DESIGN OF A BORING FIXTURE AND PROCESS LAYOUT FOR CASING OF A FEED GEARBOX OF A LATHE MACHINE

By

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ABSTRACT

Bangladesh Machine Tools Factory (BMTF) Ltd. is a metal base Engineering Industry having sophisticated machineries and equipments. BMTF is engaged in manufacture of Agricultural machineries, Textile machineries, Machine Tools, Hand Tools, Cutting Tools, Jute & Textiles spare parts, Jigs Fixture, Dies etc.

As a matter of fact that the quality of BMTF products does not reach the desired level. Some of the products are manufactured in hundreds or thousand pieces but without having a well defined production process. Complaints from the customers regarding BMTF products has become a regular feature. If the rejection percentage for different items produced by BMTF is considered, it will amply demonstrate that quality control efforts need serious consideration in BMTF.

From the different types of products in BMTF, attention has been focused on the sector of Celtic-14 lathe machine and from this sector feed screw gearbox casing has been considered for the project work. Accordingly the existing method, proposed method and new boring fixture of the said part is described in different chapter in this project thesis. Entire sequence of

operation is shown for each operation along with sketches. This would help the technicians to visualize the operation better.

This work may be useful as an important document for the factory for future work. It is expected that if the proposed method is implemented it would yield better result to improve the quality of BMTF Celtic-14 Lathe machine.

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Chapter—I

1.1 INTRODUCTION

Bangladesh Machine Tools Factory is one of the largest manufacturing Industry in Bangladesh. BMTF was established with the goal of manufacturing Machine Tools like Lathe machine, Drill machine, Grinding machine and all sorts of Cutting Tools, Hand tools etc. At present besides the manufacture of machine tools, BMTF is engaged in the upliftment programme of the national economy by manufacturing Agricultural machineries and equipments, Textile machineries, Diesel engines, Dies etc.

Bangladesh machine Tools Factory faces a serious problems regarding its products. There is a general dearth of skilled personnel in BMTF and a lack of specialized manpower to operate the sophisticated machinery and equipment available in BMTF. Many technicians do not understand the working drawings. As such often they can not maintain the required tolerances. Lack of standardization of specifications as per market demand is another major problem in BMTF. Complaints from the customers regarding BMTF products has become a regular feature. If the rejection percentage by the customers for the different items produced by BMTF is considered, it will amply demonstrate that quality control efforts need serious consideration in BMTF. Products of road side workshops, indian smuggled goods and imports etc. have reduced the market size of BMTF products. Moreover, because of high overhead cost, it is difficult for BMTF to complete with its competetors. As an example, the present cost of a Celtic-14 Lathe produced at BMTF is Taka One lac & seventy five thousand whereas there are other Celtic-14 lathes of nearly same specifications available in the market at a much cheaper rate.

At the early stage BMTF got the method of manufacturing process of Celtic-14 from a company of France, but detailed description of method was not given in there and as such it was not helpful for the technicians. It was very difficult to extract proper information required for an accurate performance. Moreover, these were not adaptable to BMTF machines and Tooling facilities. BMTF management then took decision to manufacture it by conventional way. But it turn out to be a costly process due to high rejection and low output.

The present work aims at providing some suggestions to the existing manufacturing procedures of feed screw gear box casing of Celtic-14 lathe machine to improve quality. However, it is to be noted at this point that to ensure quality product, top management must evolve an overall quality assurance programme in the organization.

From the different types of products in BMTF, attention has been focused on the sector of machine tools and from this sector Celtic-14 lathe has been considered for the project work. Because of the time constraints, this project concentrates on the improvement of the boring operation of feed screw gear box casing of Celtic-14 lathe only. It is expected that if the same methodology proposed in this study is applied to manufacturing operations of the parts of other products, BMTF may go a long way to remove many of the manufacturing difficulties and to produce quality products.

1.2 AIMS AND OBJECTIVES

The existing process of feed screw gearbox casing of Celtic-14 lathe was closely observed and several defects have been found during manufacturing process.

The project work aims at solving those defects. The objective of the study are as follows:

1. To study the existing process of feed screw gear box casing of Celtic-14 lathe and to observe the problems caused by the existing process.

2. To study the types of complaints of the customers for feed screw gear box casing of Celtic-14 lathe.

3. To modify the existing process of boring operation for feed screw gear box casing and develop a more scientific method for the same.

4. To design a new boring fixture for the proposed method.

Chapter — II

2.1 DESCRIPTION OF PROCESS LAYOUT

2.2 JIGS & FIXTURE : DESIGN PRINCIPLE

Chapter — II

2.1 PROCESS LAYOUT

Process layout is the systematic determination of the methods by which a product is to be manufactured economically and competitively. It is an intermediate stage between designing and manufacturing the product. It synthesizes into a plan of manufacturing such factors as the volume of output needed–the operators, tools, and equipment necessary and estimated manufacturing costs for producing the product. The process layout provide specifications for the proposed manufacturing process on process sheets which designate in appropriate detail, the proper sequence of operations and the facilities and tools required.

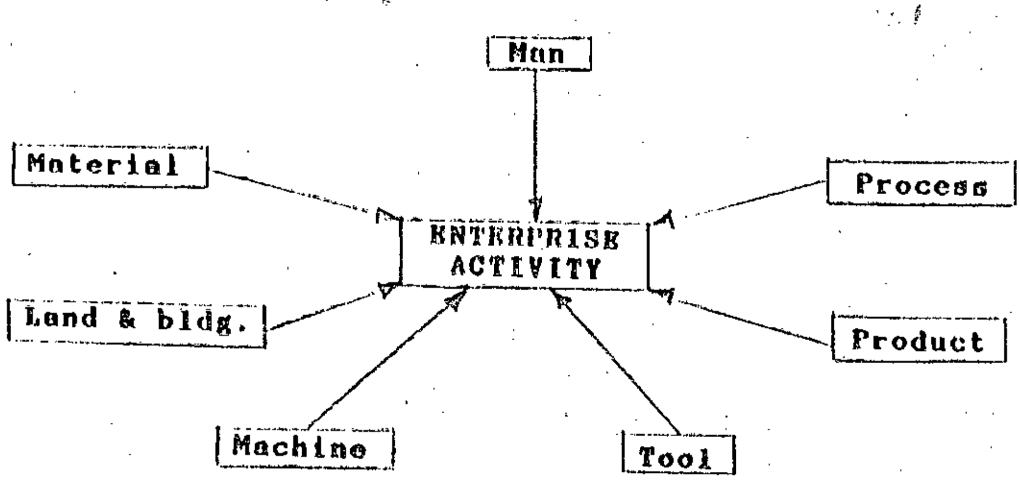
Process layout procedure may vary some what with each individual but in general, it includes the following steps.

1 Analysis of part drawing and specification
2. Listing of basic operations
3. Selection of processes
4. Determination of sequence of operations.
5. Selection of proper machinery with allied tooling.
6. Selection of cutting tools and cutting condition.
7. Specifying the gauging
8. Estimating operation times
9. Document of the process plan.

Actually various production elements are involved to produce products and to render services. These elements include

1. Man
2. Material
3. Machine & tools
4. Method
5. Land & building

Any enterprise must organize its production activities by integrating the production elements effectively so as to produce the products to meet the quality, quantity and the delivery date required by the customers.



2.12 IDENTIFICATION OF PRODUCT FUNCTIONS

1. Standards of parts
2. Assemblying procedure
3. Conditions and environment under which the product is used (heavy duty resistance, wear resistance, corrosion resistance, etc.)
4. Durable life
5. Considerations for designing.

2.13 IDENTIFICATION OF INDIVIDUAL PARTS

1. Material properties

   - Is the material easily available ?
   - Is it technically feasible to obtain required hardness ?
   - Is the material workable after heat treatment ?
   - Are there possibilities of strains and cracks be developed ?

2. Dimensions, Shape, Weight

   - Is there proper equipment available for the required machining ?
   - Is the shape of a part easily subject to strains or cracks, during machining ?
   - Is the material easily available ?
   - Isn't the machining allowance large when using purchase materials ?

   - Are the dimensions specified in the part drawings given in a way to provide for each of machining ?

3. Places to be machined

   - How are the datum planes and lines determined ?
   - Is there proper equipment available for the required machining ?
   - Is machining relief provided ?
   - Is parts fixing method during machining satisfactory ?

4. Machining Accuracy

- Doesn't the required accuracy produce an excessive quality ?
- Are the necessary equipment, jigs & tools available ?
- How is the accuracy inspection method arranged ?
- Are the properties and shape of material adequate to obtain necessary accuracy ?

2.14 CONSIDERATION FOR EXAMINING MACHINING METHOD

1. Dimensions of any part of a product which allows for change to an extent shall be finalized according to the dimensions of the material easily available.

2. Semi-finished materials (drawn material, pipes, etc.) in the market or standard articles (key, etc.) shall be used as much as possible in order to reduce processing cost.

3. Part of the work for which dimensional accuracy is not exact shall be shaped at the secondary processing of material (casting, forging, cutting).

4. Economical cutting-out of material shall be deviced to provide for less machining cost as well as less materials cost.

5. Heat treatment in the middle of processing shall be avoided as much as possible by providing refining on the material.

6. The number of processes and machining time shall be reduced by reexamining machining accuracy.

7. The machining accuracy shall be determined in accordance with existing equipment, jigs & tools.

8. Products shape shall be determined by taking into consideration of machining methods and tools to be employed.

9. Machining standards and shapes shall be reduced by integrating parts.

10. Machining time shall be reduced by separating parts.

11. Machining standards and shapes shall be determined so as to make set-up work easier.

12. Care shall be taken in machining before and after heat treatment which always causes deformation.

13. Special care shall be taken when machining sheet metal structures which easily develop deformation or chatter.

14. Detail instructions shall be provided to the place where exact accuracy is required because machining accuracy is influenced not only by machines but by tools to be used.

2.2 JIGS AND FIXTURE - Design Principle

2.21 Introduction

Jigs and fixtures may be defined as devices used in the manufacture of a number of similar parts of machines to make interchangeable work possible at a reduced cost, as compared with the cost of producing each part individually. Jigs and Fixtures serve the purpose of holding and properly locating a piece of work while it is being machine, and are provided with necessary appliances for grindings supporting, setting and gaging the tools in such a manner that all the work produced in the same jig or fixture will be alike in all respects, even with the employment of unskilled operator.

As a general rule, a jig is a special tool, which while it holds the work or is held into the work, also contains guides for the respective tools to be used, whereas a fixture is only holding the work while the cutting tools are performing the operation on the piece, without containing any special arrangements for grinding these tools. The fixture, therefore, must itself, be securedly held or fixed to the machine on which the operation is performed, hence the name.

2.22 Concept of Interchangeability

In the present type of production system it is well accepted fact that there is no necessity of making the components to the same dimensions which are given by the designers. It is also a very difficult job to make the component perfectly as per design. By a determined variations in the basic dimension, the above difficulty in manufacturing the component may be eliminated, which increases the rate of production and reduce the unit cost of the product.

If two components of an assembly picked up randomly from their respective lots, and are assembled without any difficulty, then this kind of production is referred as interchangeable production. Interchangeable production means the production of parts to such a degree of accuracy that will ensure an assembly, which will meet the functional requirements.

Jigs and fixtures are the main figures in producing the interchangeable components.

2.23 Objects of Jig and Fixture

The main object of jig and fixture is to make the production procedure easier and quicker. This reduction of cost is obtained in consequence of the increased rapidity, with which the machine may be built, and the employment of cheaper labour, which is possible only when using tools for interchangeable manufacturing. Another object not less important is the accuracy. It is always preferable to object not less important is the accuracy. It is always preferable to take into the consideration of time factor, whenever the jig design is made.

The cost of 'jig' should be overcome by the total cost of a piece in mass production. Therefore, in designing of any jig, experience technicians it is concluded that for jig design, it is not necessary to consider all the forces and torques on the job. Because, it is a very difficult and lengthy job to analyse all the forces and calculate the stresses on job as well as on tool. This procedure is neither economical nor practicable. Because a factory can not bear such a huge time for designing a jig. Besides these difficulties some other abnormal data we can get from designing the jig by the above method. Therefore, it is not wilfull that first finding all the data accurately and then assuming them. But one thing should be kept in mind, that in some complicated designs the calculations are a must.

2.24 Points of Consideration.

While designing a jig, the following rules may be given as the main points to be considered for design.

1. Compare the cost of production of the work with present tools, with the expected cost of production using the tool to be used, and see that the cost of building should not be in excess of expected gain.

2. Make all clamping and locating devices as quick acting as possible.

3. Make the jig 'Fool proof' i.e. arrange it, as the work cannot be inserted except in the correct way.

4. If possible, make all the clamps for internal parts of the jig or fixture.

5. Round all the corners.

6. Provide handles for ease of handling.

7. Provide feet in large drilling and boring jigs.

8. Provide abundant clearance for chips etc.

2.25 Underlying Principles of Jig and Fixture Design

Jig and fixture design is based upon a number of fundamental principles which must be understood properly and their function appreciated before work is commenced on actual designs. The aim of any design should be simplicity. As the designer get the experience in job his design will become more efficient and shall be confering i=more and more to these principles. Some of the common principles are discussed below:

i. Rigidity.
ii. Clearance between jig and component.
iii. Swarf clearance.
iv. Postiioning.
v. Locating points and supports.
vi. Fool proofing.
vii. Clamping.
viii. Reduction of idle time.
ix. Design of safety.

x. Component should be ejected.

xi. Spring locations.

xii. Jig base.

xiii. Accuracy.

xix. Easy loading and unloading.

xv. Jig bushes.

One of the most important questions to be decided before making a jig is the amount of money that can be expended on a special tool for the operation required. In many cases, it is possible to get a highly efficient tool by making it more complicated and more expensive whereas a less efficient tool may be produced at a very small expense. To decide which of these two types of jigs and fixtures should be designed in each individual case depends entirely upon the circumstances.

i) **Rigidity.**

Jigs and fixture should be rigid enough, particularly in case of milling fixture, becuase they have to bear intermittent cuts. Therefore, for fixture body cast iron is used which absorbs shock.

ii) **Clearance between Jig and Fixture Components.**

There should be plenty of clearance between the jig and component to take care of variations in dimensions in mass manufacture. Such a clearance is also necessary for chips to pass out enough through the opening between component and jig plate rather than choke the jig bush while trying to come out through it.

iii) <u>Swarf Clearance.</u>

In small jig the importance of providing good swarf clearance is particularly important in large drilling jigs and particularly those made from castings, adequate swarf clearance can be provided by designing the jig with cored holes, at points where swarf is likely to accumulate. These holes also serve to let the minute particles go out with the coolant.

iv) <u>Positioning.</u>

Positioning refers to establishing the desired relationship between the jig or fixture, and cutting tool.

In case of single machine cut, where the jig or fixture is strapped to the table, positioning may occur only once, at the bet-up of fixture. In case of drill jigs, where number of holes are to be drilled positioning occures, each time a bushing is aligned to the drill.

v) Locating Points and Supports.

The most important requirements in the design of jigs are that good facilities be provided for locating the work. The locating of work in jig should be quickly and accurately. The two component parts of the machine should be located from corresponding points and surfaces.

When the work to be machined; varies in shape and size, as in case of rough castings it is necessary to have at least some of the locating points adjustable.

a. Locating and supporting surfaces should where ever possible be removable. Generally surfaces should be of hardened material.

b. Locating points should be clearly defined. The use of large flat machined surface should be avoided, otherwise it will collect unwanted chips.

c. For easy removal of work, locating or supporting pins, should be fitted into through holes and not blind holes.

A workpiece can be positively located by means of six pints, so positioned that collectively they restrict the workpiece in nine of its degrees of freedom. This is known as six point location method.

While choosing the locating points following considerations are to be made.

1. Points more than necessary should not be provided.

2. Locating points should be choosen as apart as possible.

3. Most satisfactory locating points are those in the mutually perpendicular planes.

4. All locating points which require replacement due to wear and tear, should be easily replaceable.

Locating Devices.

The following are the locating devices, which are generally used in practice:

1. Various types of jacks and supporting pins
2. Cylindrical locators or locating pins
3. Conical locators
4. Diamond pin locators
5. Vee-block locators

vi) Fool-proofing.

If possible special arrangement should be made in the design of the jig so that it is impossible to insert the piece in any but the correct way. Mistakes are often made on this account in shops where a great deal of unskilled labour is used, pieces are placed in jigs and upside down, or in some way other than the correct one, and work that has been previously machined is entirely spoiled. Therefore whenever possible a jig should be made "fool-proof".

vii) <u>Clamping.</u>

The function of a clamping device is that of applying and maintaing sufficient counteracting holding force to a workpiece to withstand all tooling forces.

The clamping arrangements should be as simple as possible, without sacrificing the strength. The main aim of clamps are that they should be convenient for the operator. Therefore, it is advisable to avoid the complicated clamping arrangements, clamps should be quickly operated to reduce the idle time of machine.

Following points are to be noted for designing of any clamp.

a. Clamping should always be arranged directly above the points supporting the work.

b. Fibre pads should be riveted to clamp faces where metallic contact with the work would cause damage.

c. Arrange all the clamps and adjustment on the side nearest to the operator.

d. Clamping arrangement should be easily removable from the work.

e. Use fixed stops against the cut which will take the direct thrust of the cutters.

Clamping Devices.

Some sort of clamping devices are an essential part of both jigs and fixtures. Clamping may bve complex or simple but it must fulfill the following design requirements:

1. The clamping devices must hold the workpiece rigidly against all disturbing forces.

2. It should also keep the workpiece firmly in contact with locating pins or locating surfaces.

3. The time required to loosen the clamp on the workpiece and tighten it again on next piece should be minimum. Compression spring should be used to lift the clamp away from the workpiece.

4. The clamping devices when subjected to vibrations, or heavy pressure must be positive and should not distort.

5. The clamp, while holding the workpiece should not damage it. Thick section should be choosen for bearing clamping forces.

6. Placement of nut or hand wheel should be such as to control the amount of pressure to be exerted on the workpiece.

7. The movement of the screw, lever or cam of the clamping device whether of the rotary or reciprocating type should be strictly limited to make the device quick acting.

Types of Clamps.

There are so many types of clmaps used in production work, some of them are given below:

1. Strap-clamps.
2. Screw clamps.
3. Hinged clamps.
4. 'C' clamps.
5. Wedge clamps.
6. Quick actiong but typo clamps.
7. Toggle clamps.
8. Quick acting-cum-operated clamps.
9. Bayonet type quick acting clamps.
10. Multiple clamps.

viii) **Reduction of Idle Time.**

As described earlier that our main aim is to reduce the manufacturing time of the job. Therefore, the method of location and clamping should be such as to reduce the idle time.

ix) **Design for Safety.**

All sharp edges should be removed from details forming the jig or fixture unit. Head of Allen bolts which are extensively used in builtup jigs should not protrude above the surface of the dies. These should go in the recess provided for the purpose. Heavy bore jig if required to be turned should be provided with trunions to reduce the labour of operator.

x) Component should be Ejected.

Wherever possible arrange the jib so that when unclamped, the component is either partially or completely ejected, so saving the need for hammering or struggling with the piece.

xi) Spring Locations.

The number of locations on any rough component should never exceed three in any one plane. The component will sit on three points without rocking. However for further supports to be provided, should be spring loaded, so that after the component is on the three fixed positions others will automatically rise to tough the component through the medium of the springs. These spring locations can then be locked in position.

xii) Jig Base.

A jig which is not bolted to machine table must be provided with four feet instead of whole bottom surface lying on the machine table. In this way the jig will rock of it and is not standing square on the machine table, due to some chips under one of the feet and warn the operator.

xiii) Accurancy.

All operations produce variations in their results. Jig and fixtures designer has to determine what variations can be permitted in an operation. The variations arises from the following caudes:

1. Variations in the dimensions of the workpieces coming by an operation.
2. Variation in material conditions.
3. Defects in tools and machines.
4. Wear.
5. Deflection.
6. Thermal expansion.
7. Dirt, chips and burrs.
8. Error of human judgement, limits, tolerances and deficiencies of skill.

xiv) Easy Loading and Unloading.

The process of loading and unloading the component shoule be as eacy as possible. On heavy components the operator should be able to slide his component in to fixtures.

xv) Jig Bushes.

The drills, counterbores, reamers, boring bars etc. should be guided to the desired point through steel bushes, fixed in the jig plate. Bushes are hardened and ground. In the larger jigs the full jig plate can not be hardened because that will be uneconomical and impracticable. Whereas the bushes when worn out due to friction of coming out chips can be replaced on requirements. Most of the wear is due to the action of chip and the rate of wear, depends largely on the material being drilled.

Drill bushes may be classified as follows:

i. Fixed bushes (Plains or headed)
ii. Liner bushes
iii. Renewable bushes
iv. Slip bushes
v. Screw, or clamp bushes
vi. Special bushes.

2.26 CLASSIFICATION OF FIXTURES

There are so many types of fixtures used in different industries for different components. but they may be classified on the basis of their working operations such as:

1. Milling fixtures
2. Turning fixtures
3. Grinding fixtures
4. Broaching fixtures
5. Assembly fixtures
6. Welding fixtures
7. Slotting fixtures
8. Boring fixtures
9. Miscellaneous fixtures.

2.27 MATERIALS FOR JIGS AND FIXTURES

Since it is cheap and easy to work with, wood was probably the first material to be used in constructing jigs and fixtures. But now it is not considered good for most precision tooling purposes due to lack of its strength. Therefore, modern jigs and fixtures are made of metals. The most frequently used metals are iron and steel, although aiuminium is also preferred sometimes for light weight works.

General, tooling metals should have the following physical characteristics.

1. Good formability.
2. Good strength properties.
3. Ability to retain close dimensions.
4. Resistance to handling impacts.
5. Salvageability.

A widely available form of iron called cast iron should never be used for fabrication of jigs and fixture, because cast iron is brittle, and subjected to breakage on handling. Wrought iron is an excellent material for the fabrication of jig and fixtures, but in modern practice mild steel is used, because it has similar physical properties as the wrought iron and even it is cheaper. The type of steel used in constructing a jig or fixture depends primarily upon such considerations as cost, method to be used in fabricating or assembling the tool, and the load; which the finished structure will be required to support.

Whenever a low-weight structure is required, aluminium and magnesium alloy may be advantageously used.

Methods of Construction.

Owing to the recent developments with welding, 'built-up' structures are now widely used. A built-up structure can be defined as any physical unit, which is made by assembling two or more members. It cannot be constructed with the accuracy of a cast streucture. Built-up structures normally comprise standard sections such as, rounds, pipes, squares etc. Further to fabricate the steel structure, arc welding is preferred economically.

Materials for Jig and Fixture Elements.

In a wide sense mild steel can be used for jig and fixture body.

