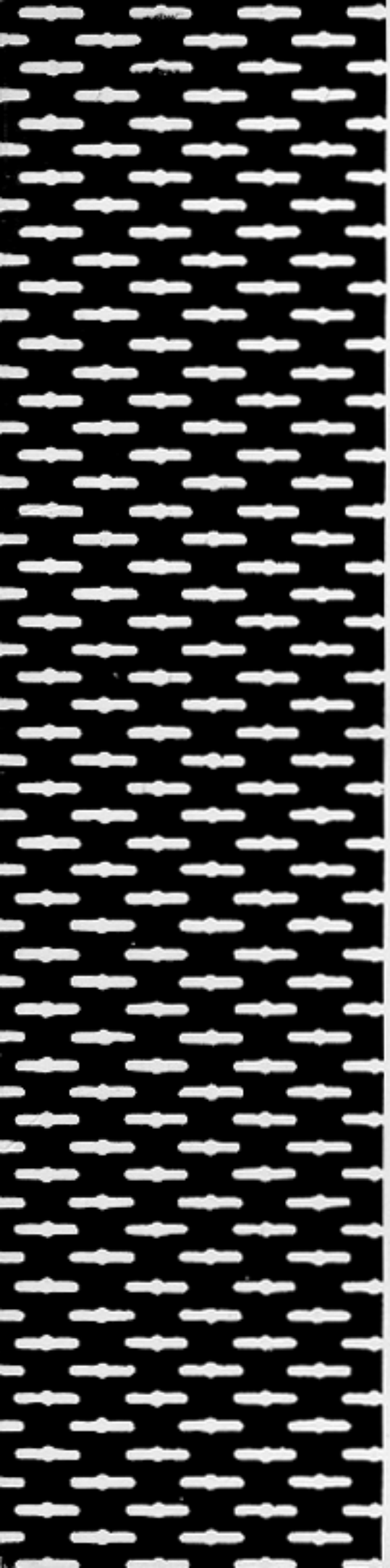


FAC

MANUAL

Z1-05

FAC

Universal Construction System

MANUAL

Catalog No. Z1-05

FAC

® Made in Sweden

Transitoria Trading Company AB

Kungsgatan 29 · Stockholm C · Sweden

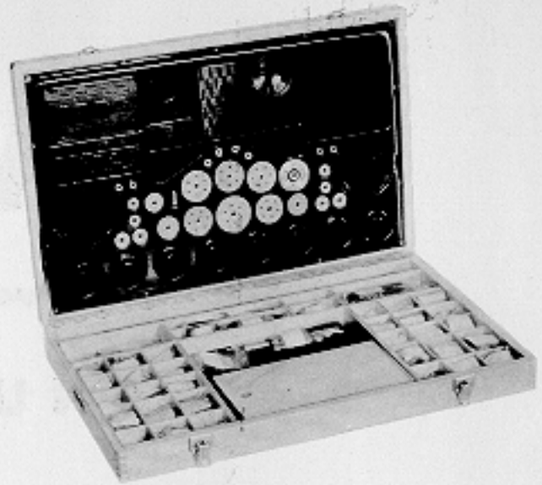
Telephone: 10 15 17 · Telegrams: "Transitoria"

Patents: Australia No. 163390, Brazil No. 53971, France No. 1063092, Great Britain No. 745129, New Zealand No. 107439, Sweden No. 141953, USA No. 2841918. Patents pending in other countries.

FAC X1

The basic kit, containing approx. 2.600 parts.

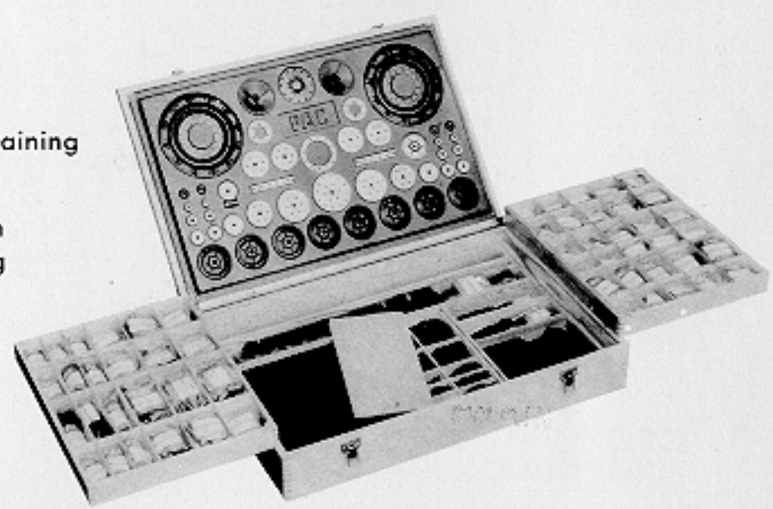
Size: 60 x 39 x 7,5 cm
Weight: approx. 13 kg



FAC X2

The industrial kit, containing approx. 4.700 parts.

Size: 60 x 39 x 11 cm
Weight: approx. 20 kg



All FAC parts are available as individual items

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Cap. 1

Principles of FAC

The fundamental concept of FAC is the limited number of simple but versatile, high-quality standard components, allowing innumerable combinations due to their logical dimensioning and design.

The backbone of FAC structures is the round steel Rod, fig. 101, selected because of its mechanical qualities. It has the same bending moment in all directions and is easily cut to any desired length. — Rods may be joined by Couplers, i. e. small grooved plates, which are screwed together in pairs to hold the Rods rigidly.

Besides the Plain Rods there are Threaded Rods. Their center section is similar to that of a Rod, but the ends are cut down in diameter and threaded. These threads mate with Tapped Sleeves of the same outside diameter as the plain middle part, fig. 102.

Fig. 101

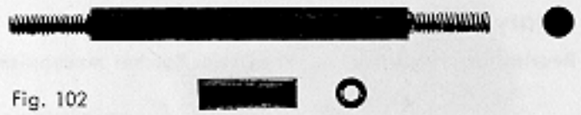


Fig. 102

The Rod diameter is designated by the symbol [r] and the thread diameter by the symbol [s]. Both measurements are fundamental in the FAC system.

Two Rods may be coupled together by means of Clamps, fig. 103. The distance between Rod centerlines, designated by the symbol [m], is then determined by the sum of the Screw diameter [s] and the Rod diameter [r], thus

$$[m] = [s] + [r].$$

[m] symbolizes the **FAC module, the common dimensional denominator for all measurements relating to the interchangeability and versatility of FAC components.**

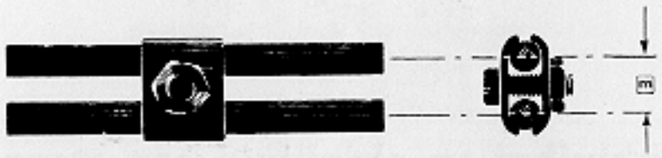


Fig. 103

When screw holes appear in pairs on Couplers and on other parts, the distance between hole centers generally is 2 [m]. The reason for choosing this measurement is illustrated in fig. 104, where the distance between the centerlines of two adjacent Rods is [m].

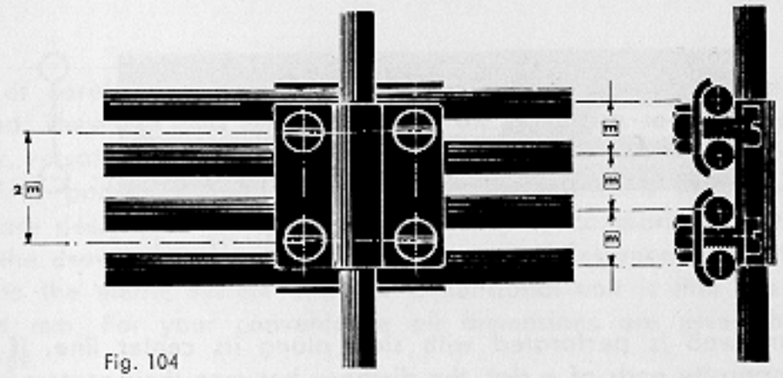


Fig. 104

Cross and T-couplers permit the joining of Rods at right angles to each other in the same plane, see figs. 105 and 106. Two identical Couplers have been placed face-to-face with the ends of the Rods meeting at the crossing centerpoint.

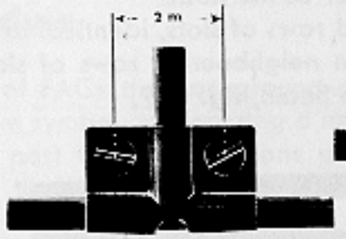


Fig. 105

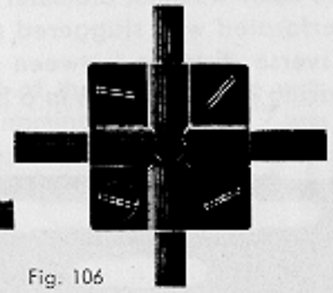


Fig. 106

If the positions of the Cross Coupler and the T-Coupler are reversed on the opposite (nut) side, as indicated in fig. 107, two parallel Rods may be joined to a single Rod at right angles, with all three Rods in the same plane.

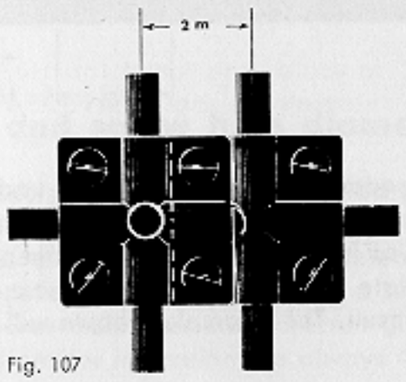


Fig. 107

The distance, center-to-center, between the two parallel Rods is the same as between two screw holes, i. e. 2 m. Beams, fig. 108, may be regarded as a development of two parallel Rods into a single constructional element. The function of the Rods is taken by the Beam flanges, formed from the web material. Accordingly, the distance between beam flange centers is 2 m.

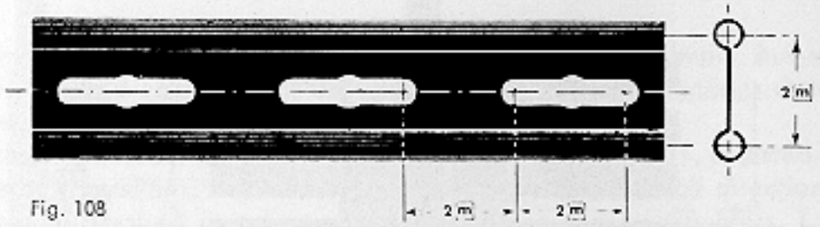


Fig. 108

The Beam web is perforated with slots along its center line. If Screws are placed in opposite ends of a slot, the distance between their centers is 2 m, as is the center distance between two Screws placed in the adjoining ends of two neighbouring slots.

The slot width corresponds to the Screw thread diameter. As the Rod diameter is bigger, the slots are drilled in the middle to permit the passage of a Rod, or of a Shaft of the same nominal diameter as the Rod.

Plates are perforated with staggered rows of slots, identical to those in the Beam webs. The transverse distance between neighbouring rows of slots equals m, the longitudinal spacing is the same as in a Beam, fig. 109.

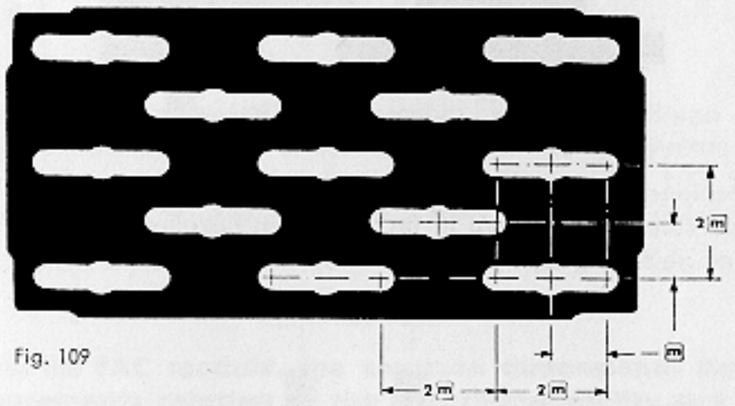


Fig. 109

Plates are used as needed together with Rods and Beam Sections. When a platform is desired, Plates may be simply butted together with Rods placed between the edges. The sequence of holes will then be unbroken and the module distances continued from Plate to Plate. Flanged Plates butt direct against each other flange-to-flange with the same result. The examples shown will demonstrate the unlimited versatility of FAC.

FAC standard dimensions

A number of carefully chosen measurements and manufacturing tolerances are standardized. They are used in dimensioning all FAC parts to obtain a maximum of simplicity, versatility and interchangeability.

In the FAC parts drawings, pp. 58-75, these standard measurements and tolerances are designated by symbols, which simplify comparisons between parts and make the drawings easy to read. FAC parts are designed and manufactured according to the metric system and the dimensional unit is thus the millimeter, abbreviated mm. For your convenience all dimensions are given both in mm and in inches.

Certain typical measurements and design details recurring in several FAC components are discussed below. For the sake of clarity they are generally not repeated in the part drawings.

The FAC module

m

In »Principles of FAC» the background of the FAC module was described. It is represented by the symbol m denoting a nominal measure of 7 mm = appr. .28 in.

A majority of part linear dimensions are derived from this module by simple multiplication, so that the module is a common dimensional denominator.

The Rod diameter

r

For **Rods** and **parts with the same outer diameter as Rods,** as well as for **holes and grooves** designed to take Rods, a common diameter symbol r is used, denoting a nominal diameter of 4 mm = appr. .16 in. Actual rod and hole diameters in manufactured parts are modified to obtain a suitable running fit.

