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COLLEGE OF AERONAUTICS

(Proposed Cranfield Institute of Technology)

DEPARTMENT OF PRODUCTION ENGINEERING

DESIGN PROJECT 1968/9



REPORT OF COMPONENT SUPPLY AND
SEPARATION COMMITTEE

THE DESIGN OF A VERSATILE AUTOMATIC
ASSEMBLY MACHINE

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SUMMARY

This report outlines the techniques for automatically feeding the components of an electrical contact block and describes the design of a feeding system for each component.

All components of the contact block were initially analysed for automatic feeding and redesigned where necessary.

Existing feeding methods were examined and consideration was given to their versatility. Decisions were then made as to the feeding system for each component.

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1. INTRODUCTION

This report is one of a series which give full details of the design project 1968/9. A Management Report (ref. 1) is available which summarises the work done and the conclusions reached during the course of the project.

The terms of reference of the Component Supply and Separation Committee were to provide design details and specifications of the equipment that will be required to feed and orientate the components of a contact block which is to be automatically assembled. Included in the specification is the requirement that versatility should be of prime importance. Because the orientation and supplying of components invariably requires special tooling, which suits a particular component, this report has only considered in detail the feeding of components comprising the contact block.

The components that were to be fed originally are shown in the Assembly Analysis Committee Report. Certain components were redesigned and feeding equipment is supplied with standard workheads in some cases.

Initially, the characteristics of each component in relation to mechanised feeding were studied, and it soon became apparent that the redesign of some components would greatly reduce the complexity of the feeding equipment, and yet, not affect the function of these components. The redesigns of some components were carried out and recommendations for these were made to the Assembly Analysis Committee. The type of feeders was then decided upon and tracking and escapements were designed.

As well as specifying feeding equipment this Committee was responsible for designing the system that is required to transfer the contact block from the main assembly machine to the final fixing screw head.

Collaboration with the other committees in all aspects of design was considered of great importance, in particular the Control and Motivation Committee, which provided the control for all escapements and the manufacturing head.

It should be emphasised that the approach to design by the Committee has, of necessity, been mostly theoretical. A common attitude in the approach in Industry is that this is the initial design which will be developed and proved. Only when the parts are actually timed down the feed track can feeder performance be quoted with accuracy.

Details of costs have not been included because all costs have been given to the Economic Planning Committee and are provided in their report.

2. ANALYSIS OF COMPONENTS

Before deciding upon a type of feeder it was necessary to analyse each component that was to be fed. By this means any characteristics of the part which may serve as a help or a hinderance to automatic feeding were considered. Special attention was given to any characteristic which would require complicated mechanisms to achieve a single orientation. If this could be altered a relatively simpler method of achieving an orientation could be used.

Provision of equipment for feeding the parts of the contact block was made for the following:-

- a) Housing
- b) Cover
- c) Plunger assemblies (N/O and N/C)
- d) Fixed Contacts (N/O and N/C)
- e) Insulation Plate
- f) Coil Springs.

a) Housing

This is a rectangular part made of a phenolic resin, and is suited for automatic feeding except for a cut out in the housing which would require sensing. It was decided that a simple modification to the design of the housing would eliminate the requirement of a sensor and orientating mechanism.

This component was, therefore, redesigned by the committee and this is shown on fig. AA/11. It can be seen that the cut-outs were centralized in their respective halves of the housing. Thus the need to distinguish between the front and rear of the housing was eliminated. As a result of this the control plates (N/O and N/C) were altered in design.

b) Cover

The cover is a flat rectangular part and is symmetrical about its centre line, and has no outstanding characteristics to impede automatic feeding.

c) Plunger Assemblies (N/O and N/C)

This part is already orientated after assembly from which it seems logical that it should be maintained in this state. The assembly contains a number of components which are loosely connected and, therefore, the feeding of these assemblies must be controlled. Feeding efficiently with any of the random parts feeding techniques would be impossible.

d) Contact Plates (N/O and N/C)

The contact plate, after redesign, is shown on figs. AA/31 and 32. The redesigned form is a result of the redesign of the housing. Although cost savings on material were obtained, the problems involved in feeding and orientating were increased.

There are four types of contact plates, for both hole mounted and base mounted contact blocks, which are N.O. right hand and left hand. These components are all made of brass and are basically S-shaped. When they are correctly orientated, these components will be able to hang between two rails.

e) Insulation plate

This component is of a flat rectangular shape with no unique characteristics, and is made from a resin impregnated paper. The part is very light and, due to its thickness, it would have to be stacked into chutes to be fed efficiently.

f) Coil Springs

The coil springs in the contact block are of conical shape and are open ended. These are extremely undesirable parts for automatic feeding. Therefore a design change or a method of feeding is required other than automatic separation from bulk. A more detailed investigation of feeding coil springs is given in Appendix I.

3. FEEDING OF COMPONENTS

3.1 General feeding systems

There are many methods of feeding the contact block components to the assembly machine, but they fall into two classes.

- 1) Mechanically unscrambling components from bulk and orientating components into single file.
- 2) Manual unscrambling and orientating from bulk.

Class 1 utilizes feeding equipment such as vibratory bowls, reciprocating tube hoppers, rotary disc hoppers, centrifugal hoppers etc.

Class 2 utilizes methods of feeding components to an automatic assembly machine in the correct orientation by using magazines or other in-process storage devices.

The time that was available restricted the Committee to consider feeders which were suitable only for the contact block. A great deal of research is being carried out into classifying components in such a way as to readily determine the most suitable feeder for a particular type of component. (P.E.R.A.) (ref. 7).

Briefly the types of feeder that are readily available on the market at present are:-

a) Elevating hopper feeder

This feeder is most suitable for components when a large random storage capacity is required. If the floor space that is occupied by the feeding equipment is of prime importance, this type of feeder would not be used.

The orientating of the component is not positive, inasmuch that a great reliance is placed on gravity to orientate parts. Its most suitable application is for use in conjunction with machine tools.

b) Rotary disc feeder

This type of feeder is most suitable for components of disc or cylindrical form. In view of the desire to have versatility in the system this device was considered unsuitable.

c) Vibratory bowl feeder

For the machine being considered this was the type of feeder which offered the scope required by the machine, in general, and by the contact block in particular.

The ability of this feeder to deal with fragile parts, the positive force applied to the component through orientating devices and the facility of being able to deal with components of irregular shape, deems this the feeder to be recommended for the assembly of the contact block.

With this feeder, space is utilized to a maximum due to the spiral flight configuration. Further considerations regarding the features of bowl feeders are given in Appendix IV.

When the size of the components and the vibratory bowl used is such that storage capacity within the bowl is small, and that frequent refilling is required then a bulk storage hopper can be used in conjunction with the vibratory bowl feeder.

Bibliographies 1 and 2 give complete analyses of performance and comparisons of various types of feeders.

In-Process manufacturing heads

This is where the manufacturing operation on a component is coupled to the assembly machine, and is mainly carried out on components where the manufacturing process involved is simple and no swarf, burrs etc. are formed. Processes which could be suitable are small press work and, sometimes, spring winding.

In-Process storage devices

In large systems such as that involved in the contact block assembly it is often necessary to hold a bulk of orientated components between operations. This situation arises when a sub-assembly station is used to feed another sub-assembly or main build station, and where manual operations are to be integrated with the assembling system. In both of these instances an in-process store of parts is necessary to reduce dependence of the fed station on the feeder in case of a breakdown. This will, therefore maintain the overall assembling rate of the complete unit.

For each instance the requirements of the fed station are in terms of the speed that parts are consumed, the orientation required and the nature of the assembly. There are two systems where the necessary storage is achieved, the first is to fill a container from the feeding assembly and re-orientate the parts at the machine. The major limitation is the nature of the assembly, which in many cases will not withstand a sorting process at this stage without high risk of damage. Also, the principle of maintaining an already orientated part, in a known position is ignored and re-orientation may require costly equipment. The second system is to hold the assembly in a fixed, known orientation between stations in tooling or magazines of expendable or re-usable type. The main limitation to this system is the possible high cost of containing and motivating large quantities of accurate tooling and powered motivation or large quantities of material for in-process packed storage.

The aim of an in-process storage system is, ideally, to maintain orientation and motivate part assemblies in the quantity required by the cheapest effective method. To this must be added the need for versatility in the system since the cost of the most effective system may be offset by the fact that it can be used subsequently.

The types of in-process store can be divided into 3 broad categories:-

- 1) Spiral vibratory elevators.
- 2) Mechanically or manually handled series of magazines with manual or mechanical loading systems.
- 3) Complexes of tooling containing the part assemblies.
eg. spirals or hairpin layouts of rails.

The advantages and disadvantages can be summarised as:-

1) Spiral Vibratory Elevators

- a) The cost of elevators is high and, in many cases, tooling of a specialised nature will be required to cover the whole path of the part assemblies.

- b) Large quantities of parts being vibrated will possibly cause a great deal of noise, and also the vibration effect will cause serious wear on the track. For assemblies which contain loosely connected components, vibrators may cause these assemblies to fall apart unless constrained by some method.
- c) The effective motivation of parts is good and the rate of delivery can be varied over a wide range.

2) Magazines

- a) Expendable material packing can be expensive and create disposal problems such as to make a method viable only if sufficient simplicity has been achieved.
- b) Magazines should not need changing too often if this is a manual operation and mechanical loading is preferred.
- c) Mechanically motivated magazines could be attached to a belt or chain be rolled or slide freely into the output dispensing system. This involves complex control systems for either method.
- d) These systems have much to recommend them when the feeder system is manually unloaded and the operator could place them in a waiting magazine. In totally mechanised systems magazines will generally be limited to a number of special applications.

3) Complexes of tooling

- a) Systems of tracks or rails must not have bends that could cause blockage.
- b) Motivation can be difficult where gravity is not relied upon unless regular shapes such as spirals are used.
- c) The in-process store can conveniently be held whilst travelling between stations when their distance apart is large.
- d) This type of system is useful where tooling can be produced at a low cost and accurate location is important.

3.2 Feeding systems recommended

It was decided by the committee that, wherever possible, components should be fed by the vibratory bowl feeder, thus creating overall standardisation of feeders. This will result in a saving in spare parts requirements, and ease the training of operators and maintenance staff.

The advantages of vibratory bowl feeders over hoppers are:

- 1) They are highly standardised.
- 2) Different components can be completely orientated by the same bowl, with tooling modifications.
- 3) They are reliable and virtually maintenance free over a long performance life.
- 4) Controlled rate of feeding components is available.

The housing and the fixed contacts are to be fed by vibratory bowl.

The Committee considered that the insulation plate could be supplied more efficiently by being manufactured on the machine and transferred directly to the contact block assembly. The reasons for this are given in section 6.

As stated previously, the plunger assemblies and the cover and spring assembly are both unsuitable for a random automatic feeding technique. The maintaining of the assemblies in a fixed orientation, after part assembly, is essential to avoid breakdown of parts. Therefore it was decided to design a system where the parts are stored in a fixed orientation and are fed to the workheads. The in-process storage system is shown in fig. CS/01. The main reasons for the use of the spiral elevator designed as shown in fig. CS/01 are the low costs and the versatility it offers.

The motion is positive through the brushing action but not so severe as to cause high pressures on parts at the pick-off end. In general the system has the same tooling requirement as a spiral vibrator but has a cheaper and more effective motivation for the type of assemblies being held. The utilization of floor space is good and the position of the system relative to the final pick off point is not critical. The whole system is one that could be totally converted with a change of tooling which consists of the spiral coil with associated feed in and out tracks. Also, by using channel section tracks there is a possibility of different components subsequently using the same spiral coil. Other advantages can be seen in the discussion of the design in the next section.

3.3 Specification and design of feeders

The choice of a vibratory bowl feeder introduces the problem of load sensitivity. This is the reduction in feed rate caused by the reduced bulk volume. Methods of overcoming this are:-

- a) To use a bulk storage hopper which is poised above the vibratory bowl which maintains parts in the bowl at a certain level.

- b) To use a pneumatic vibrating unit which substantially reduces the load sensitivity of the system.

The pneumatic vibrating unit is marginally more expensive than the electric type, but the increase in cost is justified by the versatility of this type of unit.

The dimensional features of the untooled bowl have to be selected with reference to a particular size range of component. This is to ensure adequate storage volume and that the bowl radius to component length ratio is high enough to minimise jamming on the flight. With particular reference to the components of the contact block, the appropriate details of the bowls required are given in fig. CS/02 and CS/03 and were determined from the considerations described above.

The spiral in-process parts elevators are shown in fig. CS/01. The framework is fabricated from standard channel and tube of the structural type. The loads imposed are light and the main stresses are induced by the weight of the tooling and components in a state that can be considered as static, and not requiring allowances for dynamic effects in design.

The top and bottom armed supports are of channel section, and joined at the central point of each by a heavy gauge seamless tube. The rotating brushes are of the wooden backed 3 inch (76 mm) long nylon bristle type, with adjustable arms at the top and bottom of a fixed steel backing plate. The central rotating tubular shaft is mounted on thrust ball races to rotate on the central shaft. It carries three pairs of adjustable arms at 120° to each other. These adjusters will move the brushes outwards to contact the parts in the spiral track, as the bristle reduces in length due to wear. The adjustment must be made on a regular maintenance basis with replacement of the brushes when worn. The whole system has relatively few moving parts that can be damaged by use at the low speed of movement. The drive is made through a single phase Smiths a.c. Motor with an integral gearbox driving the central shaft through a belt and pulley system. Tension adjustment is made by means of slotted fixing holes in the motor. The speed is dependent upon the required feedrate. The speed allowed for is about 1,000 assemblies per hour.

For the plunger assembly spiral coils of 12 in (300 mm) diameter and 18 in (450 mm) in height are used. This gives a capacity of approximately 1,300 part assemblies using track design as in drawing CS/13. The speed of rotation is taken to be such that the brushing motivation is twice that of the assembly output to ensure positive filling of the outlet end of the track. The speed is calculated as follows:-

$$\frac{1000}{60} \text{ assy/min} \times 2 \text{ per assy.} \times \frac{0.5}{12} \text{ pts./assy.} \times \frac{1}{3} \text{ per brush} \\ \times \frac{1}{\pi \times 1\frac{1}{2}} \text{ rev/ft.} = 0.1475 \text{ rev./min} = 0.15 \text{ rev./min.}$$

The only difference in the N/O and N/C plunger assembly is in the tooling and these factors will be discussed in section 5.1 and 5.2.

For the spring and cover assembly a spiral coil of 18 in (450 mm) diameter and 36 in (910 mm) in height is used. This gives a capacity of approximately 1,020 part assemblies using track design in fig. CS/15. As previously, the speed is derived from:-

$$\frac{1000}{60} \times \frac{0.5}{12} \times \frac{1}{3} \times \frac{1}{\pi \times 1\frac{1}{2}} = 0.49 \text{ rev/min}$$

The load on the motor consists of frictional drag in bearings and drive and the drag on the three brushes. The expected total torque loading is very small and well within the capacity of the motor and gearing unit.

The stability of the framework and the location of the tooling coil are secured by the vertical mild steel straps, which are bolted in position at the top and bottom. With the exception of the tooling the whole frame can be paint finished. The tooling is described in section 5.2.

The concept of this design allows for variations in tooling to be easily incorporated as follows:-

- 1) Change in type or cross section of tooling can be made by bolting in the new unit.
- 2) Change in tooling diameter can be accommodated by moving the vertical support straps along slotted holes in the main member.
- 3) Change in overall height and capacity of tooling coil is accommodated by a change in the length of the brush which is screwed to the back plate.
- 4) Change in speed of feeding can be effected by alteration of final drive ratio of vee belt and pulleys.

4. ORIENTATION

The Assembly Analysis Committee, which was responsible for the design of the pick-and-place head, stated a preferred orientation for the parts at the "picking" points. The Component Supply and

Separation Committee designed to meet these requirements, which were to present the components at the pick position in the orientation in which components are to be assembled in the contact block.

For each component fed by vibratory bowl methods, the orientating tooling in the bowl was designed by theoretical methods only, and the orientation of component as it comes out of the bowl may, necessarily, be changed by the track and escapements, so that the Assembly Analysis requirements are achieved.

The method of orientating the housing and the fixed contacts within the bowls is discussed in the following pages.

a) Housing

This component is required to be at the pick-up point in the position shown in fig. CS/O2, with the open-side facing upwards. The housing was redesigned by the Committee in order to make it symmetrical, except for the fixing screw holes, about two axes.

If the housing travels along the bowl flight on either end, or on its edges, a wiper blade will reject the component. However, a component with the open face downwards will pass through the slots which are shown in fig. CS/O4. Corresponding to the position of these slots, the flight is angled down towards the bowl centre, thus causing the housing to slide back into the bowl. The housing is then situated at the outlet of the bowl in the desired orientation.

b) Contact plates

It should be emphasised that the redesign of these components meant that they were not available and ideas for orientating could not be verified experimentally.

To test the behaviour of the contact plates under realistic conditions a number of parts would have to be made; and to do this was not practicable. Therefore, the design of the orientation devices for this component serves only as a guide.

From the report of the Assembly Analysis Committee, it can be seen that there are two types of contact plate namely, N/O (normally open) and N/C (normally closed). The layout of the bowl feeders is such that both types, or a combination of both types, can be fed at the same work station.

Reference is made to fig. CS/O3 which shows the bowl layout, and is applicable to both the N/C and the N/O contacts. The contact plate is "handed", and one bowl is required for each "hand". It is recommended that double flighting is fitted into the bowl and two tracks are then used to convey the contacts to the escapement.

An alternative to this is to have single flighting, and an escapement at the bowl outlet, to feed two feed tracks. In the figure, tracks 1 and 2 convey one "hand" of the contacts, and 3 and 4 the other.

The contact blocks are of five types with -

- a) Four N/O contacts
- b) Four N/C contacts
- c) Two N/O and two N/C contacts
- d) Two N/O contacts
- e) Two N/C contacts.

Taking each case separately:-

a) Figure CS/03 applies for the general arrangement of the vibratory bowl feeders. Details of the orientating method are shown in figs. CS/05A for what is defined as the right-hand contact. Orientations B, C and D, as stated on the figure, are eliminated by the wiper. Those in orientation A travel along the flight in a clockwise direction with the silvered (or contacting) surface leading. Upon arrival at the slot in the flight, the contacting surface passes over the slot, but due to the position of its centre of gravity, the terminal end drops into the slot and the contact is then vertical. The contact is supported in a stable position by a ledge running beneath the flight over the length of the slot. This ledge supports the terminal end of the contact. Providing that the amplitude of vibration is correct, the contact will travel along the flight in this position.

When the contact reaches a position coinciding with the air jet, it is blown off the flight through a cut-out in the bowl wall. This cut-out has a profile to coincide with that of the contact. The block that is attached to the outer surface of the wall has a ledge machined into it. This ledge supports the terminal end of the contact. The contact pivots about the terminal end, so that the silvered surface is facing downwards. ie. the contact turns through 90° in an anti-clockwise direction. The contact travels along the block until it is positioned opposite the track. By arranging for an air jet to move the contact down the track, the track ledge (fig. CS/05A) will locate under the shoulder on the terminal end of the contact.

A similar procedure is used to orientate the N/O left hand fixed contact (fig. CS/05B), and both types of N/C contacts, as shown in figs. CS/06A and CS/06B.

It should be noted that the vibration unit must be changed from the bowl A position to bowl B position according to the following table:

	<u>Vibrator Unit</u>	<u>Bowl</u>
N/C contact (L.H.)	C.W. rotation	A ₁
N/C contact (R.H.)	C.C.W. rotation	B ₁
N/O contact (L.H.)	C.C.W. rotation	A ₂
N/O contact (R.H.)	C.W. rotation	B ₂

For a N/O, N/C contact block, four vibratory units are necessary because bowls A₁, A₂, B₁ and B₂ will be required. In this case one of the two flights in the bowls will have to be blocked so that only one contact will be fed.

c) Other components

The cover and spring assembly and the plunger assemblies are being placed in an in-process store. The orientation of these parts is generally conveniently achieved by the initial placement of the part from the process before storage. The orientation in an in-process storage system is dictated by the preferred attitude of the part assembly for most effective retention and motion and, where applicable, the cheapest type of tooling. The orientation required by the fed station is generally best arranged to occur just before being dispensed by twists in the track or special rotating devices.

5. TRACKING

Tracks are normally used as means of delivering parts from the discharge point of a bowl feeder, or hopper, to an escapement. A track can also serve as an intermediary escapement, or as a means of orientating parts. There are two main types of feed track: gravity tracks or powered tracks. The choice depends on the general layout of feeder and workhead and also, the required feed rate. As gravity tracks are satisfactory for the application being considered and are far simpler and cheaper than powered tracks, the Committee has decided to use these where applicable.

The feed tracks are designed to minimise the space that is occupied by the feeder. The tracks are also designed so that a buffer stock of parts is provided in them to balance out any fluctuations of feed rate and also, to allow the workhead to continue operating if a blockage occurs. Each track is designed to a precise contour depending on the configuration of the part being fed. The part is confined in a particular orientation and yet allowance is made for the part to slide freely.

5.1 Layout of tracks

The housing and the contact plates are to be fed by a vibratory bowl. The general layout of the bowls and tracks for these components are shown in figs. CS/02 and CS/03. The discharge

points of the bowl feeders are above the level of the conveyor, so that the inclination of the tracks are at least 30° to ensure that the required feed rate is obtained.

Figures CS/07 and CS/08 show the layouts of the tracking from the manual assembly stations to the in-process place unit. In essence, the whole system is one long length of track, where the coil is simply a means of compressing the space requirement.

The layout of tooling is, in all cases, dependent upon the exit from the feed station taking a path to the bottom of the spiral. This means that the lowest part of the tooling must drop to a reasonable distance below the output point of the feeding system, to provide a gravity motivated drop for parts. The part assemblies are raised to the top of the spiral and allowed to fall under gravity along the track to the escapement. Once again, the slope of the track must be adequate to obtain the desired feed rate although the conditions are different from that stated above because, normally, this section of the tooling will be full of parts. A small pressure from the parts being pushed around the spiral will improve the condition.