Jig Bodies.

There are two common forms of construction for both jigs and fixtures; built up bodies, and cast iron bodies. In the built up structure the component may be made of steel or cast iron. If cast iron then the pieces are machined and joined with dowels and screws, because cast iron cannot be properly welded. And if the components are of steel then it can either be built up using dowels and screws of fabricated by welding.

Jig Feet.

When castings are used the feet are cast integral with the body. If the feet are to be added after words then they are of steel and are hardened and finish ground on assembly.

Jig Bushes.

In terms of minimum diameter the materials for drill bushes may be as follows:

1.	Upto 15 mm Outside diemeter	...	Silver steel
2.	15 to 30 mm O.D.	...	Cast Steel
3.	Over 30 mm O.D.	...	Case hardend Mild Steel

Locating and Clamping Devices.

Most of the locating and clamping devices are made from steel but those s=components which come in contact with other components, are hardened, and working surfaces are ground. Silver steel is used for parts like dowel pins, bars for handles etc. Threads should be left soft.

Jigs weight and strength.

The designer must use his judgement in regard to the amount of metal pub into the jig or fixture. It is desirable to make these tools as light as possible, in order that they may be easily handled be of smaller size and cost less in regard to the amount of material used for their making.

Feet.

Ordinary drill jigs should always be provided with feet or legs on all sides which are opposite the holes for the bushings, so that the jig can be placed level on the table of the machine. On the sides of the jig where no feet are required, if the body is made from a casting, it is of advantage to have small projecting lugs for bearing surfaces when laying out and planning.

2.28 Summary of Principles of Jig Design.

Summarizing the principle referred to, the following may be given as the main points to be considered in the designing of jigs and fixtures.

1. Before planning the design compare the cost of production of the work with present tools with the expected cost of production using the tools to be made, and see that the cost of building is not in excess of the expected gain.

2. Before laying out the jig or fixture, decide upon the locating points and outline a clamping arrangement.

3. Make all clamping devices as quick acting as possible.

4. Make the jig fool proof, that is arrange it so that the work can not be inserted except in the correct way.

5. Locate clamps so that they will be in the best position to resist the pressure of the cutting tool when at work.

6. Make all clamps integral parts of the jig or fixture.

7. Avoid complicated clamping arrangements which are liable to wear or get out of order.

8. Place all clamps as nearly as possible opposite some bearing point of the work, to avoid springing.

9. Core out all unnecessary metal, making the tools as light as possible, consistent with rigidity and stiffness.

10. Round all corners.

11. Provide abundant clearance and holes for swarf removal.

Table - 1 : Classification of machine fixture

HOLE MACHINING	
Single-point cutter	Multiple point cutter
Boring jigs	Drill jigs Tapping jigs Reaming jigs Honning & lapping jig.

SURFACE MACHINING	
Rotary motion	Straight line motion
Lathe fixtures	Planning, shaping and sloting fixtures

Multiple point cutter	
Milling fixture for circular feed	Milling fixtures for straight line feed
Fixtures for circular grinding	Surface grinding fixture sawing fixture

The complete planning, design and documentation process for a fixture consists in the widest sense of three phases design preplanning, fixture design and design approval. The general consideration in fixture design can be summerized as follows:

1. Loading and unloading of part

   1.1 Manual lifting or hoisting

   1.2 Lowering or sliding part into position

   1.3 Unloading to floor

   1.4 Use of magazines, conveyors and chutes for receiving and returning part

   1.5 Speed of motions

   1.6 Ease of motions

   1.7 Safety in manipulations

2 Locating parts in fixture for ready access of cutting tools.

   2.1 Concentric to an axis

   2.2 Vertical and horizontal from established surfaces

   2.3 Vertical and horizontal from discrete points

3 Clamping of part

   3.1 Speed

   3.2 Size of clamping forces

   3.3 Direction of clamping forces

   3.4 Location of clamping forces

   3.5 Manual or power actuation of clamping elements.

4 Support of part

   4.1 Against clamping pressure

   4.2 Against tool forces

   4.3 Stability of part and avoidance of elastic deformation

5. Positioning cutting tool relative to loaded fixture.

5.1 Rotating

5.2 Sliding

5.3 Tilting

6 Cooland supply and return

7 Chips

7.1 Removal of accumulated chips

7.2 Chip disposal.

Chapter – III

3.1 EXISTING METHOD FOR BORING OPERATION OF FEED GEAR BOX CASING OF CELTIC-14 LATHE

3.2 NATURE OF DEFECTS FOR FEED GEAR BOX CASING

3.3 DEFLECTION OF BORING BAR WITHOUT USING OF INTERMEDIATE SUPPORT UNDER EXISTING METHOD

3.4 PROPOSED METHOD FOR BORING OPERATION OF FEED GEAR BOX CASING

3.5 BORING FIXTURE DESIGN FOR FEED GEAR BOX CASING

3.11 EXISTING METHOD FOR BORING OPERATION

The existing method of boring operation of the feed gear box of Celtic lathe is described in the following:

Operation Layout sheet

Part name : Screw cutting and feed gear box casing

Material : Cast iron

Op. No.	Operation Name	Machine
1	Mill rear and front sides	Horizontal milling
2	Mill top side	Horizontal milling
3	Mill the two lateral sides	Horizontal milling
4	Drilling	Drill machine
5	Finish mill rear side	Vertical machine
6a	Boring	Boring machine
b	Counterbore a internal rose to 22H7 dia Counterbore a internal rose to 26H7 dia	
7	Check scribe and Centre punch oil hole inspection	
8a	Drill ten 4.25 mm dia holes on 18 mm depth	Tap machine
b	Tap ten 5 MA holes on 19 mm depth	

Operation Layout sheet (Contd.)

Op. No.	Operation Name	Machine
c	Counterbore two 11 mm dia holes to 18.5 mm dia on 1 mm depth	
d	Drill two 5 mm dia holes (for 6 MA) to fasten bushes Drill eight 5 mm dia holes (for 6 MA) to fasten cover	(
e	Tap eight 9 MA holes to fasten cover	
f	Drill four 3.25 mm dia holes for 4 MA Drill a 6.5 mm dia on 9 mm depth Drill two 5 mm dia holes for 6 MA to fasten bushes Counterbore four 3.25 mm dia holes to 4.5 mm dia on 3 mm depth	
g	Tap four 4 MA holes	Tap machine
h	Tap two time two 6 MA holes to fasten bushes	
i	Drill three 3.25 mm dia holes on 12 mm depth Drill two 6.75 mm dia holes (8 MA) including one blind hole on 19 mm depth	
j	Drill three 5 mm dia holes (6 MA) on 19 mm	
k	Tap 2 times three 4 MA holes on 7 mm depth	Tap machine
l	Tap three 6 MA holes on 12 mm depth	
m	Tap a 8 MA hole on 13 mm depth Tap a 8 MA through hole Tap three 1/2" gas holes.	

OPERATOR INSTRUCTION SHEET FOR BORING OPERATION

Description of steps of operation

- Drill a 20 mm dia forehole on 30 mm depth (axis IV)
- Drill a 26 mm dia forehole on 30 mm depth (axis II)
- Drill a 25 mm dia forehole on 33 mm depth
- Drill a 26 mm dia forehole on 8 mm depth (axis I)
- Drill a 25 mm dia forehole on 20 mm depth
- Drill a 26 mm dia forehole on 30 mm depth (axis III)
- Drill a 25 mm dia forehole on 36 mm depth

Turn the fixture up side down

- Drill a 20 mm dia forehole on 37 mm depth (axis II)
- Drill a 20 mm dia forehole on 37 mm depth (axis I)
- Drill a 20 mm dia forehole on 37 mm depth (axix III)
- Drill a 1st 19 mm dia hole for 1/2" gas
- Drill a 2nd 19 mm dia hole for 1/2" gas
- Drill a 3rd 19 mm dia hole for 1/2" gas
- Counterbore a 29 mm dia chamber on 1 mm depth

Turn the fixture up side down

- Drill a 1st 11 mm dia hole
- Drill a 2nd 11 mm dia hole
- Drill a 3rd 11 mm dia hole
- Drill a 4th 11 mm dia hole
- Drill a 1st 7.75 mm dia for pin hole
- Drill a 2nd 7.75 mm dia fore pine hole

Keep the fixture in the original position

- Reaming a 22H7 dia forehole on 30 mm depth (axis IV)
- Reaming a 28H7 dia forehole on 37 mm depth (axis I)
- Bore a 26H9 dia forehole on 33 mm depth
- Bore a 28H7 dia forehole on 8 mm depth (axis I)
- Bore a 26H9 dia forehole on 20 mm depth
- Ream a 28H7 dia forehole on 30 mm depth (axis III)
- Bore a 26H9 dia forehole on 36 mm depth

Turn the fixture up side down

- Ream 22H7 dia forehole on 37 mm depth (axis II)
- Ream 22H7 dia forehole on 37 mm depth (axis I)
- Ream 22H7 dia forehole on 37 mm depth (axis III)
- Counterbore 30H9 dia on 1 mm depth.

3.12 MAIN FEATURES OF THE EXISTING METHOD

The operator instruction sheet should contain all necessary informations regarding machining operation. But the existing instruction sheet does not provide such informations, which causes a great difficulty for an operator.

The cutting tools such as drill bit, boring tool, counter boring tool, reamer etc. that have been used in various operations are not specifically mentioned in the instruction sheets.

In the existing instruction sheet, the support zone, location where the boring operation are to be done are not clearly specified. There are eleven holes to be drilled and bored subsequently but these are not clearly mentioned in the said sheet. It was difficult to identify the operational sequences properly. Moreover, there are no sketches in the specified sheet which causes serious problem for an operator.

Operation layout sheet consists of machine list. But this list is not well defined. For boring operation, it was mentioned in the sheet as Boring machine, no other informations was given. As there was no specific Jig-Fixture for Boring operation, it would really be difficult to understand the methodical approach that have been shown in the operator instruction sheet. On the other hand the RPM, Feed, depth of cut for respective operation were not mentioned. No information was given regarding tool material, size specification etc.

In the existing method, the boring operation is carried out into three phases: drilling, boring and reaming. But how much martial will be removed from those operations was not mentioned in the sheet.

Therefore, from the above duscussion, it is clear that it would really be difficult for an operator to work with the existing instruction sheets which are inadequate to provide necessary informations.

3.2 NATURE OF DEFECTS OF FEEDGEAR BOX

In this chapter, various type of complaints launched by the customer for screw cutting feed gear box of Celtic lathe have been described. Complaints are being collected from the complaint file of the Bangladesh Machine Tools Factory Ltd. of which some of the main defects have been shown here. Complaints are categorizedand entered in the table under the title like Nature of Complaint, Complaint by, Probable causes etc. From the nature of complaints it will be easier to study the extent and seriousness of the manufacturing defects in the production of feed gear box casing of celtic lathe.

It is also apparent that the most of the complaints are in the field of manufacturing. The problems related to design and assembling may also be considered in the manufacturing problem

Various Complain of Feed Gear Box

Sl. No.	Nature of Complaints	Complaint by	Probable cause	Remarks
01	Bore of the feed gear box increased by 0.2 mm	GRC Fan Ltd.	Machining was not done properly	Manufacturing fault & lack of inspection
02	Main shaft become bend	Khulna shipyard	Heat treatment was not done correctly	Manufacturing fault
03	Base plate of the handle was to be shifted	Khulna shipyard	Improper assembling was made	Assembly fault
04	Bush of the change gear was to be changed	Khulna shipyard	Improper method of production	Manufacturing fault
05	Teeth of the gears were broken	Pahartali Textile & Hosiery mills	Proper material & heat treatment was not maintained	Manufacturing fault
06	Feed mechanism of the gear box was defective	Bangladesh Educational Equipment Board	Drilling and boring holes were not accurate	Manufacturing fault
07	Thread of drain plug defect	- do -	Improper inspection	Assembling fault
08	Excessive oil was coming from Head stock	Acmi Jute Mill	Oil seal of was not good	Assembling fault
09	Abnormal sound was developed	Acmi Jute Mill	Gear meating was not properly done	Manufacturing fault
10	Thread cutting was not done correctly	S.K.M. Jute Mills	Manufacturing of gear was not correct	Manufacturing fault
11	Gear could not be changed freely	S.K.M. Jute Mills	Allignment of the shaft was not done correctly.	Manufacturing fault.

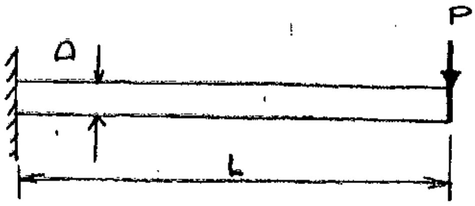
3.21 TYPES OF MANUFACTURING DEFECTS FOR GEAR BOX CASING

1. Dimension of the holes are not accurate
2. The axis of the holes do not lie on the same line
3. The centre distance of holes is not properly maintained according to the requirement
4. The key way of the gear is inclined
5. The diameter of the bore is eccentric
6. The facing of the bore is not done properly
7. The grinding of inside and outside surface of bush is in accurate
8. The parallelism between two surfaces are not maintained with tolerances
9. The center distance between holes varies
10. During broaching operations the angles are not maintained properly.

The defects mentioned under points 1, 2, 3, 5, 8, 9, 10 are related to defective boring operation of the different holes. The present work aims at minimized these defects by introducing an appropriate boring fixture for these operations.

3.3 Deflection of Boring bar

The deflection of Boring bar without using intermediate support can be calculated as follows:



$$\text{Deflection, } \delta = \frac{PL^3}{3EI}$$

$$\text{where, } I = \frac{\pi D^4}{64}$$

Here, P ---- the cutting force Kg_f

L ---- the length of the bar

E ---- modulus of Elasticity

I ---- the moment of inertia

D ---- the diameter of the boring bar.

The moment of Inertia

$$I = \frac{\pi D^4}{64}$$

$$= \frac{\pi \times 30^4}{64} = 39{,}998.59 \text{ mm}^4$$

$$\text{Deflection, } \delta = \frac{PL^3}{3EI}$$

where, P = 75 kg_f (source: Machine design by R.K.Jain)

L = 225 mm

$$E = 30300 \text{ k psi} = \frac{30{,}300 \times 10^3}{25.4^2 \times 2.2} \; kg_f/mm^2$$

$$= 21.35 \times 10^3 \; kg_f/mm^2$$

$$\text{i.e. } \delta = \frac{75 \times 225^3}{3 \times 21.35 \times 10^3 \times 39778.59} = 0.34 \text{ mm.}$$

The value of deflection is not desirable to maintain proper dimension of the part.

3.4 PROPOSED METHODOLOGY

The existing operation layout and instruction sheets were studied and a completely new set of instruction sheets for boring operation was designed which will be discussed in this chapter. This method sheet is adaptable to BMTF technical facilities, qualities and accuracy requirement. These instruction sheets include all the tools, gauges either manufactured or to be manufactured. Following were the reasons why the existing method sheets were not adapted.

i. Long reamers as proposed by the existing method for reaming of holes were not found suitable for BMTF conditions.

ii. All other necessary informations like speeds, feeds of the cutter were not mentioned in the sheet.

iii. For checking and control of the part, gauges were not indicated in the existing method sheet.

iv. No operational sketchs were provided in the sheet.

Therefore, it was required to solve all these discripencies and make a process layout which would acceptable as well as workable. In this chapter the special features of the proposed method have been discussed and the corresponding operation instruction sheets (Fig. 1 to Fig. 13) have been prepared for all the boring operations. The part drawing of feed gearbox casing from different views have also been shown from page no. 33 to 38.

OPERATION INSTRUCTION SHEET					
PART NAME Feed screw gear box			OPERATION NO. 7-1		
TYPE OF M/C Horizontal boring			APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
1	Pf/00/07	-	CT/00/07-1	160	0.2

Step-1 : Drill 3 holes ø 20 through with CT.03.01.05AC$_1$/00/07-1

- Remove the tool

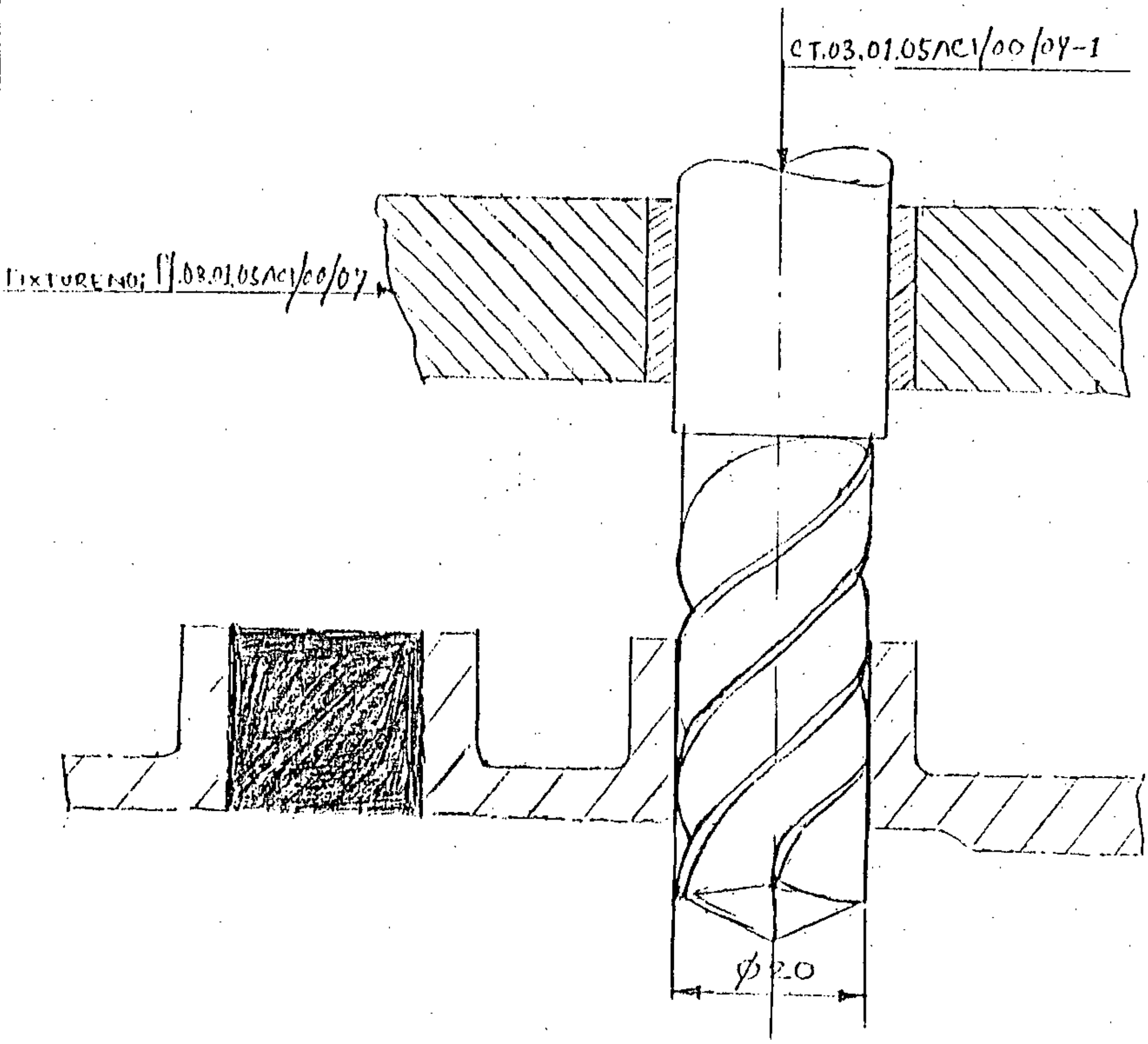


Fig. 1 : DRILLING OPERATION OF HOLE ø 20

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME	Feed screw gear box		OPERATION NO. 7-2		
TYPE OF M/C	Horizontal boring		APPLICATION	Celtic-14 lathe	
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
	Pf/00/07		CT/00/07-2	224	0.2

Step-2 : Turn the fixture 180°

- Fix tool no CT.03.01.05AC1/00/7-2
- Drill three hole ø 26 for spindle I,II & III
- Remove the tool.