The screw thread and screw hole diameter

s

Threads and **holes designed to take threaded parts** as well as **tapped holes** share a common diameter symbol: s = 3 mm = appr. .12 in. This symbol denotes the nominal outer diameter of the metric thread used. Actual hole diameters in manfactured parts are modified to obtain a suitable easy fit.

In the parts drawings screw hole diameters are not given, except when needed for clarity. Holes without diameter indication are always = s.

Clearances

When a Screw is placed in the end slot of a Beam or adjacent to a plate edge, the distance from the Screw center to the edge is 5 mm = appr. .20 in., »a» in figs. 201 and 202.

Plate edges are undercut at the corners, giving space for Couplers in girder constructions. The size of the undercut, referring to fig. 201, is: »b» = 1 mm = = appr. .04 in., and »c» = 9 mm = appr. .36 in.

Between the pair of Couplers in a joint there is a clearance »a», fig. 203, of 1 mm = appr. .04 in., to take a Beam web or a thin Plate. The slight elastic deformation occuring in the Couplers when the Screws are tightened gives a locknut effect, holding the Nuts securely even under strong vibration.

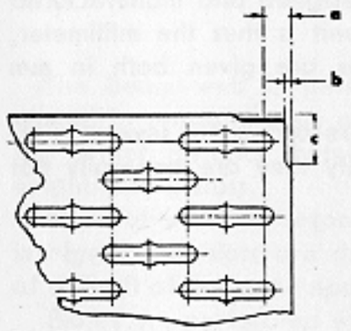


Fig. 201

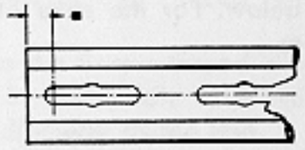


Fig. 202

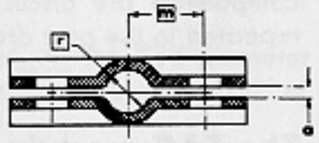


Fig. 203

Circular screw hole series

Certain wheels and wheel parts carry one or two circular series of evenly spaced screw holes. The linear distance between neighbouring hole centers is 2 [m]. Fig. 204 shows the typical hole spacing.

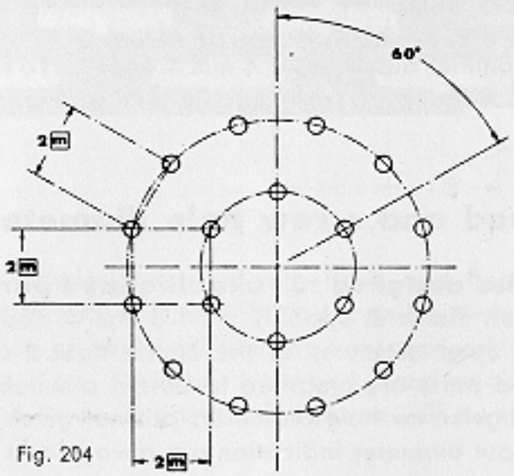


Fig. 204

Centering diameters

Parts designed to fit together concentrically, such as a Bearing in a Bearing Housing or a Wheel Center on a Wheel Disc, are manufactured to one of four standard centering diameters, designated by the symbols (v), (w), (x), (y), (z)

(v) = 8 mm = appr. .315 in.
(w) = 63.3 mm = appr. 2.49 in.
(x) = 21 mm = appr. .83 in.
(y) = 19 mm = appr. .75 in.
(z) = 7 mm = appr. .28 in.

These are nominal dimensions only; actual dimensions are modified to obtain a suitable fit.

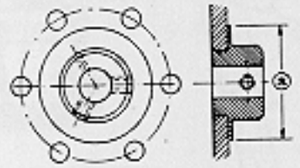


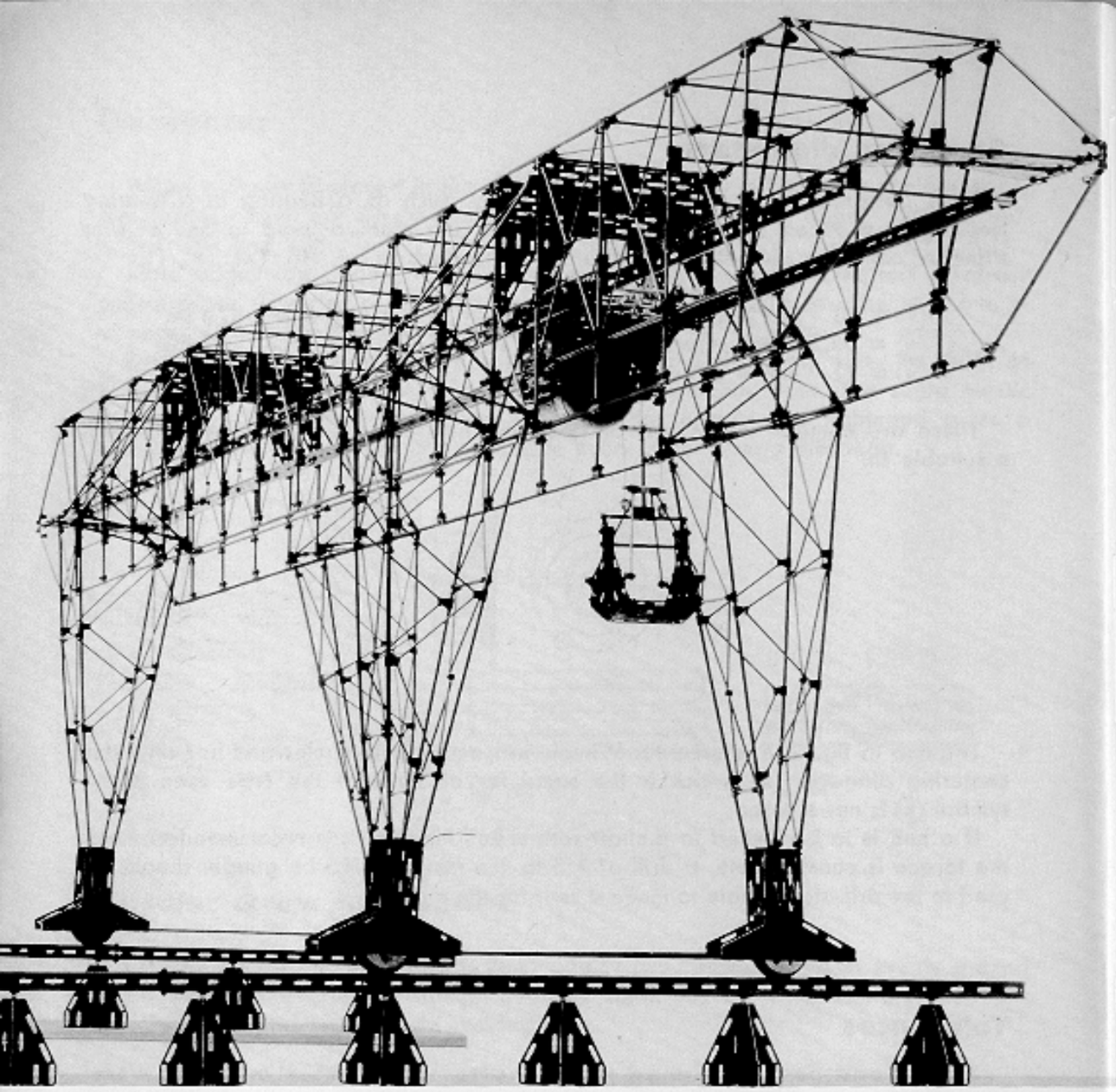
Fig. 205

The hub in fig. 205 is used for Wheels with screw hole circles and has an outer centering diameter (x), which is the same for all hubs of this type even if the symbol (x) is not entered.

If a hub is to be locked to a shaft with a Roll Pin, which is recommended when the torque is considerable, a drill of 1.5 to 1.6 mm, or 1/16 in. gauge, should be used in the drill-starter hole to make a seat for the pin.

Tolerances

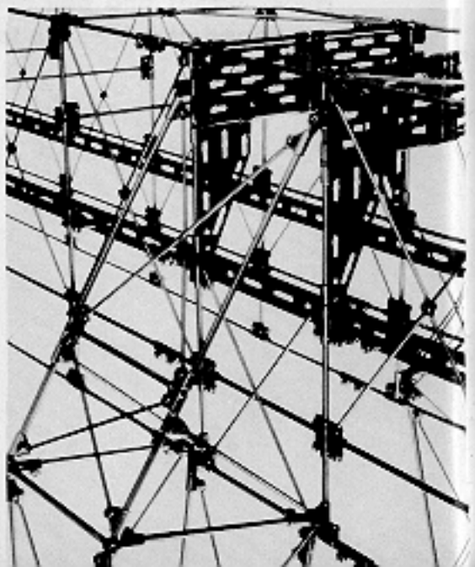
Shafts and parts designed to fit shafts, such as Wheel and Gear Wheel Hubs, Bushes and Ball Bearings, are manufactured to closer tolerances than those mentioned above — see table on page 76.



▲

Fig. 301. — Bridge crane model built largely with clamped connections.

Close-up of lattice. ▶



Assembly methods

Two methods of assembly are used in FAC, i. e. by clamping, or by screwing the various parts together. Of these, the clamping method makes use of a variety of Couplers — which incidentally rely on screws and nuts for their locking effect — and is the one most generally employed when building frameworks. Screwed connections, on the other hand, with or without the use of spacer elements, find application for various subassemblies in supporting structures and for building moving mechanisms. — This very general classification of the uses of clamped and screwed connections is, however, by no means a strict rule.

Clamp connections

Clamp connections are made with a system of Couplers and Clips which are locked around Rods and Beams. They have the advantage that they can be moved along the Rods, or Beams, until the best position has been established, and need only then be pulled tight.

The illustrations on the following pages show some examples of Rod and Beam systems and connections made with Couplers and Beam Joining Plates.

Fig. 302. — Overall view of crane.