Figure CS/08 shows the track situated between the three manual assembly positions and the spiral elevator. This track is an open 'U' section and it slopes from the assembly positions to the spiral elevator. The assembly benches are 33 in (840 mm) in height so the bottom of the spiral will be 21 in (530 mm) from the floor level for 15° slope. The end of the track which is at the work benches is 4 in (100 mm) above the working surface.

The position of the track relative to the operators means that they will always have access to an empty track whilst the machine is continuously moving parts. The whole system, as illustrated, will require that the benches are attached to the floor and are located at a certain position relative to the spiral elevator. The track can be braced from the benches on simple mild steel supports and welded in position.

To accommodate the 18 in (460 mm) rise in the spiral, the height of the exit tooling will be 39 in (1 m) above the ground thus allowing a 9 in (230 mm) drop. This system will incorporate all N/O plunger assemblies.

For N/C plunger assemblies the sub-assembly machine feeds the spiral elevator as shown by drawing CS/09. The height of the indexing table fixture is 38 in (970 mm) dropping to the same height in the spiral coil as for the N/O plunger assembly. The system of tracking follows the shape shown by the drawing and thus uses the same angle of track out from the spiral as for the N/O plunger.

Figure CS/07 shows the plunger and spring assembly layout. This uses a 36 in (910 mm) height of tooling coil so that the top of the spiral elevator, at 48 in (1.2 m) above floor level, is taken as the discharge point. This allows an 18 in (460 mm) drop to the feed position. The height of acceptance of components from the operator will be 12 in (300 mm) above the ground and so utilize a fall of 21 in (530 mm).

The tracks take the form of broad sweeps to avoid jamming, since the component has a high length to width ratio as discussed in the next section. Take-off track presents the cover with the axis of the springs vertically below the track, before it reaches the escapement.

5.2 Design of tracks

The components that the tracks were designed for are as follows:-

- a) Housing
- b) Contact Plates (N/O and N/C)
- c) Cover and Spring assembly
- d) Plunger assemblies (N/O and N/C).

The sections on the cover and spring assembly and the plunger assemblies, give details of the track designed for the in-process store.

a) Housing

Figure CS/10 shows the cross-section of the housing track. Major dimensions have been included. It should be remembered that, to maintain the required feeding rate, the surface finish of the contacting surface must be equivalent to that of a chrome-plated surface. If mild steel is used to manufacture this track, it should be case-hardened.

b) Contact Plates

It is anticipated that the tracks used for the N/O contact will also be used for the N/C contact. Figure CS/11 shows the track cross-section with major dimensions. The position of the part in the track can also be seen on this figure.

c) Cover and spring assemblies

The tracks for all in-process stores have been restricted to channel sections throughout, to obtain an easily fabricated tooling. The material used is mild steel with a heavy chrome plated finish. The steel is tough and resilient as required for this application and the chrome plate along provides sufficiently hard surfaces for sliding without vibration and good corrosion resistance.

A standard method of mounting the tooling has been adopted. The vertical tooling location strap has been drilled at appropriate intervals to accept bolts on which the tracks are welded. Reference to figure CS/12 shows the coil and spring assembly situated between two "U" channel sections which are welded to the location bolts in the mild steel strap. It can be seen that, with these location bolts at 120° to each other around the spiral, the whole coil becomes a unit construction of two lengths of channel. The location bolts act as stand off from the mild steel straps for the coil, and centring devices for it. The inlet and outlet tracks would be blended into each end of the coil by a weld operation. To avoid damage to the chrome finish, electric arc welding must be used at these places on the outer faces, leaving those on which the components move free from welding flash.

The spring projects radially outwards from the coil to avoid interference by the brushes of the motivating system. The cross section of the inlet and outlet tracks are shown in fig. CS/12. For the tracks outside the spiral, the channels are joined by a mild steel strip as shown.

d) N/O and N/C plunger assemblies

Figures CS/13 shows the track for the N/O, N/C plunger assembly tooling. The same basic principles are used as already mentioned, except for the following differences. The location bolts are welded to the individual channels and can be used to locate the coils vertically with respect to one another, and the inlet and outlet tracks for the N/C plunger assembly will require the guide plate, which is located above the assembly as illustrated, to avoid the break-up of the plunger assembly. The N/O plunger assembly is sufficiently stable to run in an open channel, and has the same tooling as the N/C assembly in the spiral with location bolt centres at 1.00 in (25.4 mm).

The internal width of the channel is important when using tracks which have bends in them, since this could create a condition of jamming. Reference to fig. CS/14 shows the condition of minimum clearance where track width must be at least $E + X$. E , Y and R are known and X may be found by use of intersecting chord and diameter principle.

$$\text{Thus } \frac{Y}{2} = X \times (\text{remainder of outer diameter})$$

$$\frac{Y}{2} = X \left(2R + \frac{E}{2} + X \right)$$

$$\text{This becomes } X + (2R + E)X + \frac{Y}{4} = 0$$

X is very small compared with the diameter and can thus be ignored. (If it is required to calculate minimum radius permissible this is discussed in ref. 6.)

$$X = \frac{-Y}{8R + 4H}$$

The negative sign has no significance for this calculation and will be ignored.

For the cover and spring assembly:-

$$R = 9 \text{ in, } Y = 1.25 \text{ in, } H = 0.2 \text{ in}$$

$$X = \frac{1.25}{(8 \times 9) + (4 \times 0.2)} = 0.0216 \text{ in (0.55 mm)}$$

$$\text{Min. width of track} = 0.2216 \text{ in (5.6 mm).}$$

It can be seen that the approximation of Y and H has no practical effect on the result. To allow for the purchase of standard channel it would be preferable to buy 0.25 in (6.35 mm) width channel.

For the plunger assembly:-

$$R = 6 \text{ in, } Y = 0.5 \text{ in, } H = 0.35 \text{ in.}$$

Similarly, the minimum width of the track = 0.355 in (9.0 mm). A standard channel of 0.375 in (9.5 mm) internal width would be used.

5.3 Design of track to transfer assemblies from the assembly machine to the fixing screw workhead.

After the functional inspection stage it is necessary to reject all incorrect assemblies. To reduce the size of the main machine, it was decided to reject the assemblies on a track prior to the fixing screw head. The acceptable assemblies still require the fixing screws to be placed, before the assembly is completed and they are placed in a subsidiary track. The contact block is positioned under the fixing screw head by the contact blocks which are waiting for assembly, pushing the end contact block against a stop.

This method of positioning was decided upon because of its simplicity and the positional accuracy required is relatively great. After the fixing screws are placed an air jet is used to blow the contact block from the assembly position to another track, where the assembly falls by gravity into a tray, from which they are packed. A layout of the track is shown in fig. CS/15.

The following specifications are required at this workstation:

- a) the track must be able to transfer assemblies and still maintain the orientation of the part.
- b) a method of rejecting unacceptable assemblies must be incorporated within the track.
- c) the track must be designed so that an assembly will be positioned accurately enough for the placing of the fixing screws.

Design of the track

A drawing of the track is shown in fig. CS/16. It is inclined at an angle of 30° , and designed so that the contact block will be able to slide with the plungers face downwards. The contact block falls down the track by gravity and is stopped at the end of the track, where it is sensed by a back pressure fluidic sensor. When a contact block is in position, it sends a signal to the workhead to commence the assembly cycle. Two back pressure sensors are required because one is used for hole mounted contact blocks, and the other for base mounted ones. As the positioning of the contact block depends on gravity alone, it was decided to calculate the required length of full track to ensure a delivery rate of at least 1 component per second, and is shown in Appendix V. From the appendix it can be seen that the track is required to have at least 3.5 in (89 mm) of components from point "A", before the required feed rate is attained.

Design of rejection mechanism

A drawing is shown in fig. CS/17 of the rejection mechanism, and it is placed at the top of the track as shown in fig. CS/15. A section of the track is hinged and is opened and closed by a pneumatic cylinder. The hinged track is normally in its closed position, so that acceptable assemblies are allowed to slide to the fixing screw head. When a reject signal is received from the inspection stage, the hinged track is opened by releasing the pressure in the cylinder, and the rejected assembly falls through the track into a scrap bin.

6. ESCAPEMENTS

An escapement is a mechanism which is usually designed for a particular type of component to separate a specific number of components in the feed track, and allow them to move to a position ready for picking or for direct assembly. An escapement can also be arranged to act as a final orientating mechanism.

All of the escapements that are designed by the Committee are activated by a condition of the pick and place unit. The control of the escapements are shown in detail in the report of the Control and Motivation Committee.

The escapements are designed specifically to satisfy the requirement of the Assembly Analysis Committee, that all components be presented in their relative positions in the contact block at the outside of the machine track adjacent to the pick and place unit.

Escapements are used for the following components:-

- a) Housing
- b) Fixed contacts (N/O and N/C)
- c) Cover and spring assembly
- d) Plunger assemblies (N/O and N/C).

a) Housing

The end of the housing track has a section of length 1.75 in (45 mm) as shown in fig. CS/18, which is designed to elevate 0.313 in (8 mm). Thus, as a housing moves into this section, a sensor activates a 0.312 in (8 mm) bore pneumatic jack. This housing is then lifted so that both of its ends are clear for the pick-and-place unit claws to contact.

b) Contact Plate

Reference is made to fig. CS/19. The tracks are numbered in the same sequence as those shown on figs. CS/05 and CS/06.

The orientation of the contacts at the end of the tracks is the same as they will be when assembled (as described previously). The remaining operation is to move the contacts to the same relative distances as in the contact block. This is carried out with pneumatic jacks A, B, C and D. The sequence of movements of the contact will be described, and this will apply to the others when taken in turn. The fig. CS/19 shows the arrangement for the N/C contacts, but an appropriate spacer has only to be fitted on face W to accommodate the N/O contact.

Consider the N/C contact in track 3. The terminal end is leading in this case, and it slides forward so that it rests on the ledge shown in section on the right hand of the main view. When the contacts are in position, ready for picking and placing, the proximity sensors maintain the jack in the position shown in the figure. With no contacts in position for picking, the jack operates, thus pushing the contact forward into the approximate position. The sensor senses the presence of the component, and sends a signal to return the jack. By the time that the jack is in line with track 3 the contact will be in place, ready for pushing. A pawl, which is fitted to the jack end, will then lift to ride over this contact. Adequate space must be available for the pawl to return to the vertical. The sequence is then repeated.

For the N/O contact, a shorter pawl must be fitted to the jack end.

c) Cover and spring assembly

The escapement for the cover and spring assembly consists of a roller, held in contact with the cover by spring pressure, which indexes each unit. The principle relies on the diameter of the roller being such that the circumference is slightly larger than the length of the component over which it rolls. In this case a diameter of 0.4 in (10.2 mm) provides an excess of 0.025 in (0.63 mm) on circumference. This will be allowed for by slip of the roller and has the additional function of providing a firm location of the part against the sensor at the take-off point at the end of the track.

The sensor, as shown by the detail on figure CS/20 is operative in the following way. The input and output are both 0.032 in (0.79 mm) diameter and the third aperture, which provides the signal when blocked, is 0.062 in (1.59 mm) diameter. Air passing through the inlet will normally be exhausted through the large aperture which, when blocked, will signal to the output.

The motivation of the roller is provided by a single phase Smiths a.c. motor with integral gearbox. The speed of rotation must be such that one rotation can be made before a pick and place unit can complete one cycle. The closest available gear ratio on a motor would provide a speed of rotation of 30 revolutions per minute. The gear ratio is sufficiently large to create a drag that will stop the motor as soon as the power is removed. A small pawl device in the gear train will stop the tendency for components to force the motor round, and allow further components through. The roller and shaft are integral parts machined from Tufnol.

The switching of the motor is performed by the switch circuit unit. This unit is machined Tufnol with a disc of copper set in thermo-setting plastic mounted on the inside end of the shaft. The copper disc has a cut out in its edge shown in the front elevation on the drawing. Two copper contacts are mounted in the contact support plate and bear on the copper disc under spring pressure. The contact nearest the centre of the disc is always in contact with the copper disc and the other contact is not when the position shown in fig. CS/21 is occupied. It can be seen that, if these contacts are positioned in one power lead of the motor, the motor will only rotate whilst both contacts are touching the copper disc. By means of a signal to short circuit the contacts, which will last only long enough for both contacts to touch the now rotating copper disc, one complete revolution will be made. The short circuit signal is provided by the fluidic logic circuit from the sensor and pick and place unit. The control system is shown in the Control and Motivation Committee Report, fig. CM/24.

The complete system is mounted along the track remote from the pick position.

As shown by the fig. CS/21 the cover is secured by the channels except at the end position where it can be picked vertically.

The sequence of operations is:-

- a) one cover and spring assembly is picked, and the pick and place unit signals the motor to start turning.
- b) one complete rotation of the roller moves the next assembly into position.

The choice of escapement was based on the following factors:-

- 1) the assembly is delicate due to the coil springs being only "clipped" in position and thus difficult to handle.
- 2) the features of the assembly available for handling are not readily located.
- 3) the flat surface lends itself to indexing by surface contact.
- 4) the method used is versatile in that the roller diameter is the only item to be changed for different feed lengths. Other indexing methods involve fixed distance index mechanisms.

d) Plunger assemblies (N/O and N/C)

The escapement for the plunger assemblies is shown in fig. CS/20. The primary requirement was that components must be taken from the in-process store and placed under the pick and place head in the correct positions. The drawing, therefore, shows the escapement and positioning system. Basically the motion consists of two Tufnol sliders moving parallel to the track and mounted on a carriage moving perpendicular to the track on fixed guideways. The vaned wheel restrains the flow of components whilst the sliders and carriage are positioning the plunger assemblies.

The motions are performed by pneumatic, double-acting, miniature cylinders. Slide A has a stroke of 2.5 in (64 mm). Slide B has a stroke of 1.5 in (38 mm) and Slide X has a stroke of 0.25 in (6.5 mm). The pneumatic cylinders for the sliders are mounted on the carriage and contact fluidic sensors at positions A out and B in. The carriage movement is monitored fluidically at X IN and X OUT. The X movement pneumatic cylinder is mounted on an angle section carrier welded to the fixed guideways and operates through a lug welded to the carriage. The A and B slide cylinders are mounted on

the carriage. For clarity, the cylinders and sensors are shown only in the plan view. The sensors are back pressure and are the same as those for the cover and spring assembly escapement; they are shown in fig. CS/21.

The object of providing these movements is to motivate the fingers which move the plungers. The slider on the A slide projects through the bottom plate of the carriage to depress the spring loaded release rocker when the carriage is in the X OUT position. The effect of this is to free the vaned wheel which has a projecting fin resting on the release rocker, when it is not depressed. The assemblies will tend to push the wheel on to this stop position due to the pressure from the spiral elevator pushing and the weight of parts in the track immediately before this escapement. The projecting fins are positioned to allow rotation of two vanes to take place.

The sequence of operations is as follows from the position shown in the drawing, which is the picking position. The two interruptible jet sensors are signalling the presence of two plungers and sensors S₁, S₂, S₃, S₄ signal slider and carriage positions.

- 1) the two plungers are picked and the logic from the pick and place unit and the interruptible jets signal the start sequence.
- 2) sliders move to slide A OUT and slide B OUT positions to contact sensor S₃, which is bonded below the carriage, and block the interruptible jets. This will drop the release rocker to fall before the next projecting fin rotates into position. This allows two plunger assemblies to move into position and replace the previous two.
- 3) the fingers are withdrawn by movement of the carriage to X IN position, which produces a signal on the sensor S₂, which is bonded below the carriage, by bringing it to contact the angle section carrier.
- 4) the sliders move to A IN and B IN positions producing a signal on sensor S₄, which is bonded to the upper face of the carriage, by bringing the slider to block the aperture.
- 5) The carriage moves to the X OUT position so that the fingers contact the plungers and depress the release rocker. This movement frees the vaned wheel and the fingers hold the assemblies back. The sensor S₁ is bonded to the topside of the carriage and is blocked by contact with the side of the track.

The Control and Motivation Committee's Report, fig. CM/22 gives details of the logic.

The mechanism is fitted to both N/O and N/C plunger assemblies with minor modification to the track as shown in fig. CS/22. The plungers are lifted by contact with the vaned wheel, to allow the pick off point of the plunger to project for contact by the fingers.

To allow for only one plunger to be picked either finger may be removed as appropriate by unscrewing it from the slider. So that only one plunger assembly can be released, the vaned wheel is removed and replaced with its opposite face to the release rocker. This face has fins projecting at positions for one vane movement.

The choice of escapement was greatly biased by the requirement to take two plungers from a bulk supply and position them accurately. To use two feed tracks requires two sets of tooling, which is expensive. A twinned system of rails at the feed end requires a mechanism of some complexity to operate from the single rail of the spiral elevator. A positioning mechanism, as described, appears to be the simplest solution to perform all the operations required.

7. MANUFACTURING HEAD FOR THE INSULATION PLATE

The possible methods of feeding this component are:-

- 1) by a hopper or vibratory bowl, then stacking into chutes and transporting to the workhead.
- 2) by loading into magazine form and feeding automatically.
- 3) by manufacturing the plates from a strip, and automatically placing the parts into the assembly.

Method 3 was chosen as it is reasonably simple to produce these plates, and this method eliminates tracks and escapements required in Method 1. Also, from P.E.R.A. Report No. 54, a vibratory bowl is not recommended for very light thin parts. Method 2 was disregarded as it increases the workload on operators, and shows no advantage over Method 3.

A requirement of the Assembly Analysis Committee was that the insulation plates be placed four, or two - depending on switch, at a time into the assembly. As it is not practical to pick and place this component, due to its shape, the manufacturing head must be able to feed the components directly into the assembly. Therefore the head must be placed directly above the track and be adjustable in the x, y and z planes for setting up. The machine must be able to continue feeding components while loading therefore, some type of in-process store is required.

Description of the design of a manufacturing head

A drawing of the head is shown in fig. CS/23. The plates are produced from a strip of material, which is in roll form. The rolls of material are on a reel consisting of four sections. The reel runs on plane bearings, and can be quickly changed when reloading. The strips are fed through feeding rollers into the shearing block and the plates are then sheared to size. They then move to the position where the plates are blown into the in-process store.

When an assembly is in position for the plates to be placed, the in-process store is indexed and the plates drop into the assembly with the assistance of an air jet.

Feeding rollers

The feeding rolls consist of one driven roll, and one free running roll. The driven roll is shaped as shown in the drawing and it is desirable to have a rubber coating for higher friction, and to give some compressive force on the strip, so that feeding is possible, the clearance between rolls is a few thousandths of an inch smaller than the thickness of the insulation material.

The feed rollers are motivated by a pneumatic double acting cylinder moving a rack, which rotates the pinions on the end of the driven rolls. The pinions are connected to the feed rollers shaft by a ratchet clutch arrangement, which allows the shaft to be rotated in one direction only, as shown in fig. CS/24. In order that the pinion does slip in the reverse direction, the shaft is restrained slightly by a friction pad, as shown in the figure. The friction pad should be made of a non-metallic material such as Tufnol, and the frictional force adjusted, by altering the compressive force in the spring, until the pinion slips on its shaft in the reverse direction and rotates the feed rollers in the forward direction.

In-process store

As stated, an in-process store is required so that feeding of components continues while loading of strip is performed. The in-process store consists of a drum, which can receive and present four insulation plates from the manufacturing head to the assembly at one time. The drum, designed and shown in drawing fig. CS/23, has a store of five sets of insulation plates but larger stores can be achieved by increasing the diameter of the drum.

The drum is index one-tenth of a revolution at a time and the indexing mechanism is shown in drawing fig. CS/25. As can be seen from the drawing, it is a ratchet and pawl arrangement, where the ratchet is fixed to the in-process store drum shaft by a key, and the pawl is used to index the ratchet. The drawing shows the pawl and ratchet after an indexing movement, while the dotted lines show

the pawl fully retracted to start another indexing movement. The pneumatic cylinder is single acting with a 0.625 in (15.9 mm) bore and 0.5 in (12.7 mm) stroke.

The drum is required to be positioned accurately, when indexed, so that the insulation plate slots are in line with the guiding slots. This is achieved by machining 10 indents, positioned equally, at a fixed distance from each other on the drum, and a spring loaded ball locates into these indents, as shown in the drawing.

Sensing required

It is possible when reloading the head to have an empty space, in the in-process store. Therefore, some type of sensing of the insulation plates is required to ensure that each assembly is supplied with all its plates. When all the plates are not sensed in the guide slots, the assembly is registered a reject and the cycle continues to receive the next assembly. The sensors are back pressure fluidic devices, which are situated in the guide slots as shown in the drawing.

Sequence of events and control of head

The sequence of events is shown in the form of a flow diagram on page 26.

A signal from the platen jacking system is sent to the manufacturing head, indicating that the assembly is present. This signal starts the cycle of the head. It is required to sense if all plates are present in the guide slots. If no plates are sensed the cycle continues and actuates a reject signal.

Back pressure fluidic sensors are placed on the stop on the indexing mechanism and on the rack so that the position of the pneumatic cylinders can be known.

The control of this head is shown in the Control and Motivation Committee's Report.

8. DISCUSSIONS AND CONCLUSIONS

The mechanism and layouts described in this report are considered the most suitable, technically and financially, to fulfil the requirements laid down by the terms of reference and the needs of other committees.

The redesign of the housing greatly reduced the complexity of the orientating mechanism required for this part but, unfortunately, an inevitable redesign of the contact plates increased the difficulties of feeding this component.

From investigations into feeding systems, it was found that the vibratory bowl hopper is the most suitable feeder for a versatile automatic assembly machine. This feeder can be used effectively with components of various sizes and configurations.

When the particular components of the contact block were considered, it was found that, although a vibratory bowl feeder had the greatest versatility, it was not always practically and technically possible to use this feeder. Therefore, some particular components and sub-assemblies required special feeding equipment to be designed. The in-process store for the sub-assemblies, although specially designed for these parts, is versatile and can be used to feed a variety of components without modifications.