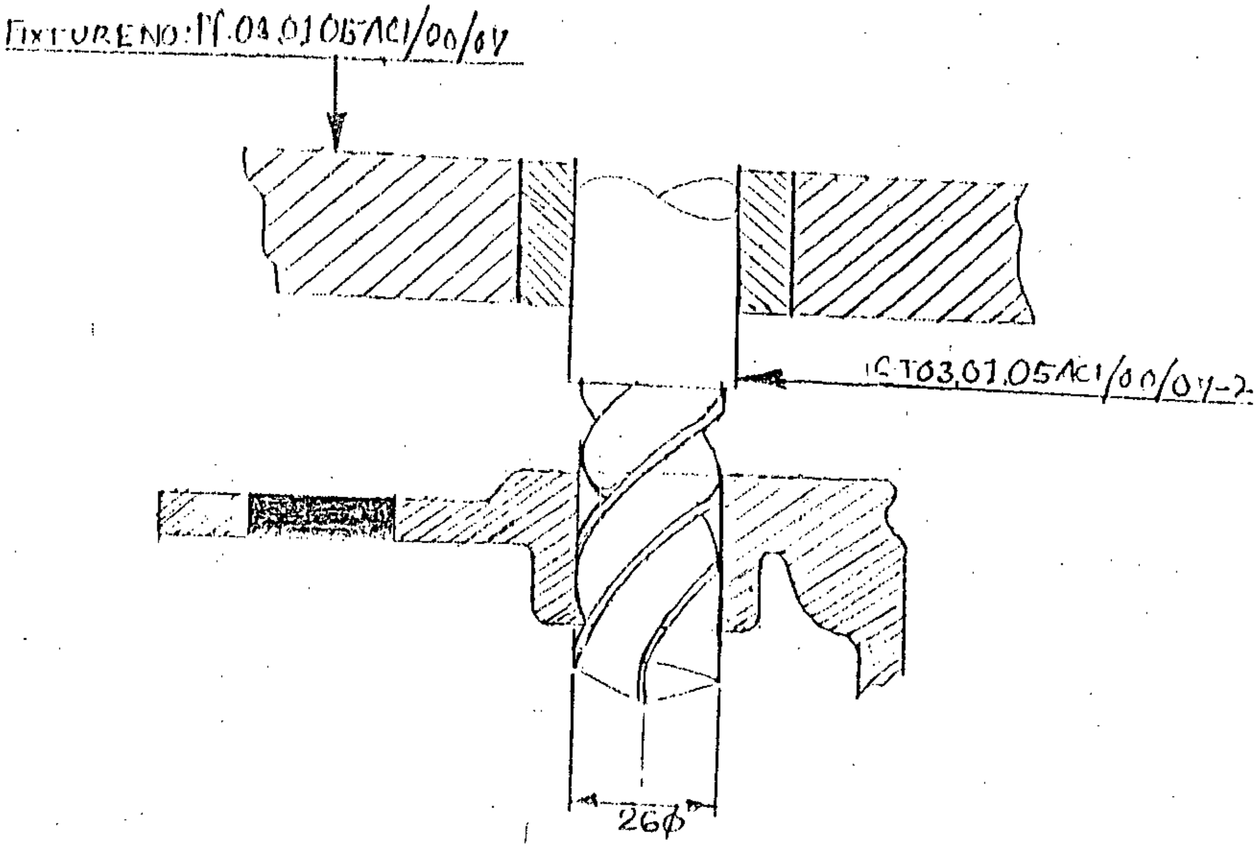


Fig. 2 : DRILLING OPERATION OF HOLE ø 26

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME	Feed screw gear box		OPERATION NO.	7-3	
TYPE OF M/C	Horizontal boring		APPLICATION	Celtic-14 lathe	
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
3	Pf/00/07		CT/00/07-3A	160	0.2
			CT/00/07-3B		

Step-3 :

- Fixing tool no. CT.03.01.05AC1/00/07-3A & removable barrel CT.03.01.05AC1/00/07-3B
- Drill 3 holes, ϕ 25)spindle I, II & III)
- Remove the tool, then move to spindle IV

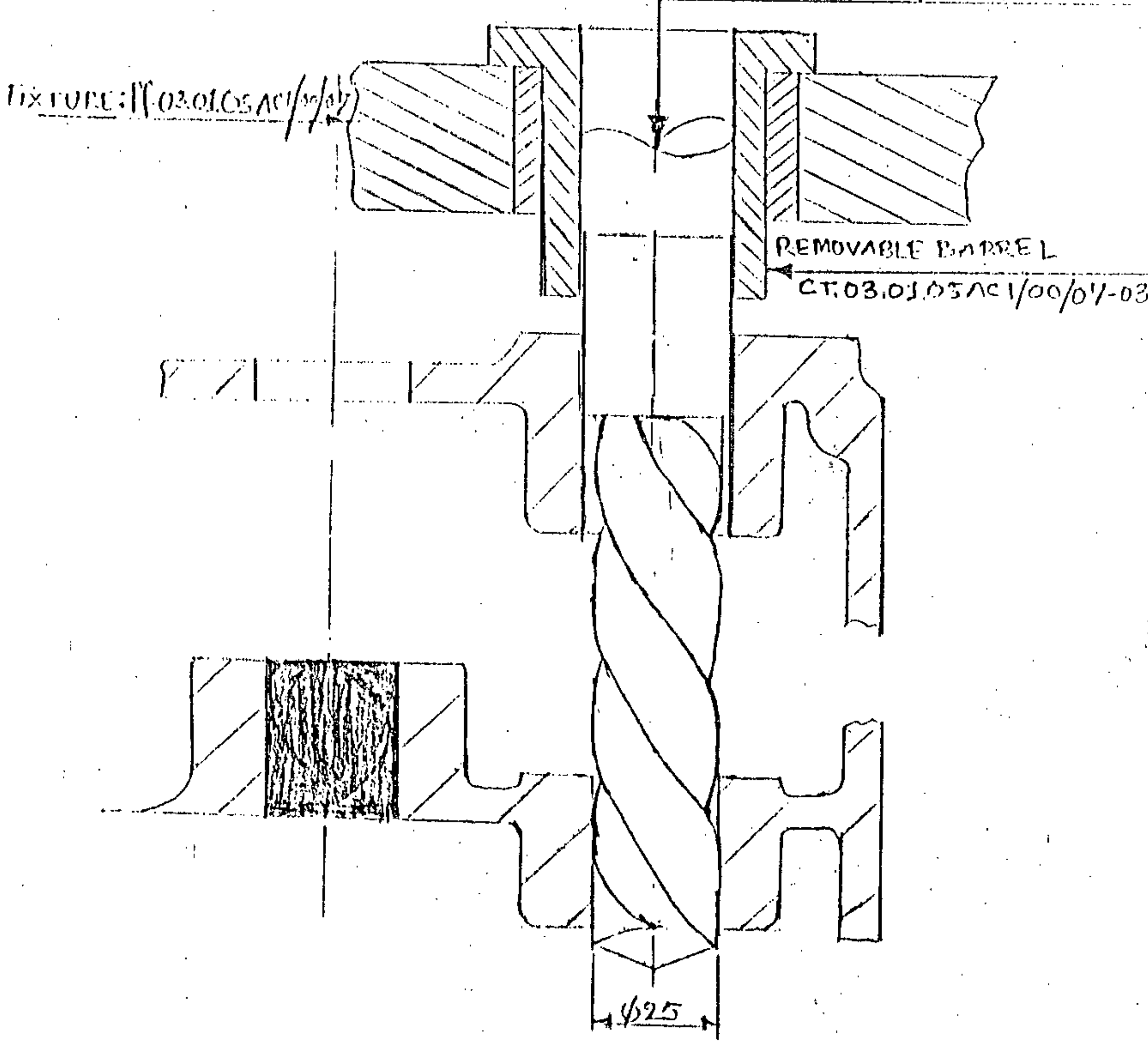


Fig. 3 : DRILLING OPERATION OF HOLE ϕ 25

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA

OPERATION INSTRUCTION SHEET					
PART NAME	Feed screw gear box		OPERATION NO. 7-4		
TYPE OF M/C	Horizontal boring		APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
4	PE/00/07		CT/00/07-4	160	0.2

Step-4 :

- Fixing tool no. CT.03.01.05AC,/00/07-4
- Drill ø 20 counter boring ø 26-7,5 depth (spindle IV)
- Remove the tool.

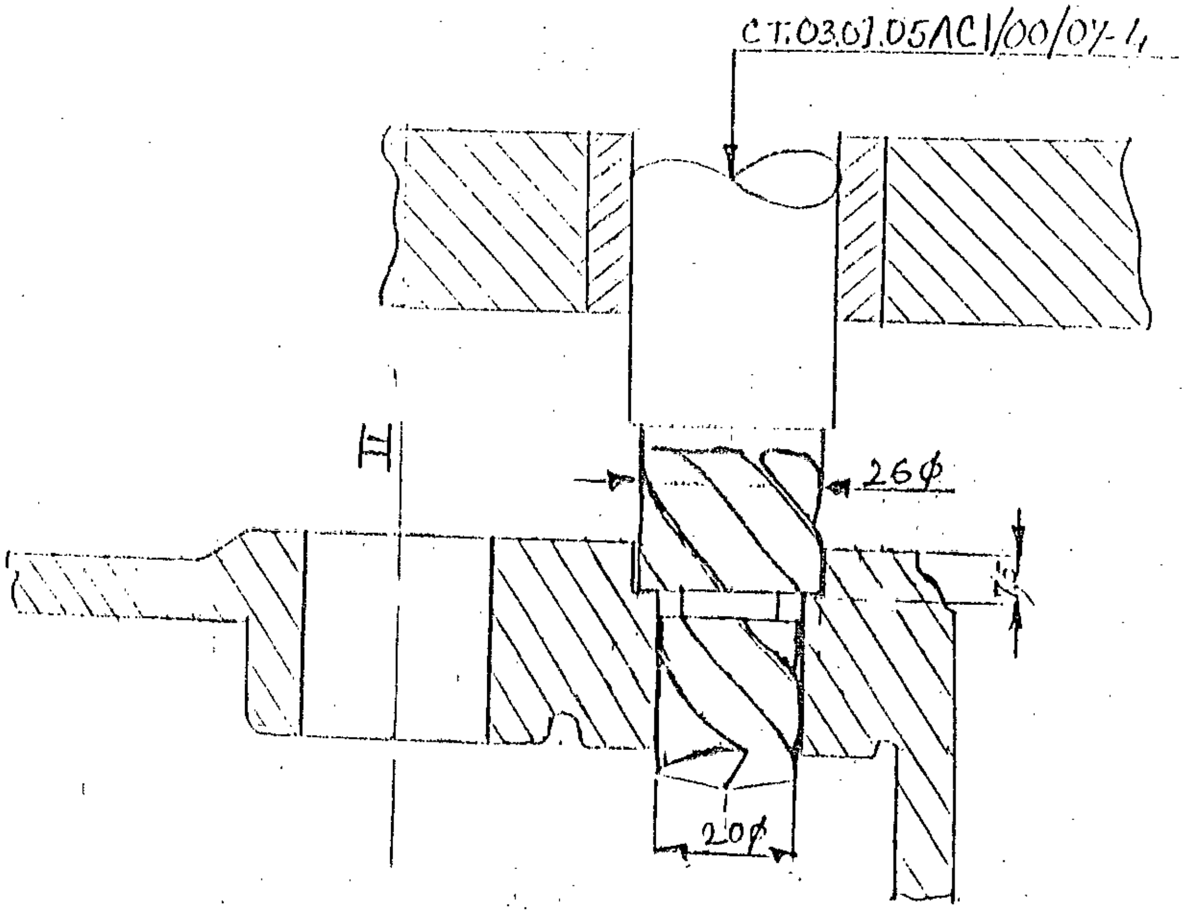


Fig. 4 : DRILLING ø 20 AND COUNTERBORING ø 26 OPERATION

DESIGN BY : NAKIB AHMED

DRAWN BY : A. SHARMA

OPERATION INSTRUCTION SHEET					
PART NAME	Feed screw gear box		OPERATION NO.	7-5	
TYPE OF M/C	Horizontal boring		APPLICATION	Celtic-14 lathe	
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
5	PF/00/07		CT/00/07-5A	72	0.2
			CT/00/07-5B		
			CT/00/07-7B		

Step-5 :

- Surfacing spindle no. 1V with tool no. CT.03.01.05AC$_1$/00/07-5A to dimension $30^{+0.0}_{-0.1}$
- Using removable barrel no. CT.03.01.05AC$_1$/00/07-5B and CT.03.01.05AC$_1$/00/07-7B
- Remove the tool.

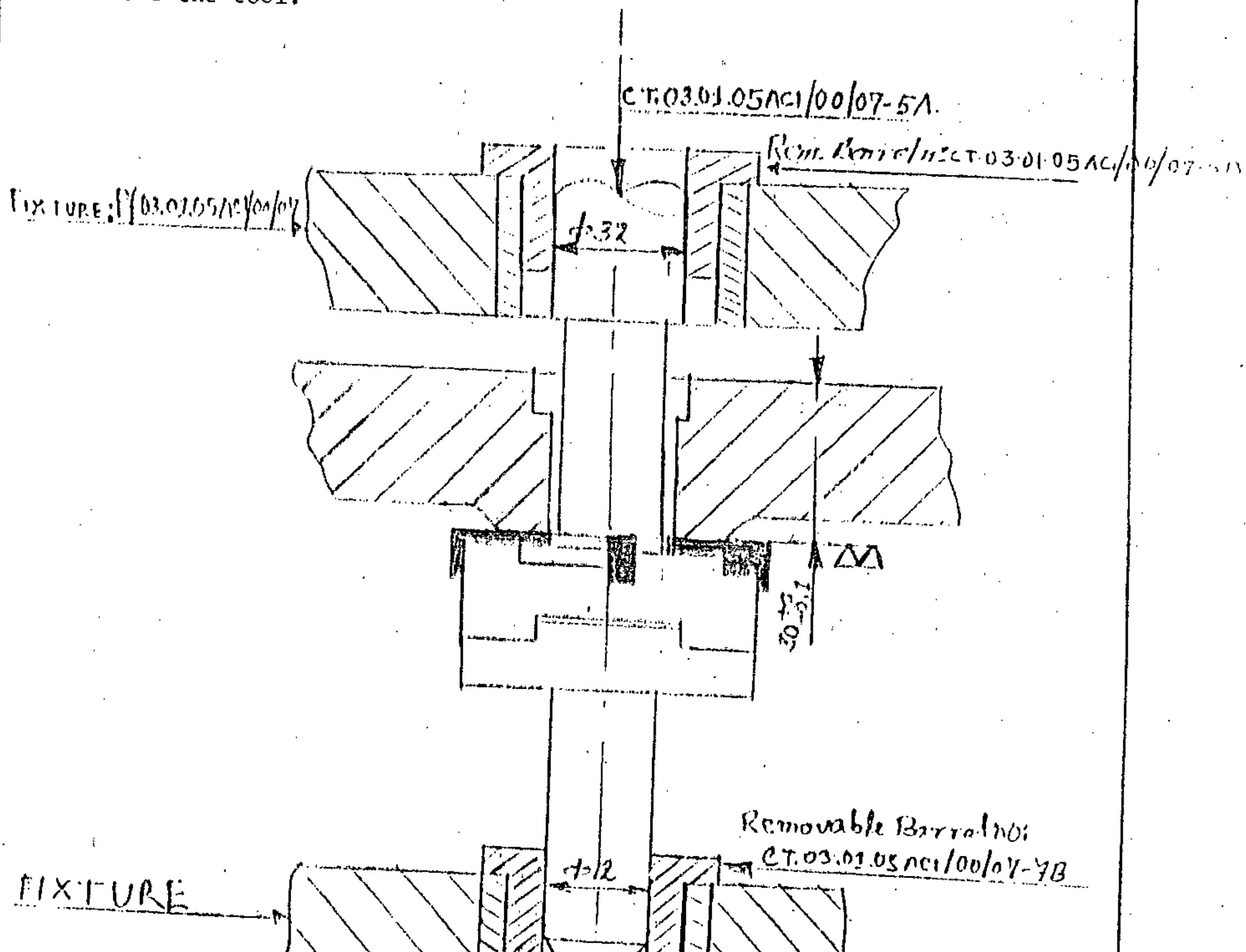
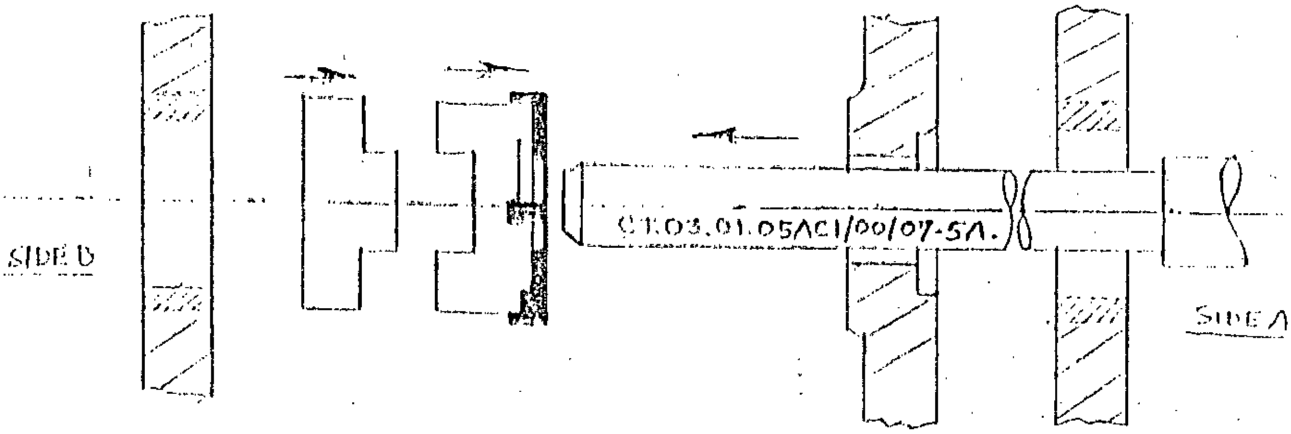


Fig. 5 : FACING OPERATION, 30 mm

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA

OPERATION INSTRUCTION SHEET					
PART NAME Feed screw gear box			OPERATION NO.		
TYPE OF M/C Horizontal boring			APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
5					

1. Introduce the boring shaft no. CT.03.01.05AC$_1$/00/07-5A in the fixture no. Pf.03.01.05AC$_1$/00/07 then introduce the facing tool and the lock on the boring shaft as per fig. below.



2. When the shaft is in the fixture, place in side A the removable barrel no. CT.03.01.05AC$_1$/00/07-5B and in side B the removable barrel no. CT.03.01.05AC$_1$/00/07-7B as per following figure.

Caution:

The barrel must be locked by using the head screw.

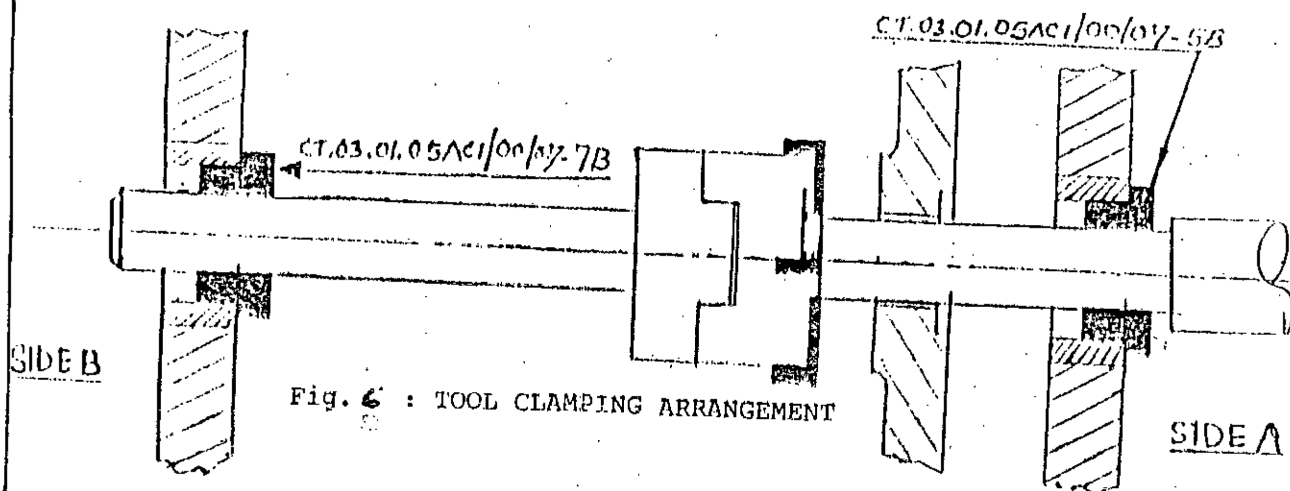


Fig. 6 : TOOL CLAMPING ARRANGEMENT

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME	Feed screw gear box		OPERATION NO.	7-6	
TYPE OF M/C	Horizontal boring		APPLICATION	Celtic-14 lathe	
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
6	Pf/00/07		CT/00/07-5A	72	0.2
			CT/00/07-5B		
			CT/00/07-7B		

Step-6

- Move to spindle no. II
- Surfacing to dimension $29.5^{+0.0}_{-0.5}$ with tool no. $CT.03.01.05AC_1/00/07-5A$ along with $CT.03.01.05AC_1/00/07-7B$
- Remove the tool

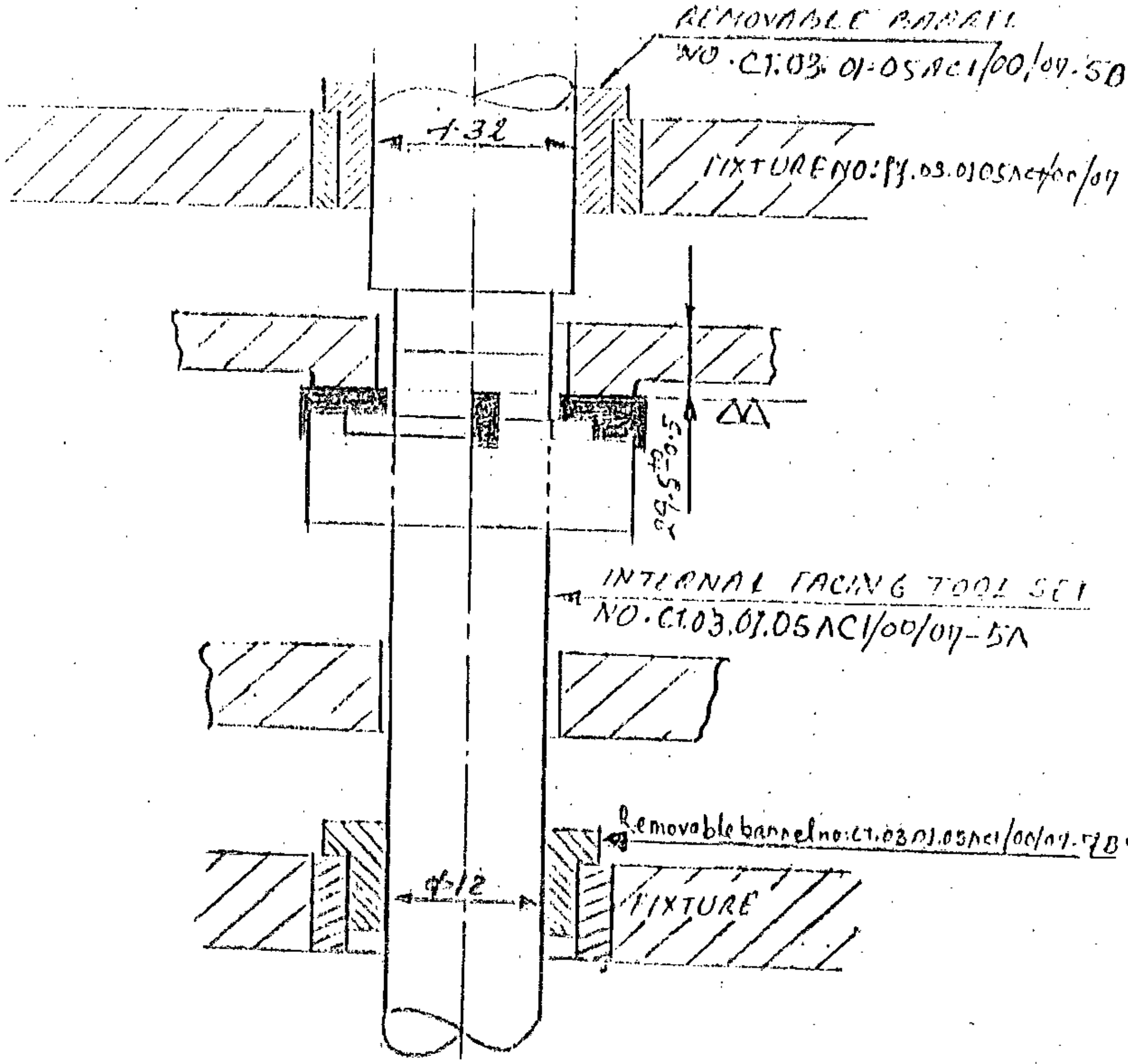


Fig.7 : FACING OPERATION, 29.5 mm

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME	Feed screw gear box		OPERATION NO.	7-7	
TYPE OF M/C	Horizontal boring		APPLICATION	Celtic-14 lathe	
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
7	Pf/00/07		CT/00/07-6	72	0.2
			CT/00/07-7B		

Step-7 :

- Counter boring ϕ 35 - 26.7 $\pm$ 0.1 depth with tool no. CT.03.01.05AC$_1$/00/07-6 and removable barrel no. CT.03.01.05AC$_1$/00/07-7B
- Remove the tool and move to spindle no.II.