▼

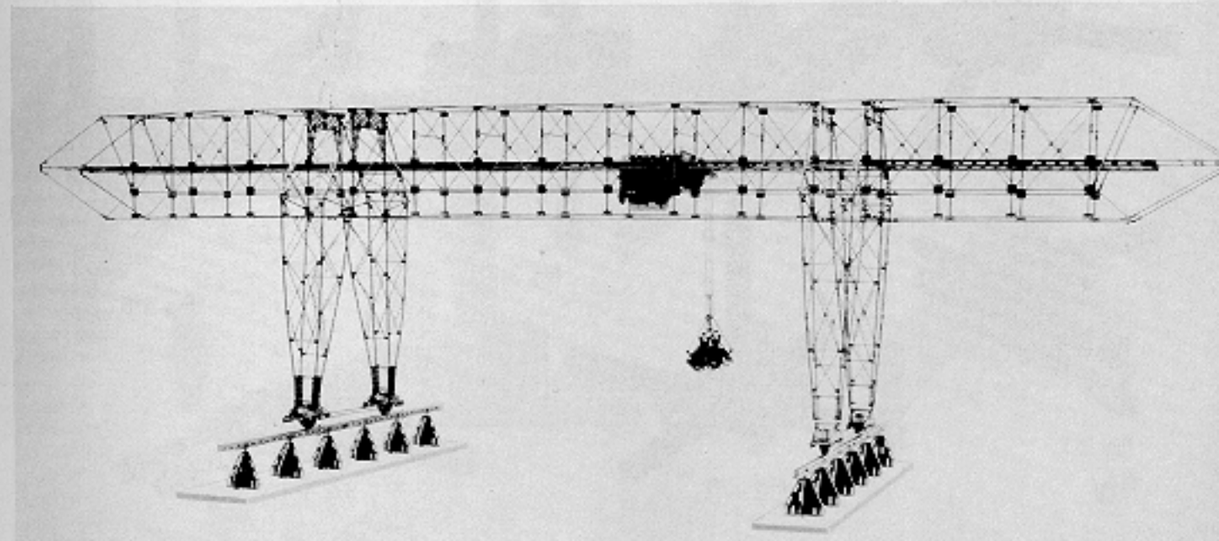


Fig 303

Fig 304

Fig 305

Fig 306

Fig 307

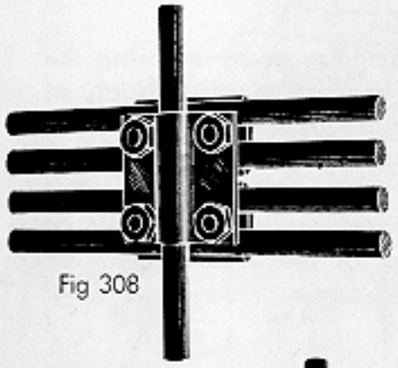


Fig 308

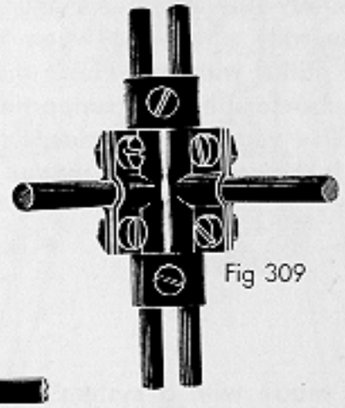


Fig 309

Fig 310

Fig 311

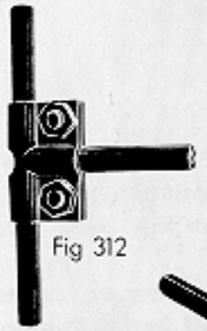


Fig 312

Fig 314

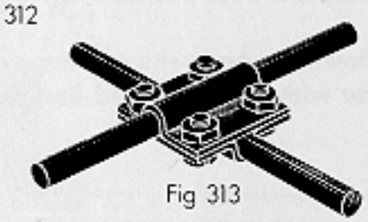


Fig 313

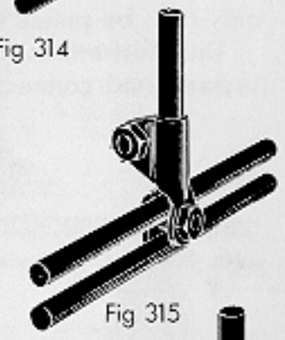


Fig 315

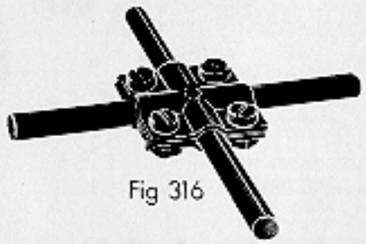


Fig 316

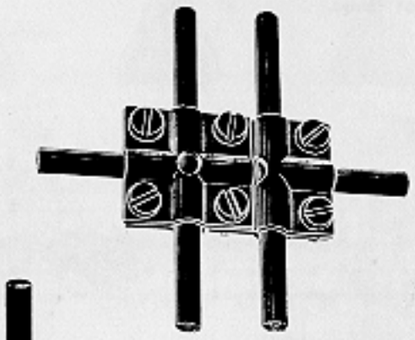


Fig 317

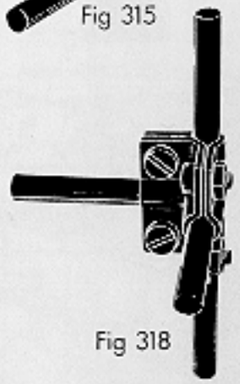


Fig 318

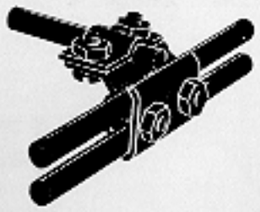


Fig 319

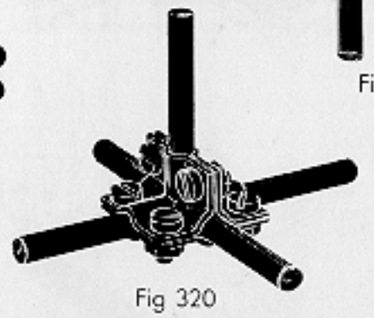


Fig 320

Fig 321

Fig 322

Fig 323

Fig 324

Fig 325

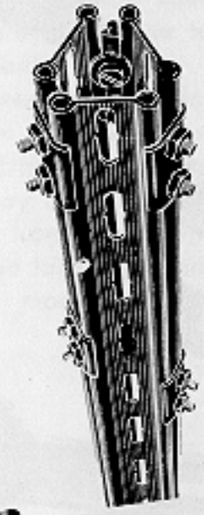


Fig 328

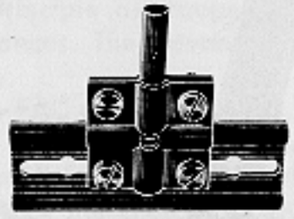


Fig 326

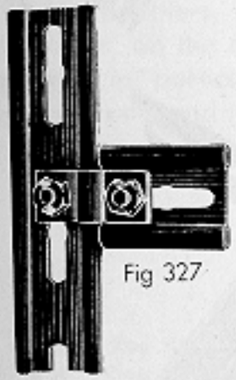


Fig 327

Fig 329

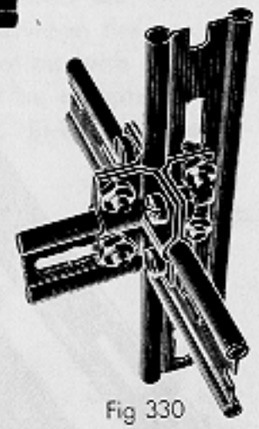


Fig 330

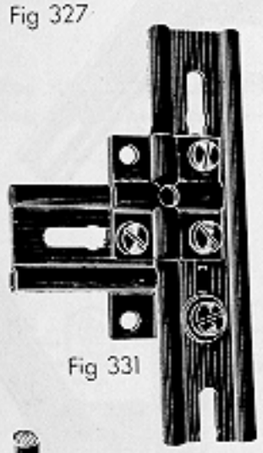


Fig 331

Fig 332

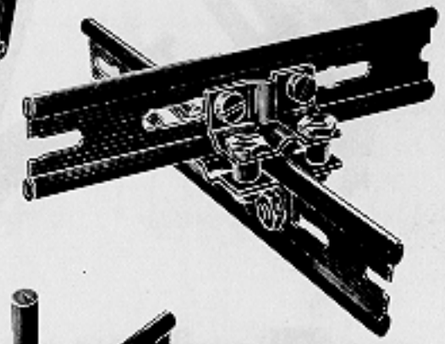


Fig 333

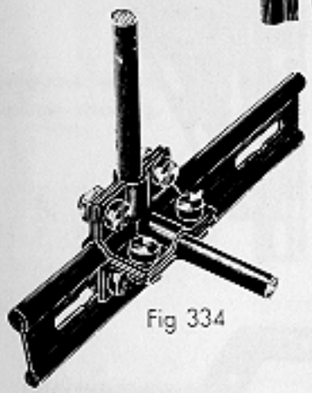


Fig 334

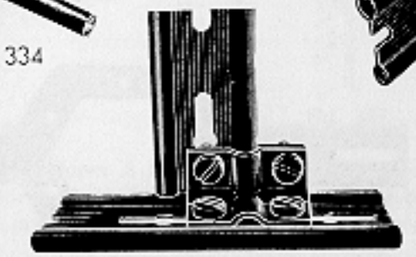


Fig 335

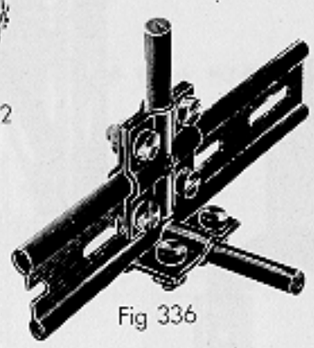


Fig 336

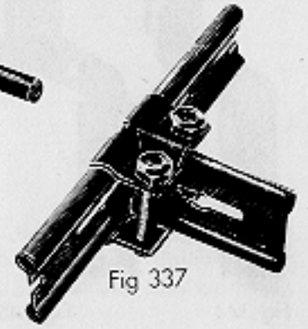


Fig 337

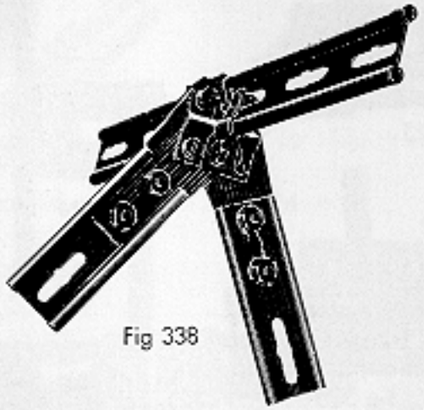


Fig 338

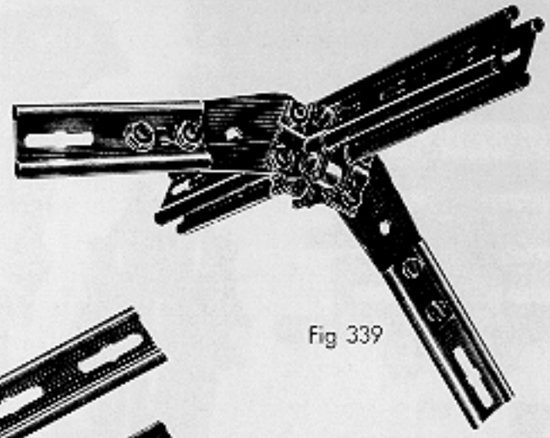


Fig 339

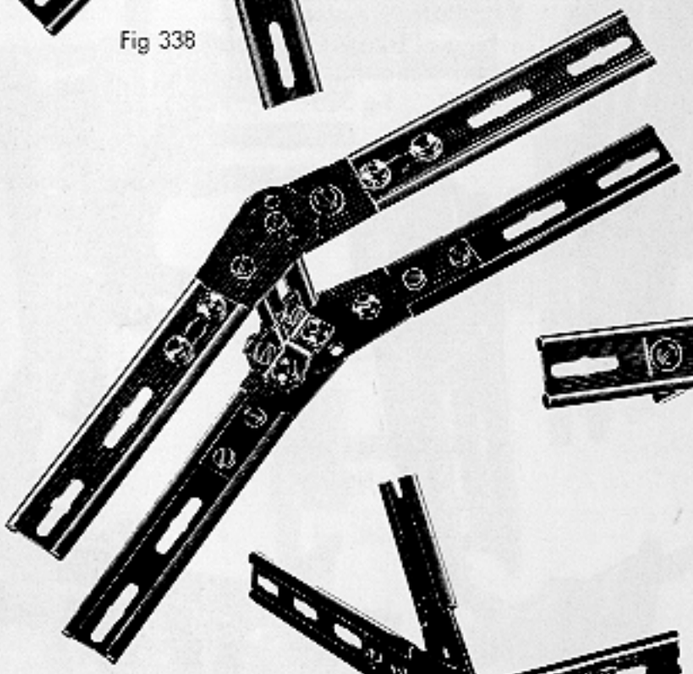


Fig 340

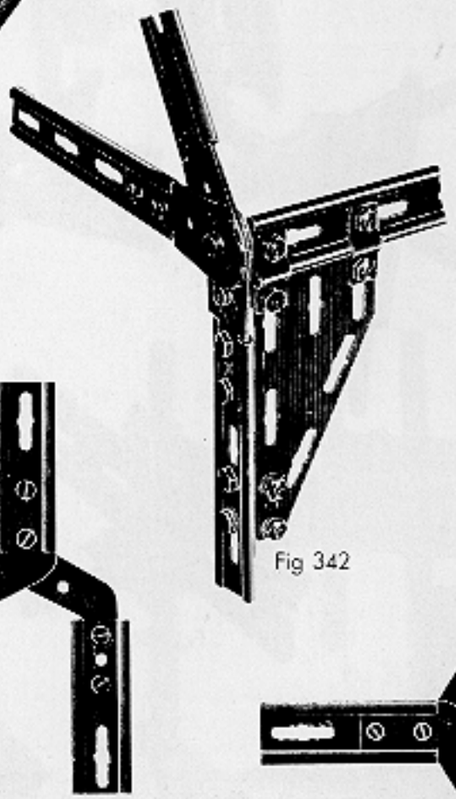


Fig 342

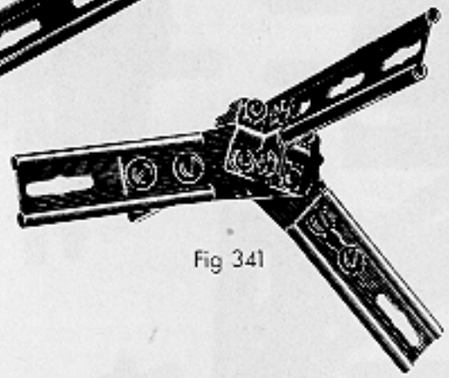


Fig 341

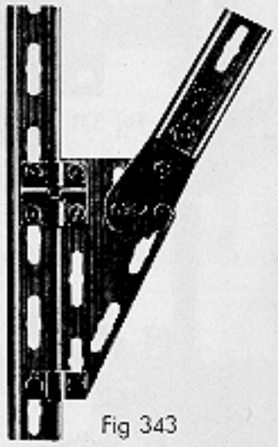


Fig 343

Fig 344

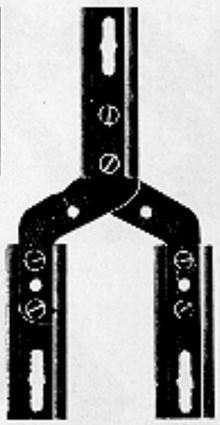


Fig 345

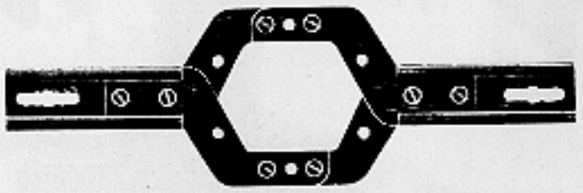


Fig 346

Screwed connections

In structures built with screwed instead of clamped connections, the need for adjustment is satisfied through the use of spacer elements of fixed lengths which can be combined according to the same principle as gauge blocks to produce well defined distances with very close tolerances. The advantage of this method of construction is self-evident.

The differentiation of measurements in the FAC system — 3 mm Threaded Parts; 4 mm Rods; 4 and 6 mm Spacer Elements — makes possible the building of a great variety of built-up framework subassemblies, bearings, brackets etc.

As a general rule it may be said that, where the choice is between the use of Clamp Couplers, on one hand, and Threaded Parts in combination with Spacer Elements, on the other, the latter method is generally the one to be adopted. This applies in particular for most shaft and piston-rod bearings, linkages, crank mechanisms, and the like.

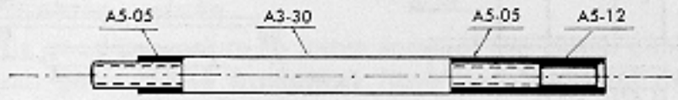


Fig. 347

Threaded Rod fitted with Tapped Sleeves to reduce the free threaded length at one end by 5 mm, and providing an internal thread — Sleeve A5-12 — at the other end.