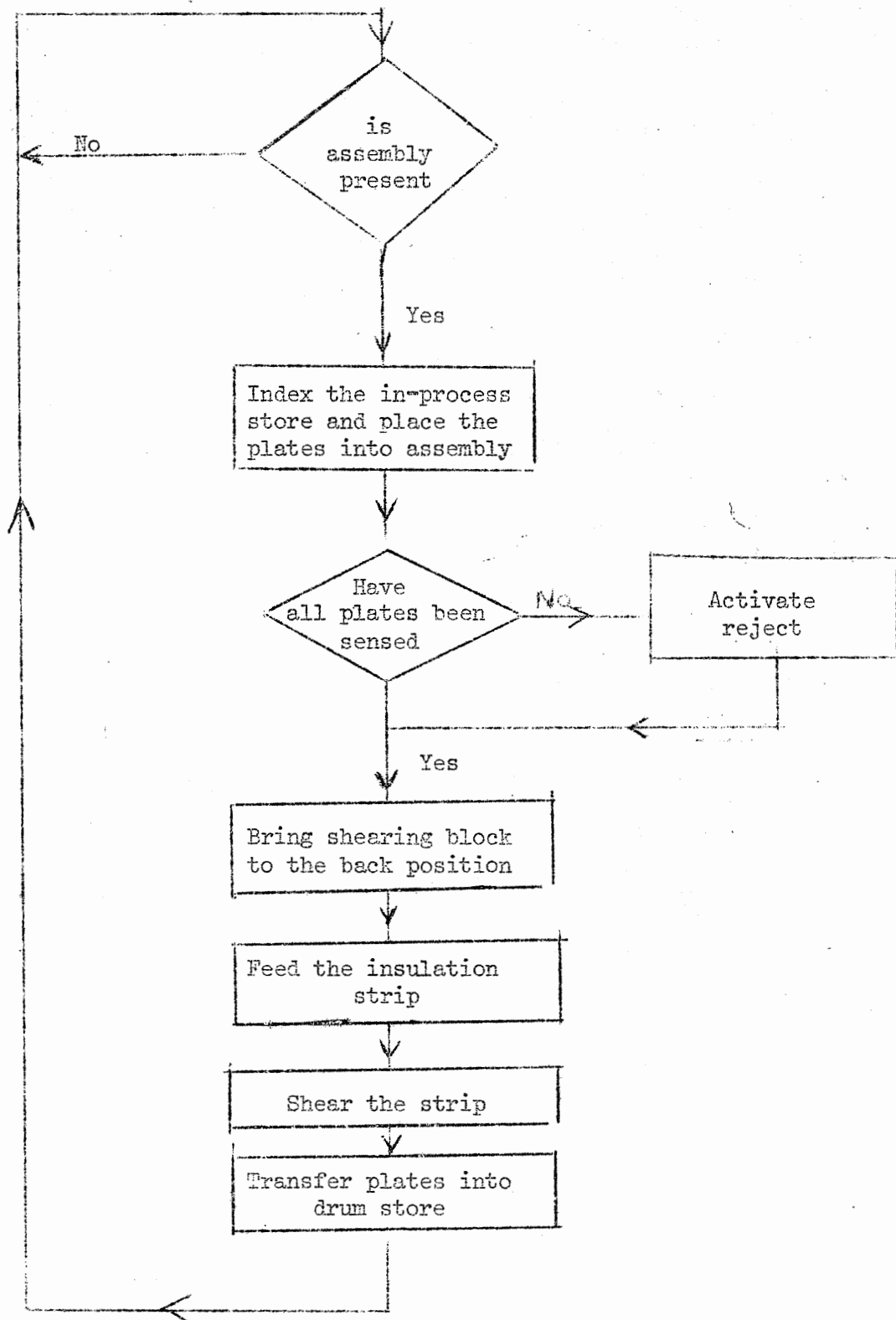
The only type of equipment which has had a rigorous analysis of performance made on it is that which works on the vibratory principle. Consequently, standardisation has been made by manufacturers in this group of feeders. This means that the choice of a feeder is often dictated by the availability and not the suitability for the application.

From the investigations, the following general conclusions on feeding systems are shown to be relevant:

- 1) feed rates must be established before decisions are made on feed mechanisms.
- 2) value analysis of parts to be fed, biased by the needs of automatic assembly, is essential.
- 3) parts which present highly undesirable features, from the point of view of automatic feeding, should be treated as a special project.

It is an interesting observation that the tooling development costs of a vibratory bowl feeder can be as high as two and a half times that of the basic equipment.

Flow Diagram



9. REFERENCES

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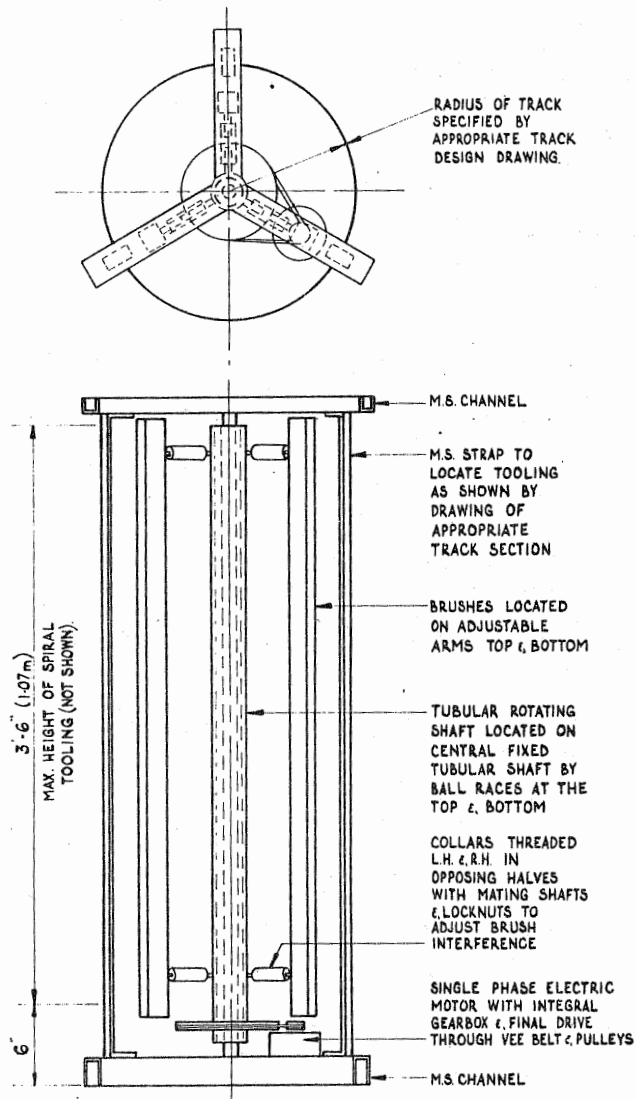
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6. G. Wittenberg Methods and Equipment for Mechanised
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7. R. Iredale Automatic Assembly - Feeding and
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11. LIST OF FIGURES

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CS/03	General layout of contact plate
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CS/05A	Bowl feeder track and orientation devices (RH, N/O contact)
CS/05B	Bowl feeder track and orientation devices (RH, N/C contact)
CS/06A	Bowl feeder track and orientation devices (LH, N/C contact)
CS/06B	Bowl feeder track and orientation devices (LH, N/O contact)
CS/07	Layout for feeding cover and spring assembly
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CS/22	Modification to track to use plunger assembly escapement
CS/23	Manufacturing head for insulation plates
CS/24	Feed rolls for manufacturing head
CS/25	Indexing mechanism for drum store.



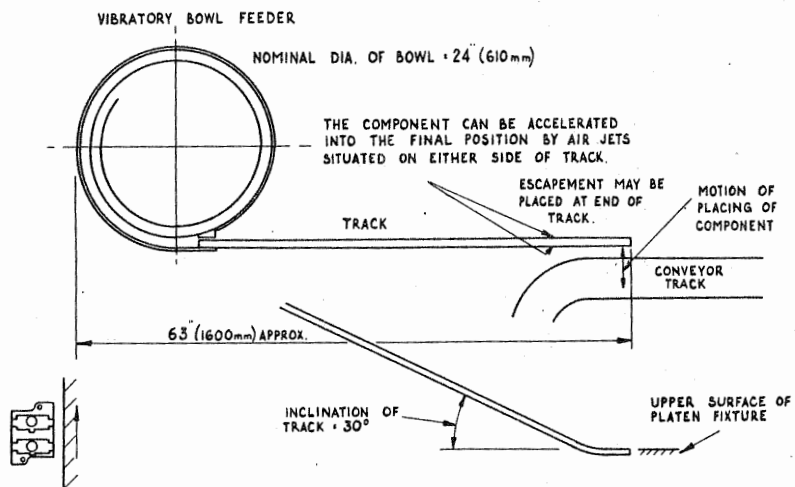
1968/69 GROUP DESIGN PROJECT

TITLE:-

SPIRAL ELEVATOR (IN PROCESS STORE)

DRG. NO

CS 01



VIEW SHOWS RELATION BETWEEN FINAL POSITION OF COMPONENT & CONVEYOR TRACK.

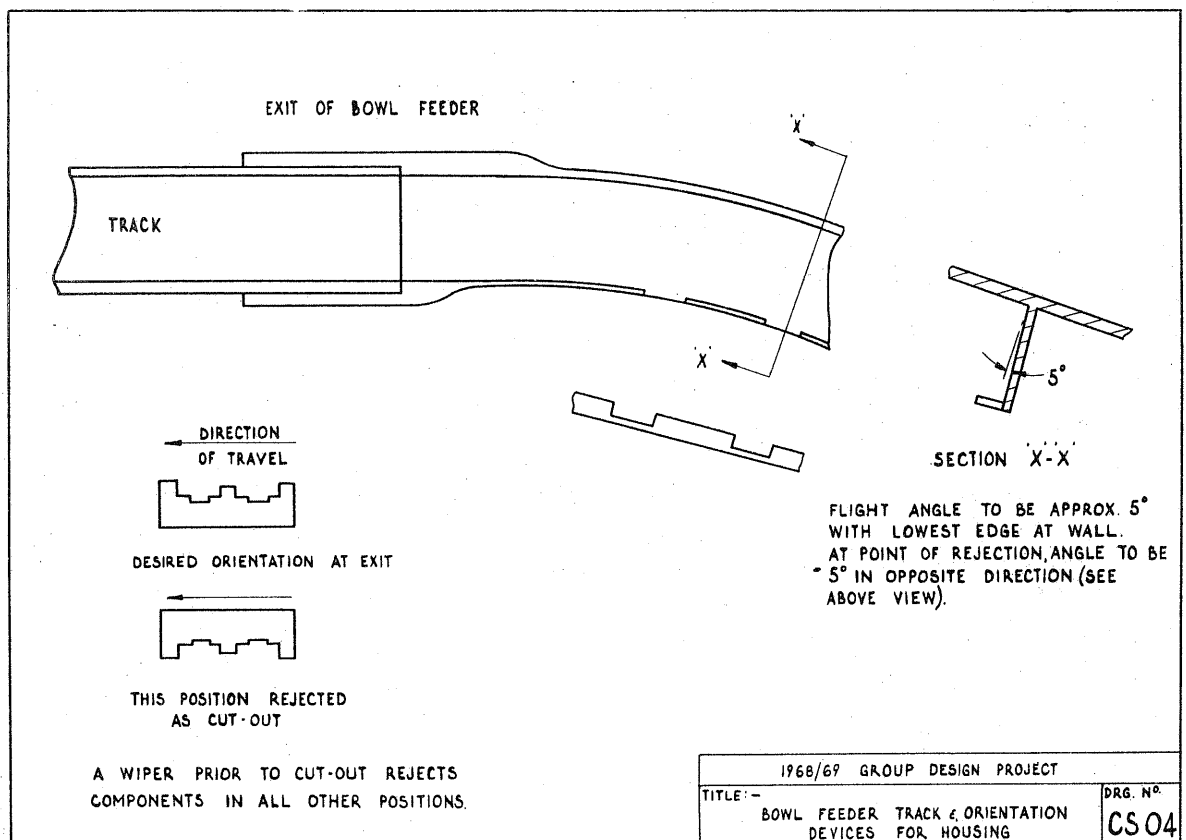
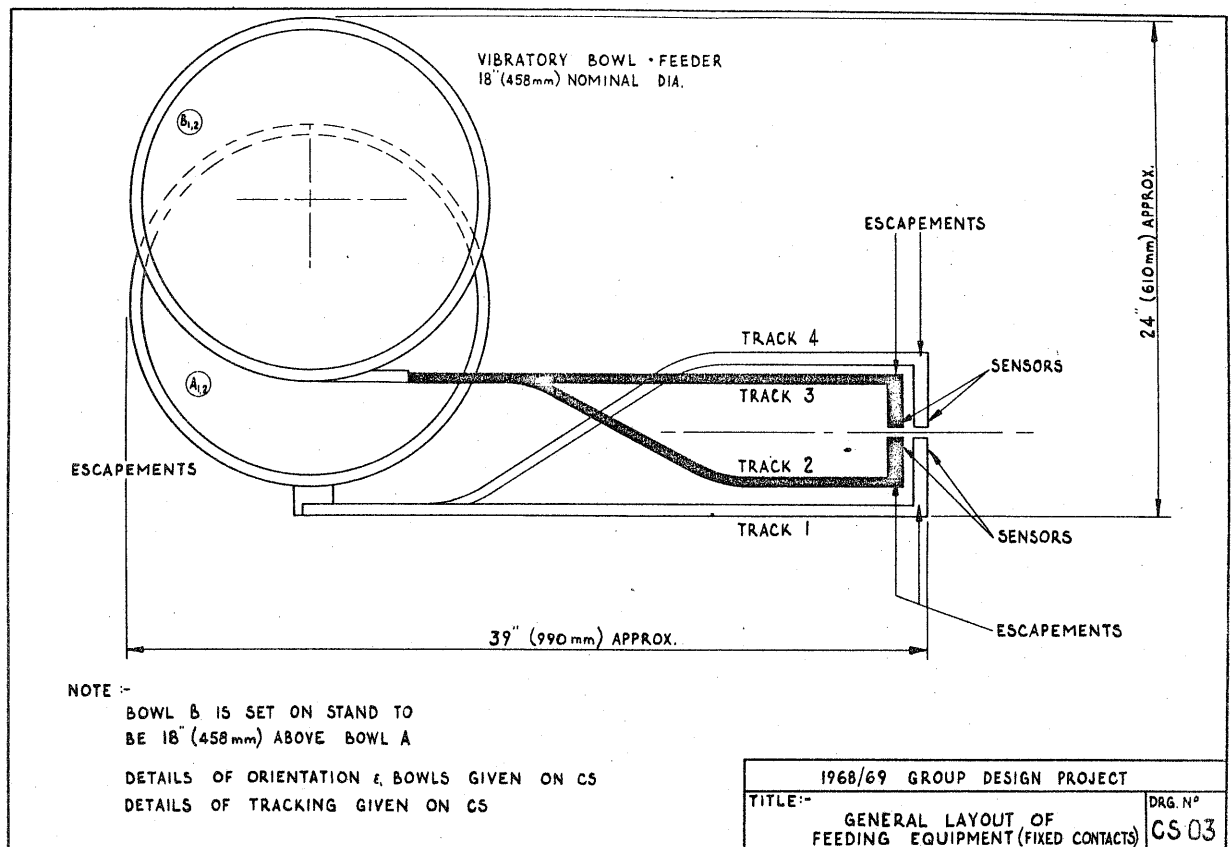
1968/69 GROUP DESIGN PROJECT

