THE SPRING RESEARCH ASSOCIATION

A FEASIBILITY STUDY ON A PNEUMATIC WIRE AND STRIP FORMING MACHINE

by

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Report No. 221

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SUMMARY

This report discusses the need for a low cost wire and strip forming machine and describes a design proposal of such a machine based on the multislide principle.

The design specifies the application of pneumatics, especially pneumatic torque units, for the various slide operations. Sequence control is made by a pneumatic plugboard in conjunction with a sequence stepping unit (Martonair 'Bi-Selector'). The design is such that simplified versions of the machine can be produced, of less versatility, but with appropriate cost reductions.

The relative merits of the design, which are mainly versatility and low cost, are discussed and comments and suggestions are invited from Members about the proposed design aspects.

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1. INTRODUCTION

This report describes a pneumatic wire and strip forming machine design based on the four slide principle.

The intention of the report is to convey to Members the principles of operation and the design proposals so that some feedback of information about Members' individual requirements can help direct our efforts to produce a design that is favourable to as many Members as possible.

The feasibility study has been undertaken to assess the degree of versatility required of the machine and also to consider the need of such a machine and whether different versions of it are required. The report highlights the relative advantages of the various design aspects and the application of pneumatics to these.

2. PRINCIPLE OF OPERATION

Fig. 1 shows the tooling and the sequence of operations that would be used in the manufacture of a wire spring clip. In this case three slides are used and there is no requirement for a press unit.

After the strip feed the front tool and cut-off slide move forward and complete their stroke. The cut-off action is timed to coincide with the capture of the strip by the front ~~tool.~~ The front tool movement causes the mandrel and strip to be moved back into the line of the side tools whereupon the side tools commence their working stroke and then retract. On retraction of the front tool the stripping tool ejects the component through the aperture in the machine bedplate.

3. MACHINE DESIGN

3.1 General

The design policy is flexible and adaptable. For example, any number of slides up to four could be built into the machine; there is provision for a press unit; and the sequence of operations is programmable by a plug board unit.

An advantage of the application of pneumatics to a wire and strip forming machine is that it lends itself to simple sequential control which, with the addition of a plug board permits variations in operation sequence to be made. Further more, pneumatics permit simplified versions of the machine (see Fig. 2) which carry appropriate cost reductions without the loss of economic viability that an electrically or hydraulically driven machine might incur.

The design aspects discussed in this report cover a more comprehensive machine with provision for four slides and a press unit. Fig. 3 gives an 'artist's impression' of such a machine.

3.2 Mechanical

Torque units are used for all operations except clamping and stripping. The advantages of torque units for this machine application are:

1. They are relatively compact.
2. All units may be mounted in a horizontal orientation on the underside of a baseplate so confining the pneumatics to an out-of-sight position.
3. The use of torque units permit crank and cam drives thereby achieving a high mechanical advantage.
4. Crank and cam driven tools do not impose stresses on the mandrel other than by the natural forming of strip or wire.

All slides are driven by independent torque units with the exception of the front tool slide which shares a torque unit with the cut-off slide. However, these slides have independent cams and therefore their stroke cycle phase relationship can be altered to suit the tool set-up.

Cams are used for the front slides in preferance to cranks because of space limitations and because the mode of operation of the front tool slide is different in that it is required to hold the strip against the mandrel whilst other operations are carried out.

Slides are shown in Fig. 4 mounted at 90° to each other, but other positions could be used.

Standard production torque units of 108 lb ft torque (rated at 80 p.s.i.) are proposed for each tool slide and for the press unit. As an alternative a torque unit of 216 lb ft may be fitted for any two diametrically opposed tool slides and/or for the press unit without modification to the existing design. If it were essential to fit the higher rated torque unit for any of the slides then it is likely it would be for either the front tool or for the press unit or both. Some degree of experimentation and the section size of the stock will prove which torque unit is required.

The feed unit will be driven by a smaller torque unit (24 lb ft rated at 80 p.s.i.) which imparts a reciprocating movement to a carriage in the feed slideway. The gripping and releasing of stock will be automatic and controlled by the reciprocation of the feed arm connected to the carriage.

3.3 Control

Control of all operations will be by a sequential pneumatic stepping unit (Martonair 'Bi-Selector' system). Feedback to the stepping unit is from sensor valves which detect the completion of each operation. The feedback and command signals are via a plugboard which permit rapid change (or an ommission) in the sequential order of operation.