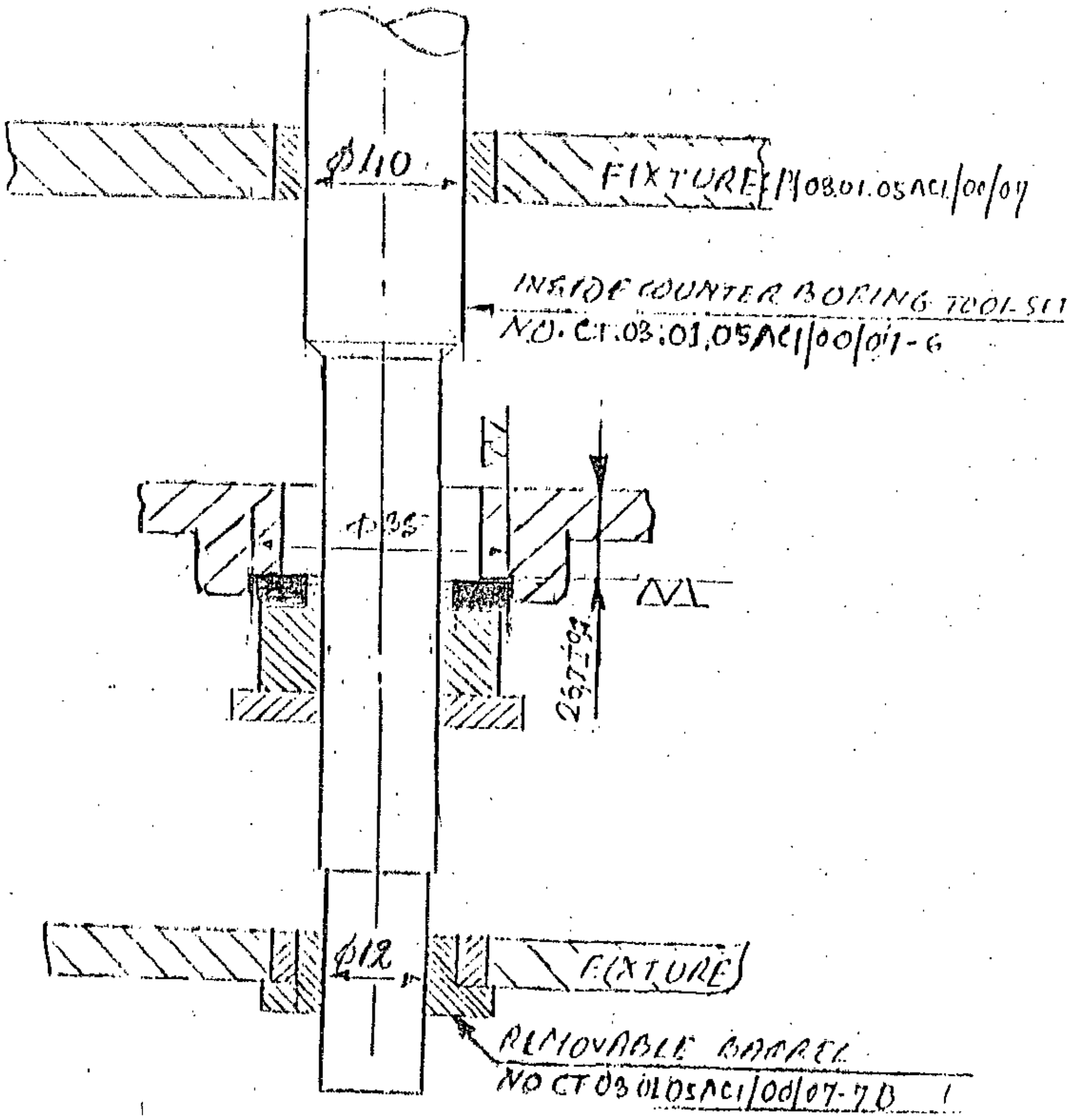


Fig. 8 : FACING AND COUNTERBORING OPERATION

DESIGN BY NAKIB AHMED	DRAWN BY A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME Feed screw gear box			OPERATION NO. 7-8		
TYPE OF M/C Horizontal boring			APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
8	PF/00/07		CT/00/07-10	160	0.2
			CT/00/07-7B		

Step-8 :

- Bore one ϕ 21.8 through and counter bore ϕ28H9 depth 7.5 with the help of tool no. CT.03.01.05AC$_1$/00/07-10 and removable barrel no. CT.03.01.05AC$_1$/00/07-7B
- Remove the tool.

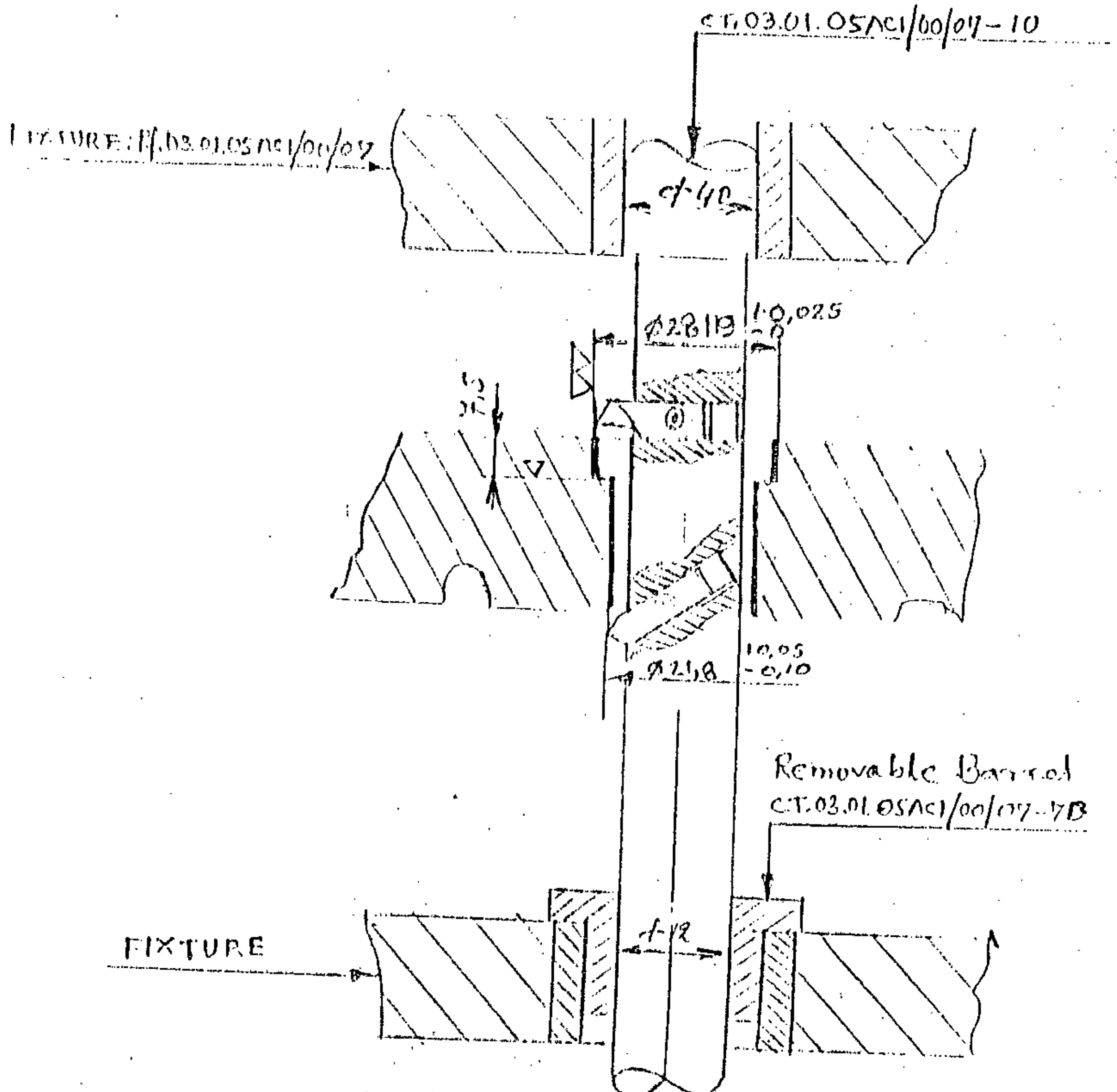


Fig. 9 : BORING OPERATION, ϕ 28

DESIGN BY NAKIB AHMED	DRAWN BY A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME Feed screw gear box			OPERATION NO. 7-9		
TYPE OF M/C Horizontal boring			APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
9	PF/00/07		CT/00/07-11	160	0·05
			CT/00/07-7B		

Step-9 :

- Bore one ϕ 22 H7 through, with tool no. CT.03.01.05AC$_1$/00/07-11 and removable barrel no. CT.03.01.05AC$_1$/00/07-7B.
- Remove the tool.

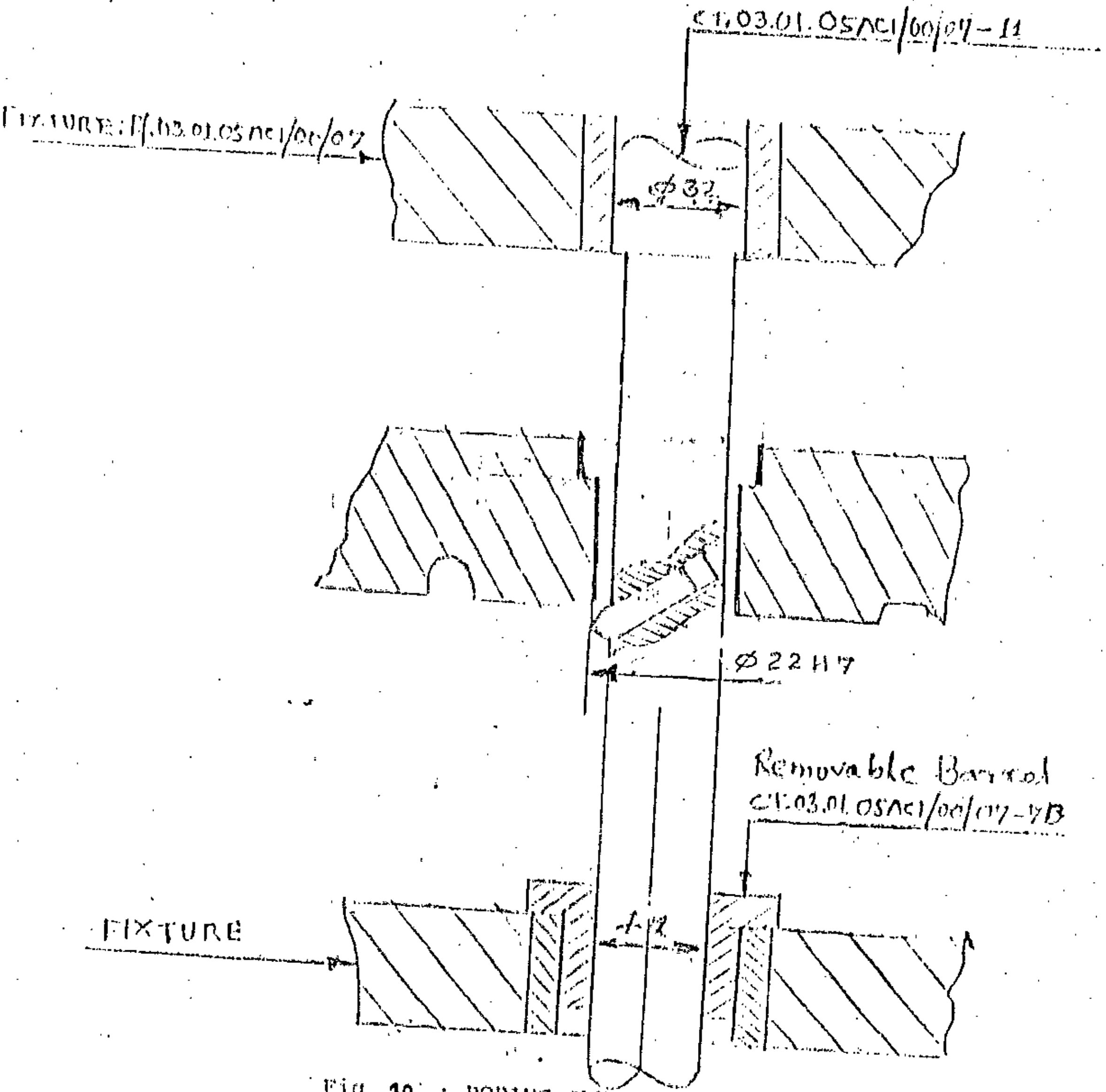


Fig. 10 : BORING OPERATION, ϕ 22

DESIGN BY NAKIB AHMED	DRAWN BY A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME Feed screw gear box			OPERATION NO. 7-10		
TYPE OF M/C Horizontal boring			APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
10	Pf/00/07		CT/00/07-7A	160	0.2
			CT/00/07-7B		

Step-10:

- Boring in spindle I, II & III 3 dia ø 27.8, 26.8, 21.8 in line using tool no. $CT.03.01.05AC_1/00/07-7A$ and removable barrel no. $CT.03.01.05AC_1/00/07-7B$
- Remove the tool.

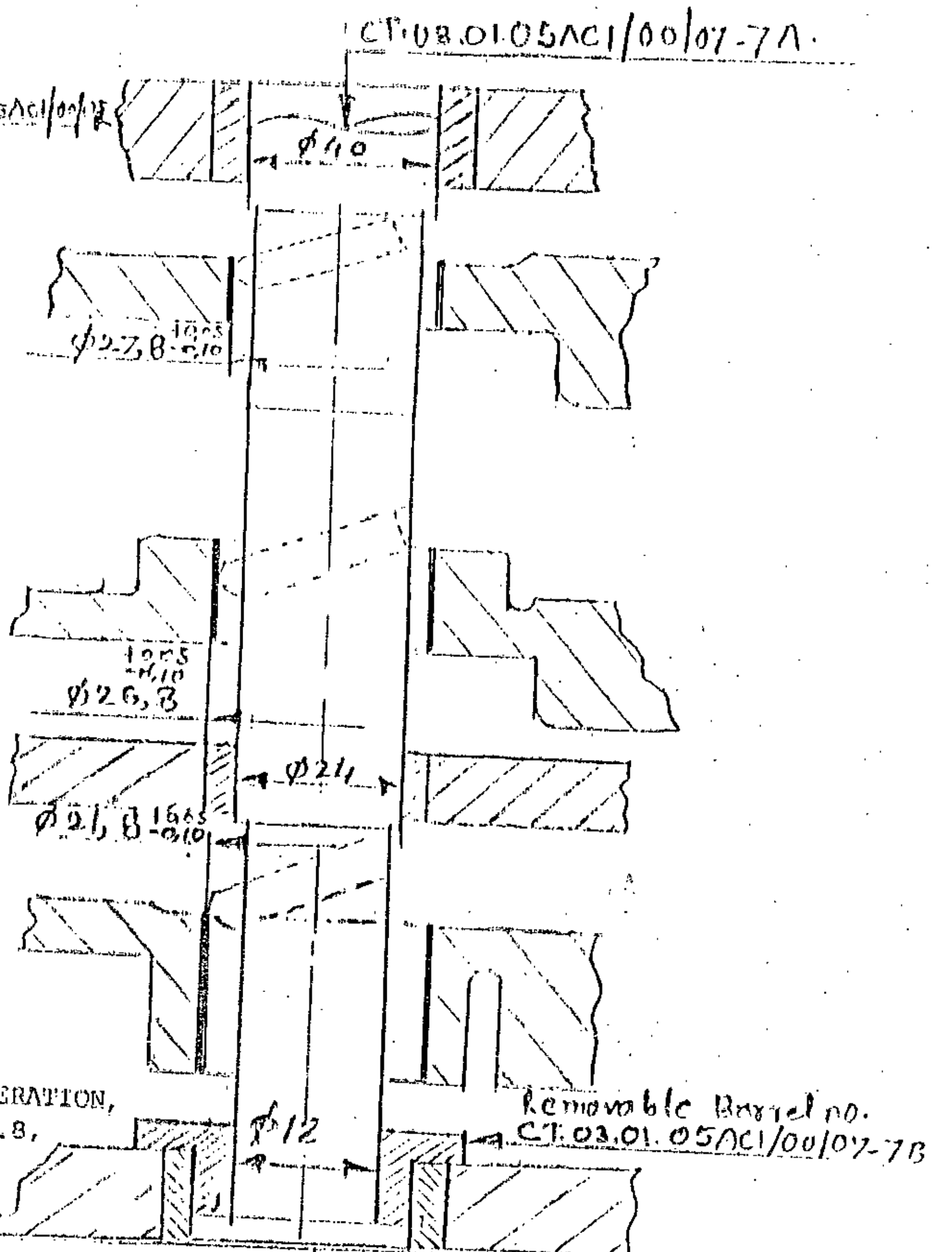


Fig. 11 : BORING OPERATION, ø27.8, ø26.8, ø28.8

DESIGN BY HAKIB AHMED | DRAWN BY A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME Feed screw gear box			OPERATION NO. 7-11		
TYPE OF M/C Horizontal boring			APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
11	FT/00/07		CT/00/07-8A	160	0.05
			CT/00/07-8B		

Step-11:

- Boring in spindle I, II & III dia ø 27 H7 & ø 22 H7 in line using tool no. CT.03.01.05AC$_1$/00/07-8A and removable barrel no. CT.03.01.05AC$_1$/00/07-8B
- Remove the tool.

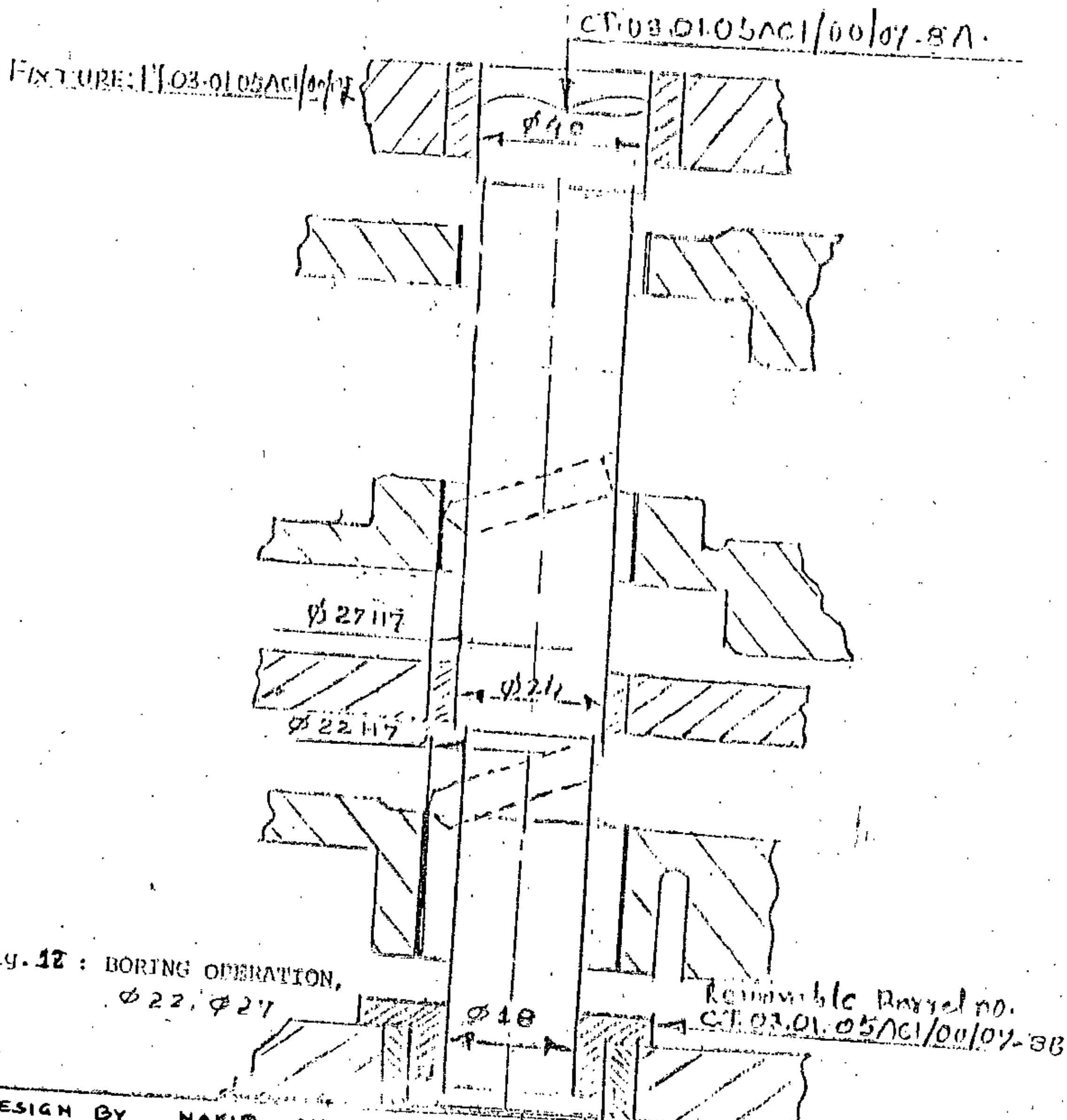


Fig. 12 : BORING OPERATION, ø22, ø27

DESIGN BY NAKIB AHMED

DRAWN BY A. SHARMA

OPERATION INSTRUCTION SHEET

PART NAME Feed screw gear box			OPERATION NO. 7-12		
TYPE OF M/C Horizontal boring			APPLICATION Celtic-14 lathe		
STEP	FIXTURE NO.	GAUGE NO.	TOOL NO.	SPEED RPM	FEED mm/REV.
12	PF/00/07		CT/00/07-9	160	0·05
			CT/00/07-7B		

Step-12:

- Boring in spindle I, II, III One dia Ø 28 H7 in line using tool no. CT.03.01.05AC$_1$/00/07-9 and removable barrel no. CT.03.01.05AC$_1$/00/07-7B
- Remove the tool.