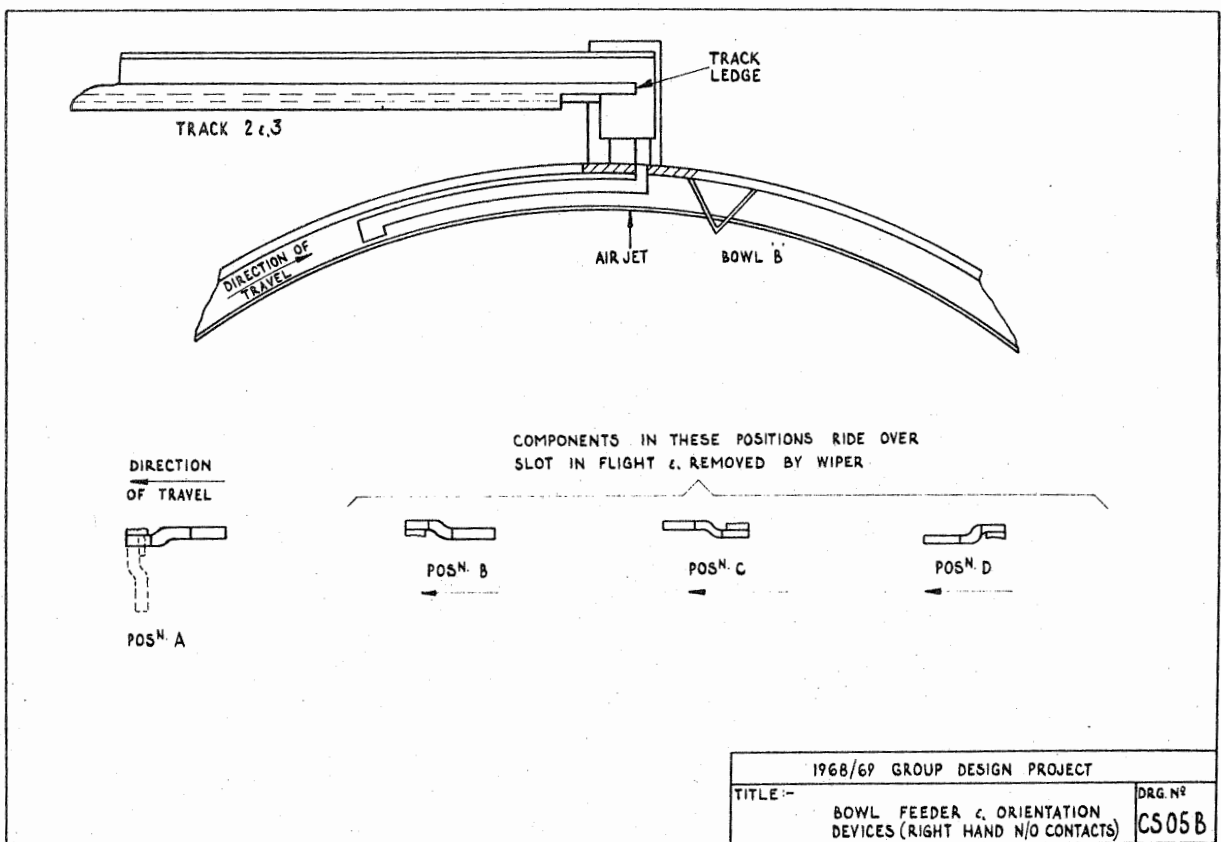
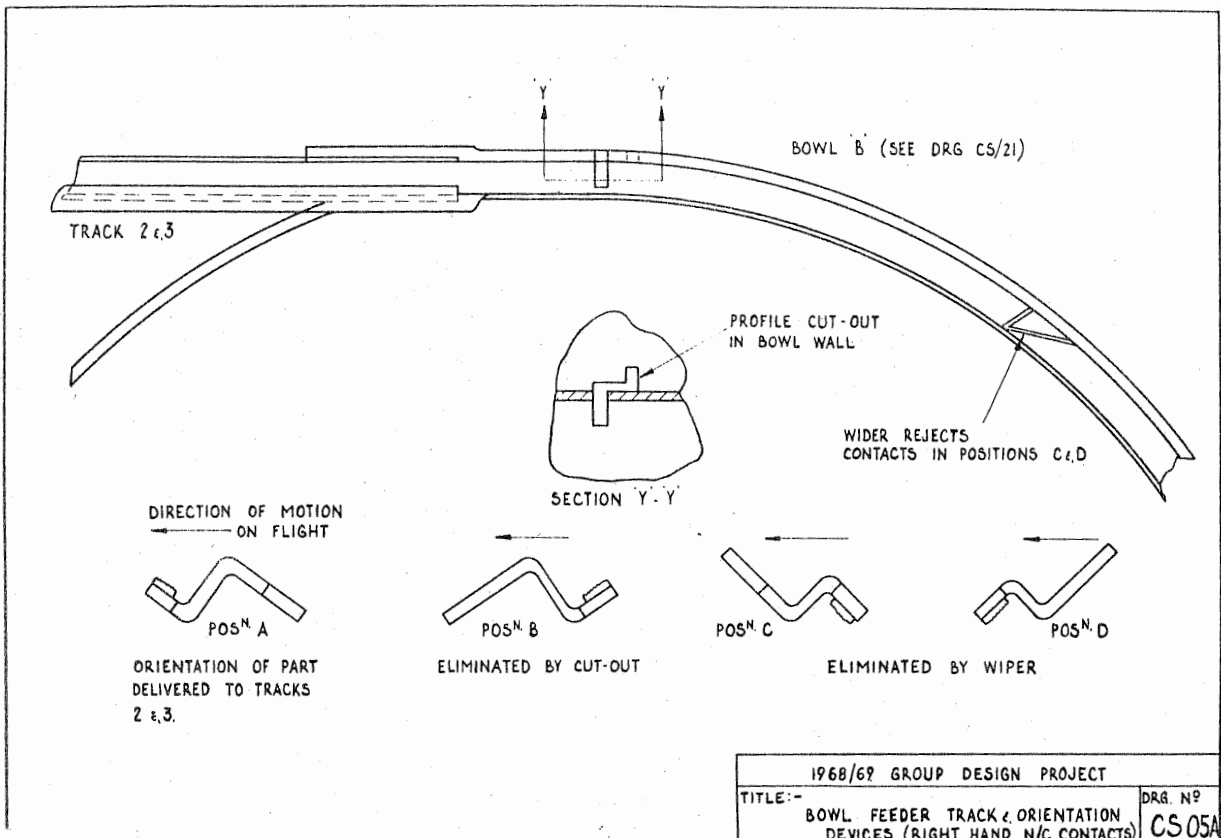
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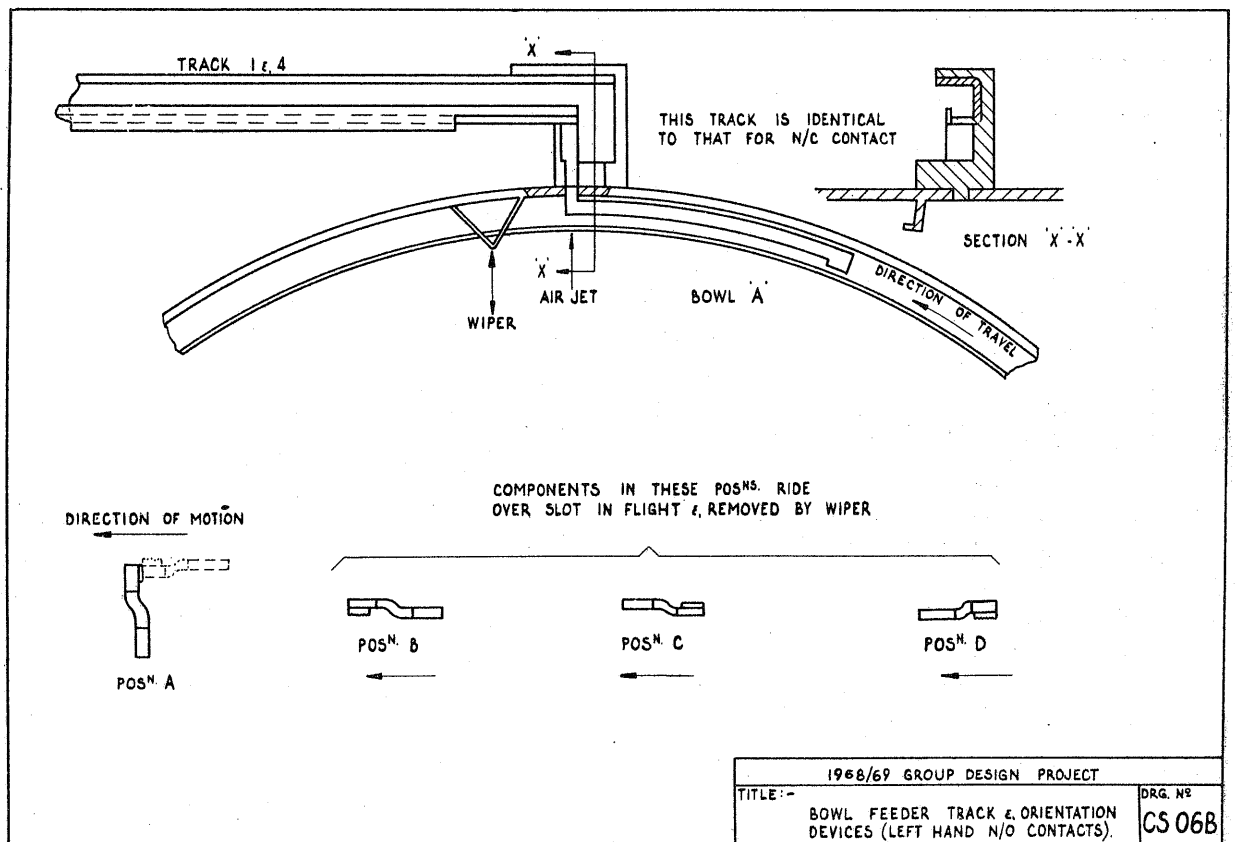
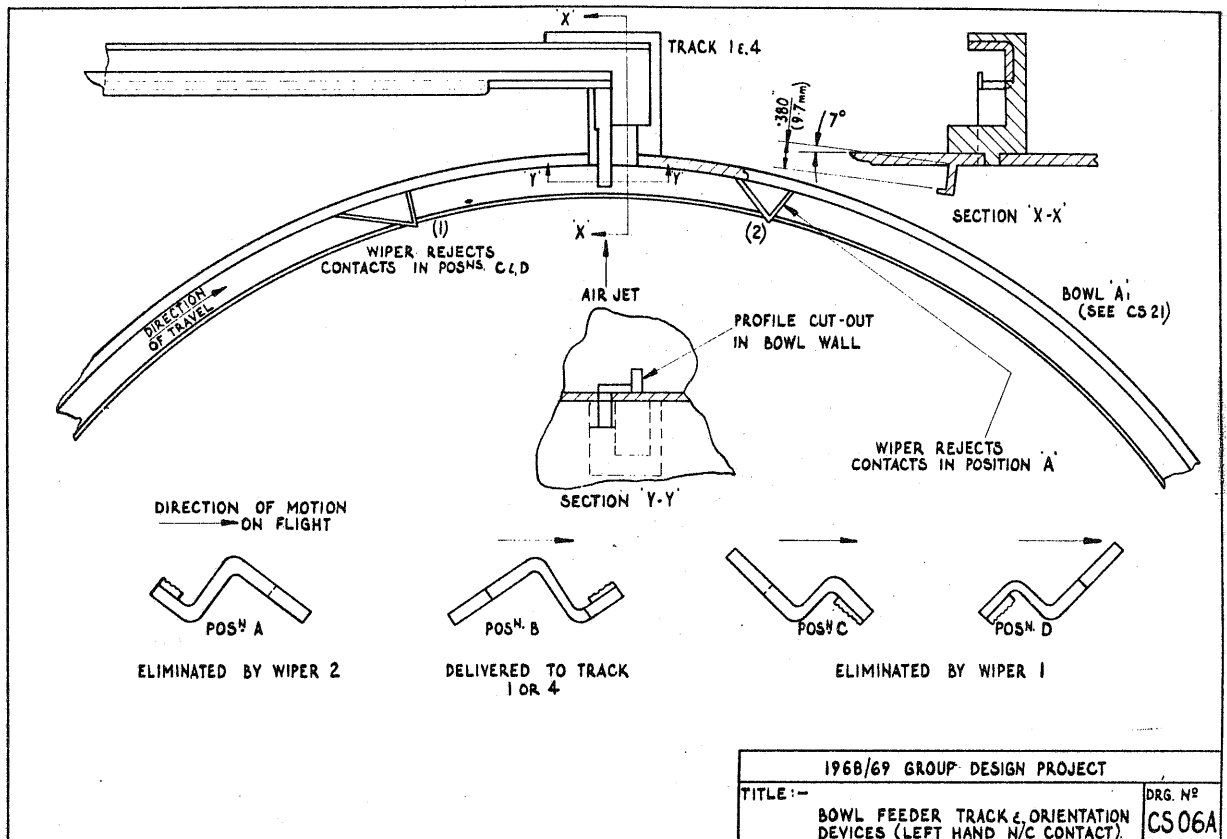
GENERAL LAYOUT FOR SUPPLY OF HOUSING

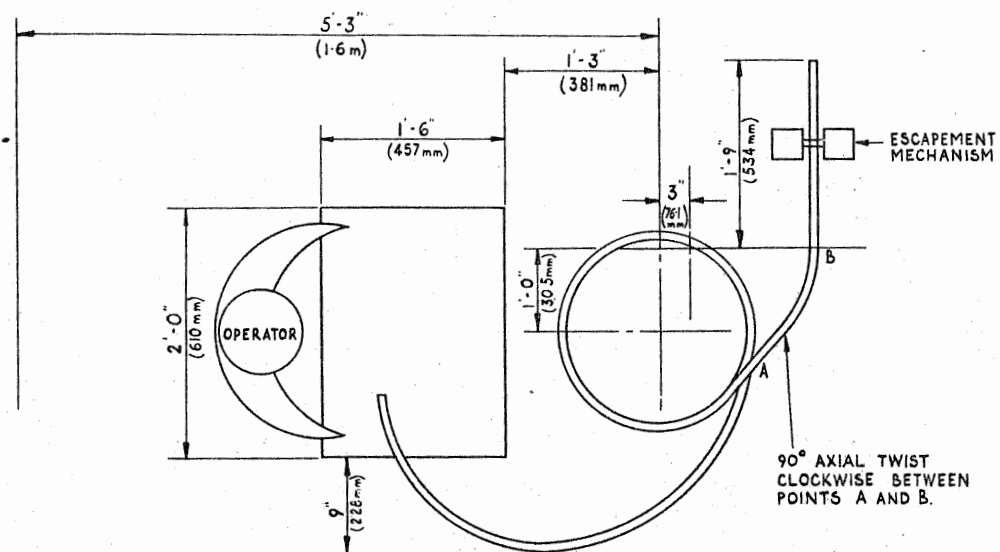
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CS 02

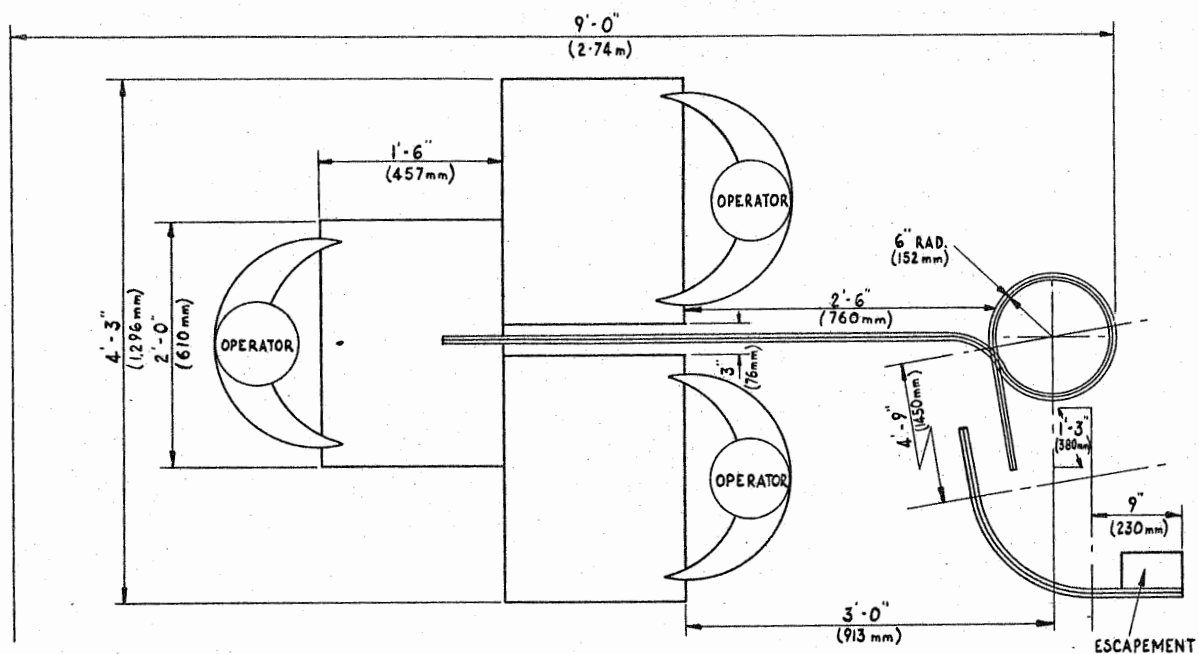




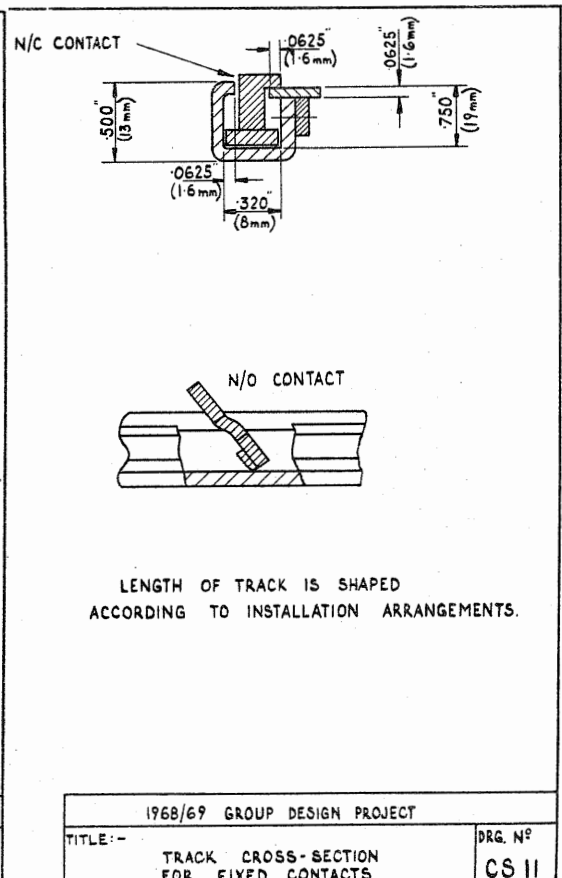
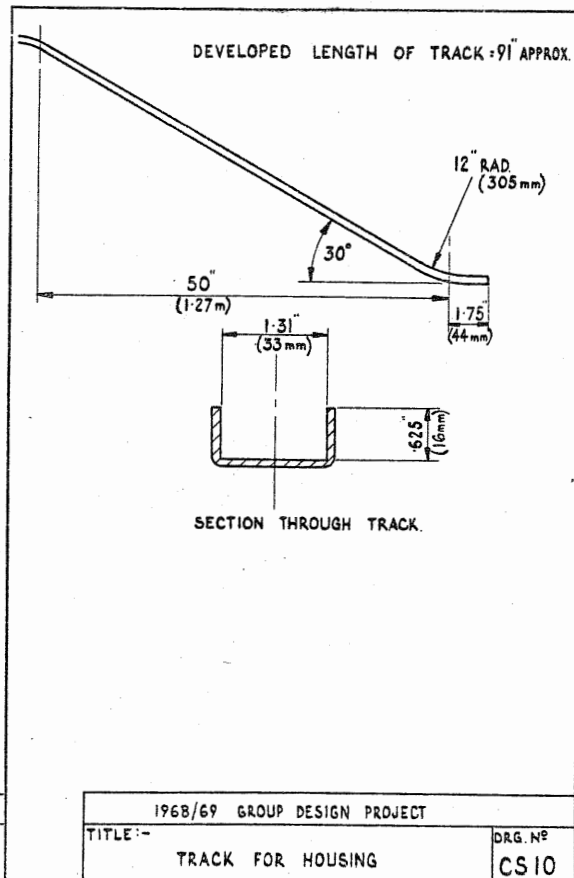
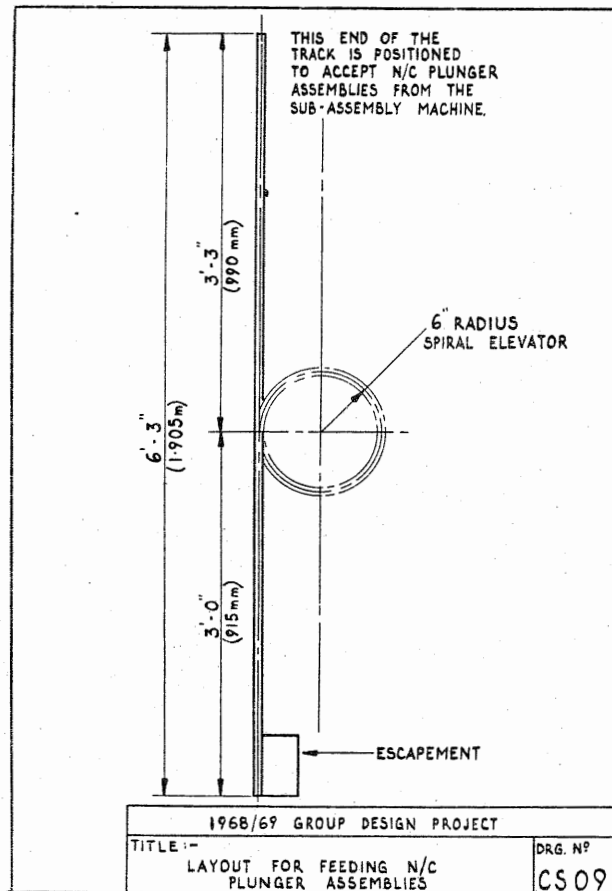




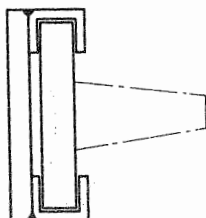
1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG. N ^o
LAYOUT FOR FEEDING COVER E. SPRING ASSEMBLY.	CS 07



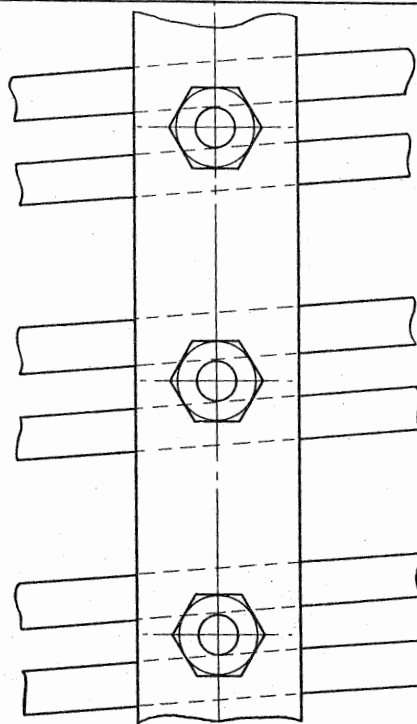
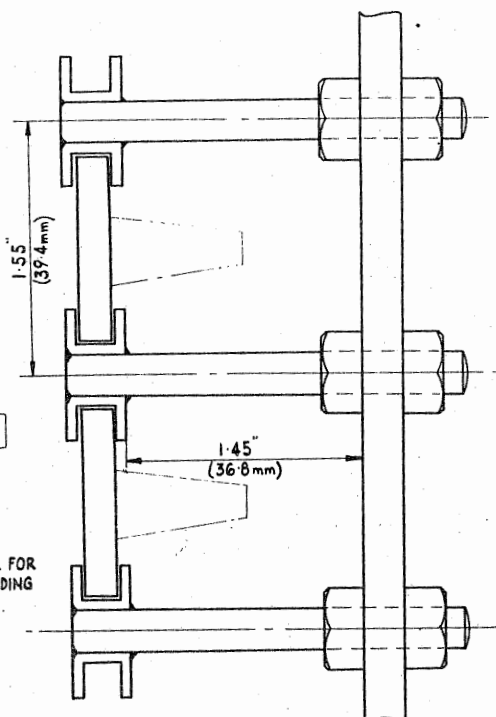
1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG. N ^o
LAYOUT FOR FEEDING N/O PLUNGER ASSEMBLY	CS 08



0.5" x 0.125" (12.7mm x 3.2mm)
M.S. STRIP WELDED IN
POSITION AT 6" INTERVALS

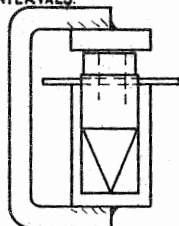


CROSS SECTION OF TRACK FOR
PORTIONS OF TRACK FEEDING
IN OR OUT OF THE SPIRAL.

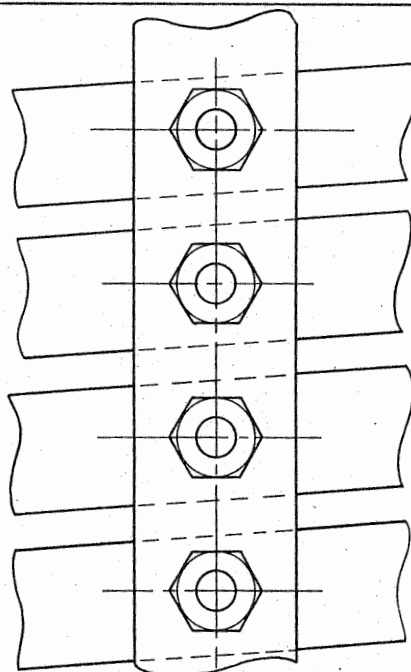
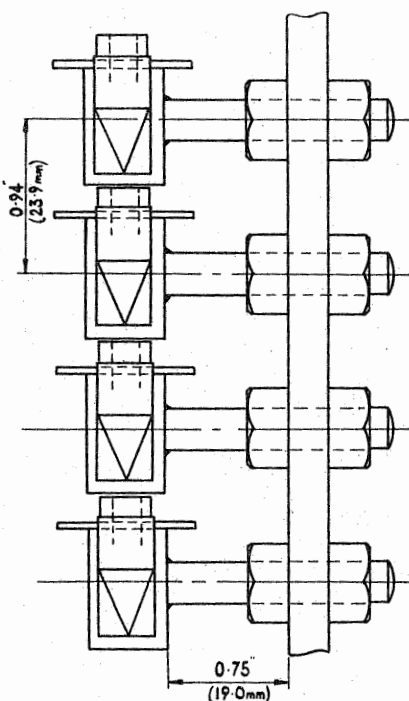


1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG. NO.
TRACK FOR COVER & SPRING ASSEMBLY	CS12

0.5" x 0.125" (12.7mm x 3.2mm)
MILD STEEL STRIP BRACKETS
HOLDING A CONTINUOUS STRIP OF
0.5" x 0.125" GUIDE PLATE OVER
ASSEMBLY WELDED IN POSITION AT
6" INTERVALS.