Alternatively a G.E.C. Uniselector may be used in conjunction with solenoid operated valves. This is an electrical stepping unit.

All air line equipment, pressure regulators, valves and the stepping unit are to be situated beneath the plugboard at the left hand end of the machine.

3.4 Machine Construction

Figure 4 shows the machine layout.

The framework or chassis consists of a mild steel base plate suitably fabricated to accept the pneumatic torque units and the associated slideways. A supporting framework is attached to the steel plate and a cabinet at the left hand end of the machine houses the pneumatic control equipment.

The design of a typical slide and slideway is shown in Fig. 5. This does not have gibs and is of simple design in view of the manufacturing and cost limitations.

The mandrel holder (Fig. 6) is suspended above the slideways by two parallel beams and is spring loaded against the movement of the front tool. Stops are provided to limit the mandrel movement.

4. PRODUCTION SPEED

It is anticipated that the machine's production rate will be about 2000 - 3000 components per hour. Production rate is limited, of course, to the cycle time which is largely dependent on speed of operation of the torque units and on the complexity of component form. Where appropriate, simultaneous operation of pneumatic units will produce a reduction in cycle time.

5. MACHINE LIFE

The 'Bi-Selector' unit has an expected life of 3 000 000 operations. The wearing parts of this unit are easily replaceable, and the makers of the unit suggest a spare sub-assembly be kept close at hand. The cost of such a unit would be about £24. Thereafter the worn parts on the unused sub-assembly could be replaced for a very small cost.

The torque unit and cylinder life is in the order of 10 000 000 operations before attention to seals would be required.

6. THREE SLIDE OPERATIONS (WITH PRESS UNIT)

	Sequence Symbol
Feed	A
Clamp	B
Punch	C
Shear / First Form	D
Second Form	E
Third Form	F
Strip	G

Typical Three-Slide Sequence

```
                  ( A + G +             )
                  ( B + A - G - C +     )
                  ( D +                 )   1 machine cycle
                  ( E + F +             )
                  ( D - B -             )
1 pneumatic       (
  cycle           ( A + G +             )
                  ( B + A - G - C +     )
                  ( D +                 )   1 machine cycle
                  ( E - F -             )
                  ( D - B -             )
```

The above sequence illustrates that two components are produced per pneumatic cycle.

7. PROPOSED SPECIFICATION

Stock Size:

1) Strip sections: Up to 1/16 in thick, up to 1 in width
2) Wire: Up to 10 gauge

Note: Stock size is dependent on torque unit size and the mechanical advantage achievable by the slide linkage.

Tooling Specifications:

Side tool stroke: 1.5/8 in
Mandrel centre line to maximum side tool retraction = 2.3/8 in

Stock Feed Length: Up to 12 in on one stroke

Production Speed: Up to 3 000 per hour

Air Consumption: Approximately 50 C.F.M. of free air

Cost of Machine: From £500 to £2 000 depending on number of slides

8. DISCUSSION

The purpose of this feasibility study on a wire and strip forming machine is threefold:

i) To find out if there is a requirement for a low cost machine based on the multislide principle.

ii) To enquire about the degree of sophistication (or simplicity) required. For example, the number of slides required and whether a press unit is required.

iii) To state the advantages and merits of the proposed design.

The merits of the proposed design can be summarised as follows:-

1. Machine is relatively inexpensive compared to motor driven mechanical multislides.
2. Machine can be simplified with corresponding cost reductions.
3. Machine sequence is programmable.
4. Choice of pneumatic units for slides.

The design can be simplified to such an extent that a machine with only one slide and without a feed mechanism could be produced. This would be suitable for bending or shear operations for small batch production work or one-off operations.

Simple designs would not, of course, require sequential control by a stepping unit. Designs which incorporate a feed unit with perhaps one slide would utilise more conventional control logic.

Bearing the points in mind, comments and suggestions about the capacity and scope of work that might be thought suitable for this machine are invited, together with any other suggestions that may be appropriate.