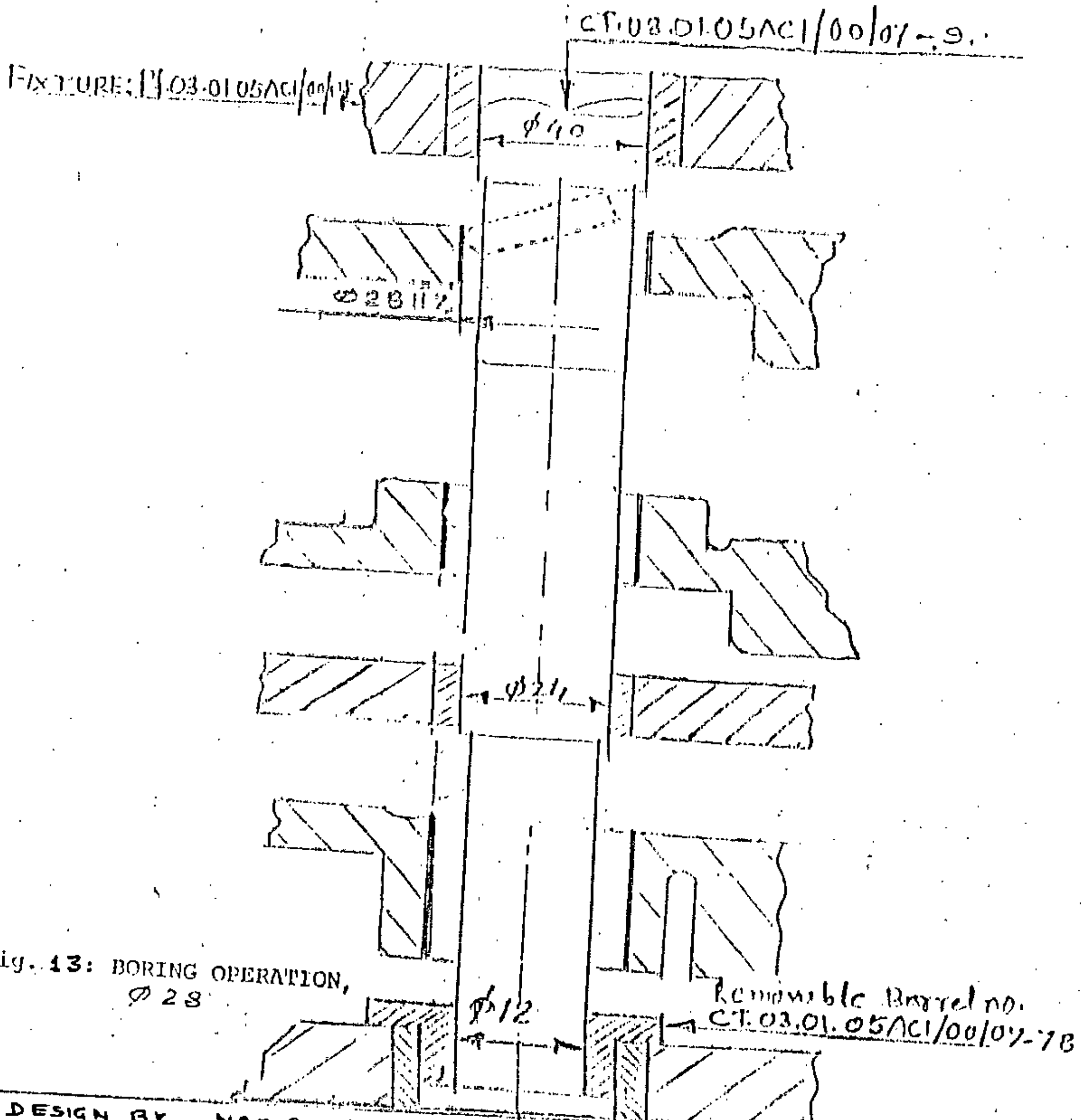


Fig. 13: BORING OPERATION, Ø28

DESIGN BY NAKIB AHMED	DRAWN BY A. SHARMA

3.31 OPERATION INSTRUCTION SHEET

Part Name	:	Feed screw Gear box
Application	:	Celtic-14 lathe
Type of machine	:	Horizontal boring machine
Operation No.	:	7

	Description of the steps	Tools & gauges	RPM	Feed mm/rev.
1	Drilling three holes of diameter 20 mm for spindle I, II & III (From left side of the fixture) Fig.4	Standard HSS drill of dia 20 mm, Gauge: Vernier	224	0.2
2	Drilling three holes of diameter 26 mm for spindle I, II & III (From right side of the fixture) Fig.5	Standard HSS drill of dia 26 mm Gauge: Vernier	160	0.2
3	Drilling three holes of diameter 25 mm for spindle I, II, III & IV (from middle of the fixture) Fig.6	Standard HSS drill of dia 25 mm Gauge : Vernier	160	0.2
4	Drilling hole of dia 20 mm & counterbore of dia 26 mm with 7.5 mm depth for spindle IV (from right side of the fixture) Fig.7	Compisite HSS drill of 20 & 26 mm dia Gauge: Vernier	160	0.2
5	Facing for spindle IV with dimension of $30^{+0.0}_{-0.1}$ mm depth (from right side of the fixture). Fig.8	End mill cutter Gauge : Vernier	72	0.2
6	Facing for spindle II with dimension of $29.5^{+0.0}_{-0.5}$ (from right side of the fixture) Fig.10	End & Face mill Cutter Gauge: Vernier	72	0.2

	Description of the steps	Tools & gauges	RPM	Feed mm/rev.
7	Counter boring of dia 35 mm with dimension of 26.7 ± 0.1 depth (from right side of the fixture). Fig.11	End & Face mill cutter	72	0.2
8	Boring of 21.8 mm through and counter boring of 28H9 with 7.5 mm depth for spindle IV (from right side of the fixture) Fig.12	Boring Tools Gauge: Inside micrometer (25 - 30 mm)	160	0.2
9	Final Boring 22H7 for spindle IV (from right side of the fixture) Fig.13	Boring Tools Gauge: Go, No go	160	0.05
10	Boring of 27.8, 26,8, 21.8 mm through for spindle I, II, III respective (from right side of the fixture) Fig.10	Boring tool for 27.8, 26.8, 21.8 mm Gauge: Inside micrometer (20-25 & 25-30 mm)	160	0.2
11	Fianl Boring of 27H7, 22H7 for spindle I, II & III (from right side of the fixture) Fig.15	Boring Tool Gauge: Go, No go	160	0.05
12	Final Boring for spindle I, II, III (from right side of the fixture) Fig.16	Boring tool Gauge: Go, No go	160	0.05

3.33 MAIN FEATURES OF THE PROPOSED METHOD

The defects identified in the existing instruction sheets have been corrected in the proposed method. The main features of the proposed method are described below.

In the proposed Instruction sheets along with the necessary informations like cutting tools, gauges, cutting speed, feed etc. are specifically mentioned. Cutting tools such as drill bit, boring tools, counter boring tools, reamer etc. used are shown (from Fig.1 to Fig.13) with specifications. The relative position of the tools, jig-fixtures are also mentioned in the sheet. For reaming and counter boring operation, no special machine is required. With the help of a multi edged cutting tool it is usually done on the same machine that is employed for boring operations. That means all the drilling, boring, counter boring, reaming operations are performed by a horizontal boring machine.

Counter boring operation may be done by the use of a tool with pilot or without pilot.

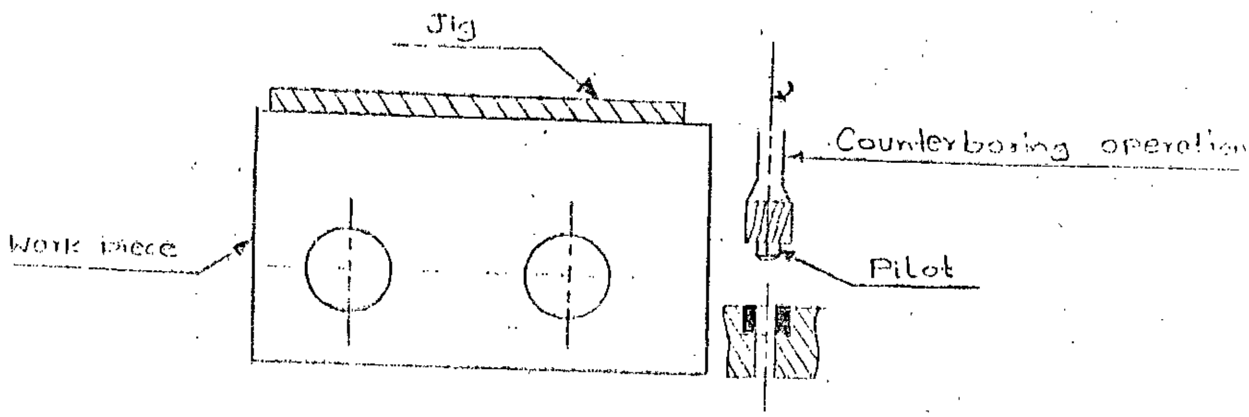


Fig. 14

Tool without pilot has been recommended for counterboring operation. In these cases the Jig would guide the tools. The drilling is to be performed by the drill with the help of a removable barrel fixed in the jig (Fig. 15). The inside diameter of the removable barrel is same as the diameter of drill and the outside diameter of the removable barrel is same as the diameter of the counterboring tool as shown below:

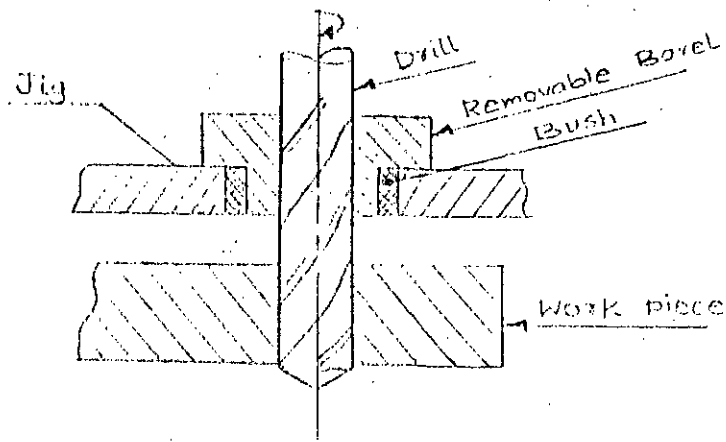


Fig. 15

In the following step the drill is to be passed through the workpiece. After making the hole, the barrel is removed from the jig and the counterboring tool is used as shown below.:

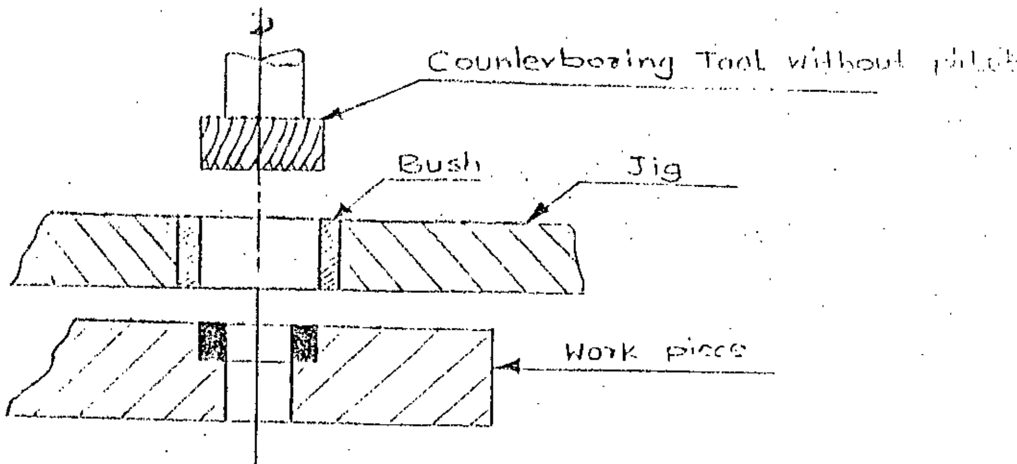


Fig. 16

The black portion of the workpiece shown in the above fig.36 is the zone of counterboring. In this case, no pilot is necessary since the bush of the jig guides the tools. However, for doing this, considerable amount of time would then be saved and also quality would improve. In order to get the quality product the critical dimension must be controlled by different precision measuring instruments such as micrometer, gauges, verniers etc. In the existing instruction sheet there is no information regarding any such instruments. In the proposed instruction sheet the name of the instruments to be used for measuring the critical dimensions have been mentioned with their proper specification.

Care must be taken so that the surface of the feed gear box casing is perpendicular to the spindle axis, otherwise accurate drilling operation will not be performed. Considering all these factors in the proposed method, a boring fixture has been designed to hold the feed gear box casing properly for drilling and boring the holes from left and right hand end surface . In this process the holes can be drilled quickly as well as accurately. Clamping time and setting time can be reduced to a great extent by using the boring fixture.

3.5 DESIGN OF A BORING FIXTURE

Boring fixture may have the characteristics of a drill jig or a milling fixture, depending upon the type of boring operation. Boring is usually accomplished with a single point tool and the size of the hole depends upon the adjustment of the tool within the boring bar.

In the case of incorrect hole location and out of roundness of boring tool it removes more material from one side of the hole than from other and does not follow the axis of the original hole. So care must be taken to avoid inaccuracies arising out of these factors.

Boring fixtures are divided into two general classes. In one, the fixture guides the boring bar, as in drill jigs, in the other, the fixture holes the work in the proper relation to the bar, as in mill fixtures. The particular class of boring fixture to be used depends upon the type of boring bar, the type of boring machine, or both. Boring bars are generally classed as a stub bar, a single-piloted bar, and the double or multiple-piloted bar. The boring fixtures are generally used for small-lot production or relatively large workpieces.

The proposed Boring Fixture and the existing Boring Fixture of Feed Gearbox were enclosed in a envelope attached with the inside back cover of the thesis. All the necessary part drawing of the Fixture have been shown in Fig. 17 to Fig. 37. Few part drawing were taken from the Existing Fixture with modification of appropriate dimensions.

PART LIST FOR BORING FIXTURE OF FEED SCREW GEARBOX OF CELTIC-14 LATHE

Part No.	Part Name	Qnty. req.	Material
1	Clamping screw	2	BMS-5
2	Support bar	1	BMS-3
3	Bush	1	BMS-3
4	Screw	1	BMS-5
5	Stoper pin	1	BMS-6
6	Socket head screw	15	BMS-5
7	Boring column	1	BMS-3
8	Base plate	1	BMS-3
9	Support piece	4	BMS-3
10	Extension piece	2	BMS-3
11	Locating pin	2	BMS-5
12	Rear guide holding	1	BMS-5
13	Locating pin	2	BMS-5
14	Work rest	2	BMS-6
15	Dowel pin	6	BMS-4
16	Boring column	1	BMS-3
17	Fixed bush	3	BMS-7
18	Fixed bush	1	BMS-7
19	Clamp pin	2	BMS-5
20	Stud	2	BMS-5
21	Work rest	2	BMS-6
22	Clamp	2	BMS-5
23	Conical seat	2	BMS-5
24	Spherical washer	2	BMS-5

PART LIST FOR BORING FIXTURE OF FEED SCREW GEARBOX OF CELTIC-14 LATHE (Contd.)

Part No.	Part Name	Qnty. req.	Material
25	Tilting head	1	BMS-5
26	Push screw	1	BMS-5
27	Support	1	BMS-3
28	Hexagonal nut	2	BMS-5
29	Plate	1	BMS-3
30	Fixed bush	4	BMS-7
31	Support	2	BMS-3
32	Removable barrel	1	BMS-7
33	Fixed bush	3	BMS-7
34	Bush holder	1	BMS-3
35	Support	1	BMS-3
36	Rear guide	1	BMS-5
37	Bolt	1	BMS-5
38	Boring column	1	BMS-4

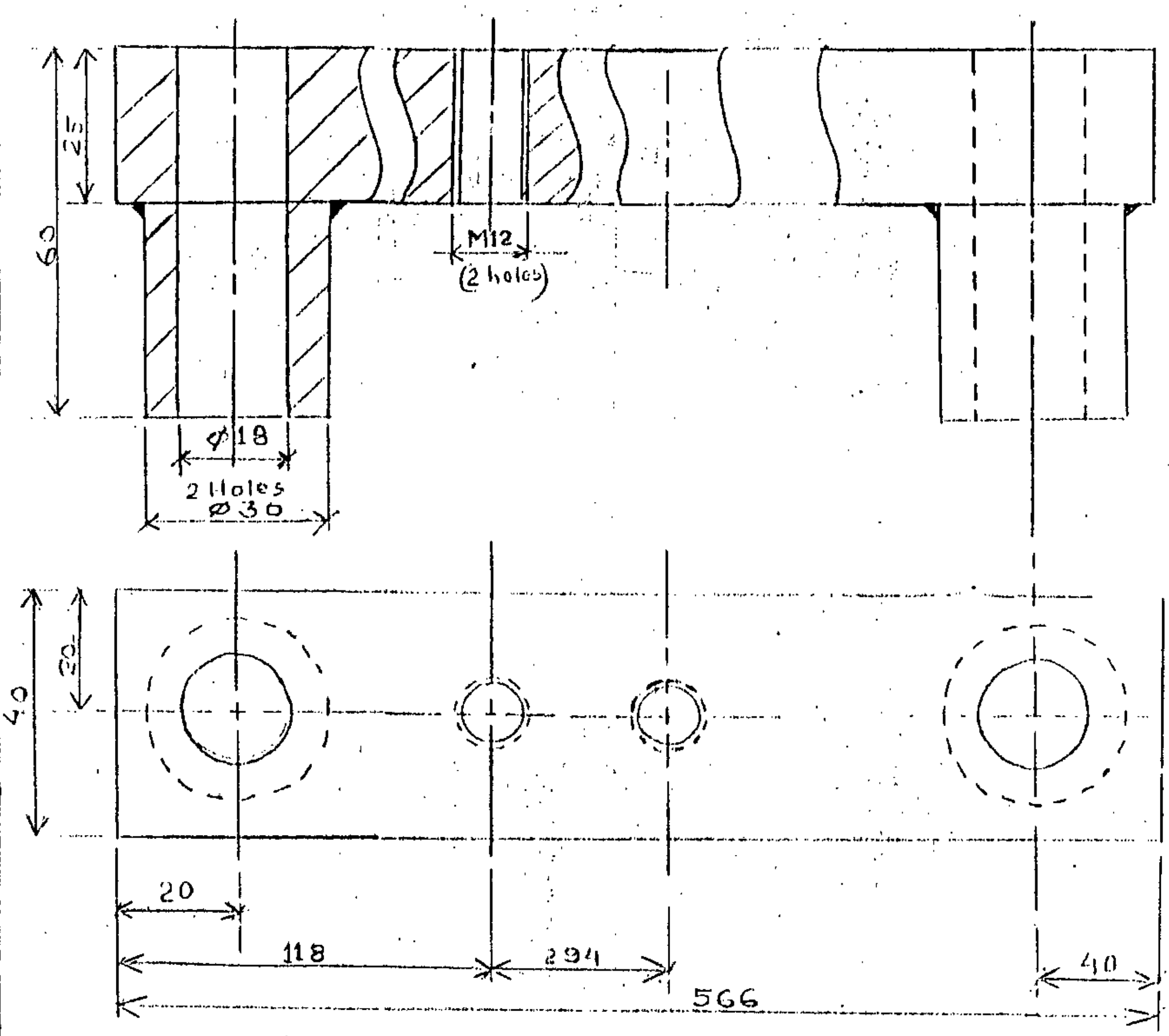


Fig. 17 : SUPPORT BAR (Part No.2) & BUSH (Part No.3)

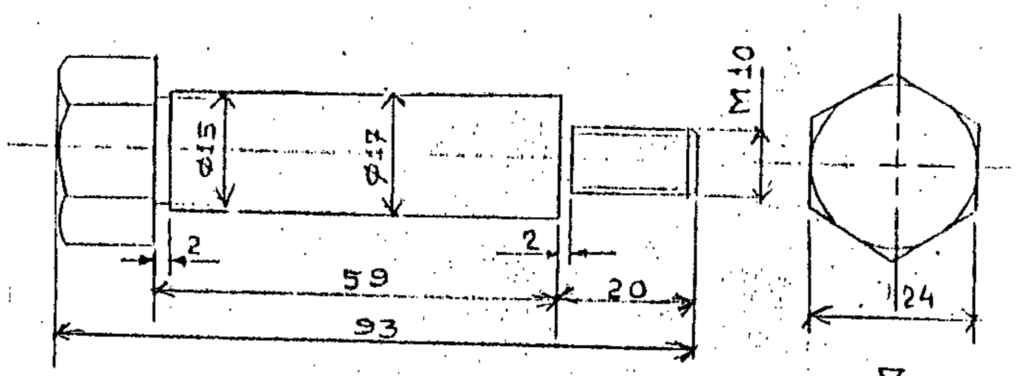


Fig.18 : SCREW (Part No.4)

DESIGN BY : NAKIB. AHMED	DRAWN BY : A. SHARMA

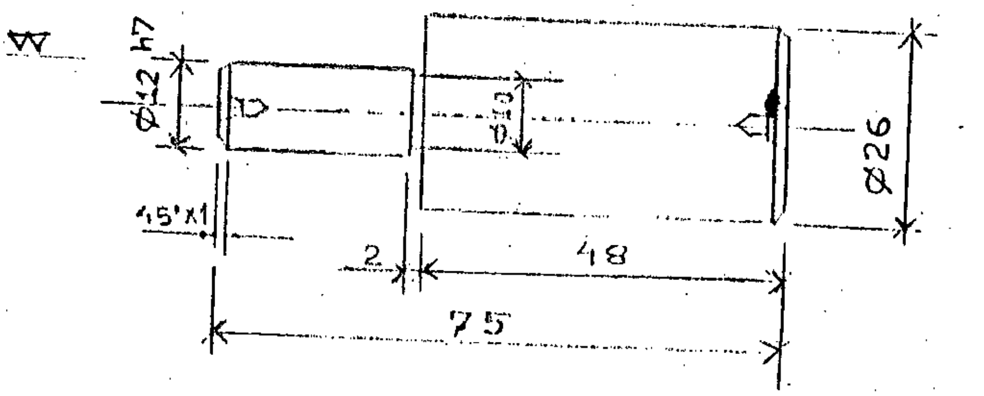


Fig.19 : STOPPER PIN (Part No.5)