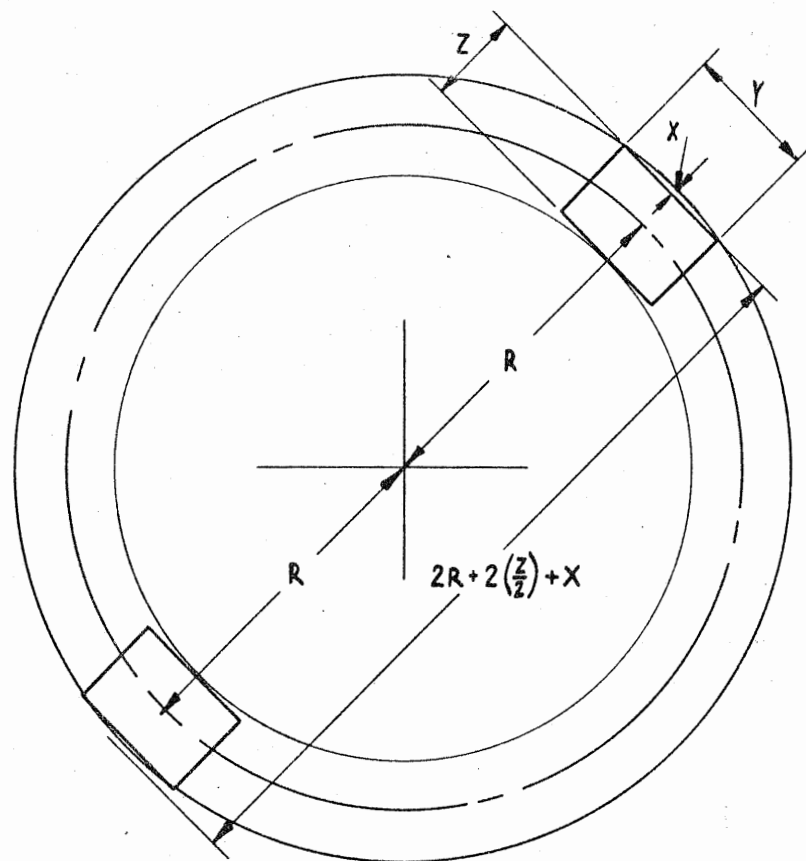


CROSS SECTION OF TRACK FOR
PORTIONS OF TRACK FEEDING
IN OR OUT OF THE SPIRAL.



N/C PLUNGER AS ILLUSTRATED FOR N/O PLUNGER ASSEMBLY
THE DISTANCE BETWEEN LOCATION BOLT CENTRES WOULD BE
1.00" (25.4mm).

1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG. NO.
TRACK FOR PLUNGER ASSEMBLIES (N/O N/C)	CS13



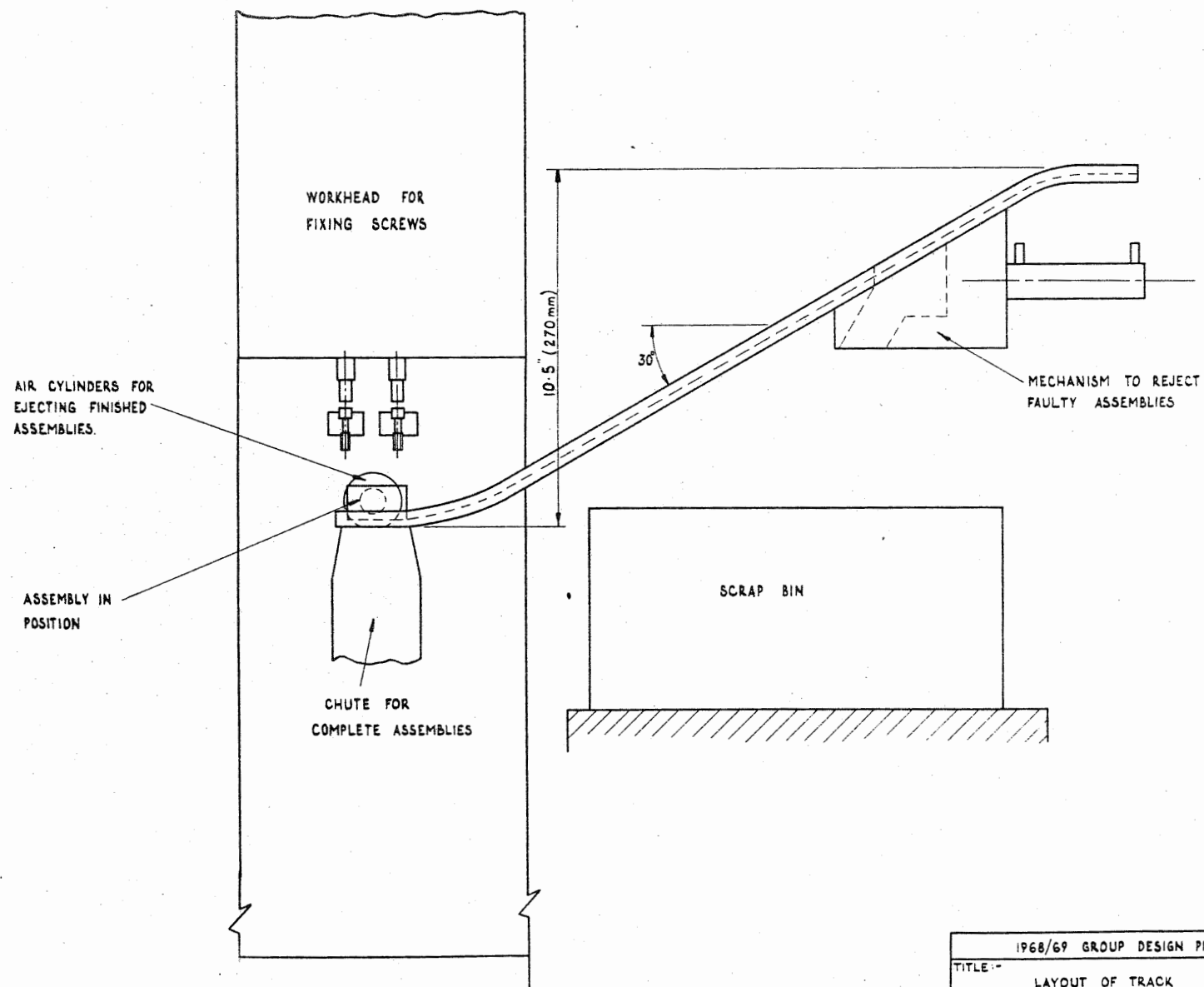
1968/69 GROUP DESIGN PROJECT

TITLE:-

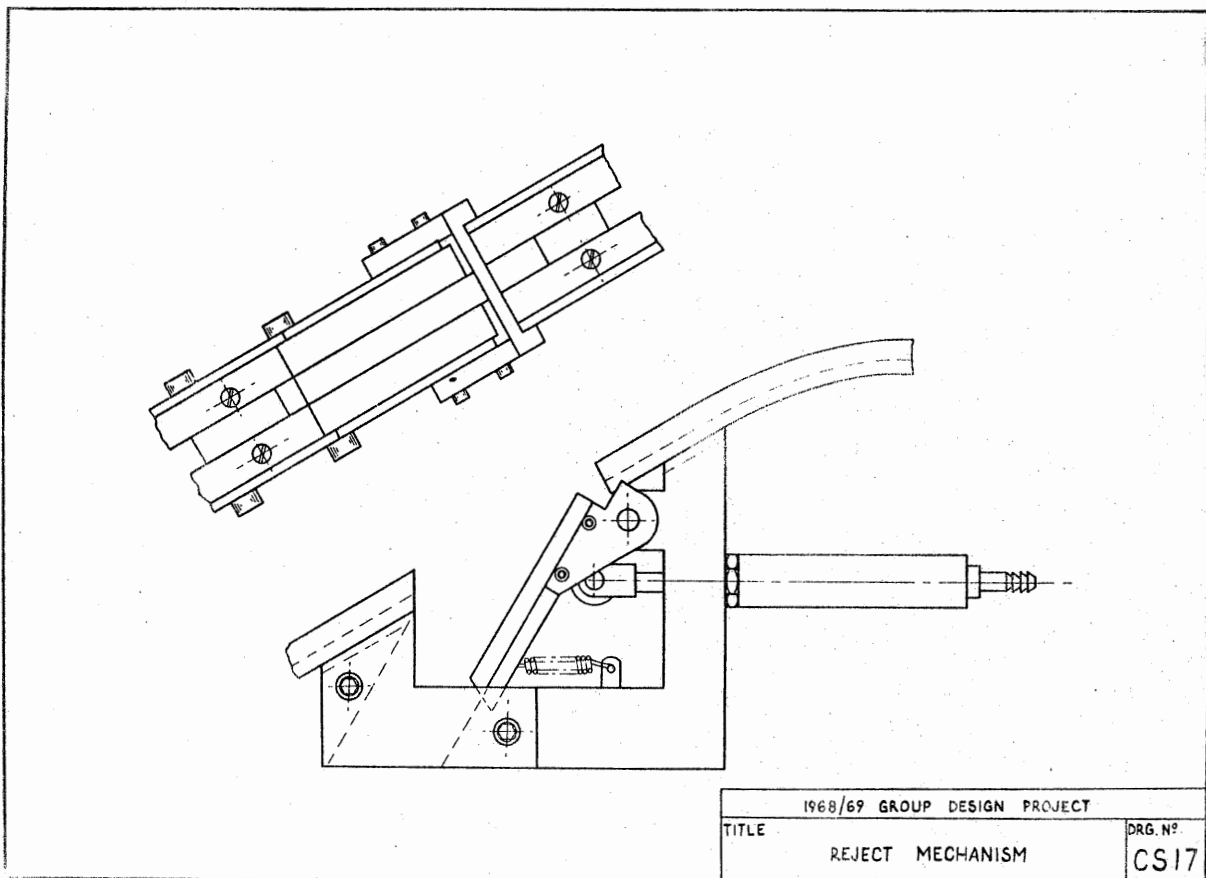
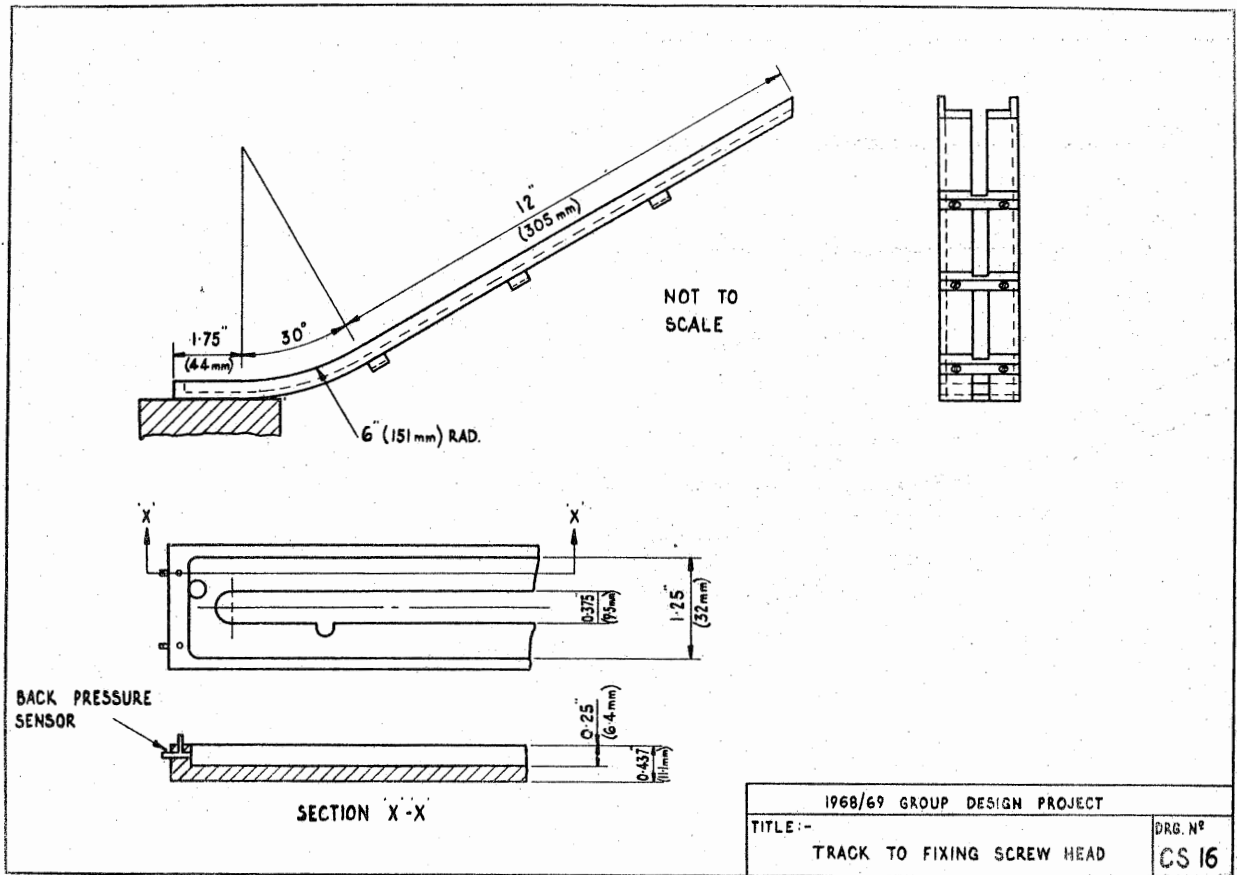
NOMENCLATURE FOR
CALCULATIONS OF TRACK WIDTH

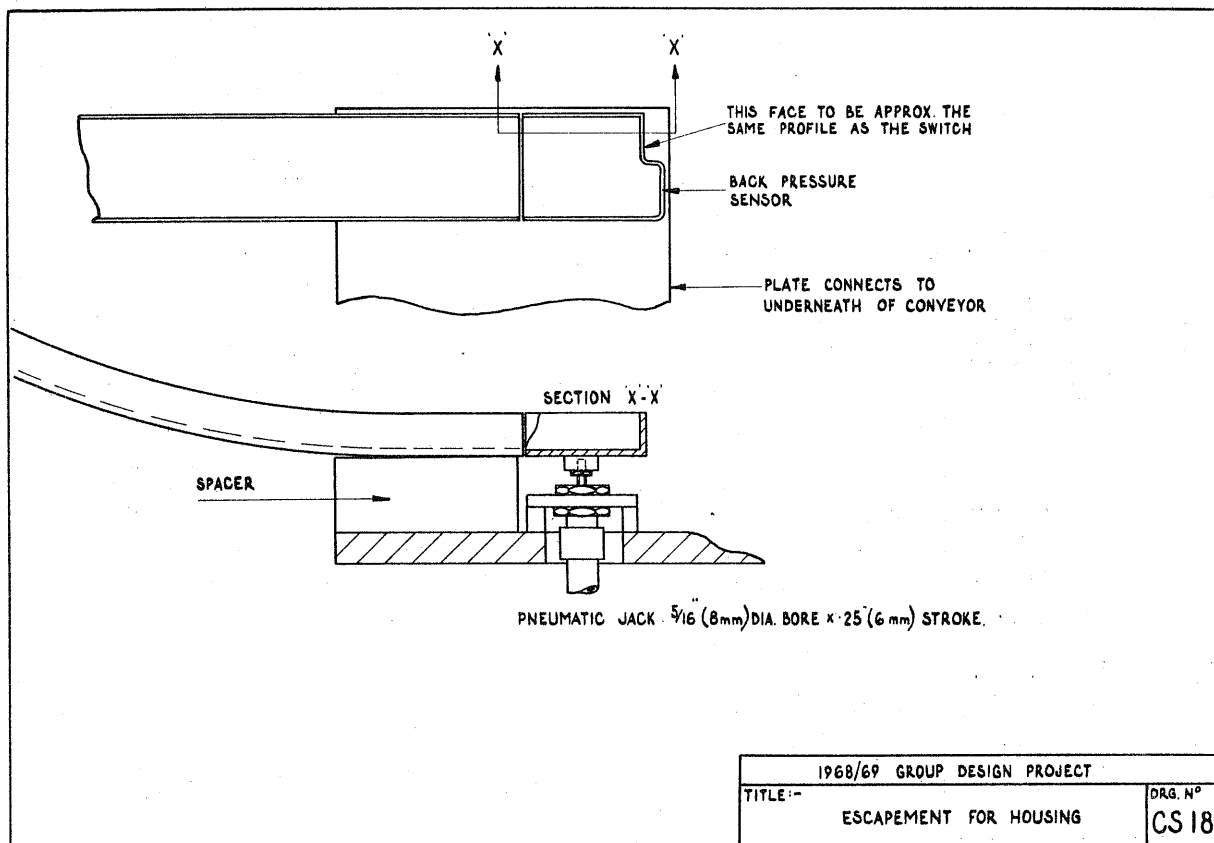
DRG. N°

CS 14

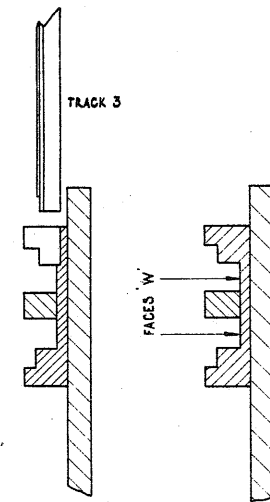
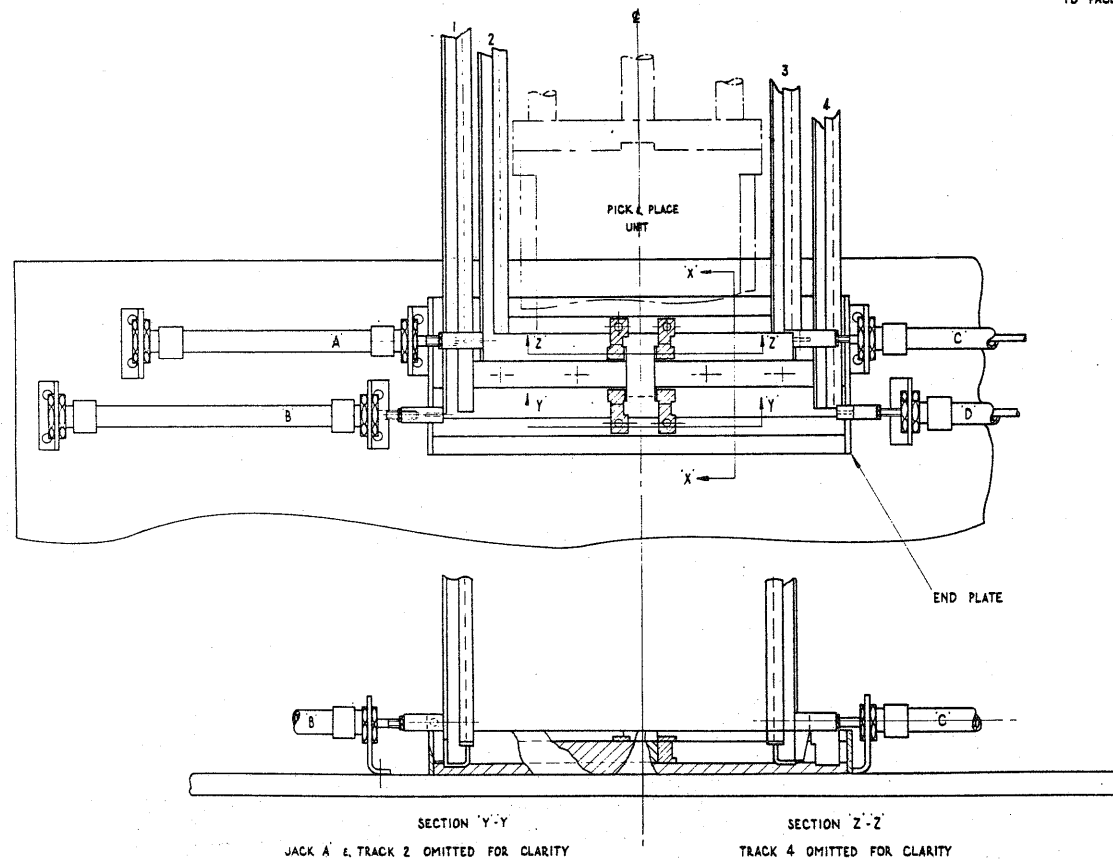


1968/69 GROUP DESIGN PROJECT		
TITLE:-	LAYOUT OF TRACK TO FIXING SCREW HEAD	DRG NO
		CS 15



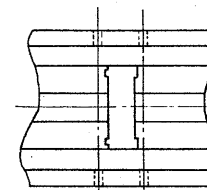


ARRANGEMENT SHOWN IS FOR N/C CONTACTS
 FOR N/O CONTACTS SPACERS ARE TO BE ATTACHED
 TO FACES 'W'. BOWLS ARE TO BE CHANGED