9. CONCLUSIONS

1. Using pneumatics an inexpensive wire and strip forming machine can be produced.

2. Simple programming facilities improve the machine's versatility.

3. Simplified versions of the machine are possible.

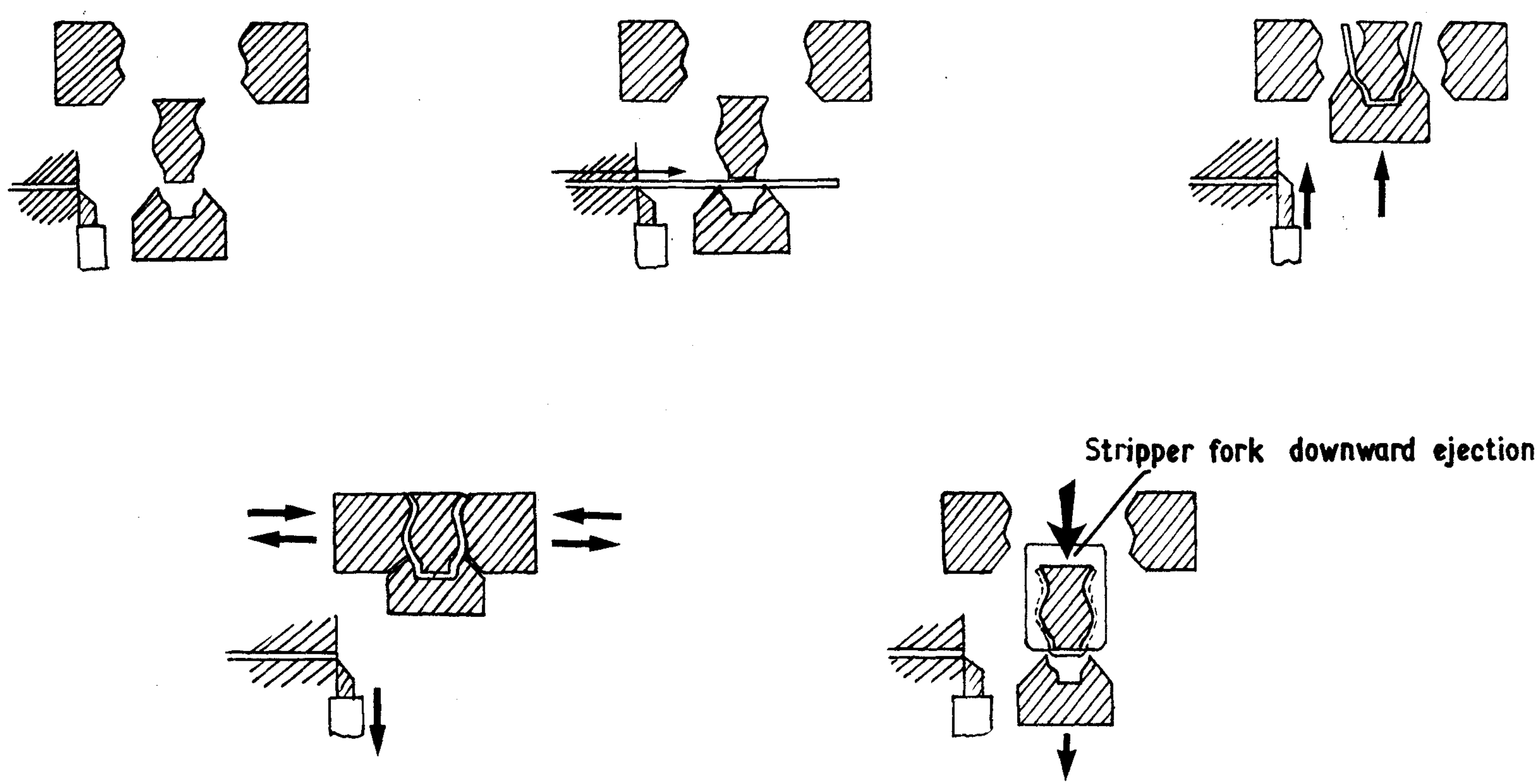
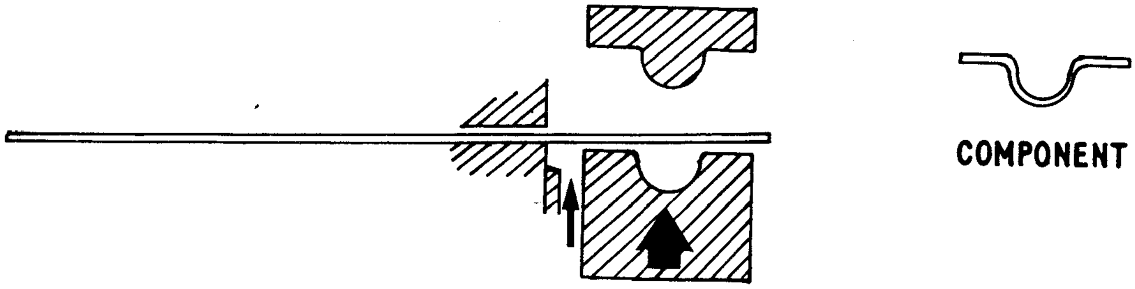
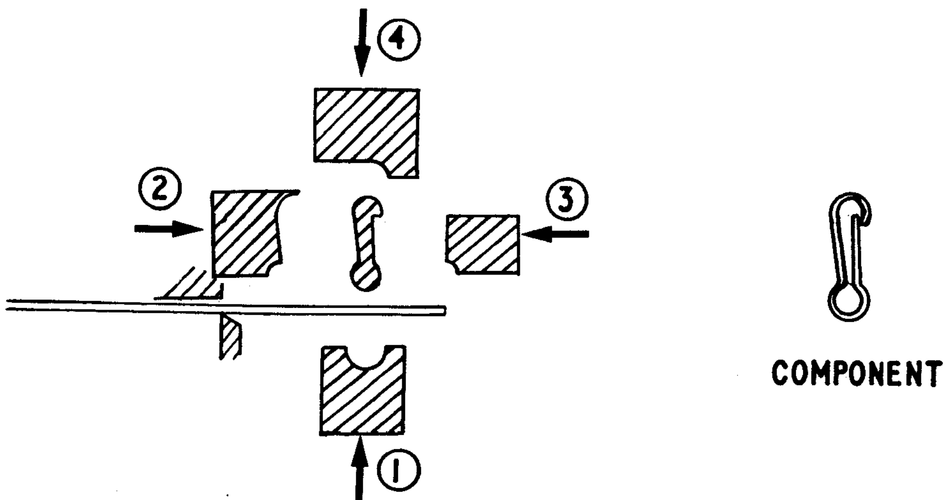