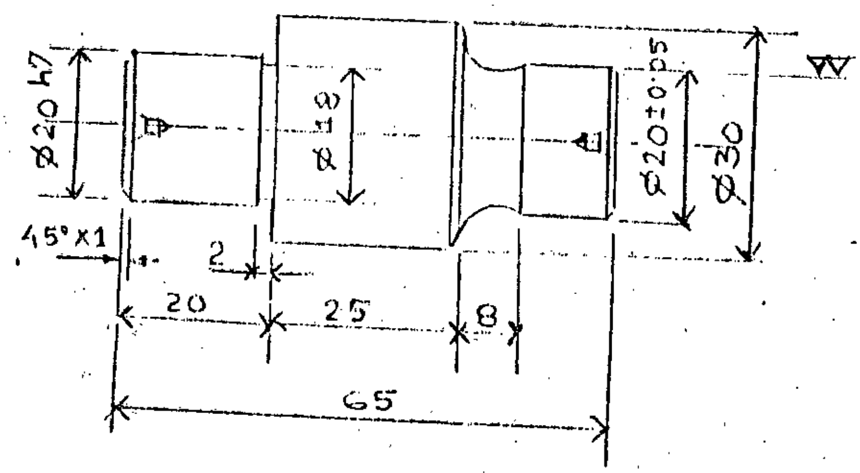


Fig.20 : LOCATING PIN (Part No.11)

DESIGN BY : NAKIB AHMED

DRAWN BY : A. SHARMA

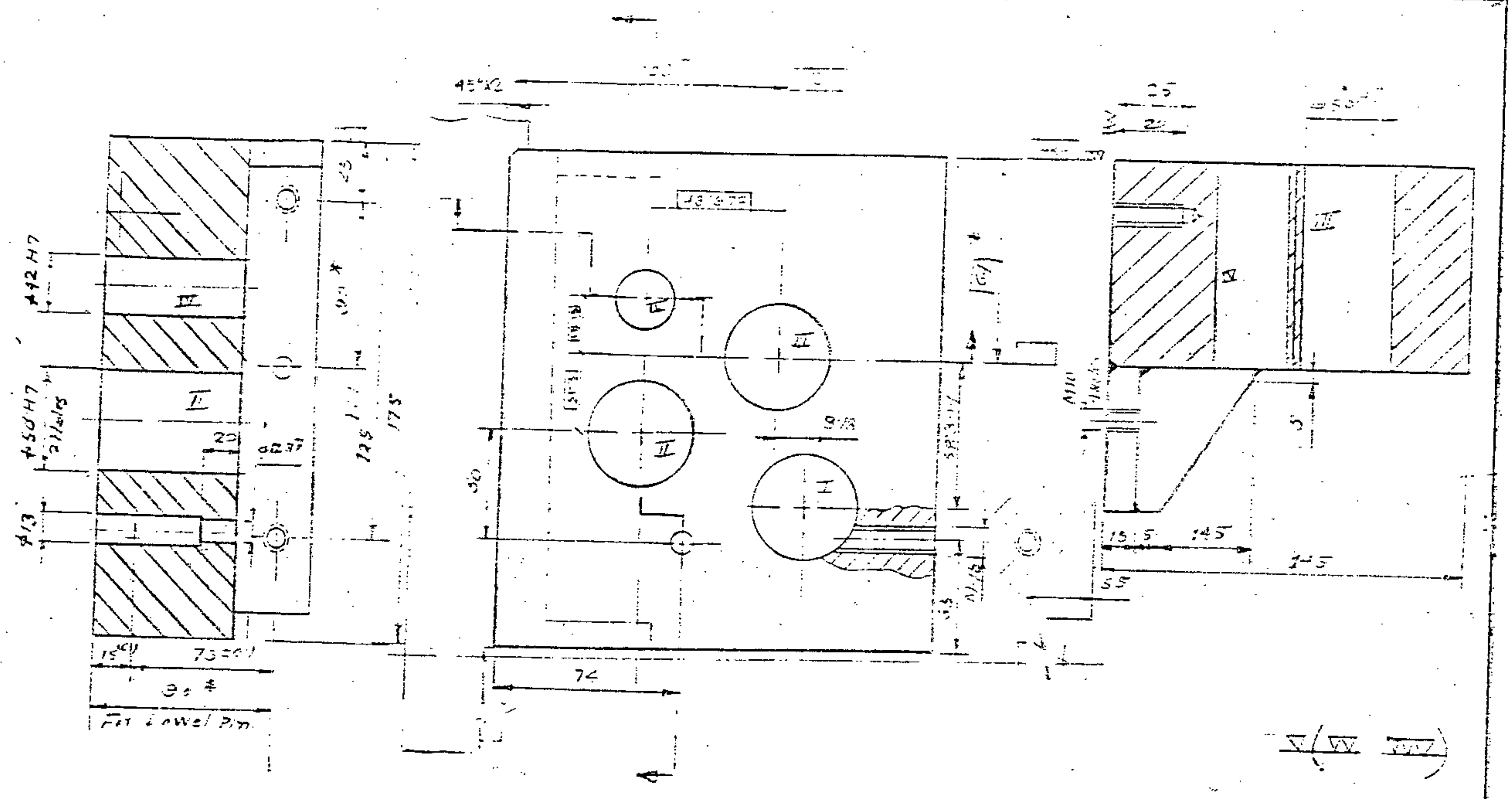


Fig. 21 : BORING COLUMN (Part No.7),
SUPPORT PIECE (Part No.9), EXTENSION PIECE (Part No.10)

DESIGN BY	NAKIB AHMED
DRAWN BY	L. ZAMAN

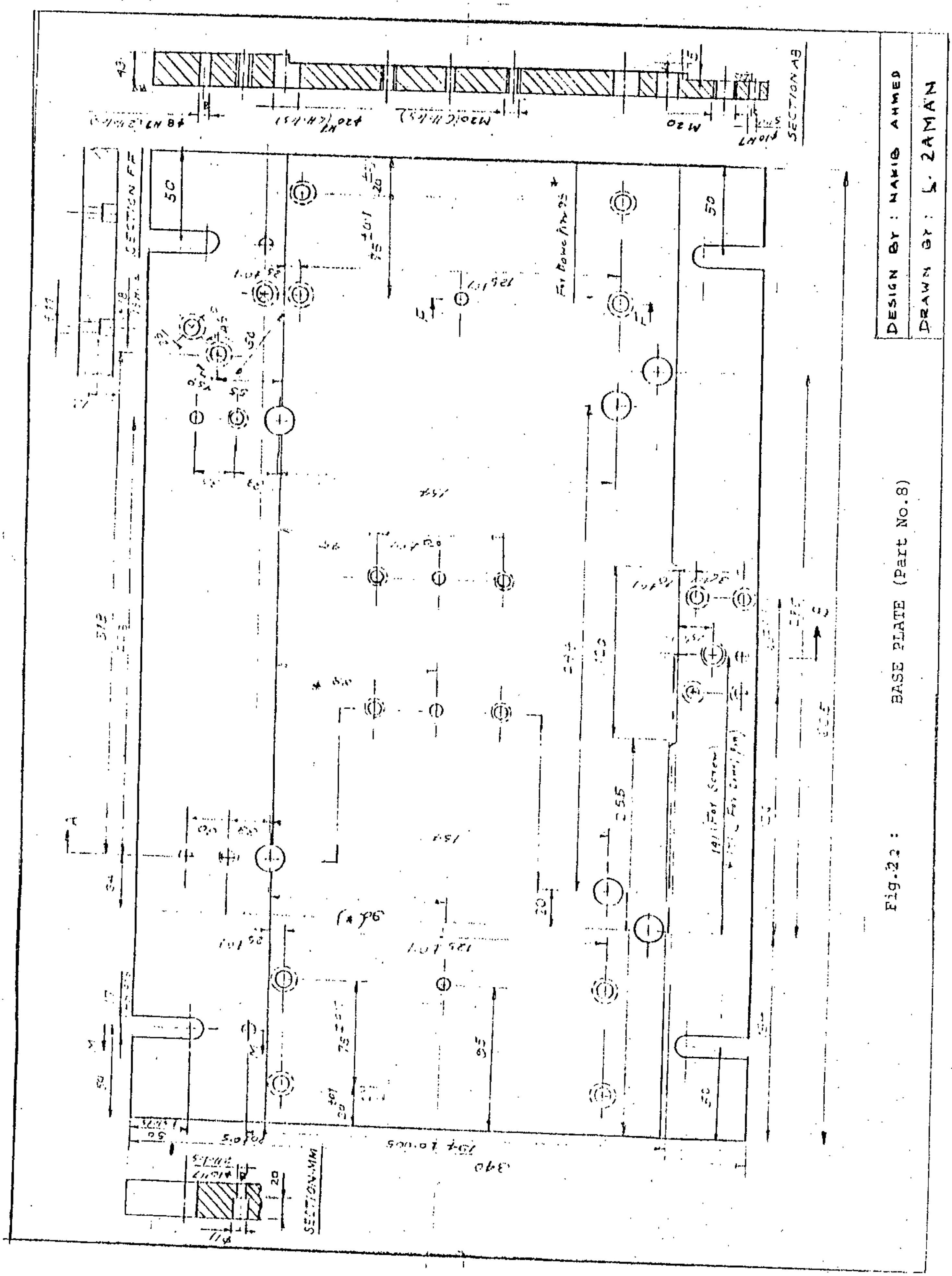


Fig.22 : BASE PLATE (Part No.8)

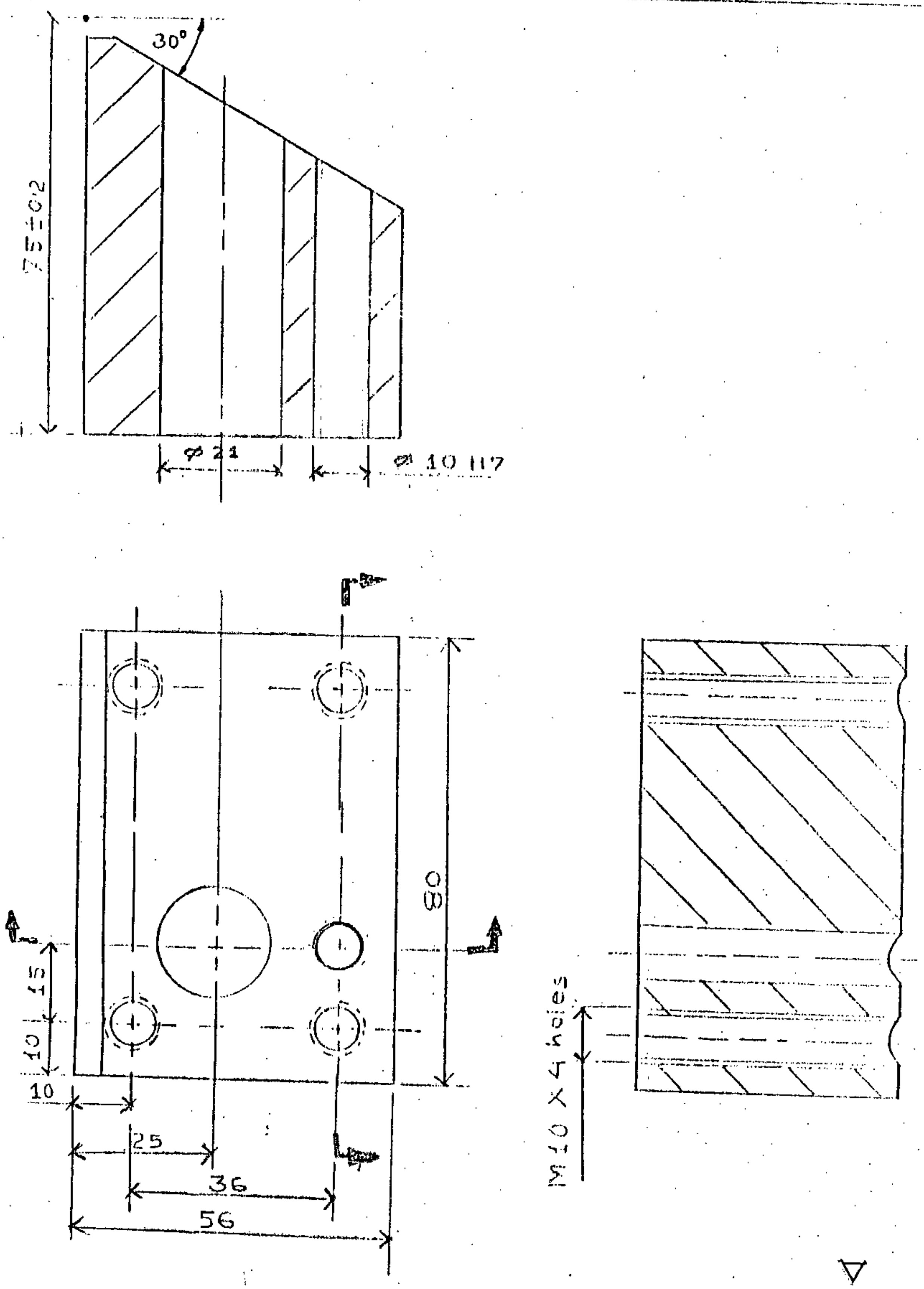


Fig.23 : REAR GUDIE HOLDING (Part No.12)

DESIGN BY NAKIB AHMED	DRAWN BY A SHARMA

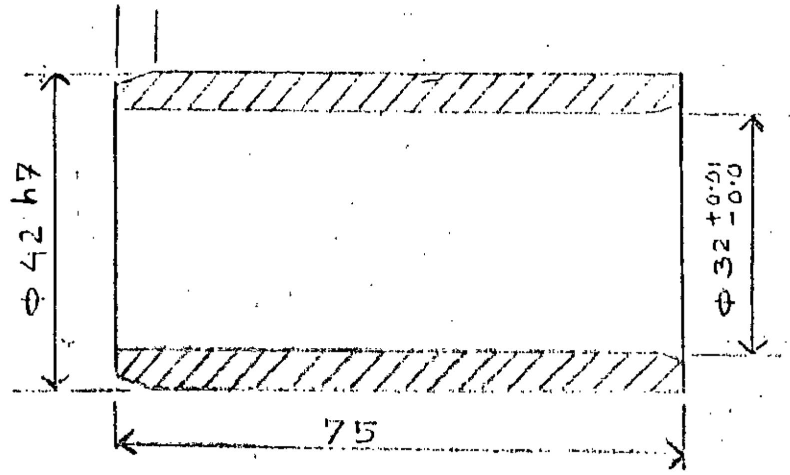


Fig. 24 : FIXED BUSH (Part No.18) ▽▽

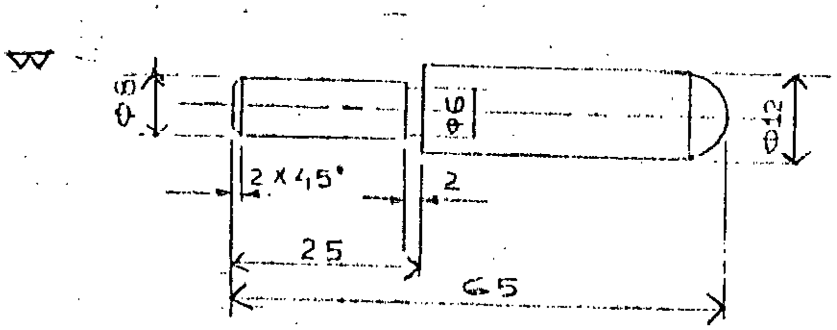


Fig.25 : CLAMP PIN (Part No.19) ▽(▽▽)

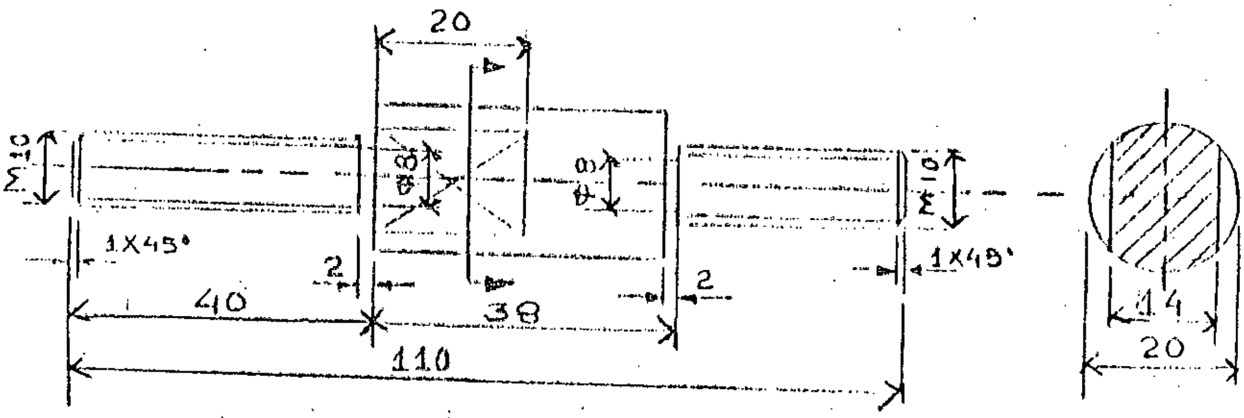
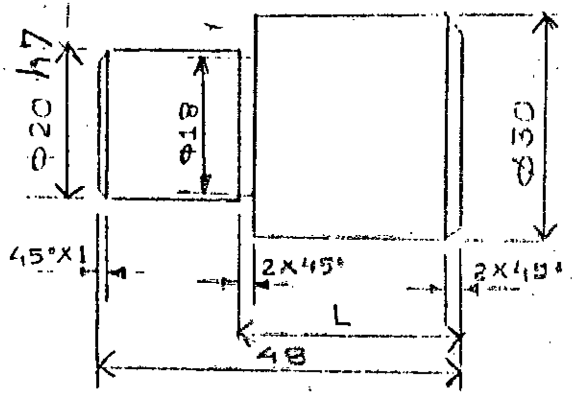


Fig. 26 : STUD (Part 20) ▽

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA



ITEM	L
(14)	$28.035^{+0.005}_{-0}$
(21)	23.0

Fig. 27 : WORK REST (Part No. 14 & 21)

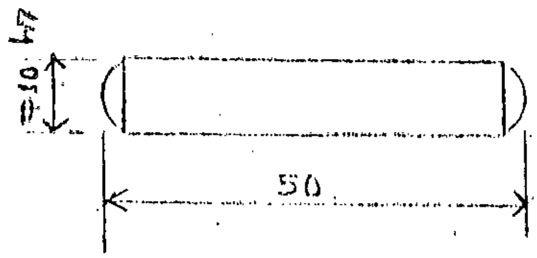


Fig. 28: DOWEL PIN (Part No.15)

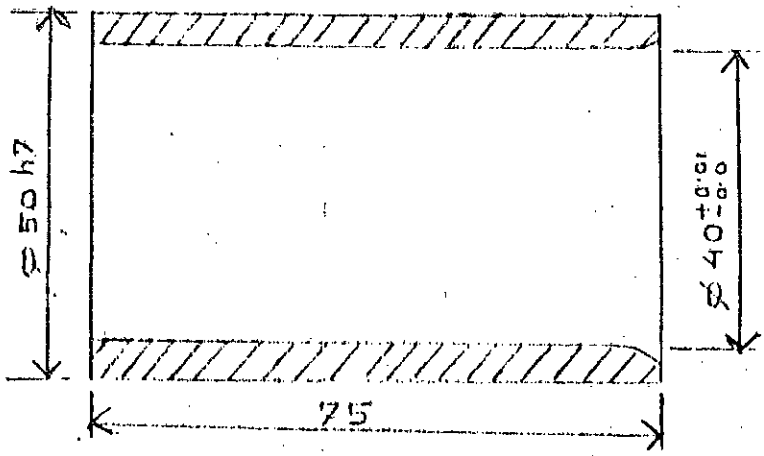


Fig. 29 : FIXED BUSH (Part No. 17)

DESIGN BY : NAKIQ AHMED | DRAWN BY : A. SHARMA

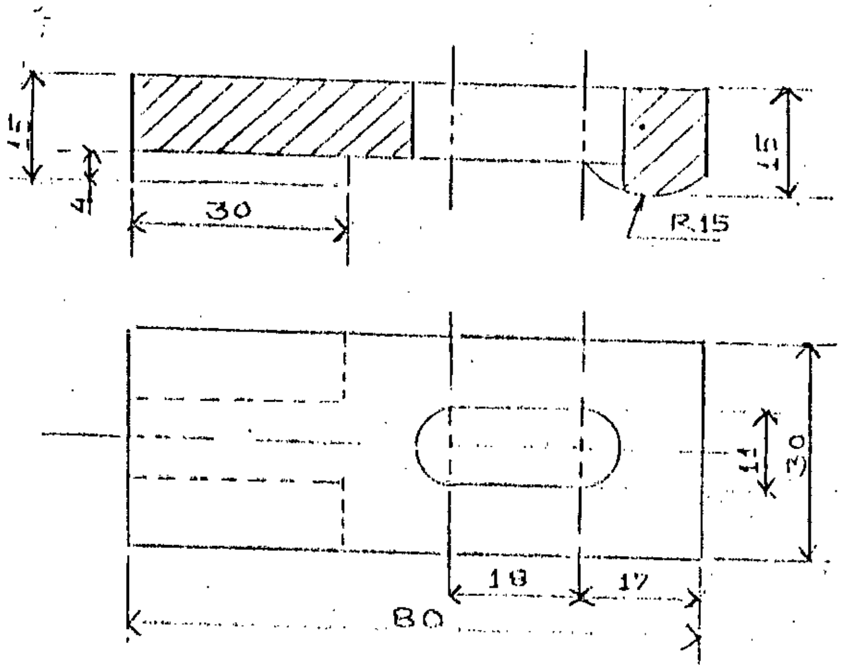


Fig. 30 : CLAMP (Part No.22)

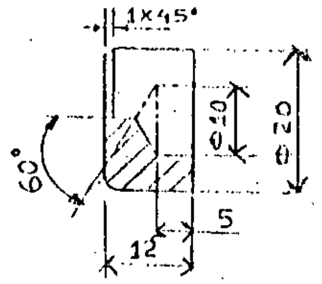


Fig. 31 : TILTING HEAD (Part No.25)

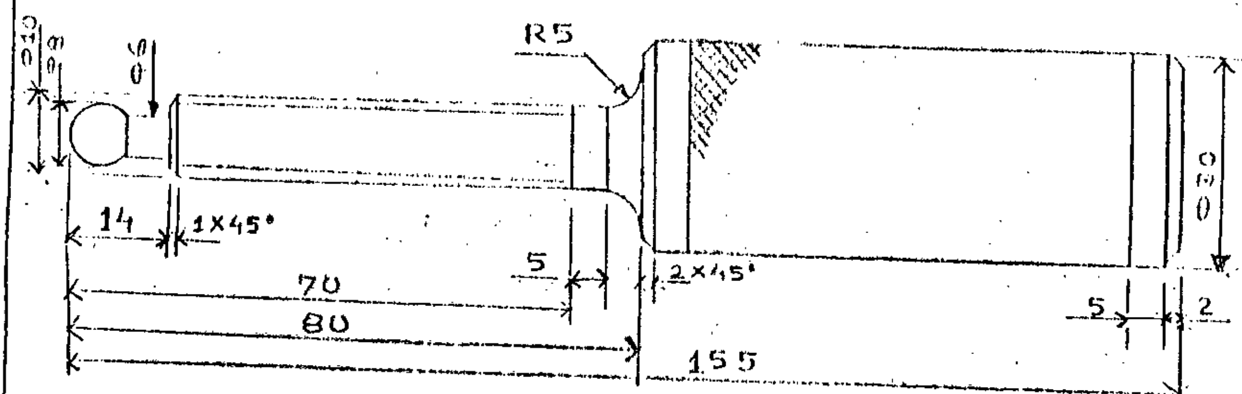


Fig. 32 : PUSH SCREW (Part No.26)

