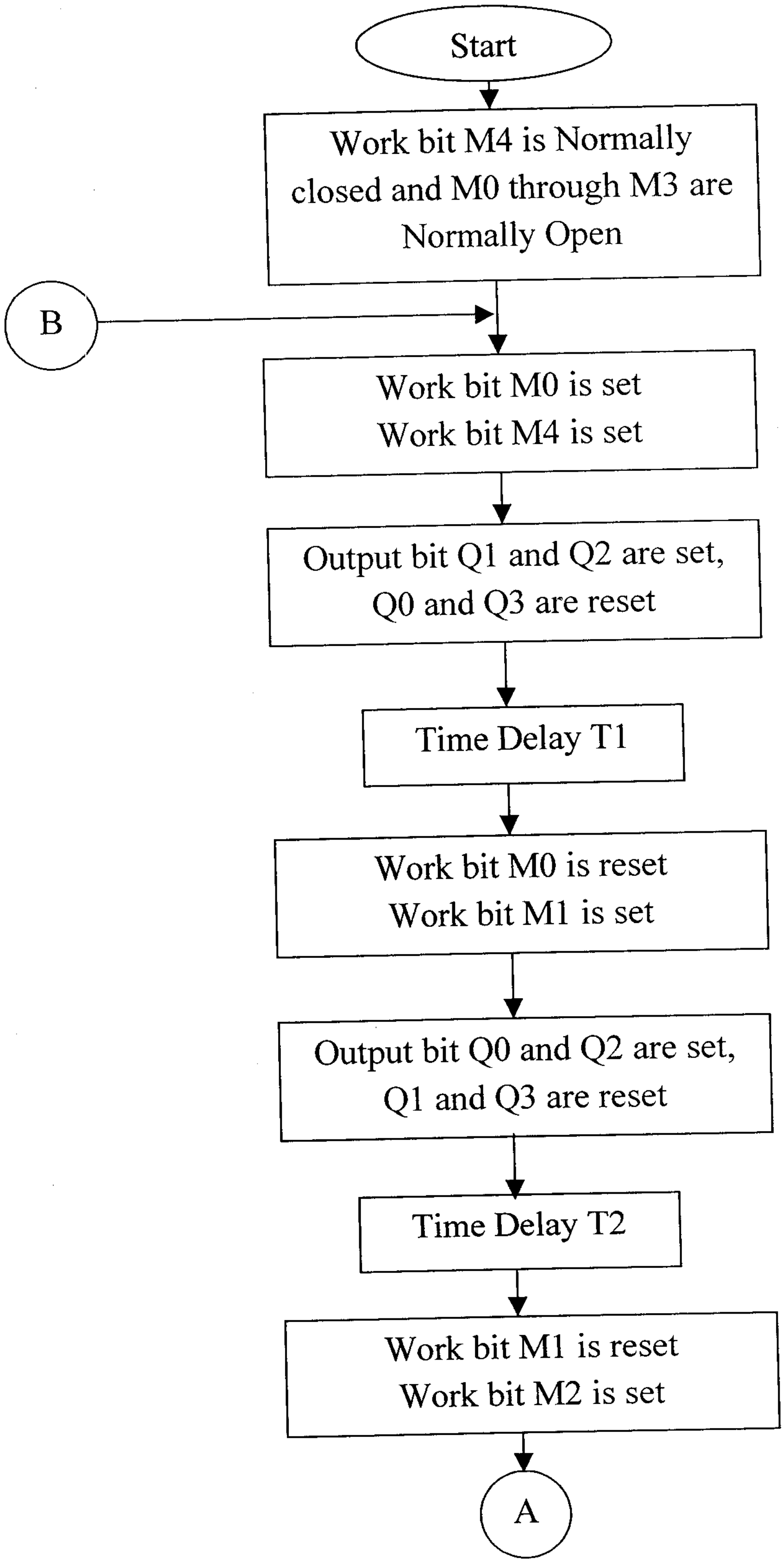
Note: Use a ZEN-8E□□/-4E□ to connect to pre-V1 and V1 CPU Units.