FIG.1 PROPOSED TOOLING EXAMPLE FOR THREE SLIDE MACHINE



SIMPLIFIED FORMING MACHINE WITH ONE FORMING SLIDE



FOUR SLIDE FORMING MACHINE

FIG. 2 TOOLING EXAMPLES

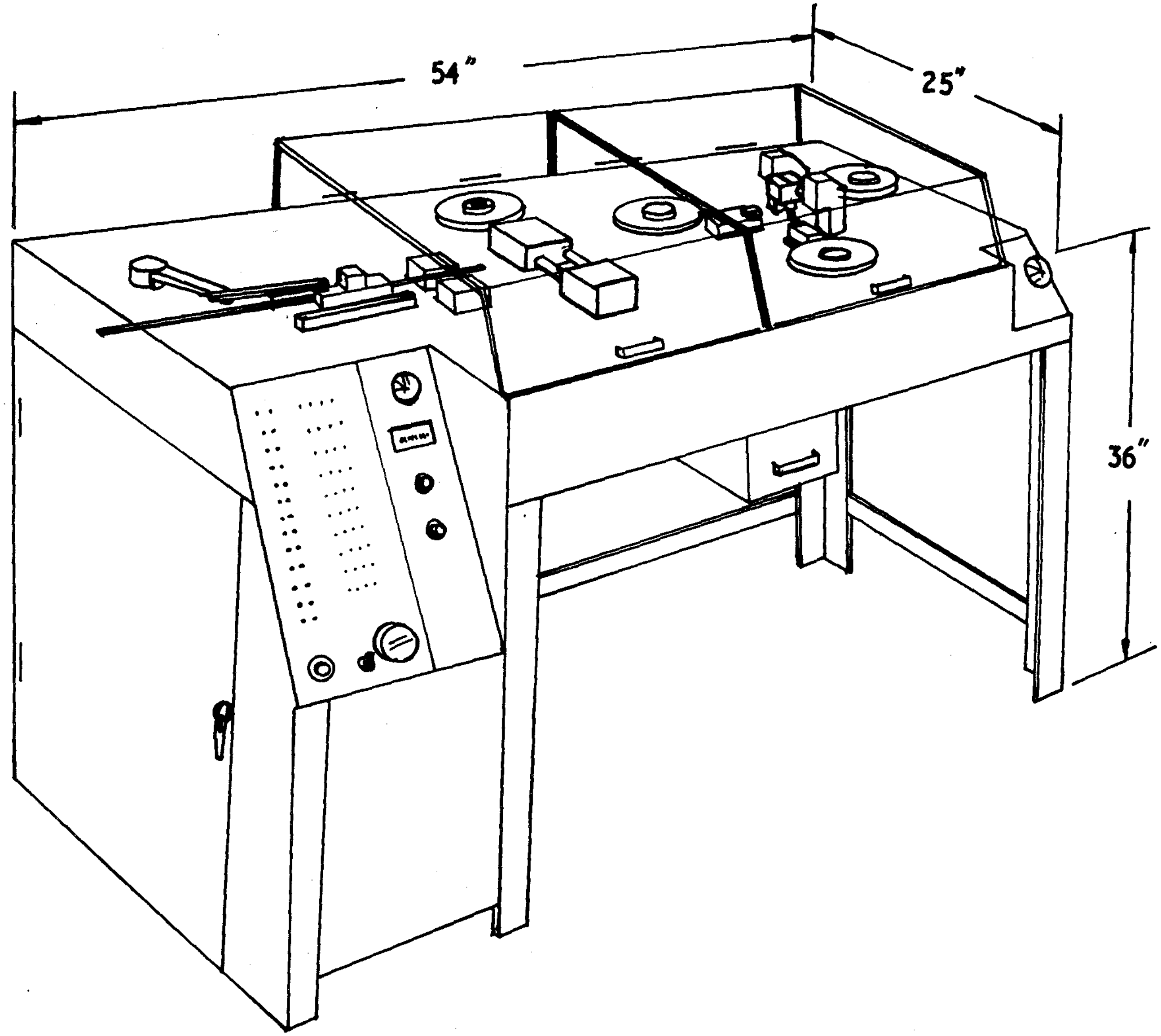
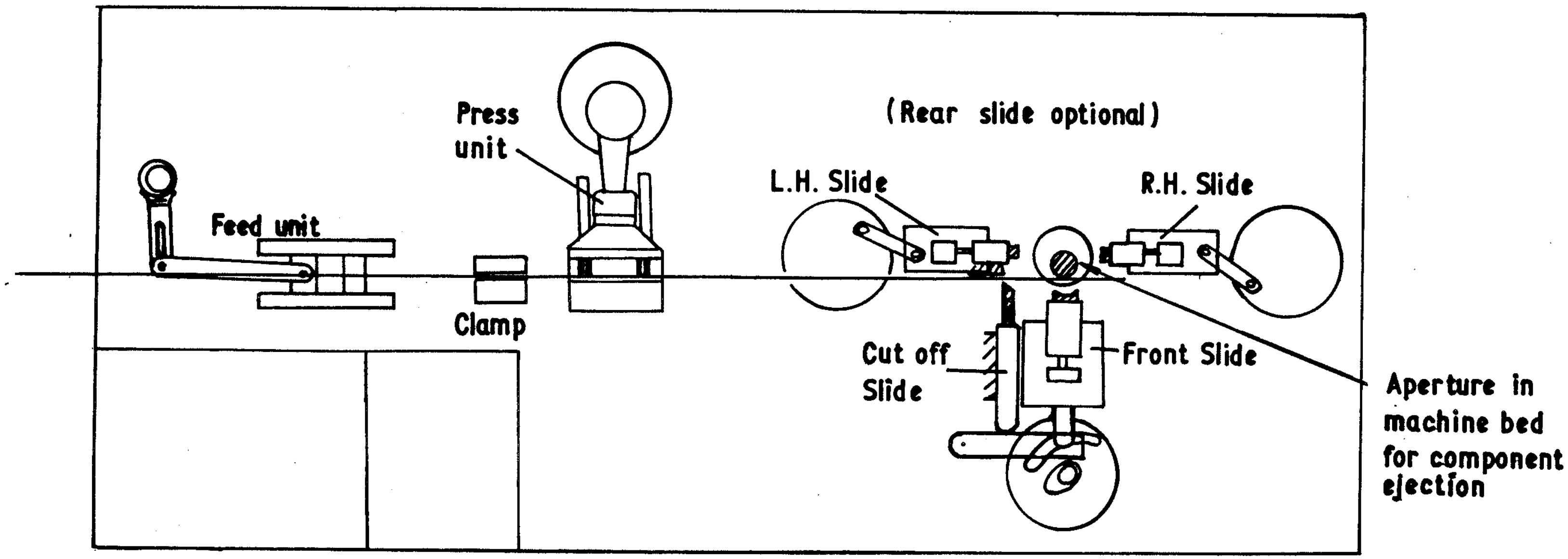