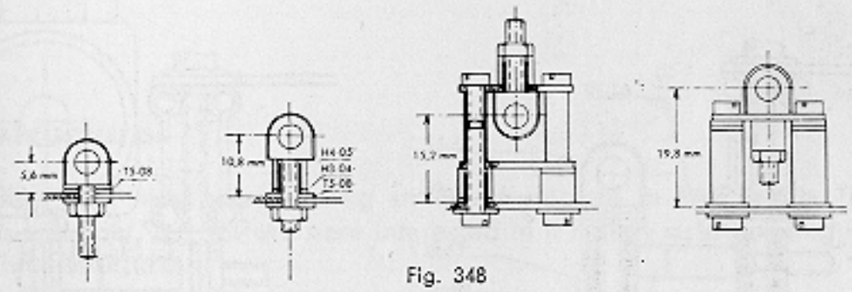


Fig. 348

Examples of the use of Washers T5-08, Sleeves H4-, and Rings H3-04 in order to obtain any desired spacing.

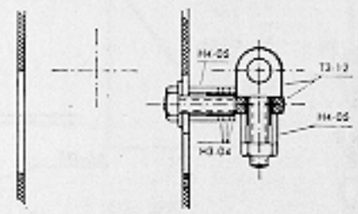


Fig. 349

The left-hand picture shows a Plate and an intended shaft center which has been deliberately so chosen that the construction method of fig. 348 cannot be employed. — The right-hand figure shows the solution of the problem, involving the use of Eye Screws T3-12, Tapped Sleeves A5—05, an other spacer elements.

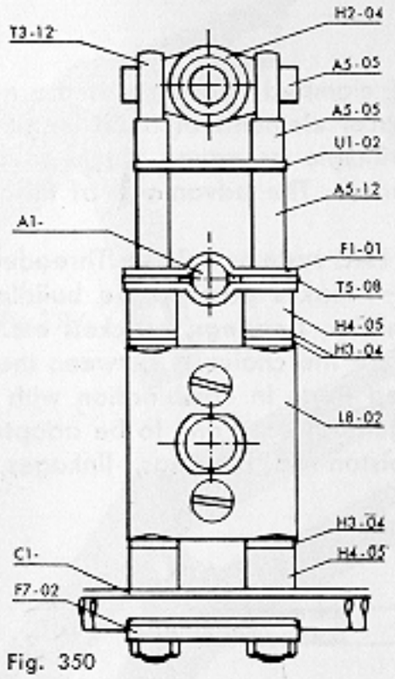


Fig. 350

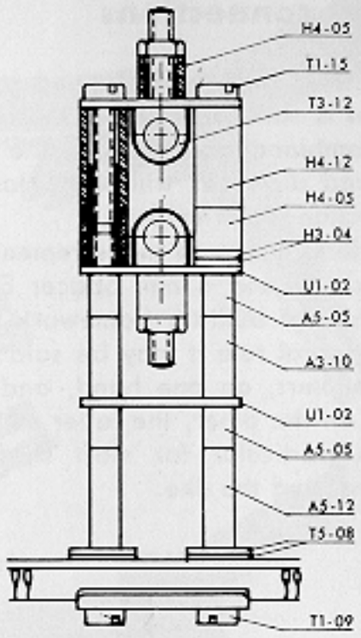
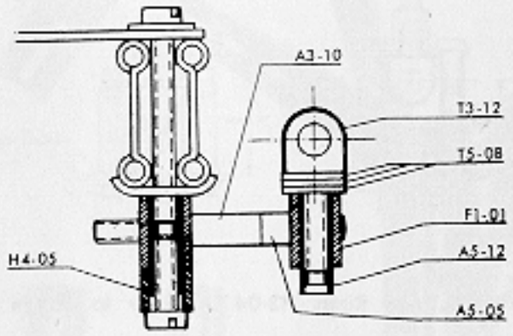


Fig. 351

Examples of bearing brackets constructed from threaded parts plus spacers; inf gi. 352, Eye Screws T3-12 form beorings for shafts with a centreline distance of 11.2 mm, suitable for a pair of P1-16 gears.



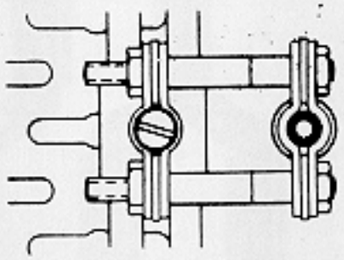


Fig. 352

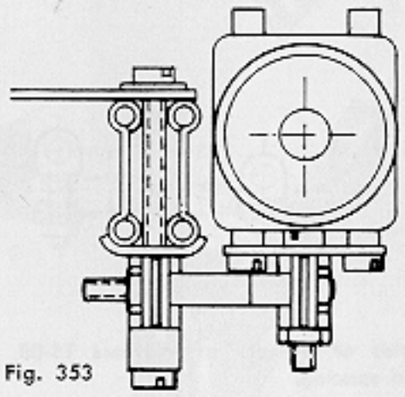


Fig. 353

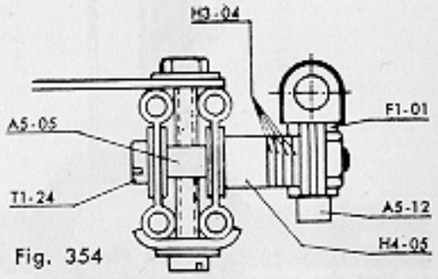


Fig. 354

Using the construction mthods shown in figs. 352—354, bearing brackets may be arranged for a shaft centreline in any desired location outside a structure.

Rigid structures

The basis of all FAC designs is the rigid structure in which the moving parts are assembled. The construction principle employed in the FAC system corresponds to, and simulates, the conventional riveted, welded, and cast structures of full-scale engineering.

Whereas these methods of construction invariably call for very careful planning down to the smallest detail, FAC designs allow considerable leeway in all directions. It is quite possible to build a workable FAC framework from only a rough or vague sketch or to interpret an idea direct in terms of available FAC structural material.

In this case, it is good procedure to leave some of the clamp connections loose, until all the various parts of the framework have been installed and adjusted to their correct final positions; only then are the clamps pulled tight.

Despite its close adherence to strict design principles, FAC allows so many and infinitely varied solutions and practices that we must restrict ourselves to giving a few examples only of characteristic designs for various purposes and degrees of loading.

Lattice structures

The lightest and most space-saving structural element in FAC is the Tie Rod. Its uses are manifold, but we are here interested in it mainly as a building element for light lattice structures.

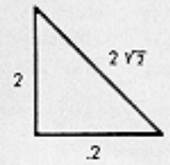


Fig. 401

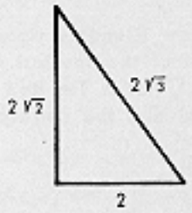


Fig. 402

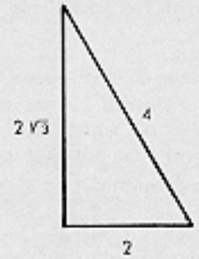


Fig. 403

The Tie Rod is available in a number of lengths which spring from the side relationships of the three 90 deg. triangles illustrated in figs. 401-403. Of these, fig. 401 shows a half-square, fig. 403 a half equilateral triangle.

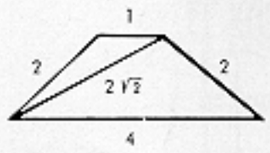


Fig. 404

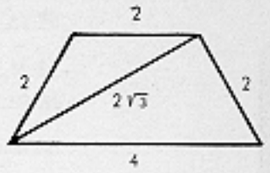


Fig. 405

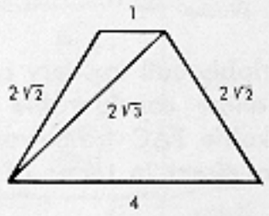


Fig. 406

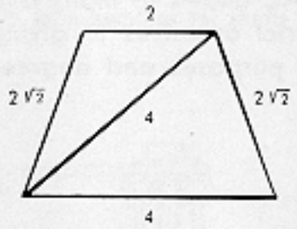


Fig. 407

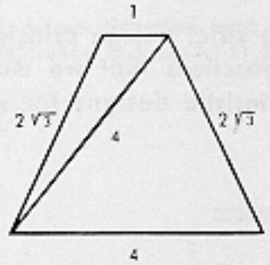


Fig. 408

Figs. 404-408. — These figures show some examples of truss elements for lattice structures, consisting of statically determined isosceles trapezes which may be built in various sizes through appropriate selection of Tie Rods from the table.

The figures appearing at the sides of the triangles denote the lengths of the sides referred to the length of the shortest element in the Tie Rod system — which is, in fact, not a Tie Rod proper but the Three-Hole Link. — Tie Rod lengths and the corresponding designations are listed below.

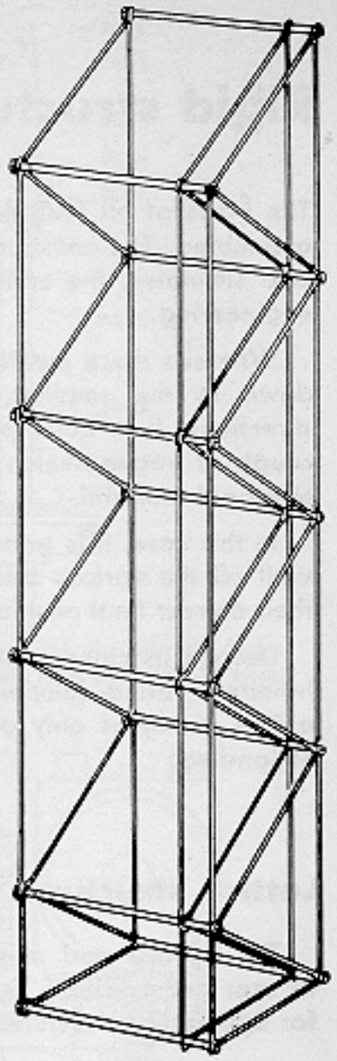


Fig. 409. — Lattice built exclusively with Tie Rods, Threaded Rods, and Tapped Sleeves.

1	U1-02	2	D1-20	4	D1-40	8	D1-80
$\sqrt{2}$	D1-12	$2\sqrt{2}$	D1-22	$4\sqrt{2}$	D1-42	$8\sqrt{2}$	D1-82
$\sqrt{3}$	D1-13	$2\sqrt{3}$	D1-23	$4\sqrt{3}$	D1-43		

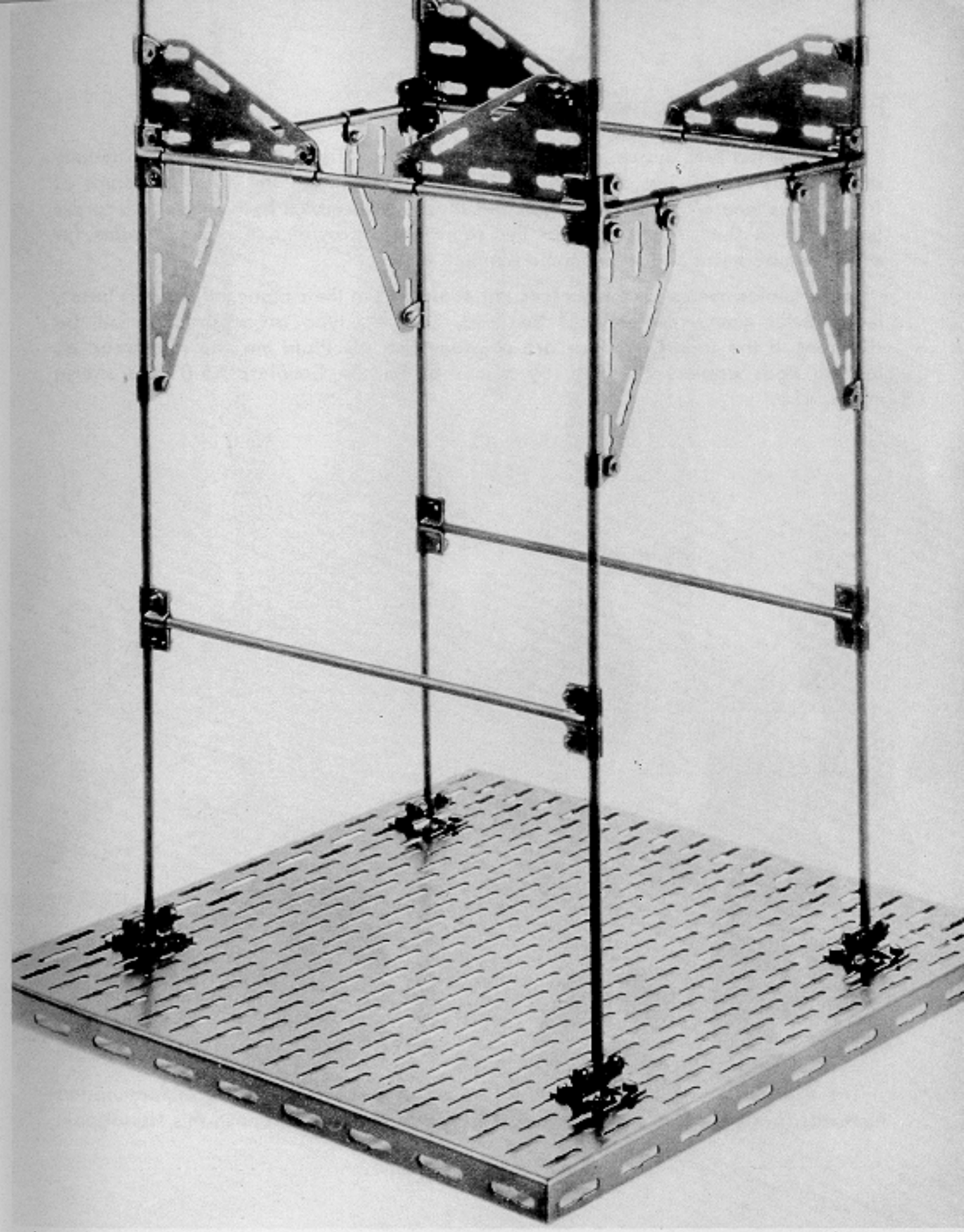


Fig. 410. — Lattice structure made from Rods A1- mounted on a baseplate C9-17. Despite the slender type of construction, the lattice has great strength and rigidity, and lends itself well to carrying various pieces of mechanism and to taking up mechanical forces of moderate size.