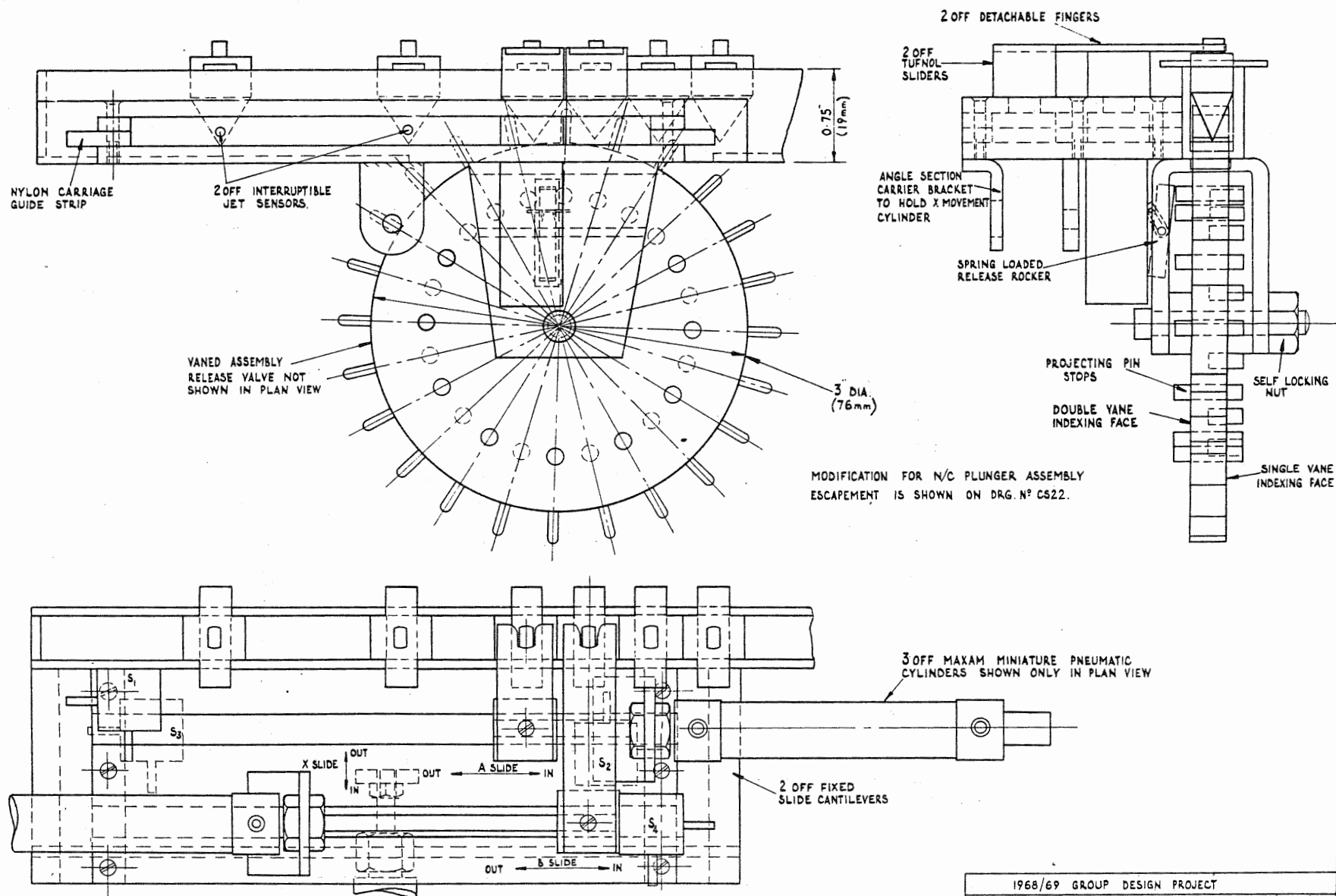


SECTION SHOWING ATTACHMENT
 POINT OF TRACK 3

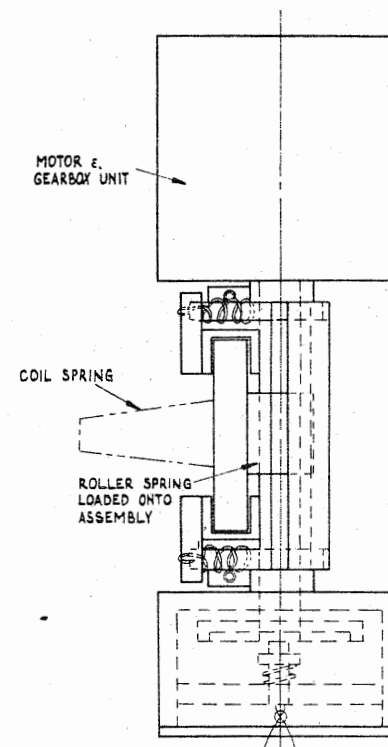
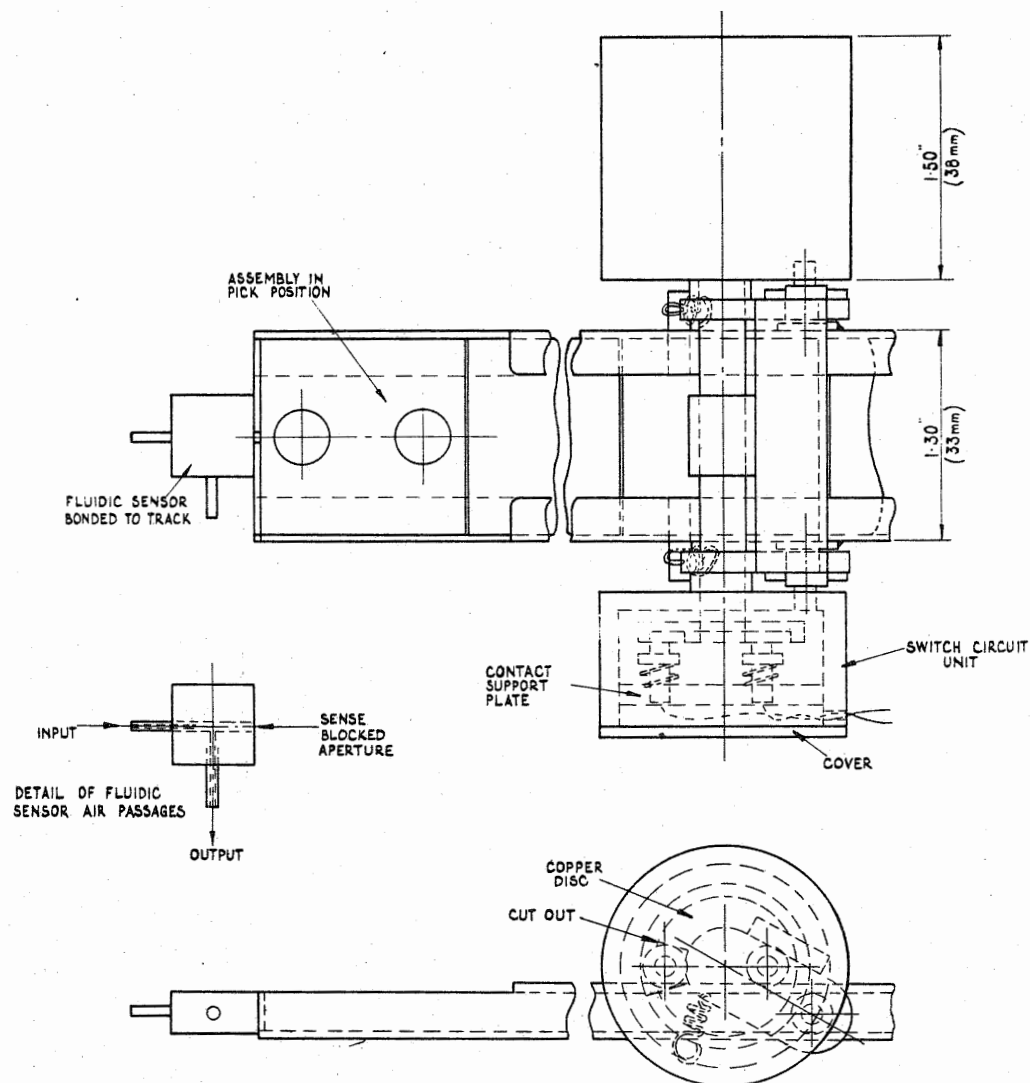
SECTION 'X-X'



VIEW SHOWING HOLES DRILLED IN
 ESCAPEMENT BLOCK FOR BACK PRESSURE
 (PROXIMITY) SENSORS.



1968/69 GROUP DESIGN PROJECT	
TITLE:-	DRG. N°
ESCAPEMENT FOR PLUNGER ASSEMBLIES	CS20

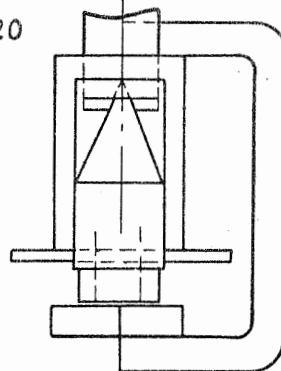


MOVEMENT
FINGERS

POSITION OF
GUIDE PLATE
CROSS HATCHED

GUIDE PLATE
ATTACHMENT
BRACKET

COMPLETE DRAWING
SHOWN BY DRG. N° CS 20



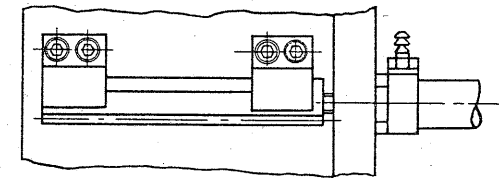
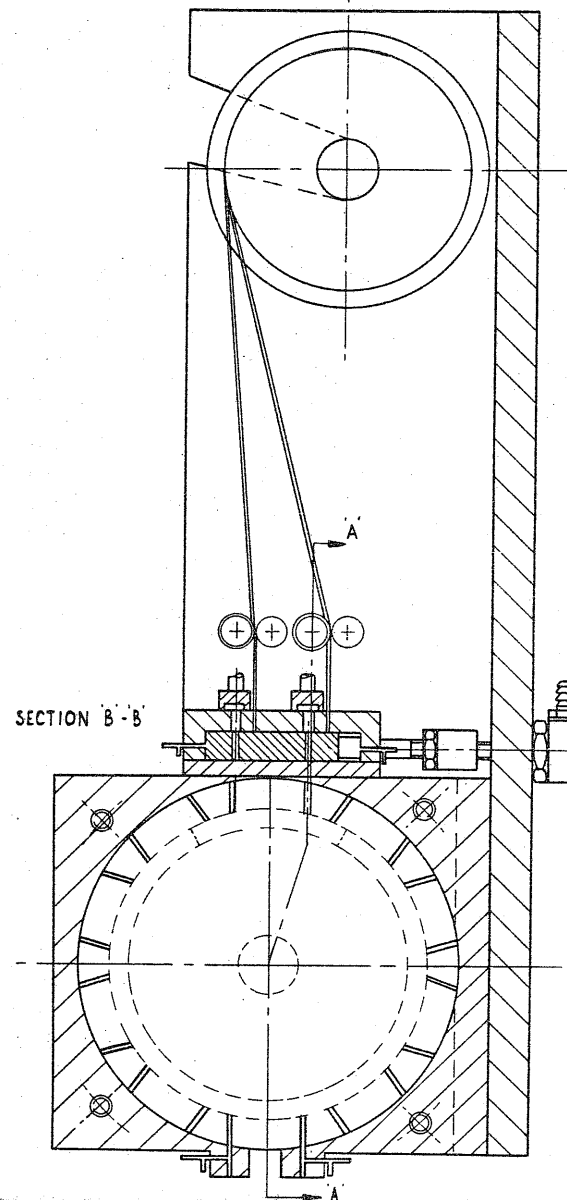
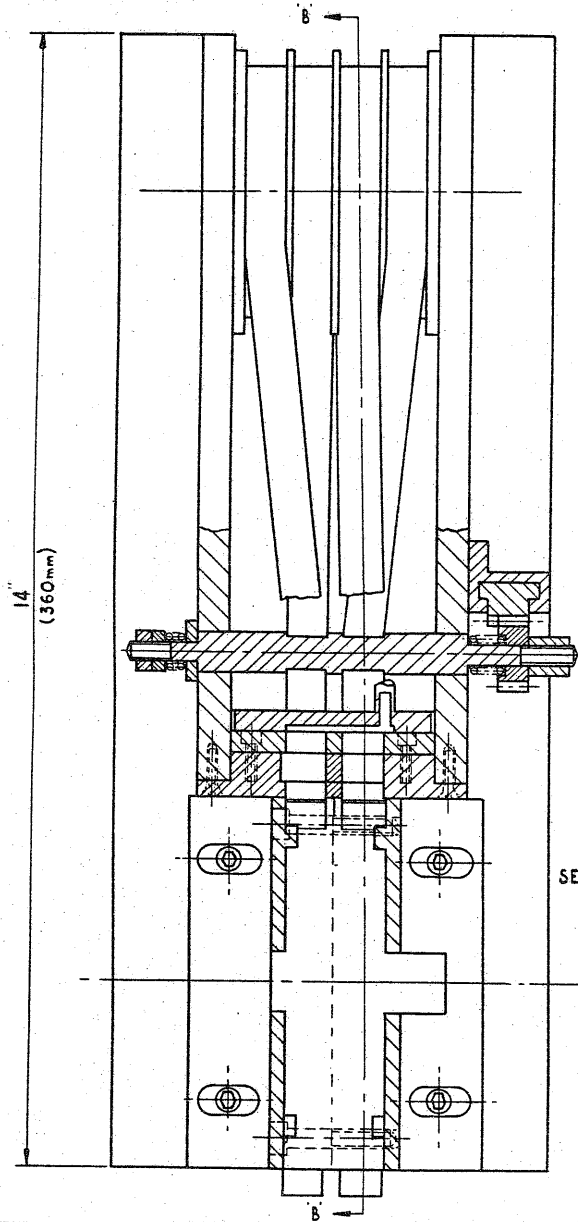
1968/69 GROUP DESIGN PROJECT

TITLE :-

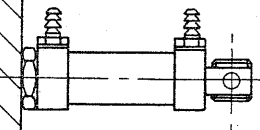
MODIFICATION TO TRACK TO USE
PLUNGER ASSEMBLY ESCAPEMENT

DRG. N°

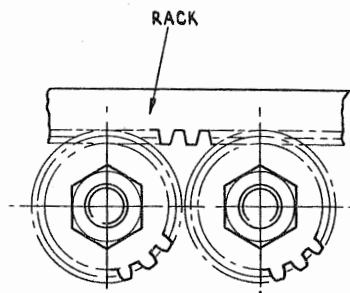
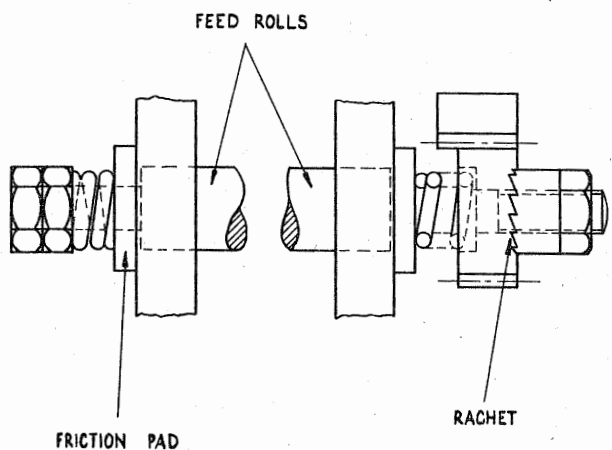
CS 22



ACTUATION OF RACK

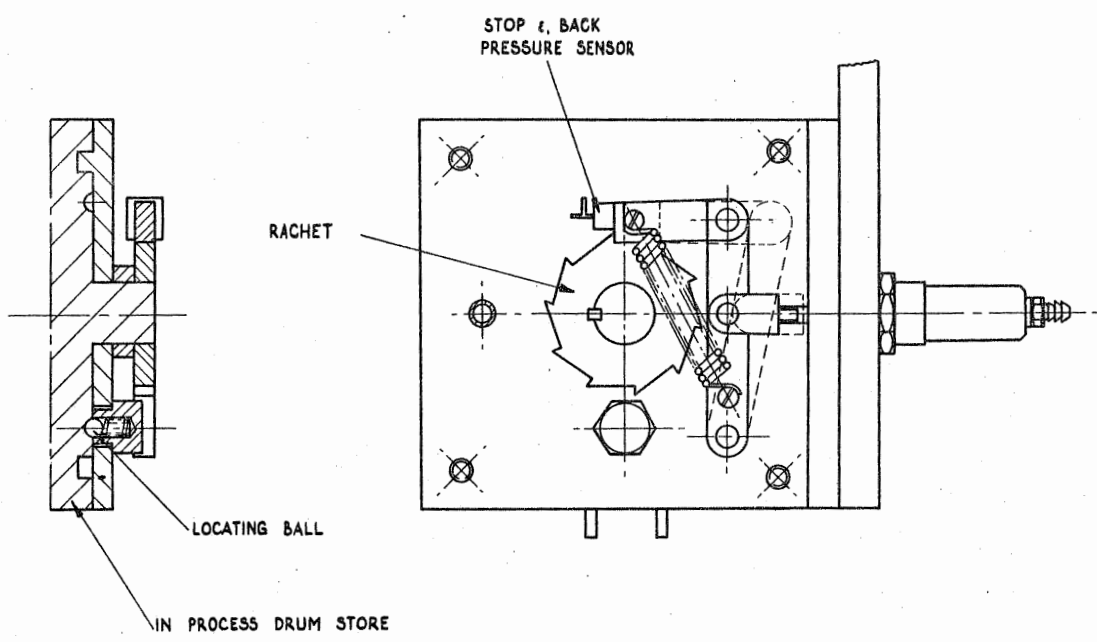


1968/69 GROUP DESIGN PROJECT		
TITLE:-	MANUFACTURING HEAD WITH IN PROCESS STORE	DRG. N ^o CS 23



PINION
 N° OF TEETH - 20
 D.P. 24 (MODULE 1.06 M/m)
 PITCH CIRCLE DIA. 0.833 ins (21.1mm).

1968/69 GROUP DESIGN PROJECT		
TITLE:-	FEED ROLLS FOR MANUFACTURING HEAD	DRG. N° CS 24



1968/69 GROUP DESIGN PROJECT		
TITLE:-	INDEXING MECHANISM FOR DRUM STORE.	DRG. N° CS 25

APPENDIX I

Investigation into the feeding of light open coil springs

The problem is very complex and the object is to suggest methods for performing the operation of supplying individual springs. Each method would require careful consideration to match it to the appropriate application and, in some cases, a proving operation is required.

This investigation must commence with an appraisal of the spring design. The major point is that it is not permissible to use an open ended coil spring and a redesign would be necessary to avoid this situation. A conical spring is permissible but undesirable. Both compression springs, as stipulated by the Assembly Analysis Committee, must be conical to permit complete flattening of the spring under load.

The possible solutions to the problem fall under three broad headings:-

- 1) Direct transfer between manufacture and assembly.
- 2) Packing into prepared containers by the manufacturer before shipment.
- 3) Sorting from bulk.

1) Direct Transfer between manufacture and assembly

Advantages

- a) These springs are normally unloaded manually from the manufacturing machine and 100% inspected. This operator can, therefore, perform the transfer operation.
- b) There are no transportation and storage costs.

Disadvantages

- a) Unless the machine can be made to produce at the same speed as the assembly operation high costs will be incurred. These can include wasted operator time or the cost of in-process stores if the machine is slowed down or the purchase of extra machines and operator time to increase output.
- b) Due to the form of these springs, in-process storage is difficult to achieve satisfactorily without tangling.

- c) Spring winding machines are normally operated by a specialist manufacturer since the particular specialist skill is required by operator and maintenance staff.
- d) To link this system to the machine, some in-process storage link is necessary to reduce dependence of the assembly machine on the manufacturing machine. This would increase complexity.

The conclusions drawn are that, for the springs in the contact block, this is not a suitable method. Other assemblies may possibly override these disadvantages and each case must be taken on its merits.

2) Packing by supplier

Only two forms of packing have been discovered. The first is mainly to avoid damage to delicate springs by placing them on corrugated paper, located by the grooves. The other is packing in polystyrene containers in individual sections. Neither of these is suitable for automatic feeding.

A type of packing which might be suitable is loading to sticky tape to store as rolls or trapping, compressed, between strips of paper. Other forms of packing suggest themselves such as wrapping the springs in a continuous chain with a polythene adherent strip and coiling the tube of springs produced. All suitable methods have the common factor of being automatically packed and in continuous form.

Advantages

- a) handling is avoided before assembly.
- b) risk of damage in transit is reduced with no chance of tangling.
- c) the operator unloading the springs from the manufacturing process is available to place springs in a packing medium.

Disadvantages

- a) extra cost of disposable materials or transport for returnable magazines will be incurred.
- b) packing and unpacking equipment may be necessary.

3) Sorting from bulk

This presents the problem of taking a comparatively fine wire spring from a tangled mass. Any method suggested must, necessarily, be theoretical but it can observe the principles of different feeding mechanisms.

The process from bulk to individual springs requires small quantities to be separated and orientated and held by in-process storage for dispensing to the machine. The method devised uses an elevating hopper to feed incrementally from bulk through a tumbler which will tend to separate the springs from one another. The tumbler will take the form of an open ended tube carrying internal vanes and inclined at an angle to gradually pass the springs through it and drop them from the opposite end into a vibratory bowl. The hopper must contain a quantity of light polystyrene tubes which will be constantly replenished as used. Cubes of the right size, weight and quantity compared with the springs will tend to become situated between the springs as they travel to the bowl flight. In the bowl, orientation takes place and only springs separated by cubes will be allowed through. The cubes then stop the conical springs interlocking. The bowl has an external rejection chute to the bulk supply to be used for tangled springs when detected on the bowl flight.

Advantages

- a) problems and costs of the other two methods are eliminated.
- b) the system offers some versatility over a small range of springs.

Disadvantages

- a) the system is very complex and expensive.
- b) considerable proving of the system would be necessary.
- c) a feed rate could not be guaranteed without much experimentation.

Recommendation

Supplier Packing appears to be the most versatile and practical method that can be used for the largest number of springs for automatic assembly.

APPENDIX II

Recommended method of feeding components in contact block not already mentioned

The components to be considered here are those that are part of the contact block assembly but, due to the redesign of some components and certain workheads, have their own feeding equipment as an integral part of the head. The feeding of these components does not directly concern this Committee and, therefore, has been omitted from the main section of the report.

This appendix will serve as a guide to feeding of these components in case it is required at any time.

Components

- 1) Cover
- 2) Moving contacts
- 3) Plunger (N/O and N/C)
- 4) Spacer
- 5) Terminal Clamp
- 6) Fixing screws, Terminal screws and rivets.

Drawings of these components are shown in the Report of the Assembly Analysis Committee.

1) Cover

This component can be fed by a vibratory bowl feeder of bowl diameter 12 in (305 mm) and flight width of 1.25 in (30 mm) and can be orientated by the tooling shown in fig. CS/B1, the flight having negative slope.

There are only four ways in which the component can lie on the flight, as shown in fig. CS/B2, and only one orientation of the component will be fed from the bowl. Orientation 2 is rejected by a cut out on the flight. Orientations 1 and 4 are rejected by an air jet which is activated when a hole is detected. The sensor is positioned so that orientation 3 is only allowed to pass.

2) Moving contacts (N/O)

The component can be fed by a vibratory bowl of diameter 8 ins. (203 mm) and flight width of 0.375 in (10 mm) and can be orientated by tooling shown in fig. CS/B3. The flight is flat at the bottom of helix and is rolled up so as to turn the component on to its edge.

Four possible orientations of contacts on edge are shown in fig. CS/B4. Orientations 1 and 2 are rejected by the cut out on the flight and fall out of the bowl into a receiver from which they are returned to the bowl. Orientation 4 is rejected by an air jet which is activated by the sensing of the cut out on the bottom edge.

Moving Contacts (N/C)

The method of feeding is similar but, because this contact has no cut out, the sensing of cut out and air jet is eliminated from the tooling of the bowl.