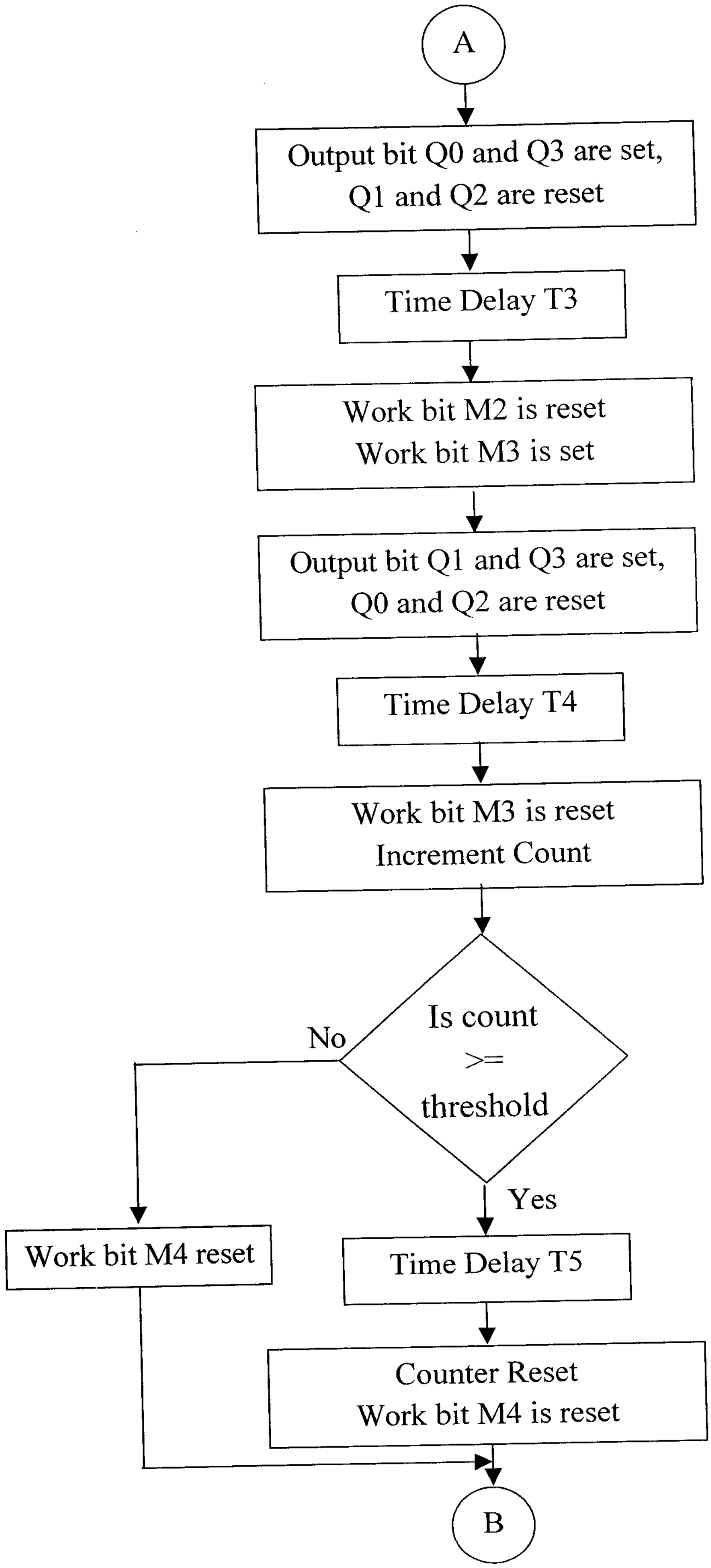
This data sheet is provided as a guideline for selecting products. Be sure to refer to the following user manuals for application precautions and other information required for operation before attempting to use the product.

ZEN Operation Manual (Cat. No. Z211)
ZEN Communications Manual (Cat. No. Z212)
ZEN Support Software Operation Manual (Cat. No. Z184-E1-03)

The PDF versions of these manuals can be downloaded from the following website.
ZEN Website http://www.zen.omron.co.jp/eng/index.html

PLC LADDER LOGIC





A
Output bit Q0 and Q3 are set,
Q1 and Q2 are reset
Time Delay T3
Work bit M2 is reset
Work bit M3 is set
Output bit Q1 and Q3 are set,
Q0 and Q2 are reset
Time Delay T4
Work bit M3 is reset
Increment Count
Is count
>=
threshold
No
Yes
Work bit M4 reset
Time Delay T5
Counter Reset
Work bit M4 is reset
B

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