Plate constructions

Plates in the FAC system come in two thicknesses. The thinner plates are mainly intended as reinforcing elements to be mounted between the Rods or Beams of frameworks where they take the place of diagonal members by taking up all forces contained in their plane and, at the same time, providing mounting points for other members stressed in the same plane.

If the plates are to take up forces not contained in their plane, or support loads, the heavier gauge plates must be used, and the type of construction will be different. If the forces or loads are considerable, the Plate may be reinforced by locking Rods against the Plate by means of Saddle Couplers A5-01, as shown in fig. 411.

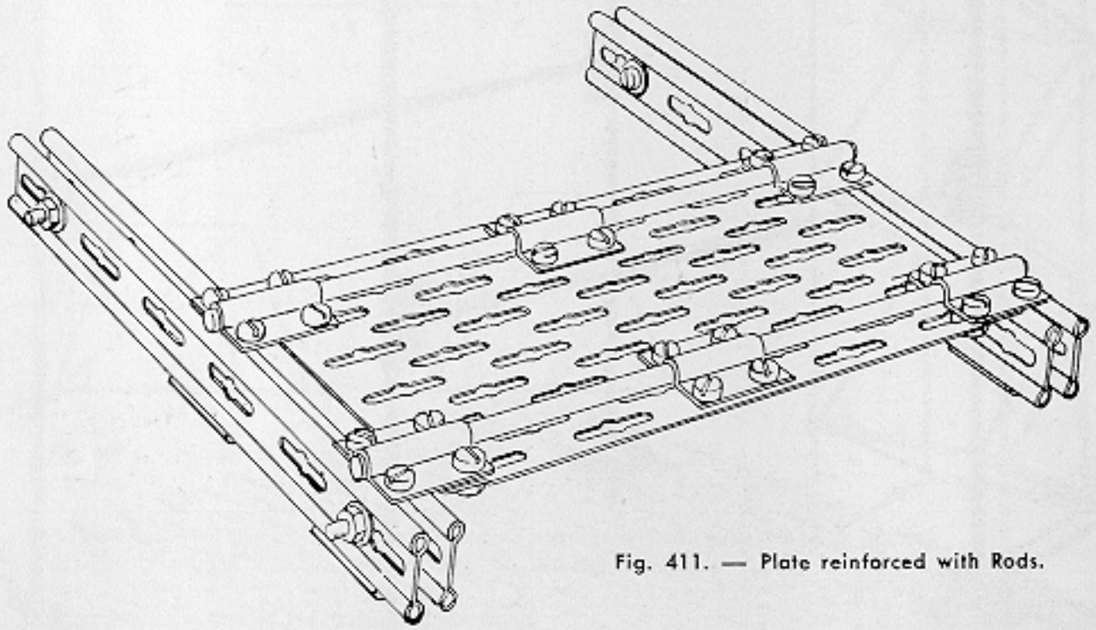


Fig. 411. — Plate reinforced with Rods.

If the forces and loads are not too great, a thin Plate may be used in the same manner.

The uses of plates are otherwise so varied as to escape a general formulation in words, and are best described by referring to the illustrations in this Handbook.

Fig. 412 — shows the mast of a traveling crane, the foot of which has been transformed into a strong box-type foundation through the inclusion of thin plates between the corner rods; above the plates, the framework has the aspect of a light lattice structure with Tie Rod diagonals. ▶

Heavy-duty framework

For machine models containing a high percentage of moving parts, and where stability of the supporting structures is an indispensable requirement, a combination of Beams and Plates with Threaded Parts and Spacer Elements predominates in framework design. The problem is to achieve maximum strength and rigidity coupled with the greatest possible number of mounting points for the various bearings, brackets, guides etc. which support the moving mechanisms, often very closely spaced.

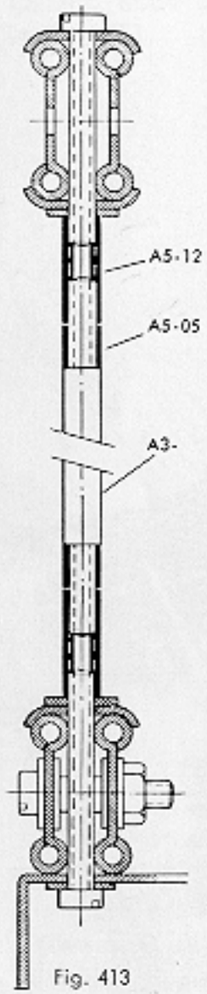


Fig. 413

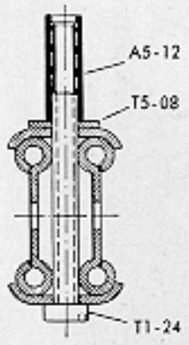


Fig. 414

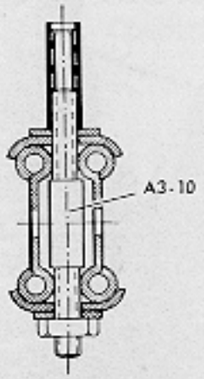


Fig. 415

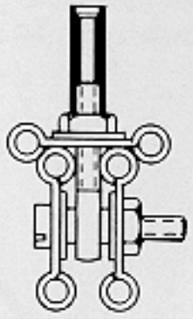


Fig. 418

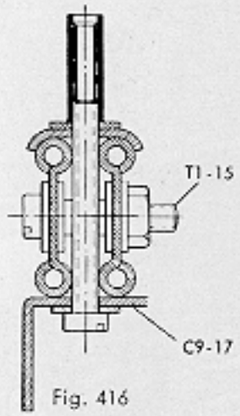


Fig. 416

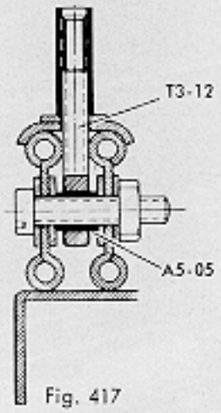


Fig. 417

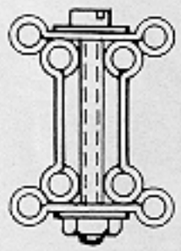
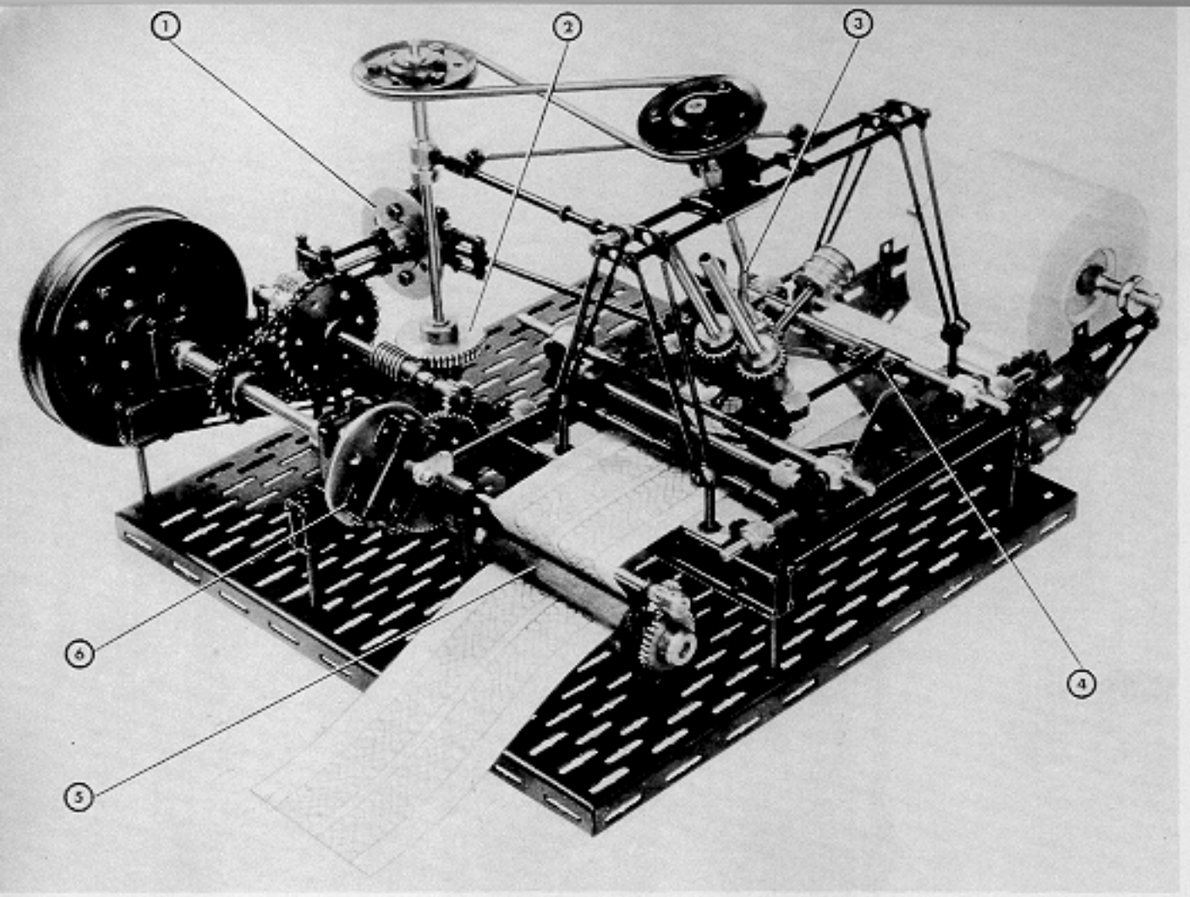
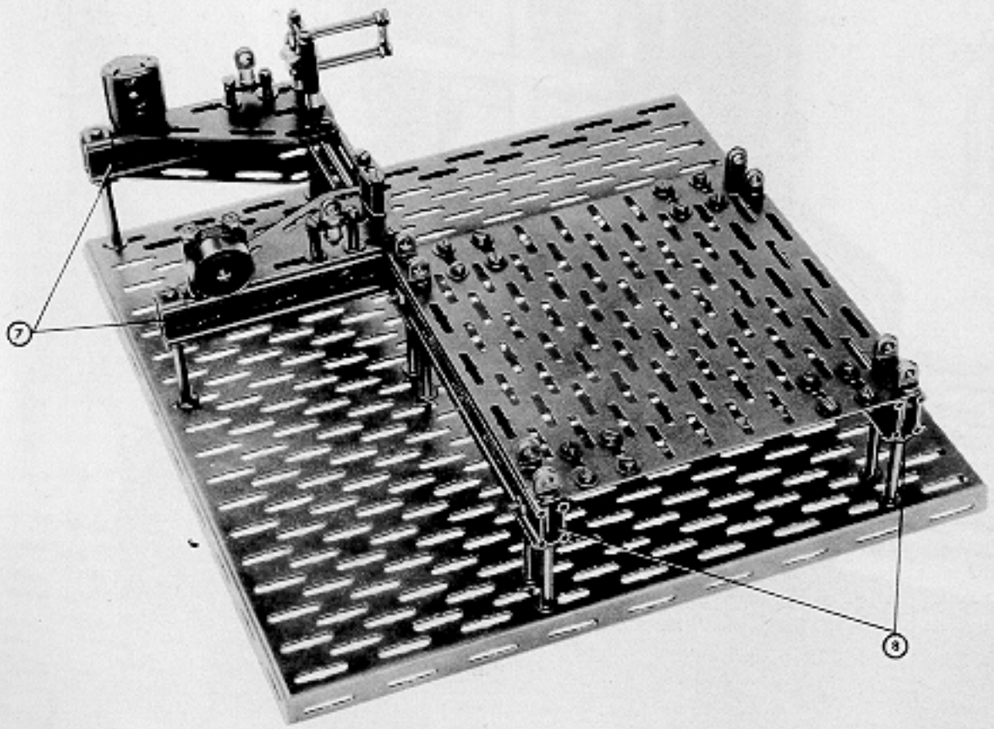


Fig. 419

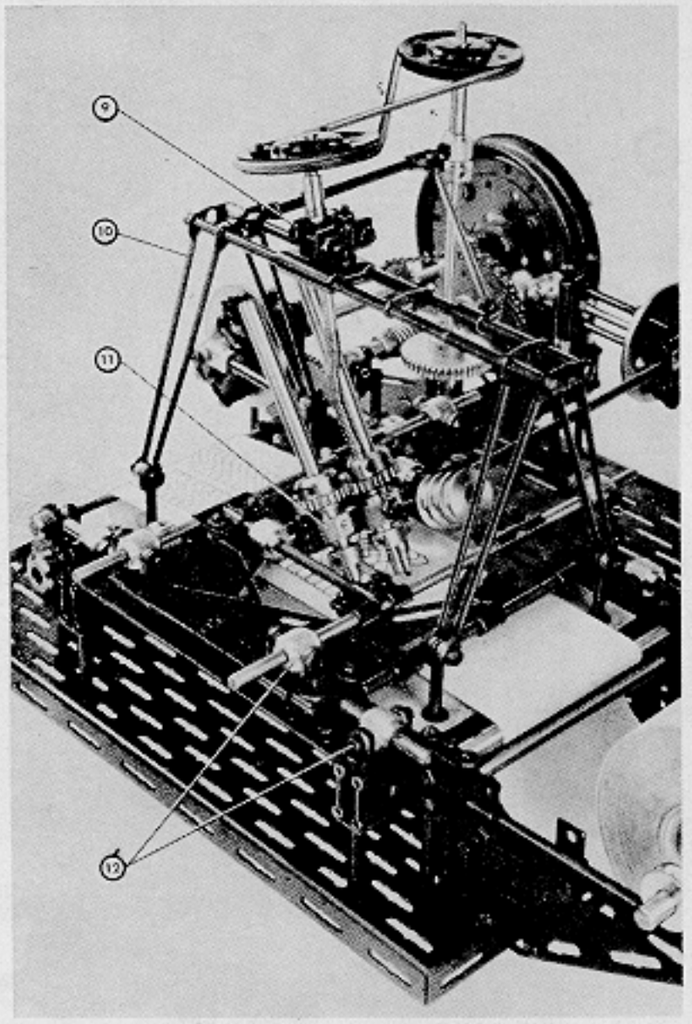
A particularly useful structural member from which highly versatile designs can be built is the Twin Beam shown above. Four Beam edges provide seats for clamping additional framework parts, bearings etc.; moreover, parts may be screwed to the Twin Beam by using the holes in the Beam webs, or mounted between the two Beams. Figs. 418 and 419 show composite Channel and Box Type Beams, respectively.