3) Plunger (N/O and N/C)

The N/O plunger has an irregularity which can not be sensed by normal methods and, therefore, this component will either have to be manually fed or fed by vibratory bowl and manually inspected so that only one orientation of the plunger is allowed at the workhead.

The N/C plunger can be fed automatically in a vibratory bowl of diameter 8 in (203 mm) and track width 0.5 in (13 mm). The track is initially flat and converges into a vee track in the last quarter of track, as shown in fig. CS/B5.

4) Spacer

This component can be fed by a vibratory bowl feeder of bowl diameter 4 in (102 mm) and flight width 0.375 in (10 mm). The flight is normally flat but warps to a negative angle at the end.

The tooling for orientation is shown in fig. CS/B6. Only components lying flat are allowed to pass under the wiper, and the pressure break allows only a single file of components to pass at a time. The negative part of the flight permits non-orientated components to return to the bottom of the bowl.

5) Terminal clamp

The initial design of this component is such that certain irregularities can not be sensed. Therefore, for automatic feeding, it is essential that the clamp is modified so as to be symmetrical or it could be automatically fed with manual inspection of orientation.

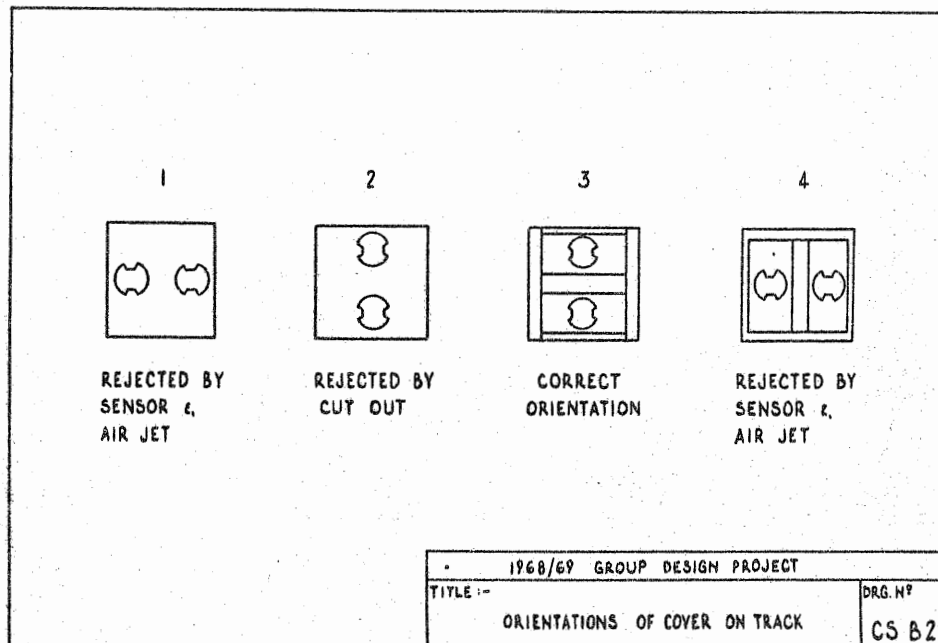
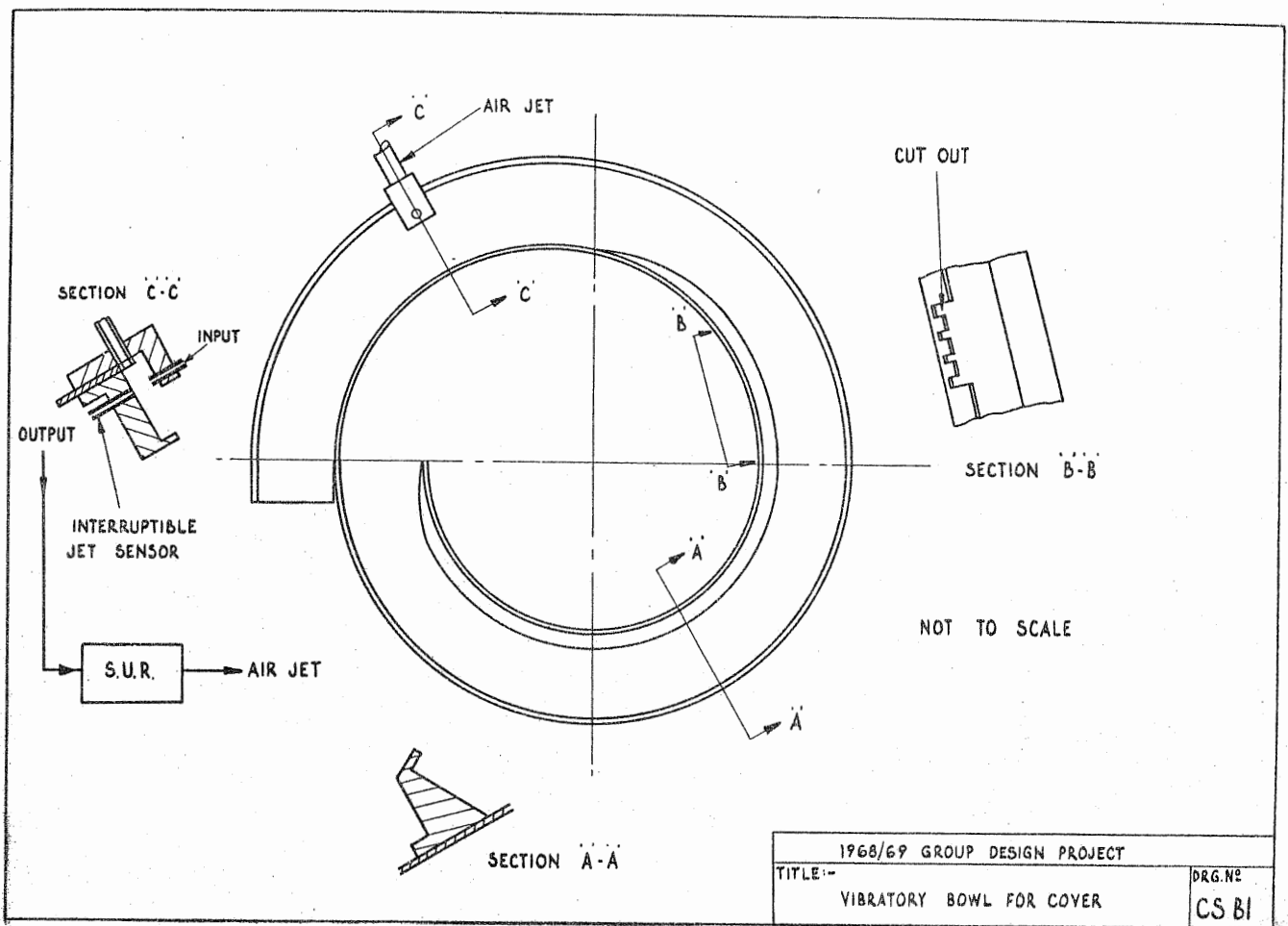
For automatic feeding the component can be fed by a vibratory bowl of diameter 4.5 in (114 mm) and flight width of 0.375 in (10 mm). The flight is flat with a ridge as shown in fig. CS/B7. The wiper is used to allow only components lying flat under, and then the pressure break allows one single row of components only. The ridge is used to accept only terminal clamps with the open end face downwards.

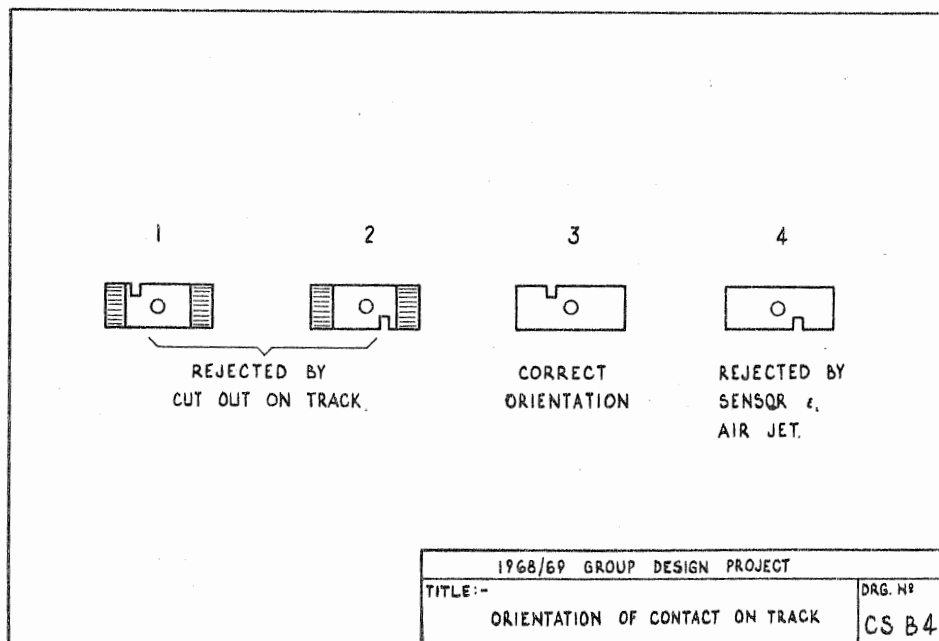
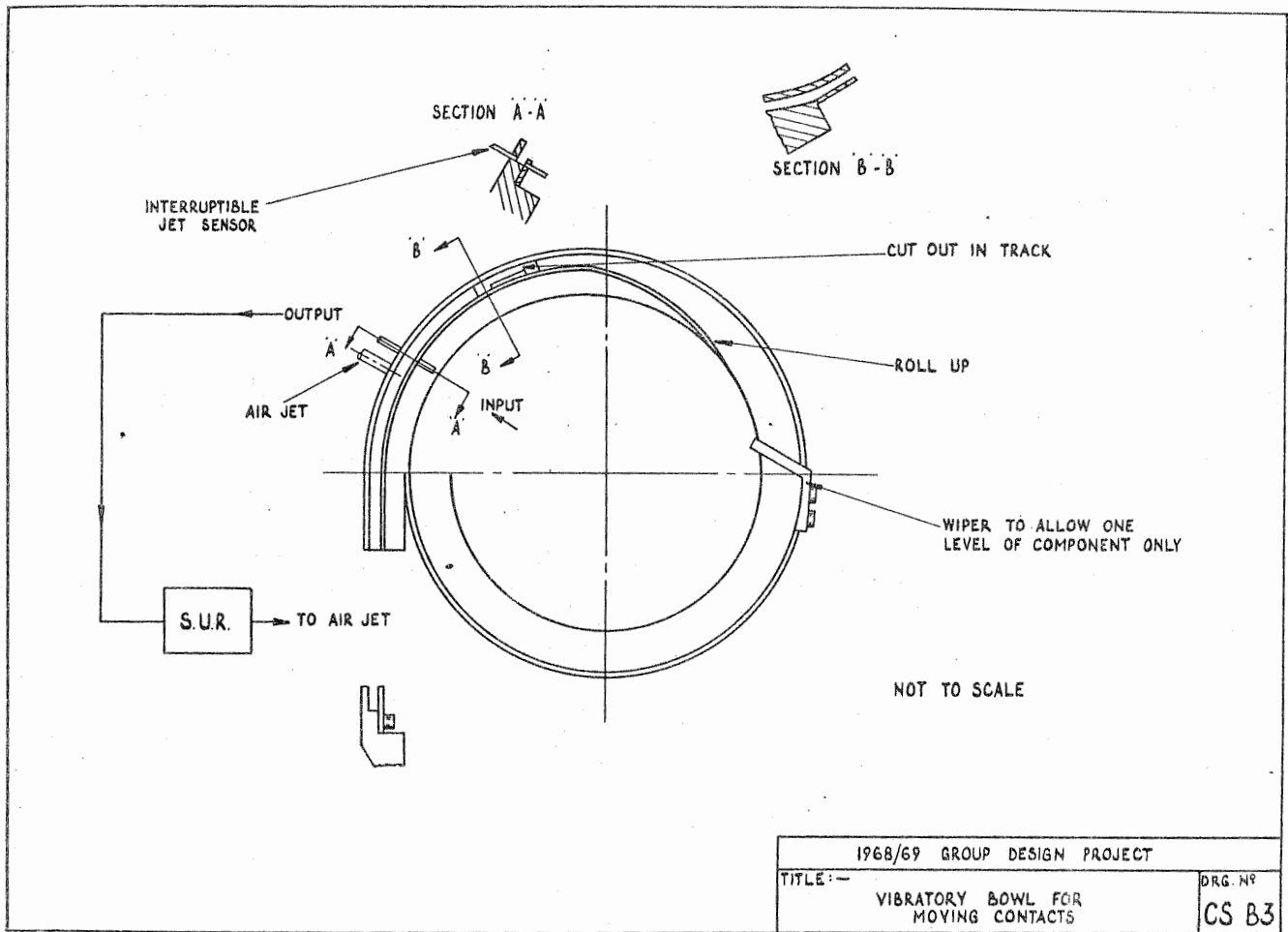
6) Fixing screws, Terminal screws and rivets

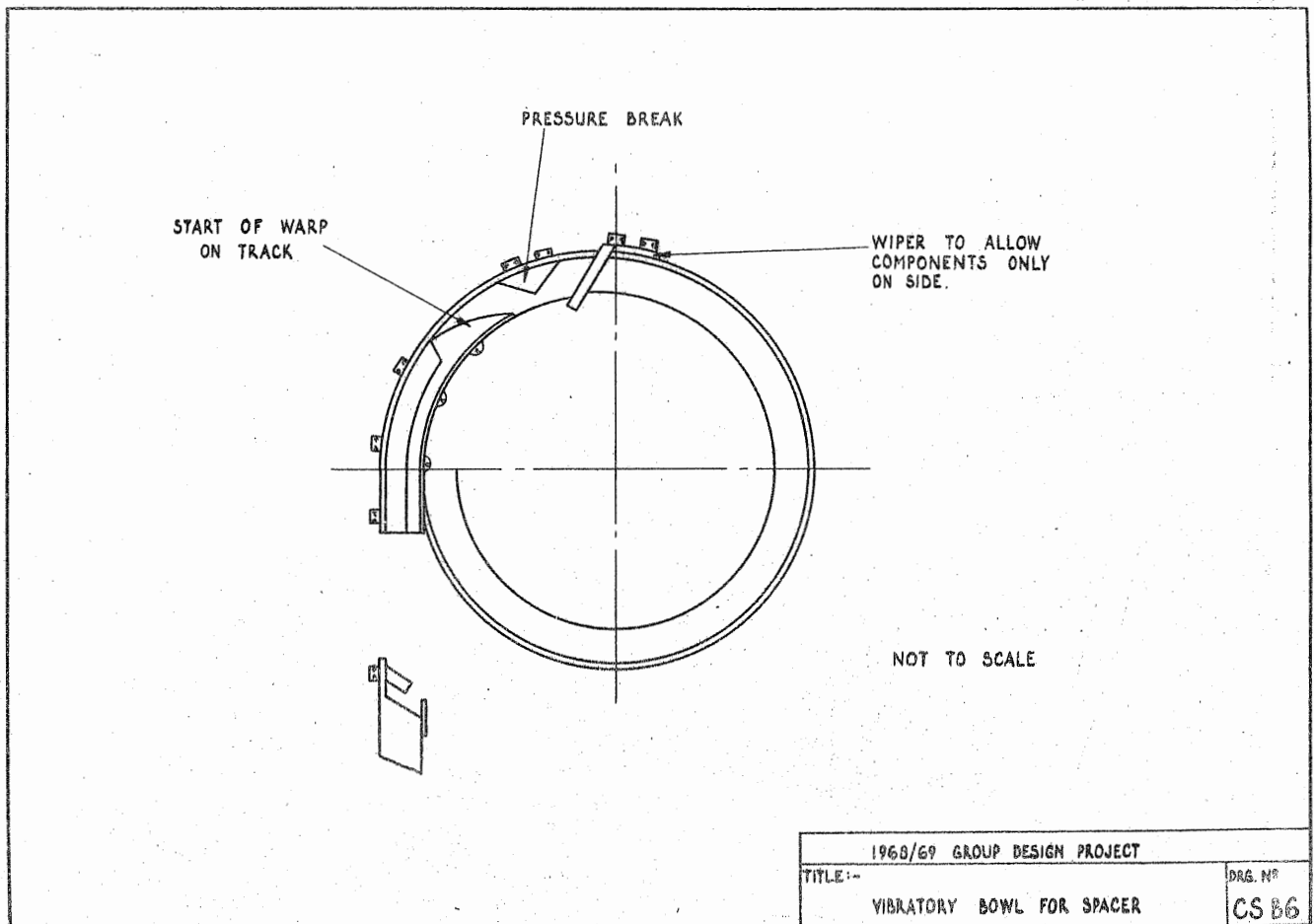
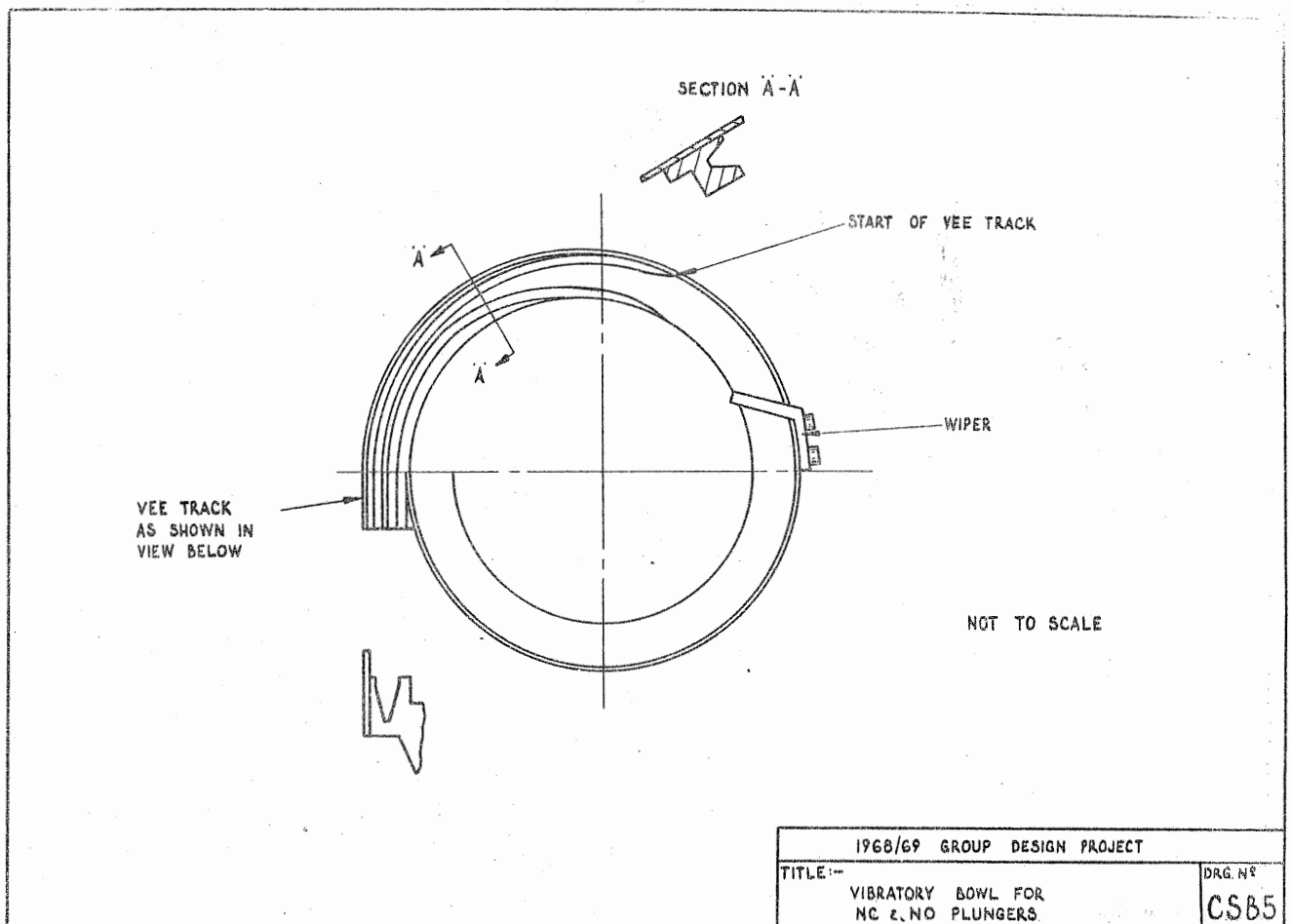
It is possible to consider these three items as one group as they are very similar in shape. Each part is circular in shape, with a head and a relatively long shank. The centre of gravity is below the head so that they will naturally orientate themselves when balanced on the head.