DESIGN BY : NAKIB AHMED	DRAWN BY : A. SHARMA

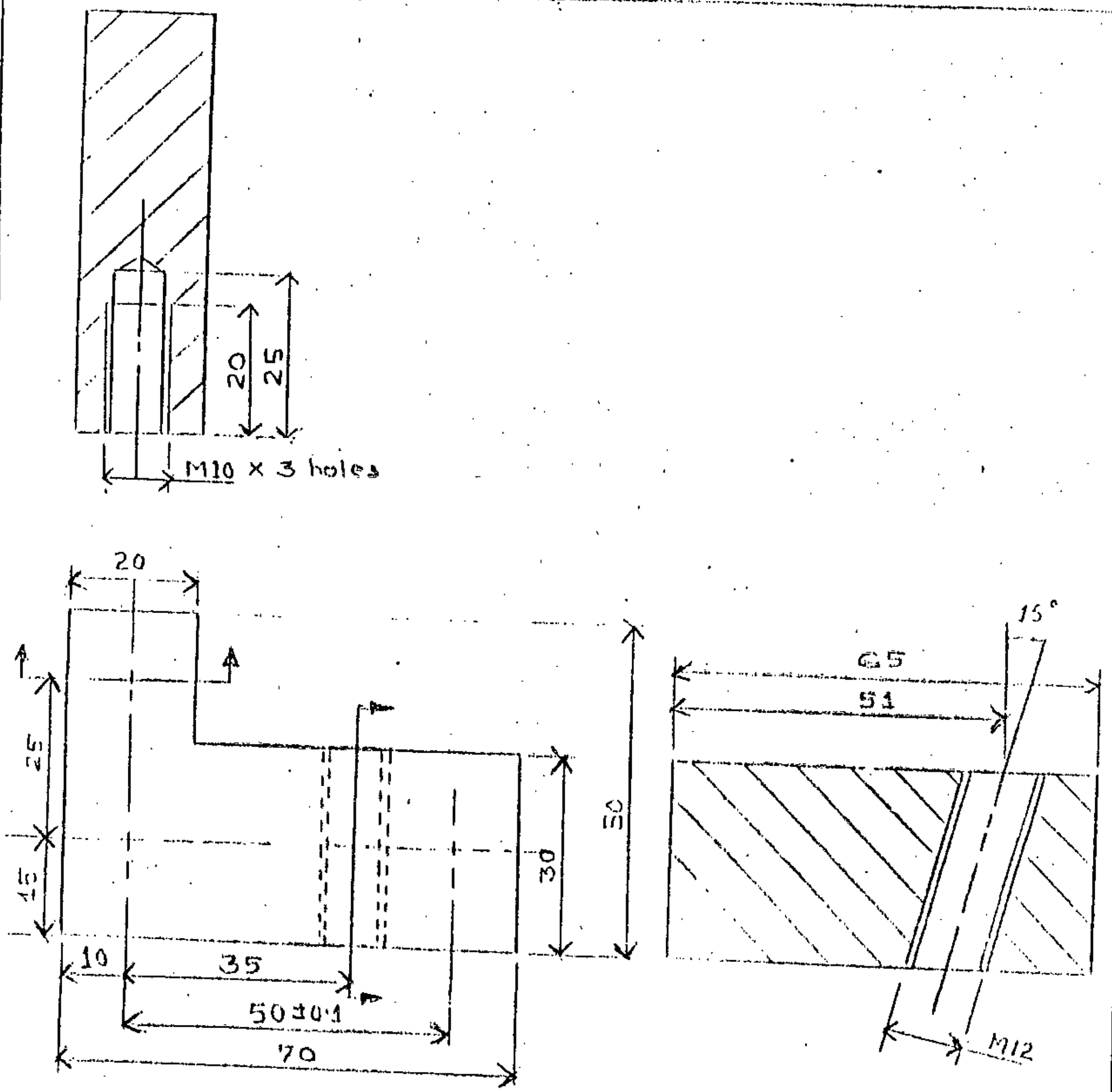


Fig. 33: SUPPORT (Part No. 27)

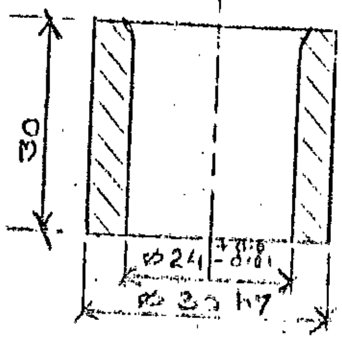


Fig. 34: FIXED BUSH
(Part No.30)

DESIGN BY : NAKIB AHMED | DRAWN BY : A. SHARMA

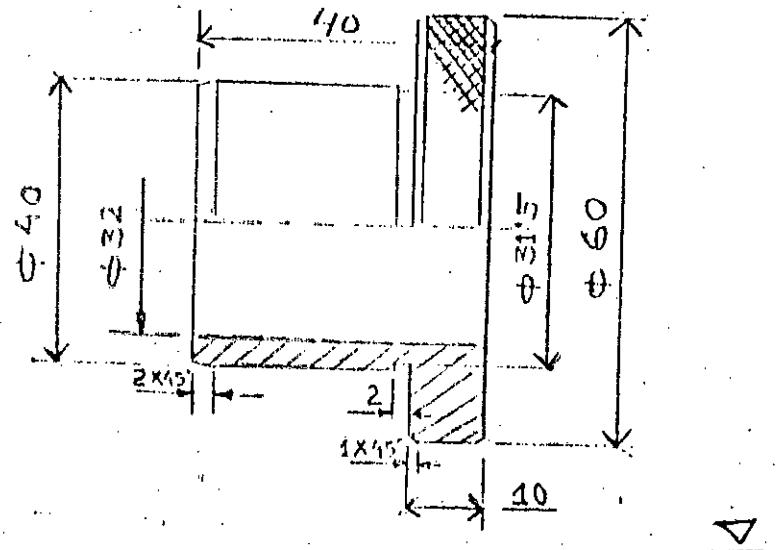


Fig.35: REMOVABLE BARREL (Part No.32)

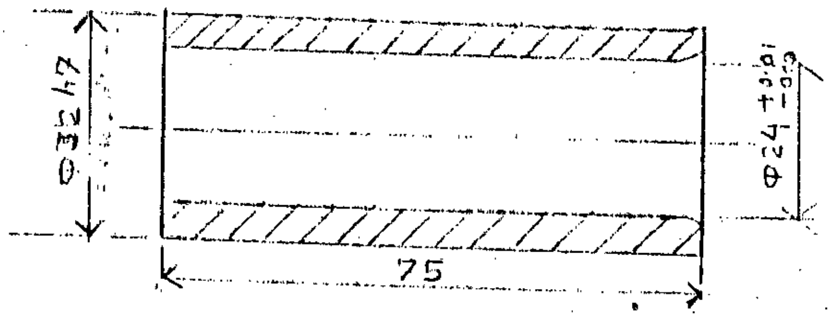


Fig.36: FIXED BUSH (Part 33)

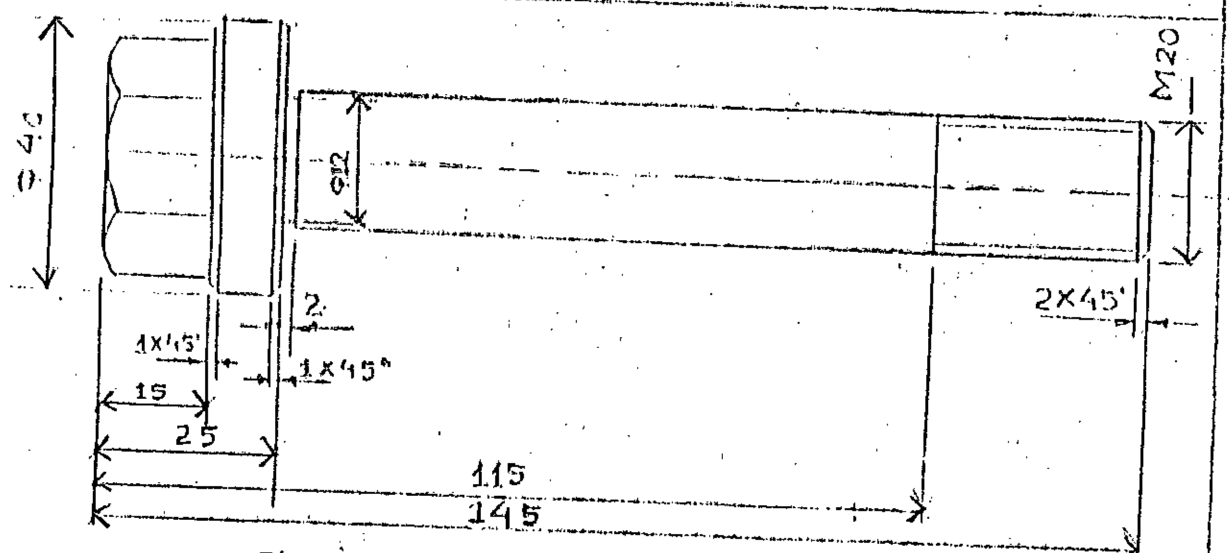


Fig.37: HEXAGONAL BOLT (Part No.37)

DESIGN BY: NAKIB AHMED | DRAWN BY : A SHARMA

3.41 MAIN FEATURE OF THE PROPOSED FIXTURE

1. Position of the locating-pins are ensures the static stability of the part.

2. The surfaces of the locating pins are machined after assembling the pins so that uniform reference plane can be obtained.

3. The locating surface area are kept as small as possible to avoid burr from previous machining.

4. The locating pins can easily be replaced if necessary.

5. The number of clamping elements are less than the locating points.

6. The clamps are in a position to operate on a wide range with sufficient strength and stability.

7. The clamping mechanism become very simple.

8. The weight of the fixture is such that it can be turned easily by 180°.

9. There is a provision to use a number of removable barrels of different diameters if necessary.

10. An intermediate support zone is introduced at the mid section of the fixture to prevent distorsion of the long boring bar.

11. All the boring operations will be done on a single machine and by single clamping.

3.42 ADVANTAGES OF THE PROPOSED FIXTURE

The advantages for using the said fixture can be summerized as follows:

1. The part can be located quickly and held rigidly.

2. The fixture can reduce working time in various phases of operation in the set up and clamping of the part.

3. The boring operation can be done more accurately as as well as quickly.

4. Setting time can be reduced to a great extent.

5. Skilled operator will not be required.

6. JOb rejection will be minimized - since the various types of manufacturing defects will be minimized due to the introduction of the new fixture.

7. It can contribute to a considerable reduction in the cost of machining, assembly, maintenance, inspection etc.

8. It lower the tool cost - since costly reamers are replaced by relatively cheaper boring tools.

Tools Factory Steel. The following table shows the composition of raw materials of structural and constructional steel.

Table-2 : Standard composition of raw materials

Material	BMTF Ref. No.	Analysis of Chemical composition in percentage				
		C	Mn	Si	P_{max}	S_{max}
Mild steel	BMS-1	0.06 0.14	0.3 0.5	0.05 0.3	0.04	0.04
	BMS-2	0.09 0.16	0.6 0.9	0.35	0.05	0.05
	BMS-3	0.15 0.25	0.4 0.7	0.1 0.4	0.04	0.04
Medium carbon steel	BMS-4	0.32 0.38	0.5 0.9	0.1 0.4	0.04	0.035
	BMS-5	0.42 0.48	0.5 0.8	0.1 0.4	0.04	0.035
High carbon steel	BMS-6	0.5 0.6	0.5 0.8	0.1 0.4	0.04	0.035
	BMS-7	0.9 1.0	0.5 0.8	0.04	0.4	0.035

These reference number i.e. BMS-1, BMS-2, BMS-3 etc. are not internationally recognised. But the BMTF authority follows its own material code for simplification of material handling. To procure the desired raw material from abroad, it is necessary to convert the BMS no. into Internation standard. The equivalent international standard corresponding to the BMTF standard are shown in the following table:

Table-3 : DMTF raw material (their corresponding international standards)

Material	DMTF Ref. No.	Related International Standard B.S.	AFNOR	AISI	JIS	DIN
Mild steel	DMS-1		Xc-10 Adx	C100g		1.0301 C10
	DMS-2	En 2R	Xc 12 A37, A42	C1126	G4051 S28C	1.0401 C15
	DMS-3	En 3A	C20c 10F2	C1020	G4091 S10C	1.0402 C22
Medium carbon steel	DMS-4	En 3A	Xc-35f	C1035	G4051 S-35C	1.1181 Ck-35
	DMS-5	En 8D	Xc45f	C1045	G4051 S48C	1.1191 CK45
High carbon steel	DMS-6	En 430	Xc-55f	C1050	G4051 S55C	1.1210 CK-53
	DMS-7		Xc-95f	C1095	CK-5	1.1760 C90W3

In the previous table B.S., AFNOR, AISI, JIS and DIN are the standards of Britain, France, America, Japan and Germany respectively. The mechanical properties of the above mentioned raw material have been shown in the following table.

Table-4 : Mechanical properties of steel materials

Material	BMTF Ref. No.	Yield point N/mm	Tensile strength N/mm	Elongation (L = 5 d) %	Hardness soft annealed HB
Mild steel	BMS-1	295	490-610	16	131
	BMS-2	335	590-780	14	146
	BMS-3	295	490-640	22	156
Medium carbon steel	BMS-4	365	580-730	19	193
	BMS-5	410	660-800	16	208
High carbon steel	BMS-6	1050	1200-1450	7	210
	BMS-7	-	-	-	217

From the table-4, it appears that BMS-1, BMS-2, BMS-3 have good formability and weldability, but they do not have enough hardenability. From the Table-4 it is also shown that the yield point and tensile strength of these materials are low. For this reason these materials are not chosen for the purpose. Similarly, for the Materials of BMS-6 and BMS-7 have low formability. But the hardness and wear resistance are relatively high. Considering the design aspect, not only the hardness but also other properties such as formability, strength, ridigity etc. are important equally. That is why these materials are not selected for fixture.

Considering all possible factors, the selected materials for boring fixture and DMS-4 and DMS-5. The characteristics of these material are:

i. High fatigue strength and toughness
ii. Higher strength and reasonable hardness
iii. Higher rigidity and shockproof.

These are the lower cost steel materials and may be considered for other application also.

Chapter — IV

ECONOMIC ANALYSIS

4.0 ECONOMIC ANALYSIS

The aim of all industrial activity is to serve cheaper goods, so that they are within the reach of all men. Jigs and fixtures are utilized to increase production, and reduce costs. The money spent to increase the production, on the manufacturing of aidignequipment is justified only, if the final account shows a profit. Therefore, before starting the design and construction of jig or fixture, its economical analysis must be worked out. If the item to be produced are few, then a large investment on the jig or fixture will not be justified.

Break even quantity of the feed gear box to be produced to meet the cost of the fixture.

Let, N_A = Annual production quantity i.e. No. of the Feed Gearbox produced in a year

D_c = Cost difference of machining per piece
The cost difference machining is determined by
$D_c = E_{A_o} - E_{A_T}$

where,

E_{A_o} = machining cost per piece without fixture

E_{A_T} = machining cost per piece with fixture (estimated)

J_A = depreciation of fixture (Tk./year)

The following some criteria may be followed for the economic conditions for the use of the fixture.

i) $N_A \cdot D_c < J_A$: The fixture is not to be adopted

ii) $N_A \cdot D_c = J_A$: The adoptation of the fixture depends upon the policy of the manager

iii) $N_A \cdot D_c > J_A$: The fixture can be adopted.

The manufacturing cost of the fixture J_1 is the sum of the design cost, manufacturing cost and inspection cost.

Manufacturing cost includes cost of material, operational cost such as machining, assembling, adjustment etc.

To compute the annual cost for the fixture the following procedure may be applied:

Let,

J_1 = Manufacturing cost in fixture

J_A = Depreciation of the fixture

n = Life of the fixture

α = Rate of average annual maintenance cost

β = Tax rate for annual fixed assets imposed on tools of assets value and insurance rate.

i = Average interest rate imposed or borrowings of the company.

Then annual cost of the fixture can be computed according to the following formula:

$$J_A = J_1\left\{\frac{i(1+i)^n}{(1+i)^n - 1} + \alpha + \beta\right\}$$

The approximate break up of the manufacturing cost of the Boring Fixture is given below. It may be mentioned here that the data of the costing has been taken from the production, planning & control department of BMTF.

Cost analysis of the Boring Fixture

i)	Total material required = 230 kg. Material cost (Tk.35.00 x 230)	= Tk.8050.00
ii)	Total approx. labour hours = 80 hr. Total labour cost (Tk.22.00 x 80)	= Tk.2560.00
iii)	Machining cost = Tk.33.57 x 80	= Tk.2685.60
iv)	Administrative overhead = Tk.27.29 x 80	= Tk.2183.20
v)	Profit margin = Tk.15,478.80 x 0.1 (10%)	= Tk.1547.80
vi)	Design cost	= Tk.2000.00

After analysing all these it has been estimated that the manufacturing cost of the said fixture would be approximately Tk.19,026.68.

Hence, $J_1 = 19,026.68$

Since the boring fixture has been designed for long term production, the life of the fixture is considered as 10 years.

i.e. $n = 10$

Generally, $\alpha = 10\%$

From the Account department of BMTF the following information have been obtained for the current financial year.

Average interest rate (i)	=	10%
Annual tax rate	=	4%
Annual insurance rate	=	5%
Annual allowance for repair	=	10%
Overhead cost	=	Tk.27.29/labour hour
Machining cost in CTD shop	=	Tk.33.57/machine hr.
Labour rate	=	Tk.22.00/labour hour

Hence as defined earlier

$$= 0.04 + 0.05 + 0.1 = 0.19$$

$$J_A = J_1\left\{\frac{i\,(1+i)^n}{(1+i)^n - 1} + \alpha + \beta\right\}$$

$$= 19{,}026.68\left\{\frac{0.1(1+0.1)^{10}}{(1+0.1)^{10} - 1} + 0.1 + 0.19\right\}$$

$$= 19{,}026.68 \times 0.453$$

$$= \text{Tk.}8619.08$$

Hence, the depreciation per year is Tk.8619.08

To find the value of D

$$D_c = E_{A_o} - E_{A_T}$$

Now,

E_{A_o} = machining cost/piece without fixture

= (labour rate + machining cost + overhead rate) x No. of hours required in machining in the existing method.

= (34.00 + 39.32 + 32.68) x 10

= Tk.1059.60

$$E_{A_T} = \text{machining cost per piece with fixture}$$
$$= (34.00 + 39.32 + 32.64) \times 2$$
$$= Tk.211.92$$

$$D_c = E_{A_o} - E_{A_T}$$
$$= Tk.\ (1059.60 - 211.92)$$
$$= Tk.847.68$$

Now, if the fixture is to be used in the boring operation then the third criteria of this article must be satisfied. From the third criteria it is shown that

$$N_A . D_c > J_A \quad \Rightarrow \quad N_A > \frac{J_A}{D_c}$$

$$\Rightarrow \quad N_A > \frac{8619.08}{847.68}$$

$$> 10.1$$

From the above result it can be concluded that if the number of the feed gearbox to be manufactured in a year is more than 11 then the use of fixture is justified.

The procedure for the net cost reduction by using the fixture is given below:

From the earlier analysis it is found that

$$D_c . N_A > J_A$$
$$\Rightarrow \quad E_{A_o} . N_A - E_{A_T} . N_A > J_A \qquad [D_c = E_A - E_A]$$
$$\Rightarrow \quad E_{A_o} . N_A - (E_{A_T} . N_A + J_A) > 0$$
$$\Rightarrow \quad E_{A_o} - (E_{A_T} + \frac{J_A}{N_A}) > 0$$

If the values are put in the above equation, then it is found that

$$E_{A_0} - \left(E_{A_T} + \frac{J_A}{N_A}\right)$$

$$= 1059.60 - \left(211.92 + \frac{8619.08}{18}\right)$$

$$= \text{Tk. } 368.84/\text{pc.}$$

Chapter – V

CONCLUSION AND RECOMMENDATION

CONCLUSION AND RECOMMENDATION

The existing method of feed screw gear box casing of celtic-14 lathe was studied throughly and the problems that arise were identified. It was found that most of the operational problems come from faulty location of bores with respect to each other. To eliminate the operational as well as manufacturing problem a Boring Fixture was developed.

The following conclusion can be drawn from the project work performed:

i. During the boring operation of feed screw gearbox casing of Celtic-14 lathe, as performed in Bangladesh Machine Tools Factory Ltd., the boring fixture can save a tremendous amount of efforts, machining time, operator's fatigue and ultimately lower down the cost of production to a greater extent.

ii. Rectification work can be avoided by adopting the proposed method since all the operations are performed perfectly. There is a provision to measure the critical dimensions by gauges. With the elimination of rectification work man hour can be saved to a great extent.

iii. Better utilization of the machine can be possible with this process. In this case the type of machines of each operation are defined. For this reason there is no problem of selecting machines and the appropriate machine is selected for the appropriate job.

iv. Since the rate of rejection is expected to be low and at the same time quality of production is expected to be improved, interruption of production target schedule can be avoided by implementing the proposed method.

This project work will serve as an important document for future work and can be implemented according to the procedure given. In this project only the method of boring operations for feed screw gear box casing have been considered but in general, for all other parts of the Celtic-14 lathe, the same procedure can be followed.