Fig. 420. — When Flanged Plates C9-17 are used as a foundation — as in this section of a printing press — Twin Beams may often be used to advantage by placing them horizontally on the Plates where they act both as reinforcing ribs and as supports for various vertical framework parts which can then be moved along the entire length of the Beams for adjustment. ▶





◀ Fig. 421. — Long-time testing machine for ball-point pens. Serrated rubber rolls 5 pull a paper strip over a table where two pens are tracing figure-of-eights on the paper. The pens are mounted on a compound slide arrangement 4, with one slide on top of the other; the reciprocating movements of the two slides are producted by two crank mechanisms 1 and 6 at right angles to each other. The pens rotate during the test, driven by a transmission beginning with worm gear 2 and ending up with flexible shaft 3.



▲ Fig. 423. — Another view of the ball-writer testing machine. The following constructional features are worthy of note:

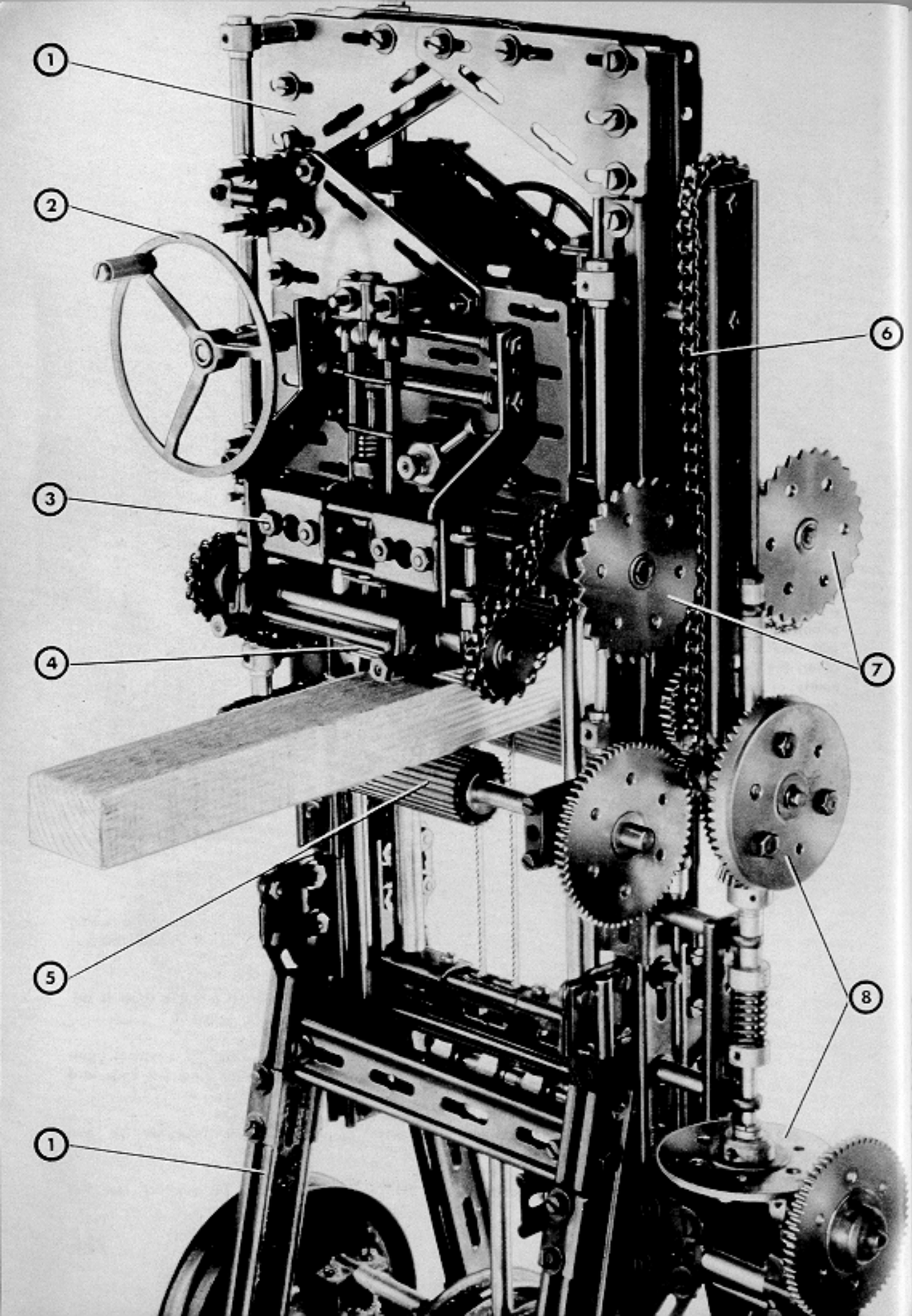
— Pivoting bearing 9 for pen drive shaft is adjustable anlong the transomof

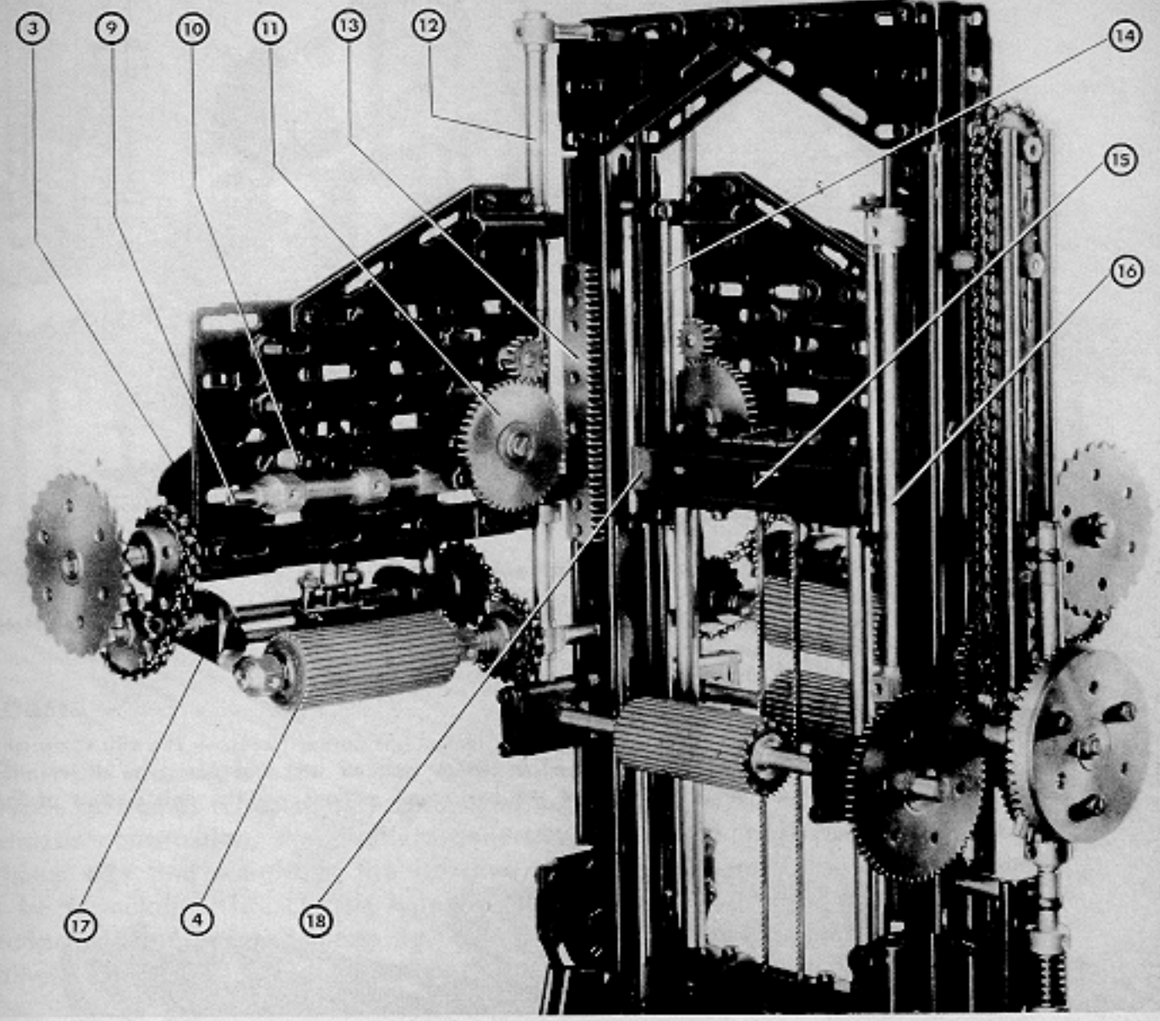
— Supporting trestle 10, which is a typical lightweight construction embodying Tie Rods and Threaded Rods with spacers.

— Rocker 11 supports the bearings for pen rotation.

— Self-aligning bearings 12 support the two slides.

◀ Fig. 422. — This picture shows the foundation plate and bed of the testing machine before assembling the moving parts; Twin Beams 7 and 8 constitute the backbone of the supporting structure.





◀ Fig. 424. — Gang saw model built with FAC parts and having all the functions of a full-scale machine. The model provides a good example of a relatively simple Twin Beam structure capable of taking up considerable mechanical stress and vibration. It also serves to illustrate the high degree of concentration of moving parts practicable in a structure of this kind.

One column of the machine frame carries the feed mechanism 8 which is driven from the crank system in the lower part of the machine frame. A friction and chain-and-sprocket transmission drives the feed rolls 4 and 5 at a speed suited to the quality of "timber" being cut, and to the number and cutting power of the saw-blades.

The upper feed roll housing 3, with feed roll 4 of serrated rubber tubing, is adjustable for height by means of handwheel 2; sprockets 7 which transmit the motion to the upper feed roll, then move along drive chain 6.

▲ Fig. 425. — Upper feed roll housing 3 opened out to show inside arrangement of feed roll 4 on spring-loaded rocker 17.

When closed, housing 3 is locked by operating lever 10 which shoots bolt 9 behind vertical rod 16. The housing is raised and lowered by turning handwheel 2 which operates gear 11 in engagement with rack 13. — The housing swings on vertical shaft 12.

The loose frame 15 in which the saw-blades are mounted, is another example of a strong light-weight movable structure made of Twin Beams and Threaded Rods reinforced by Tubular Shafts G7-. The frame is driven by the underlying crank mechanism and slides on pockenholz shoes 18 — specially made — along guides 14.