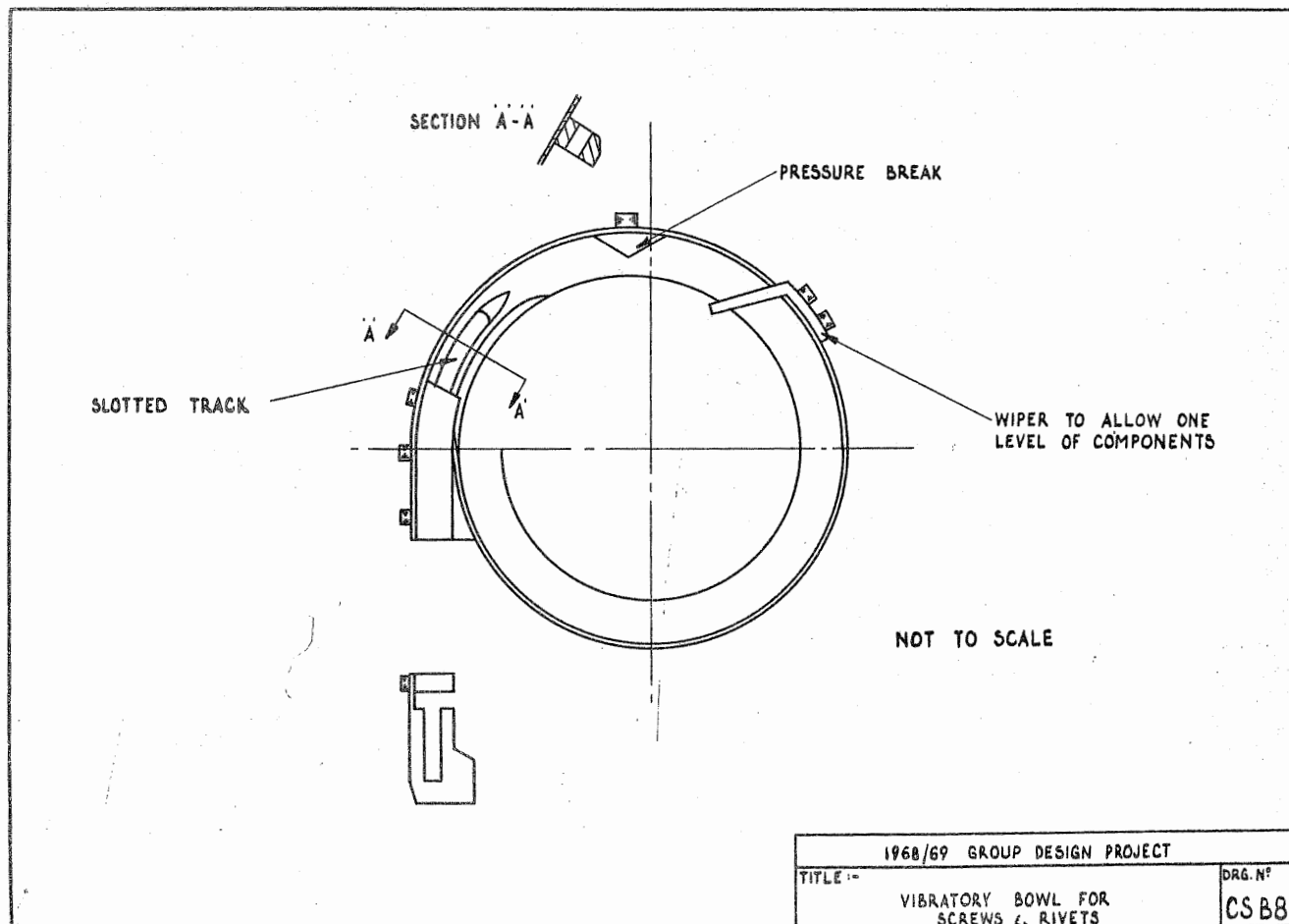
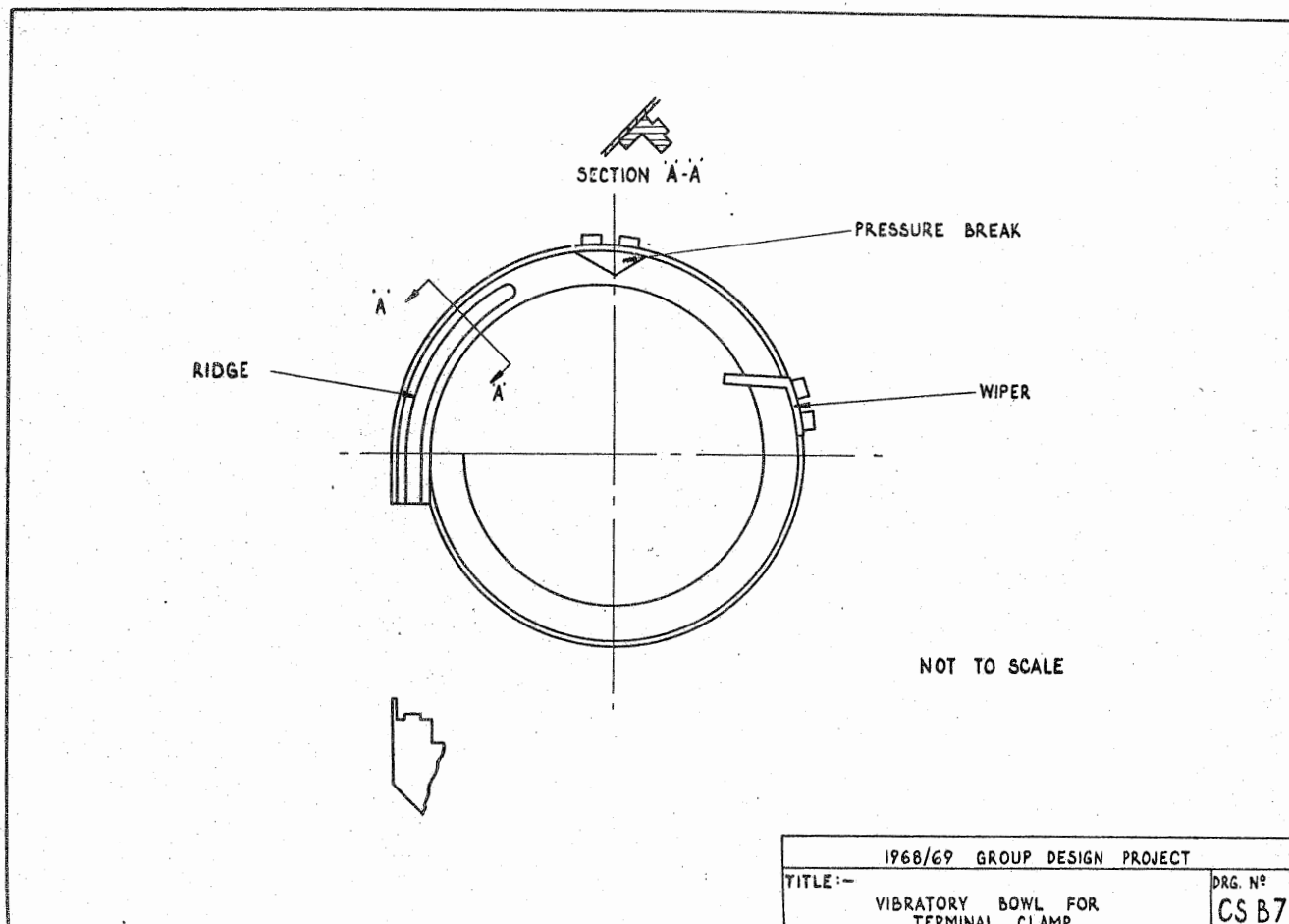
These parts can be fed by a vibratory bowl feeder of diameter 10 in (254 mm) with flight width of 0.313 in (8 mm). The flight is flat having a slight positive angle. The last part of the flight is of channel form and is of such a length that the shank of each part can pass into the channel whether the part is moving with the shank trailing or leading. The component is then travelling while suspended by the head.

The tooling of the bowl is shown in fig. CS/B8, the wiper and pressure break are used to ensure that the component approaches the channel part of flight, lying on its side and in single file.









APPENDIX III

Method of Quantifying Orientating Mechanisms

In the main report, the statement was made that a theoretical approach to the performance of parts feeders could be only a general guide. The purpose of this appendix is to describe some principles associated with orientating devices, and to describe a method of quantifying their performance.

Orientating devices are classed as either active or passive. To be precise, passive devices are filters and active devices are, strictly speaking, orientating elements as shown by (a) in fig. CS/Cl. Example of an active orientating device is a simple step which itself is termed kinetic active. Passive ones would be those such as wipers and cut outs.

Figure CS/Cl, (b) and (c), shows the various sequences that a component may go through to attain the desired orientation. The set up shown in Diagram (b), on this figure, will obviously give a greater feed rate than that shown in (c), when both systems are applied to the same component.

If there are three possible positions of the component when in bulk, say x, y and z.

Let the proportion of components in position x, y and z be p_x , p_y and p_z respectively. "p" is termed the input or mode distribution.

Say that the y position is required at the output:-

<u>Position</u>	<u>Input Distance</u>	<u>Output</u>
x	p_x	0
y	p_y	$p'y$
z	p_z	0

If $p_x + p_y + p_z = 1$ then $p'y$, the proportion at the output in position y, equals unity. This may be written

x	p_x	0
y	p_y	1
z	p_z	0

In general, the action of an orientating device may be described by the following matrix:

	output		
	p_x	p_y	p_z - input
$p'x$	a	b	c
$p'y$	d	e	f
$p'z$	g	h	j

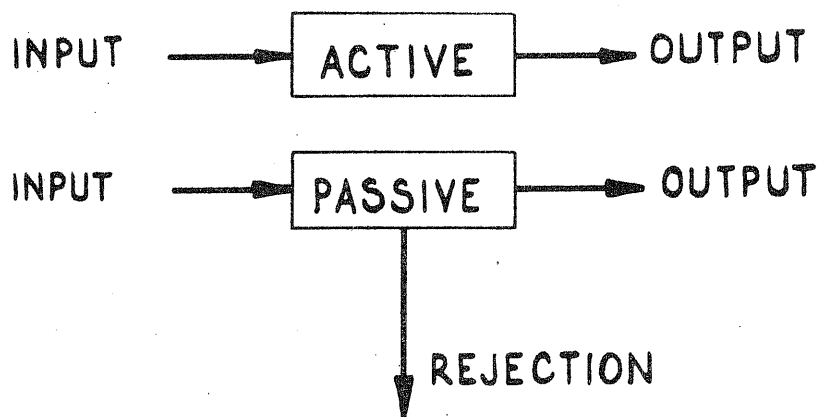
The ideal matrix for such a device is

0	0	0
1	1	1
0	0	0

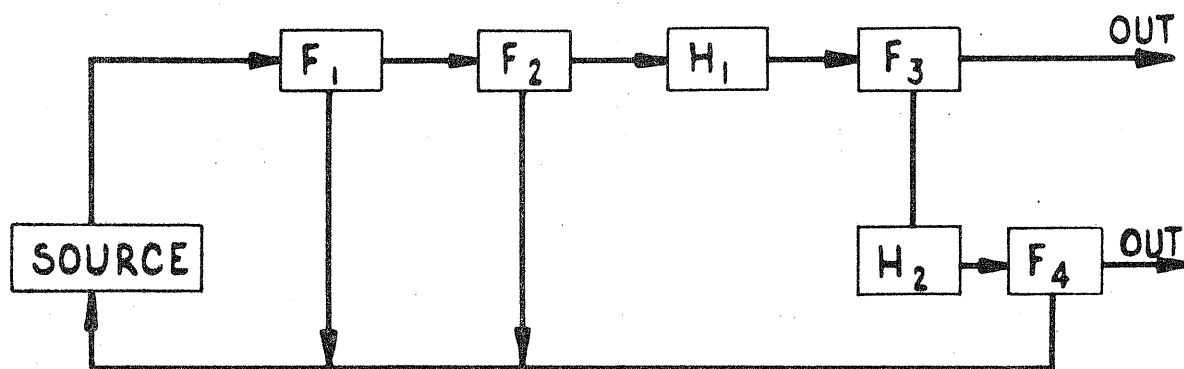
if the y position is required at the output. This means that, regardless of the position at input, the proportion of position y at output equals unity.

It follows that the matrix for an ineffective device is

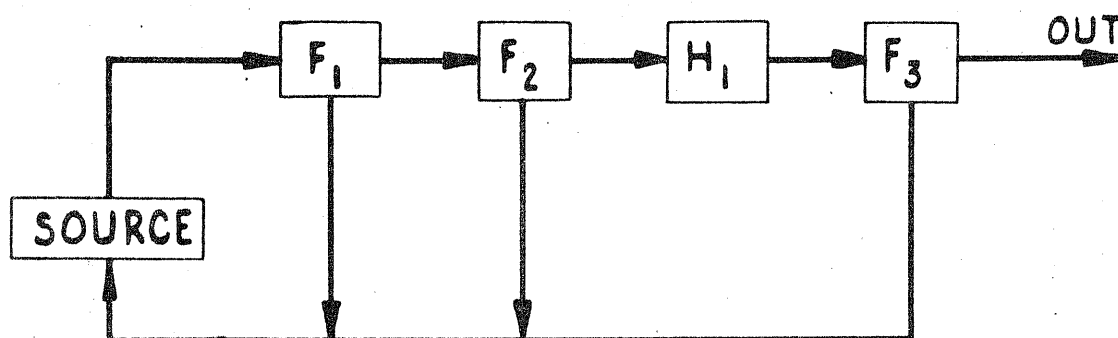
	px	py	pz
p'x	1	0	0
p'y	0	1	0
p'z	0	0	1



(a)



(b)



(c)

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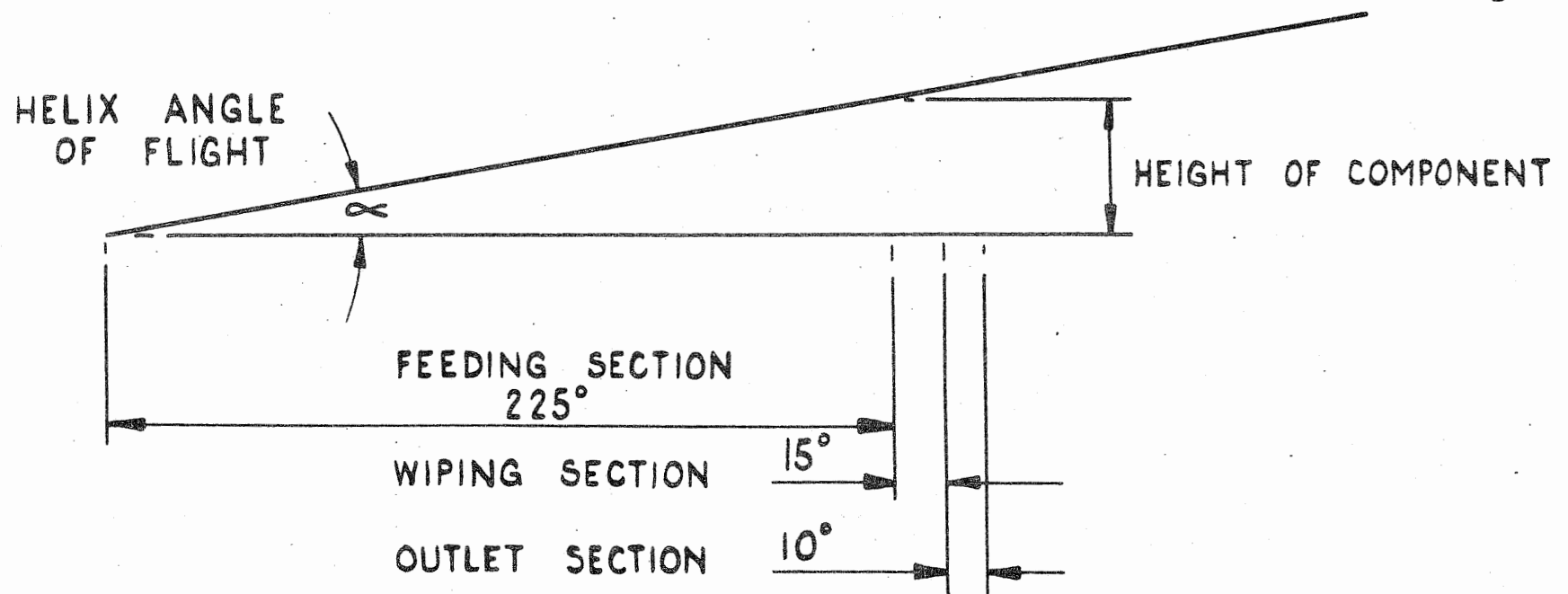
TITLE:-

FUNCTION OF
ORIENTATING DEVICES.

DRG. N^o

CS CI

DIAGRAM OF BOWL FEEDER FLIGHT
SHOWING PROPORTIONS REQUIRED
FOR THE MOVEMENT OF PART.



1968/69 GROUP DESIGN PROJECT

TITLE:-

BOWL FEEDER TRACK GEOMETRY.

DRG. N°

CS DI

APPENDIX IV

Recommendations for future application of vibratory bowls

This appendix is aimed at giving some details which should be considered when using a vibratory bowl feeder.

a) Dynamic Coefficient of Friction

The conveying velocity of the parts in the bowl flight is increased by raising the dynamic coefficient of friction between the part and the flight. This is usually done by lining the track with rubber, either strip, spray-on or dip. The value is approximately 0.8 under these conditions. For further information see ref. 6.

b) Radius of Bowl

The length of the component being fed is related to the radius of the bowl, when considering freedom of movement of the part in the bowl.

c) Component free of burrs

This is important for gaining maximum effectiveness of orientating devices and prolonging the life of the flight coating.

d) Load Sensitivity

Normally, vibratory bowls give a feed rate that is dependent on the quantity of the parts that remain in the bowl. Pneumatic vibratory bowls minimise this problem.

e) Out-of-phase Vibratory Bowl Feeders

A feeder that works on this principle is capable of producing higher feed rates than in-phase operation. The disadvantage of this type of bowl feeder, is increased cost. For further information see ref. 5.

f) Flight Helix Angle

For stability of parts, and thus greater efficiency, restriction of the flight helix angle to less than 5° is important. An optimum angle is acquired at an angle between 1.5° and 2° .

g) Large Components

These, obviously, affect the utilization of the bowl feeder, but if bulk storage hoppers are placed above the bowl, this limitation can be overcome.

Figure CS/D1 shows the function allocated to a particular proportion of the bowl flight.

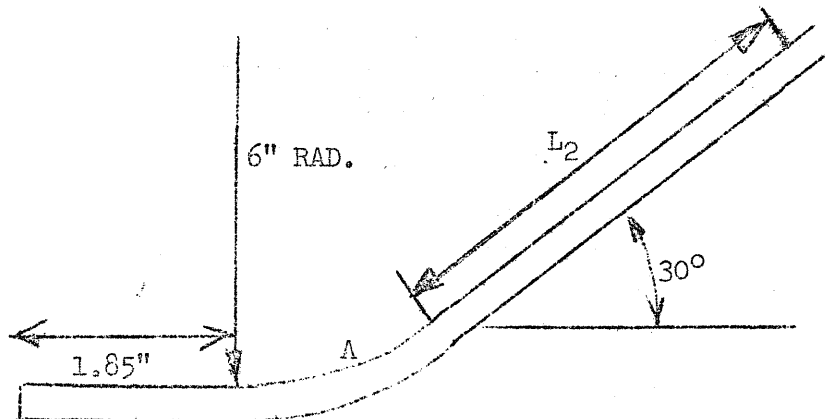
When specifications are being established for the design of a vibratory bowl feeder, certain details are required about the part to be fed. The Committee considered that this information is fundamental to the problems of parts feeding and, this was justification for its inclusion in this appendix.

The information required is:-

- a. Operation prior to bulk loading into feeder.
- b. Operation that the part would undergo after feeder discharge.
- c. Main dimensions of parts to be handled.
- d. Whether or not contaminants and deformed parts can be removed before loading.
- e. Whether or not parts are oil or grease coated at bulk loading.
- f. Abrasiveness of part.
- g. The likelihood of the requirement arising where a differently tooled bowl would be fitted to the same vibratory unit as the one being considered.
- h. Requirement for auxiliary hopper. Statement of volume required.
- i. Preference for mild steel, stainless steel, rubber lined or plastic coated bowl.
- j. Required orientation of the part at discharge.
- k. Preference for built-in or separate controller.
- l. Discharge rate: minimum, normal and maximum values.
- m. Preferred direction of rotation of bowl.
- n. Relative position of discharge points, in the case of multiple tracks.
- o. Requirement for pressure break.
- p. Power supply available.
- q. Gravity chutes - whether stainless steel or mild steel.
- r. Type of escapement - pneumatic, electrical.
- s. Consistency of parts within stated tolerances.
- t. Freedom of parts from burrs, chips, dirt etc.

APPENDIX V

Calculations for the length of track to be full to ensure
that a part is in position for feed rate required



Coefficient of dynamic friction for plastic on steel is assumed to be not more than 0.3.

Delivery time = 1 sec. Length of component 1 = 1.75 in (ref. 6).

$$\frac{a}{g} = \frac{L_2(\sin\alpha - \mu_d \cos\alpha) - L_1 \mu_d e^{\mu_d \alpha} + \frac{R}{1 + \mu_d^2} (1 - \mu_d^2)(e^{\mu_d \alpha} \cos\alpha - 2 \mu_d \sin\alpha)}{L_2 + L_1 e^{\mu_d \alpha} + \frac{R}{\mu_d} \left(\frac{e^{\mu_d \alpha} - 1}{1} \right)} \quad \dots \quad (1)$$

$$t_p^2 = \frac{2L}{a}$$

- a = acceleration of column of parts
- L₂ = length of parts in track
- L₁ = length of each part = 1.85 in
- μ_d = dynamic coefficient of friction = 0.3
- α = inclination of track = 30°
- R = radius of curve part of track.

Equation 1

$$\frac{a}{g} = \frac{L_2(0.5 - 0.2598) - (1.85 \times 0.3 \times 1.17) + \frac{6}{1.09}(0.91)(1.17 - 0.866) - 0.3}{L_2 + (1.85 \times 1.17) + \frac{6(1.17 - 1)}{0.3}}$$

$$\frac{a}{g} = \frac{0.2402 L_2 - 0.65 + 5.51(0.91 \times 0.304 - 0.3)}{L_2 + 0.216 + (20 \times 0.17)}$$

$$= \frac{0.2402 L_2 - 0.65 - 0.1295}{L_2 + 3.616}$$

$$\frac{a}{g} = \frac{0.2402 L_2 - 0.7795}{L_2 + 3.616}$$

$$t_p^2 = \frac{2L}{a} \quad t_p = 1 \text{ sec.}$$

$$1^2 = \frac{(2 \times 1.75)(L_2 + 3.616)}{(0.2402 L_2 - 0.7795)(32.2 \times 12)}$$

$$1 = \frac{3.5 L_2 + 12.65}{92.7 L_2 - 301.0}$$

$$92.7 L_2 - 3.5 L_2 = 301.0 + 12.65$$

$$89.2 L_2 = 313.65$$

$$L_2 = 3.5 \text{ in (90 mm)}$$

To achieve a feed rate of at least 60 components/min, the buffer stock must stretch 3.5 in (90 mm) along the track.