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APPENDIX

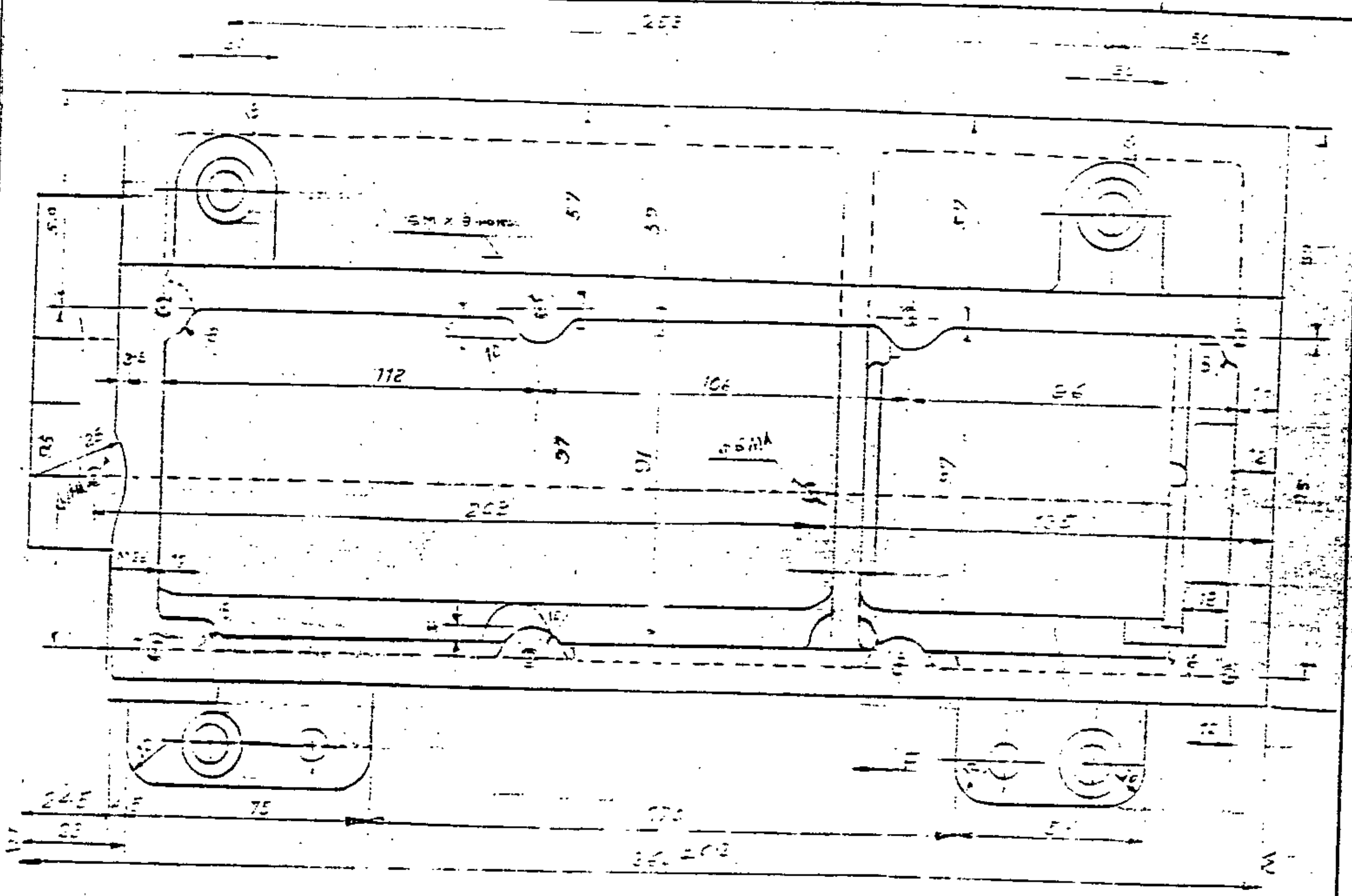

Fig.39: TOP VIEW OF FEED GEAR BOX

Copied from original blue print in reduced scale.

BANGLADESH MACHINE TOOLS FACTORY LTD.

Source : Design & Dew. Deptt. BMTF

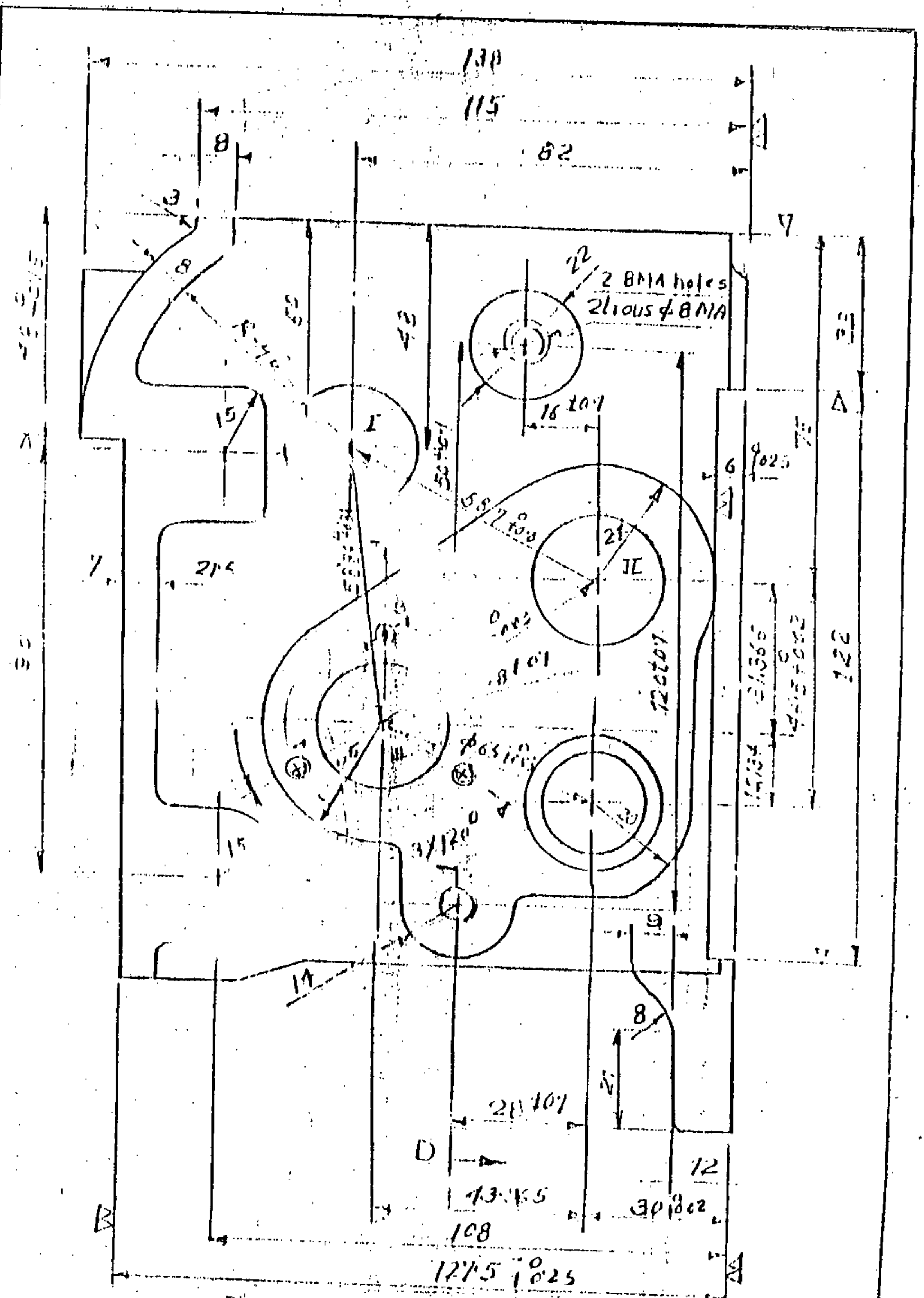

Fig.46 : RIGHT SIDE VIEW OF FEED GEAR BOX

Copied from original blue print in reduced scale.

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Source : Design & Dev. Dept. BMTF

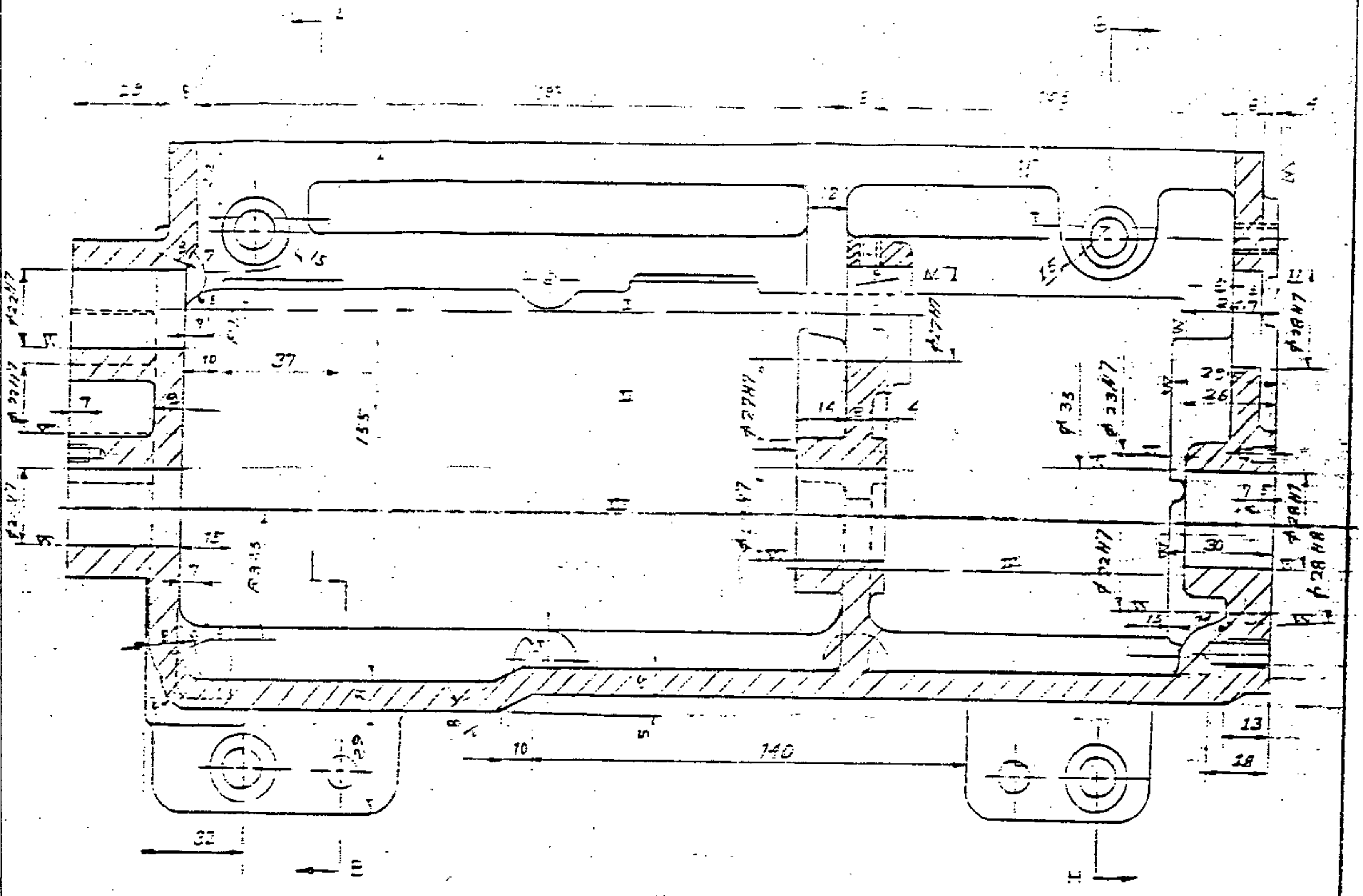

Fig.41: SECTIONAL VIEW (CD) OF FEED GEAR BOX

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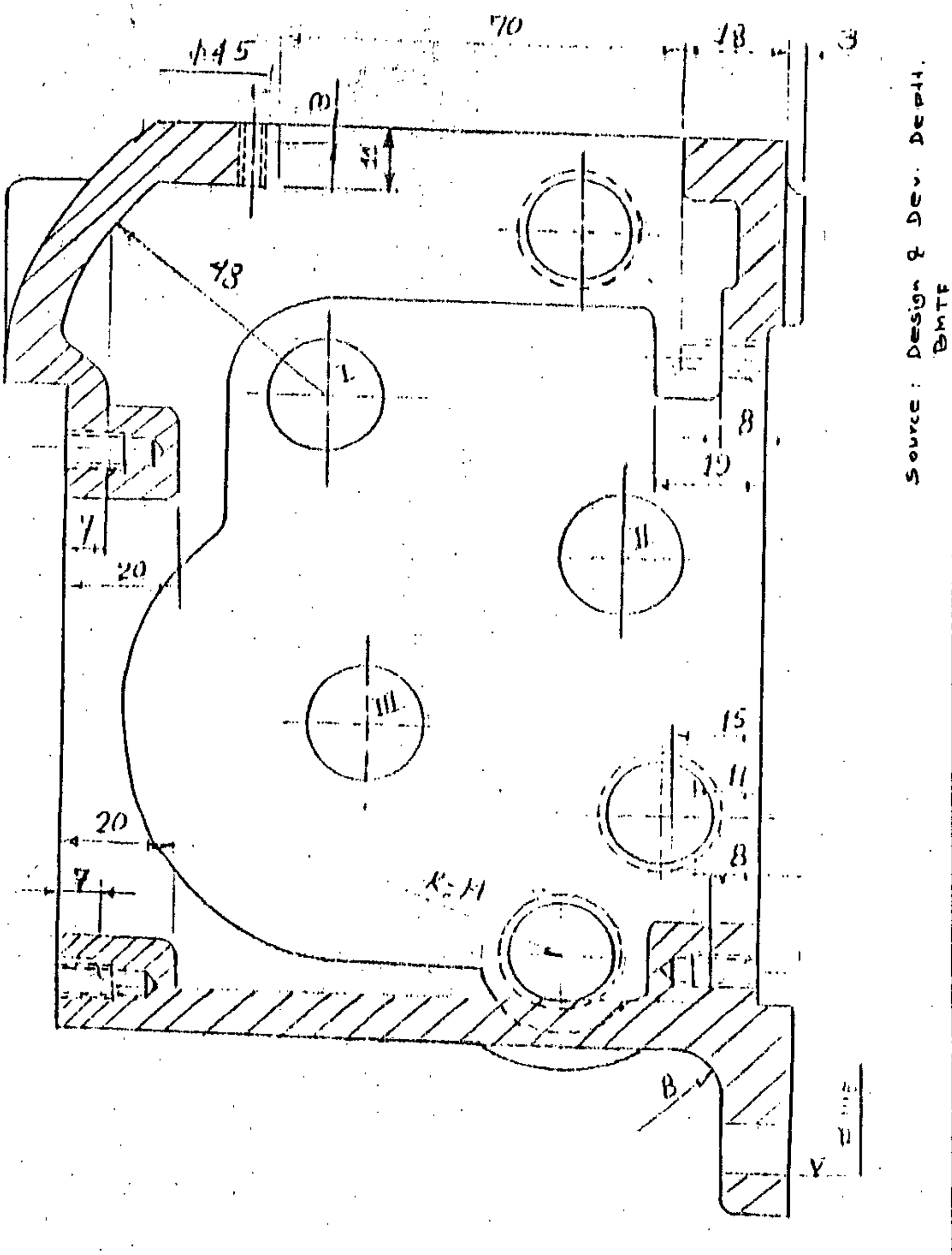

Fig.42: SECTIONAL VIEW (AB) OF FEED GEAR BOX

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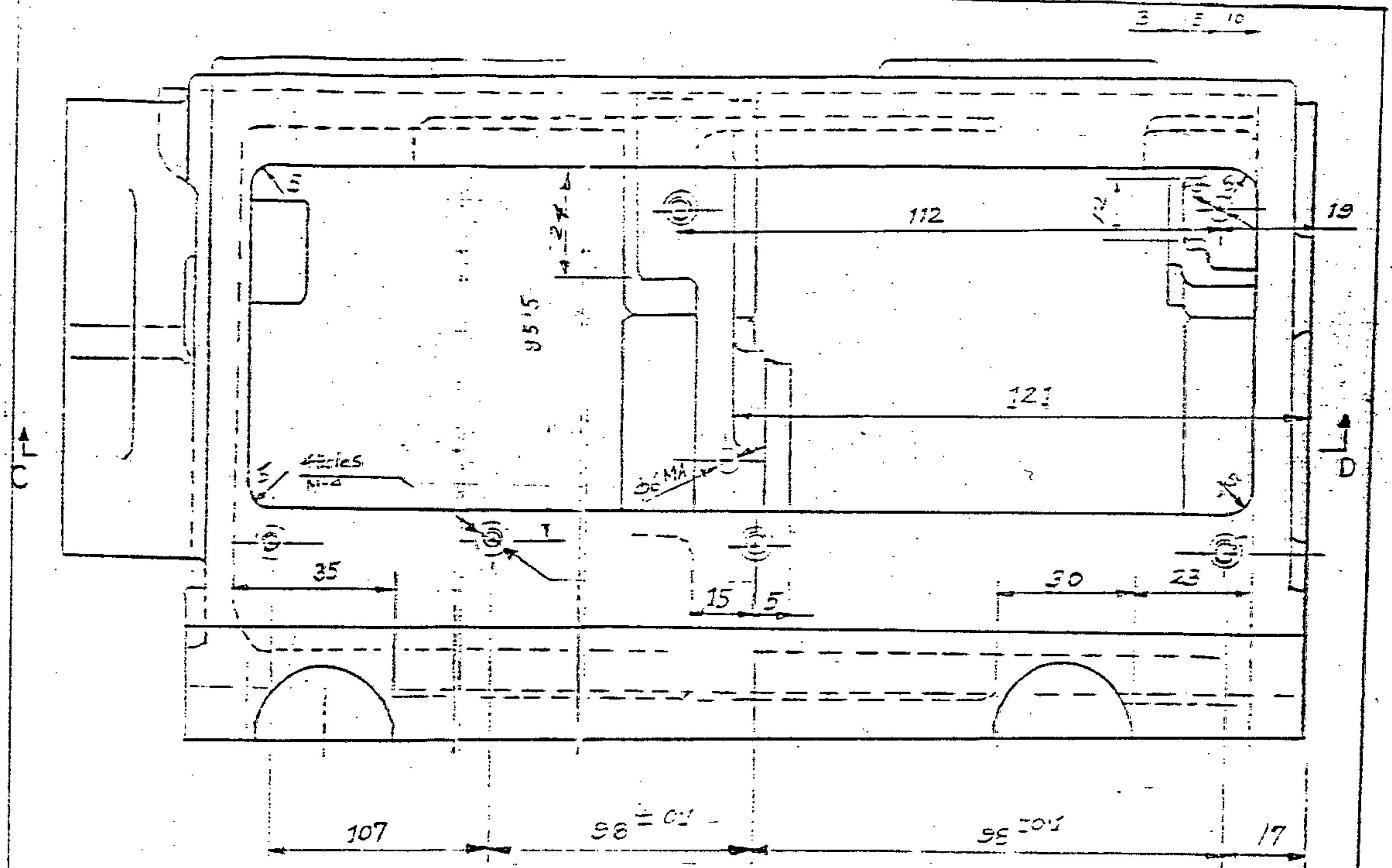

Fig. 42: REAR VIEW OF FEED GEAR BOX

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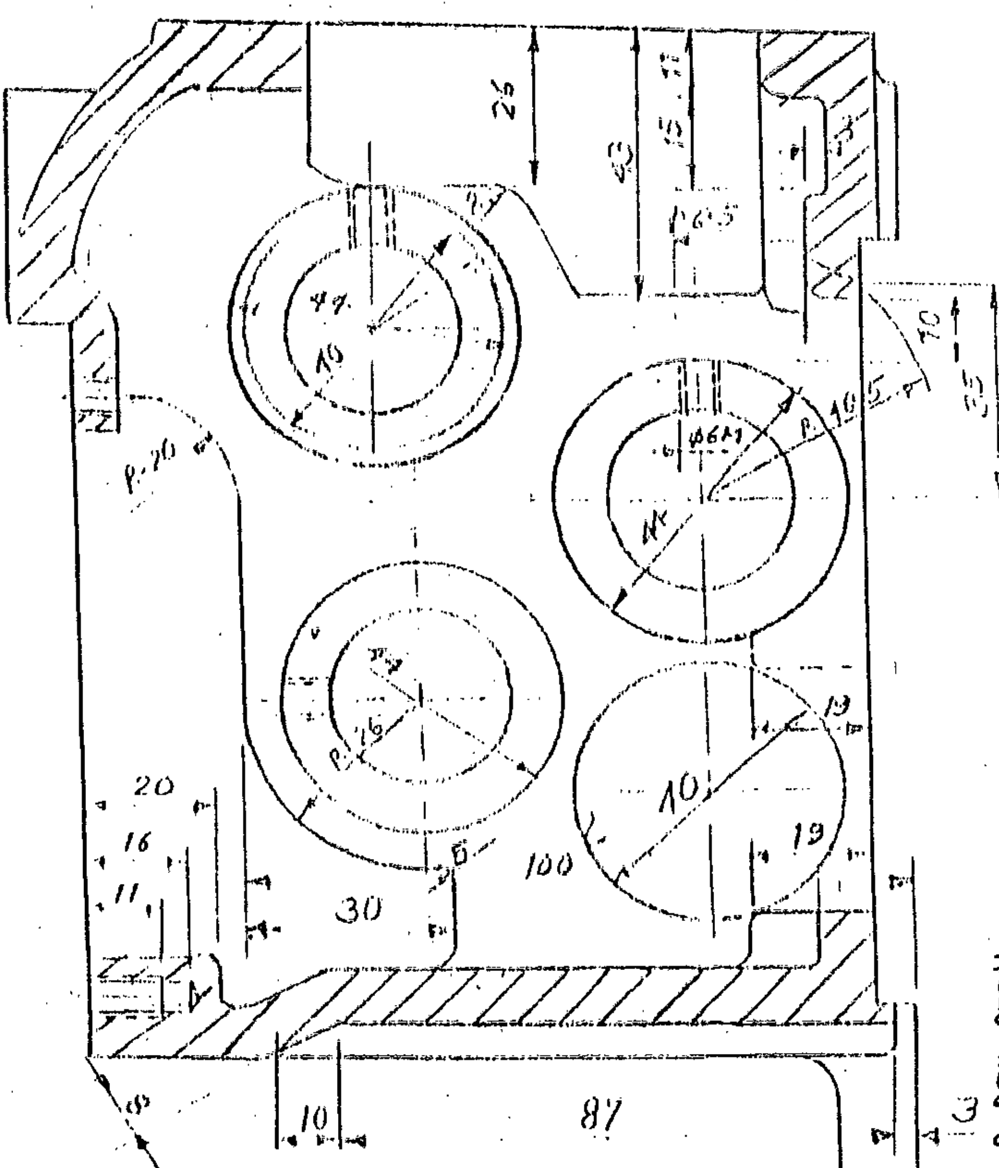

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Fig.44: SECTIONAL VIEW (EF) OF FEED GEAR BOX

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