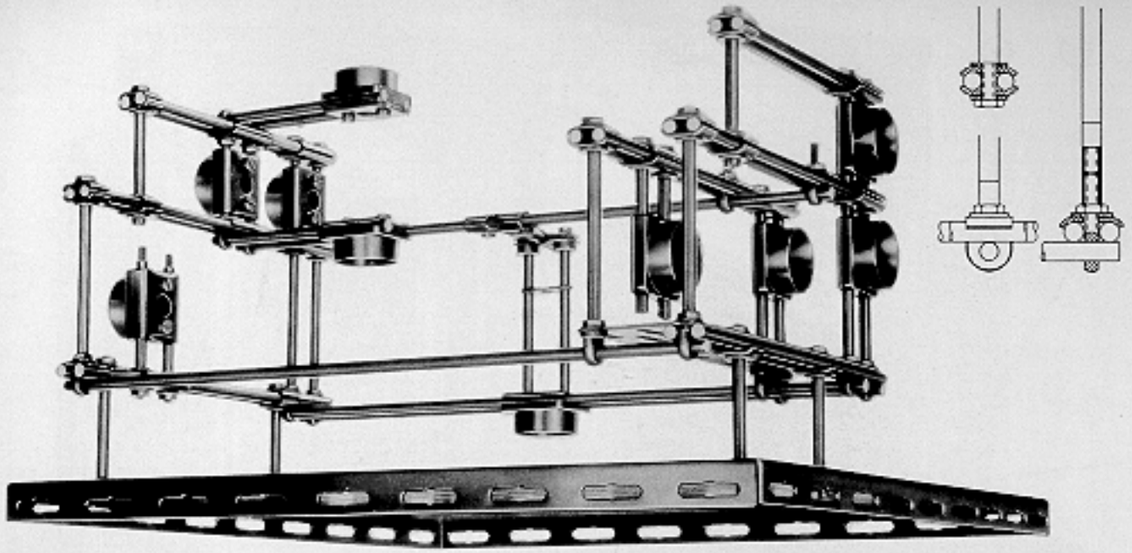
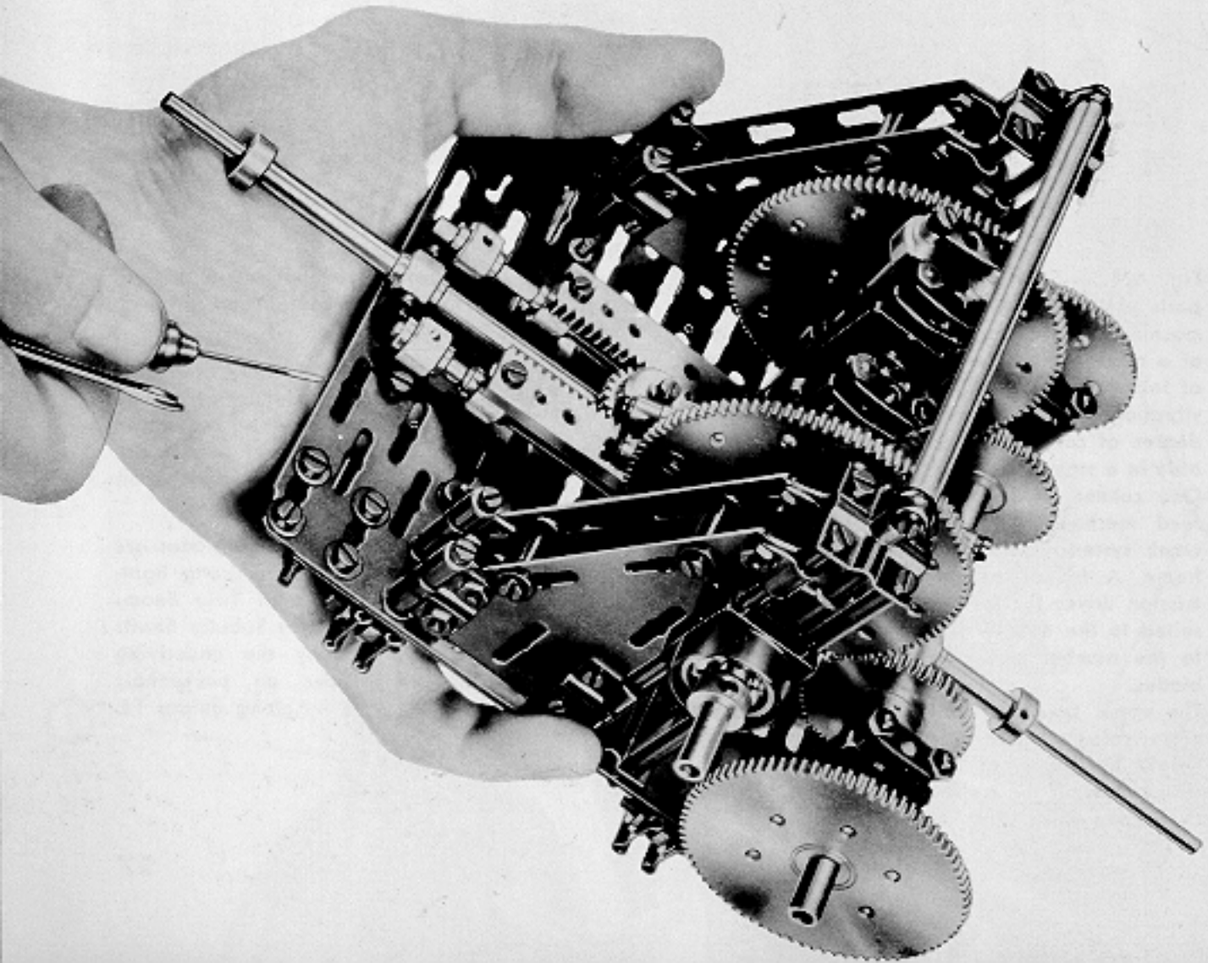


Fig. 426. — Supporting structure made up of Rods A1- and Threaded Rods A3- on a Baseplate — an easy-to-build, rigid design.
The ball bearing boxes can be adjusted vertically and horizontally to a fraction of a millimetre. Note free access from all sides of the structure.
The inset drawing shows the assembly method employed, using Eye Screws.

Fig. 427. — A specimen of subassembly building using Plates and Corner Plates. — The unit comprises two independent gear trains and crank mechanisms which drive a rack-and-gear type differential whose output movement reproduces the sum of the two crank motions. — The unit is part of the guilloche machine of fig. 431.



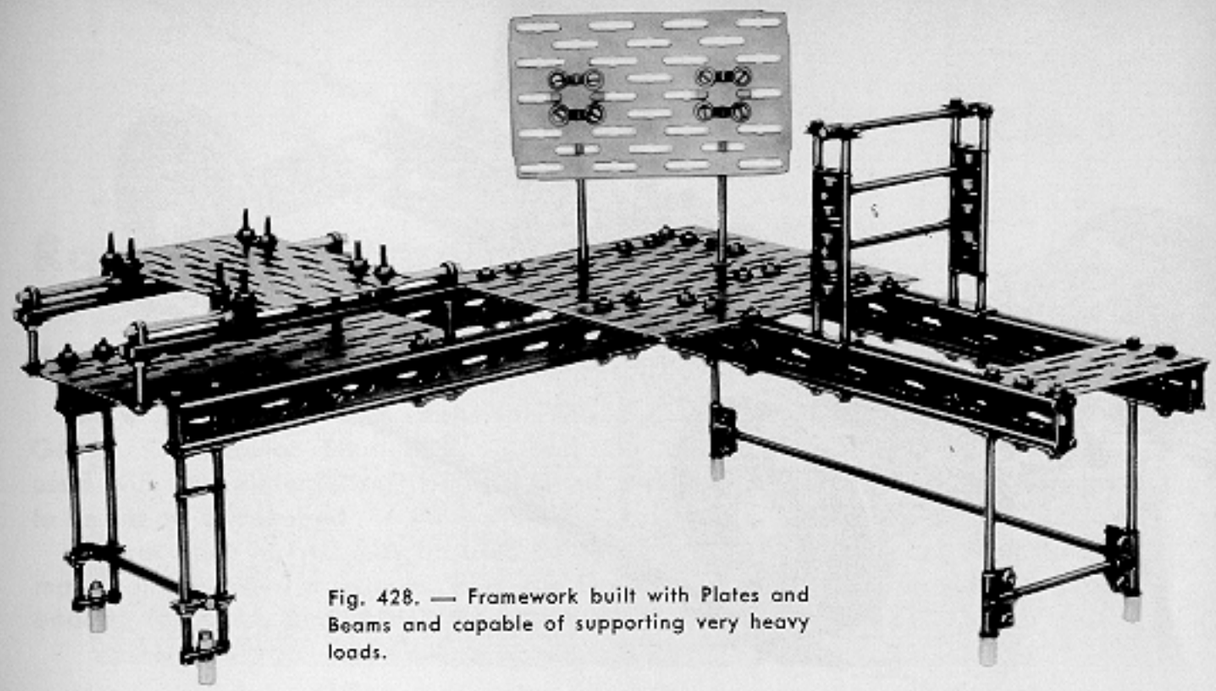
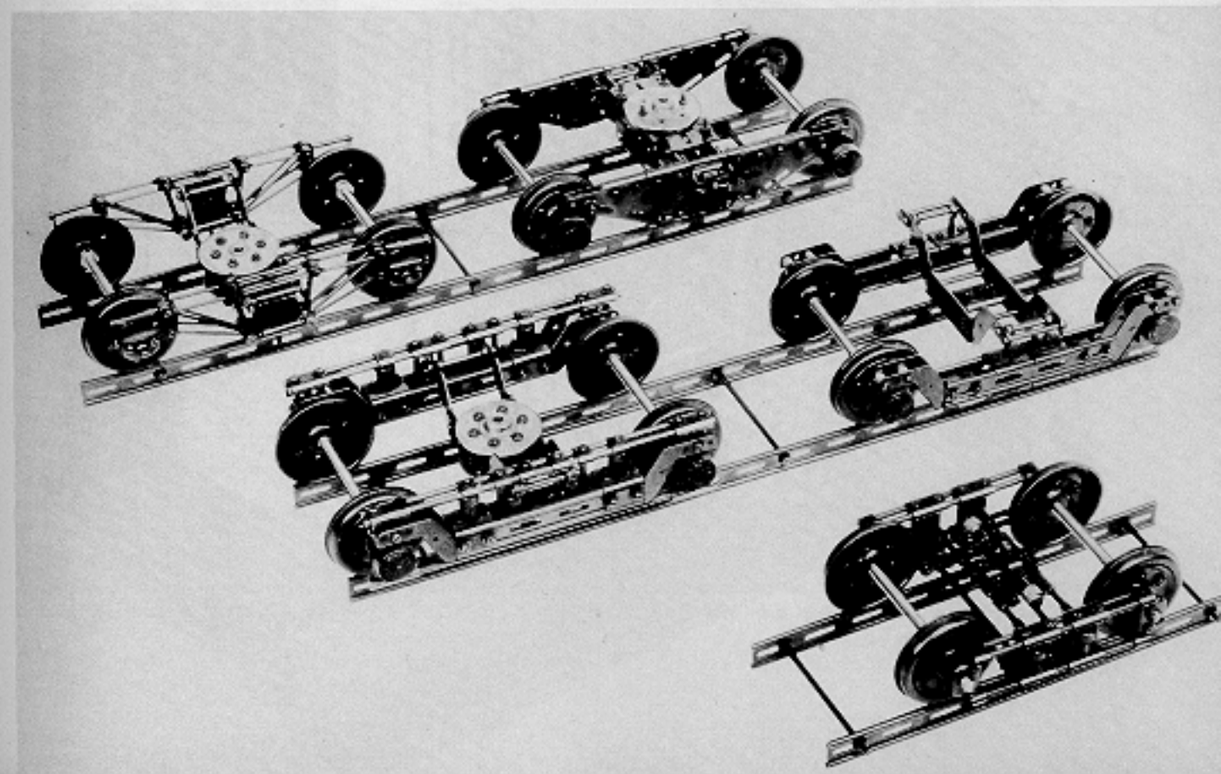


Fig. 428. — Framework built with Plates and Beams and capable of supporting very heavy loads.

Chassis

The word chassis is used in this context in the "automotive" sense to denote all types of frames as commonly used in wagons, trucks, trolleys, pivots, slides etc. In chassis construction, the problem generally is to build maximum strength into minimum size and weight of the structure, but apart from this no general rules can be formulated. The chassis type of structure is perhaps best illustrated by a selection of practical examples, fig. 429 below, which shows various designs for a railway bogie, and similar equipment.

Fig. 429.