FIG. 3 GENERAL VIEW OF MACHINE

(i) Layout of Mechanics



(ii) Layout of Pneumatics

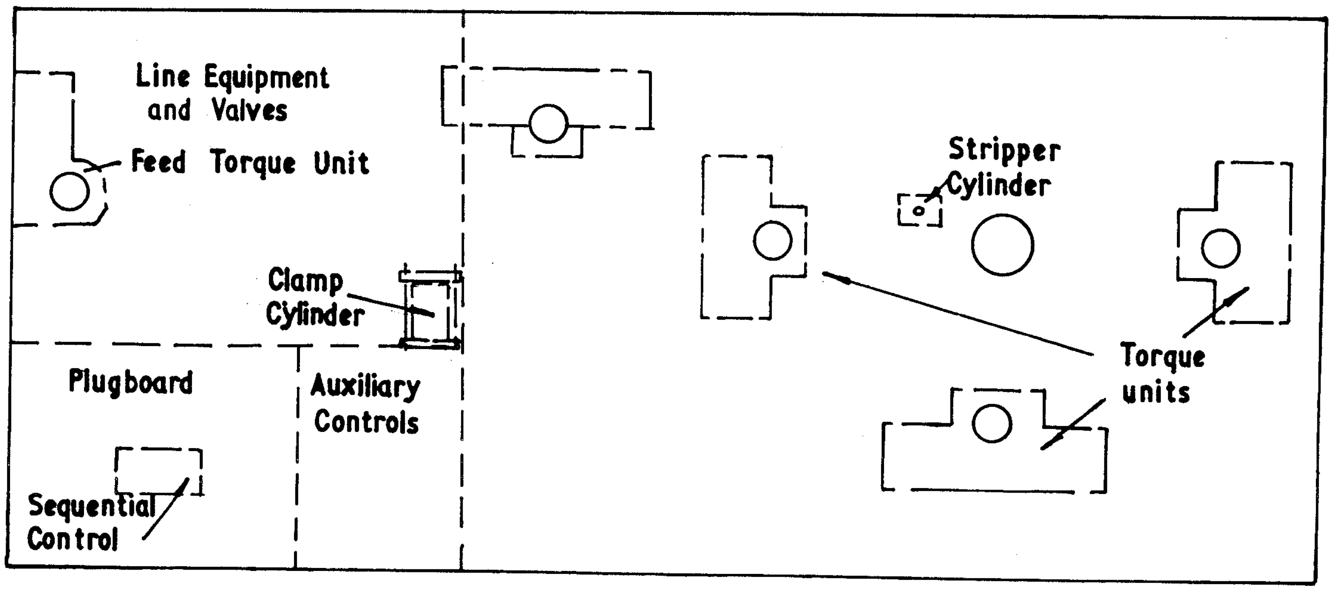


FIG.4 LAYOUT OF THREE-SLIDE MACHINE.

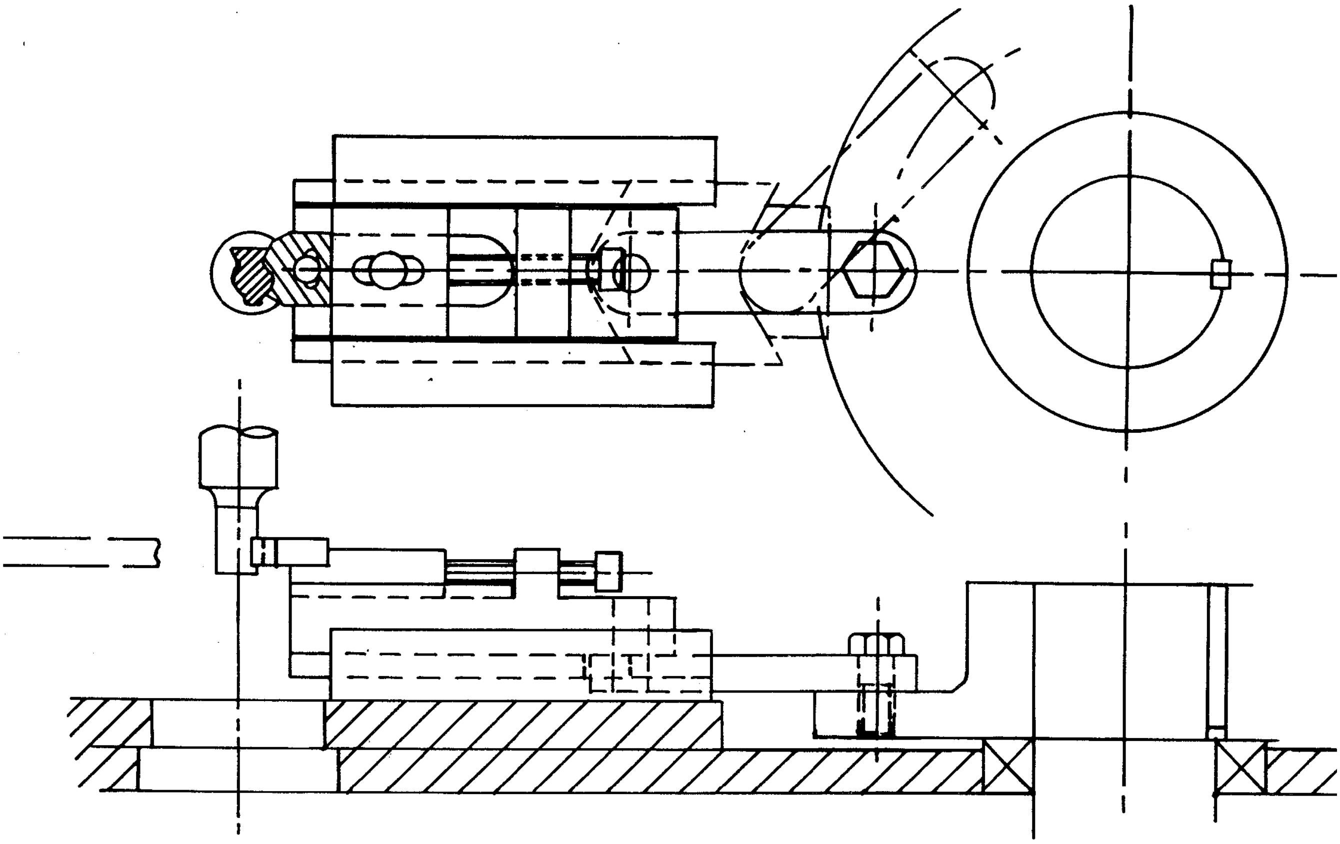


FIG. 5 SLIDE DETAIL

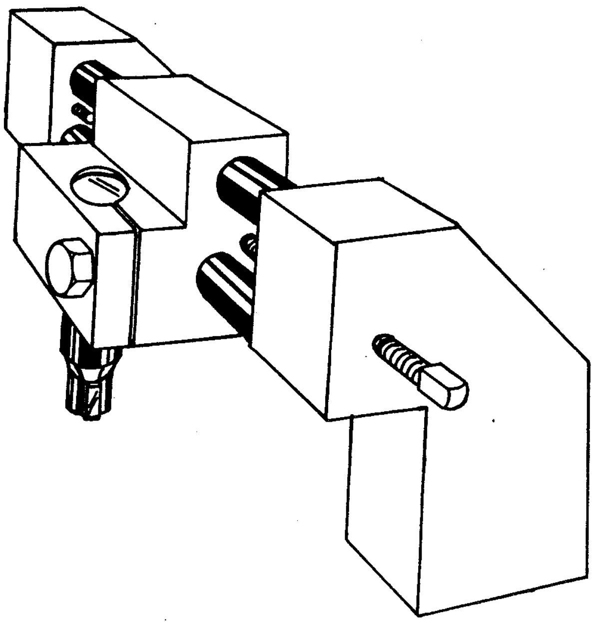


FIG. 6 MANDREL HOLDER DETAIL