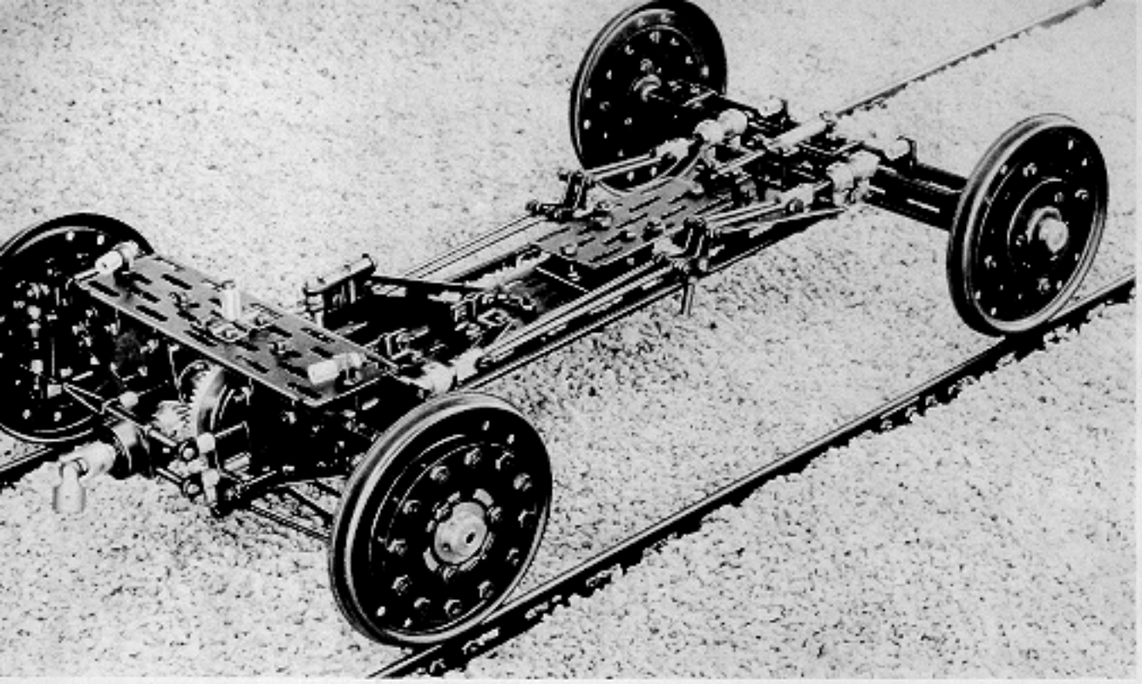
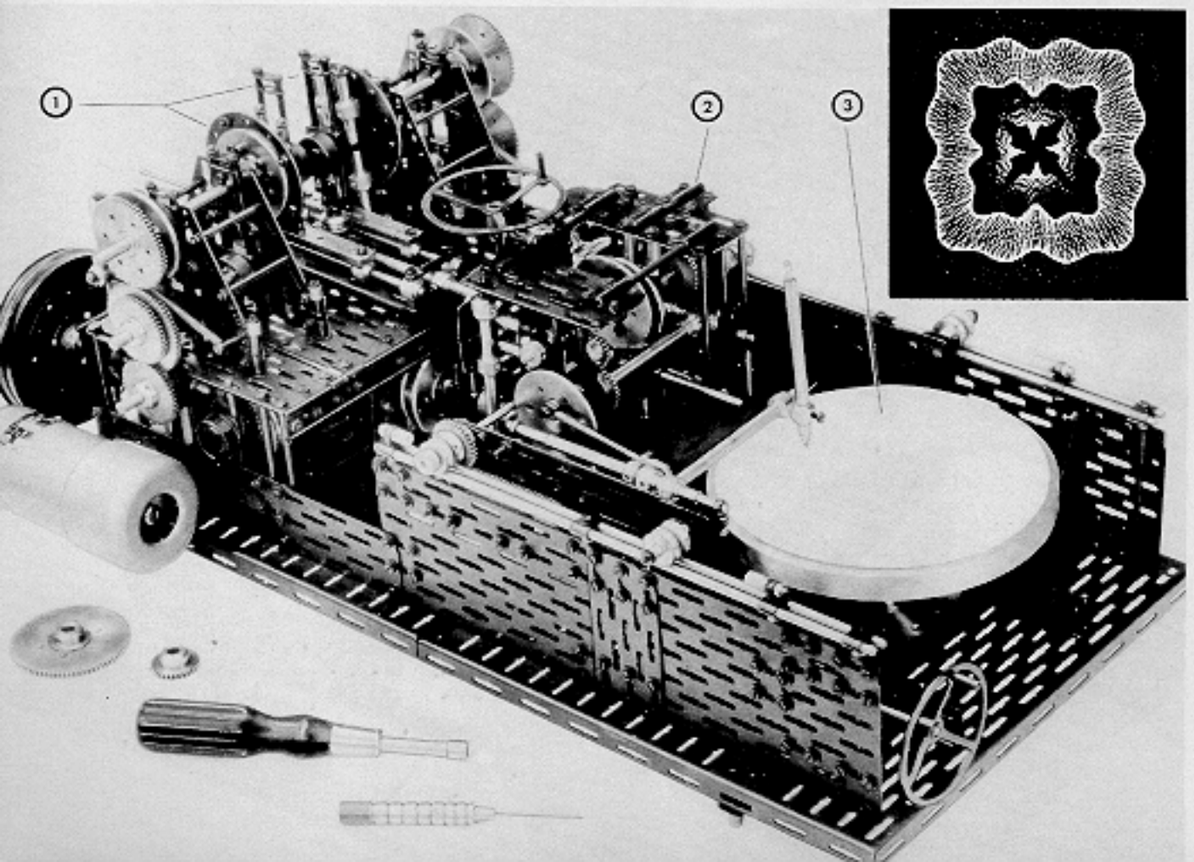


Fig. 430. — Railcar bogie with front and rear axles arranged for automatic tracking in curves, by means of Nylon buffers — Bearing Inserts — in the bogie and car frame.

Fig. 431. — This guilloche machine provides an instructive example of a machine where most structural design principles are represented. It also includes a chassis, or trolley 2, attached to the twin crank mechanism 1, carrying the stylus that traces the guilloche ornaments on the rewolving table 3. The inset pattern clearly demonstrates the accuracy attainable with FAC designs.



Rotary movements

Bearing arrangements

There are four types of shafts in FAC: 4 and 6 mm Solid Shafts, G4- and G6- ; the Tubular Shaft, G7- ; and the Grooved Shaft, G8- , which is used with the Sliding Dog, H8-01. All of these shafts are furnished in lengths to be cut off as required.

Several parts in FAC may be used as bearings for shafts, although their names may indicate other main uses, e. g. the Eye Screw which often provides a good bearing for 4 mm shafts when the speed is not excessive, fig. 421.

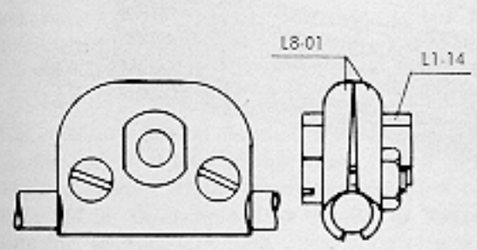


Fig. 501

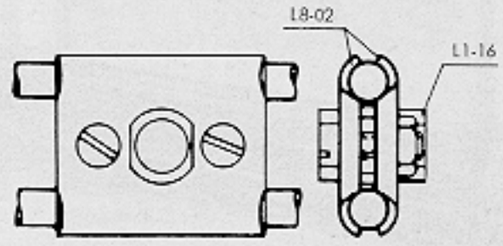


Fig. 502

Assembling a plain bearing pillow block on one, or two, Rods or Beam edges.

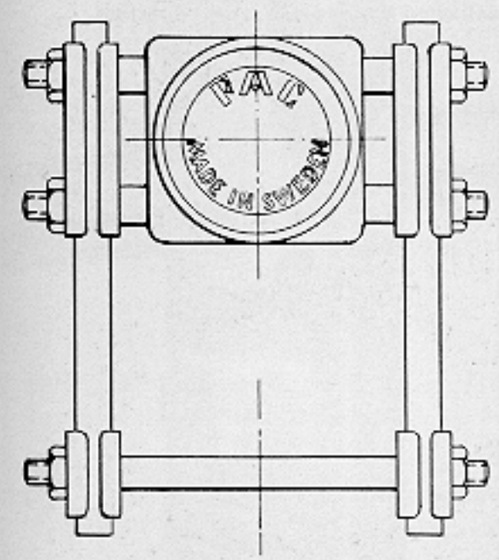
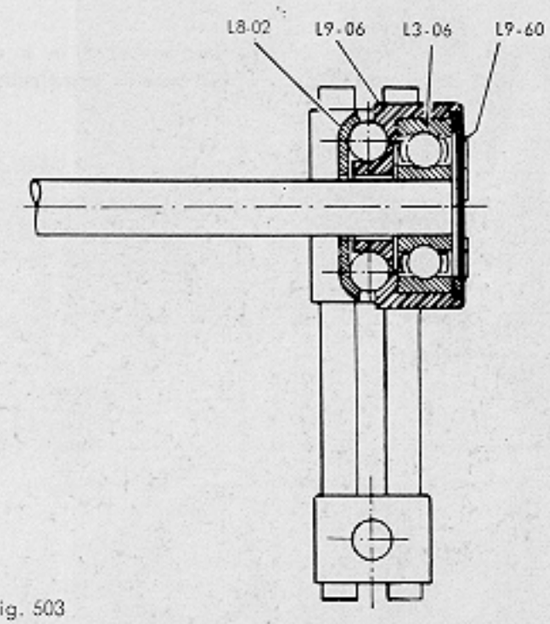


Fig. 503



The use of Ball Bearings is a direct development of the plain bearing arrangement. The Ball Bearing fits a 6 mm shaft; to use it with a 4 mm shaft, install a 6/4 mm Nylon Bearing Insert between shaft and bearing inner ring. — The Bearing is protected against grit and dust by a plastic cover.

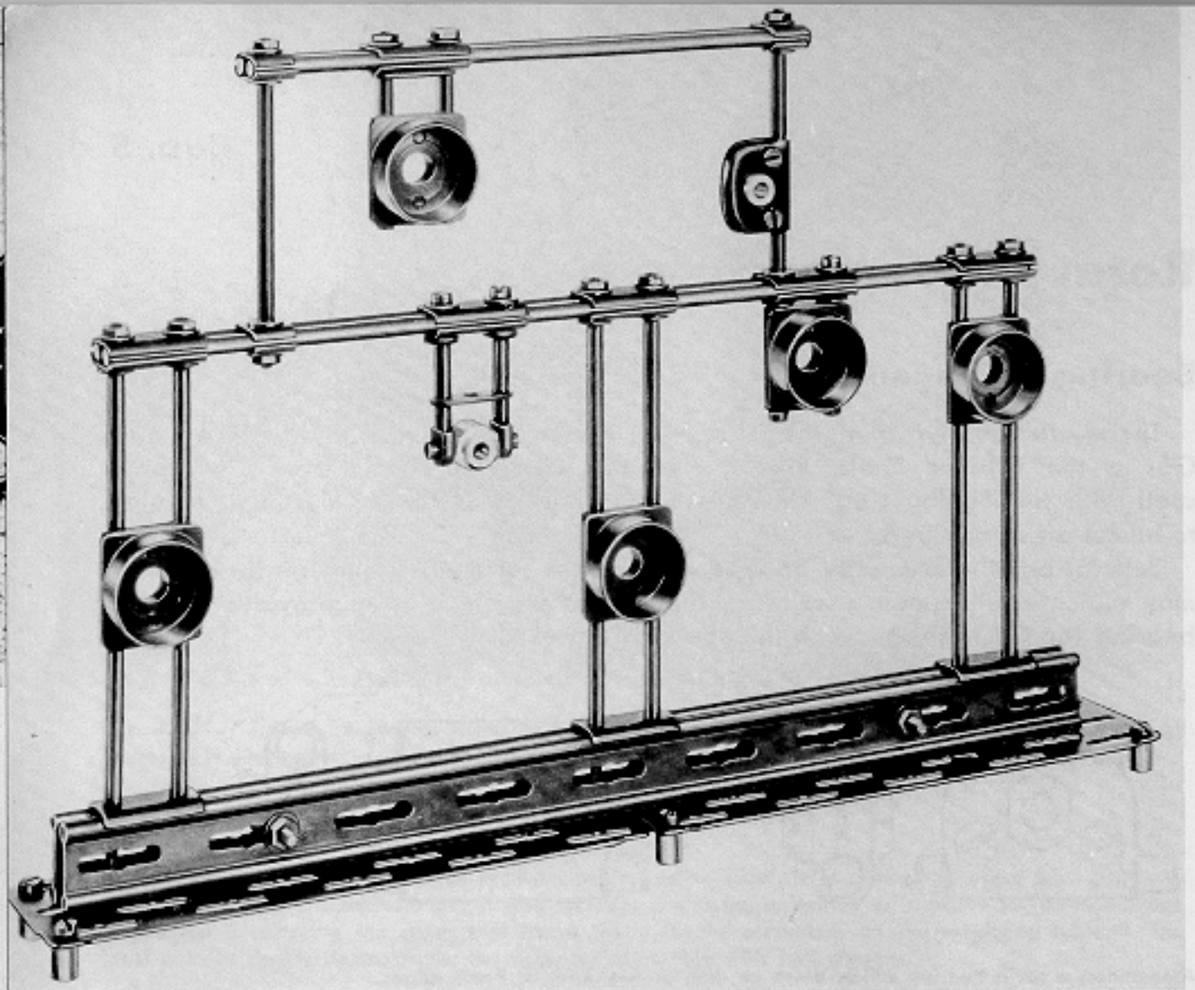


Fig. 504. — A variety of bearings mounted in a simple, yet sturdy framework of coupled Rods, Threaded Rods, and Beams, which permits practically unlimited variation in every direction.

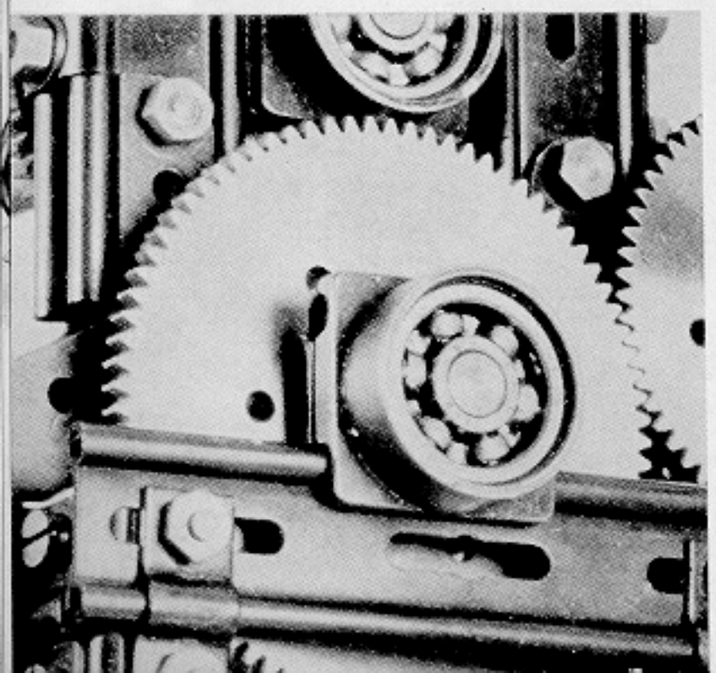


Fig. 505. — Ball Bearing Box riding a single Beam edge, leaving one groove open.

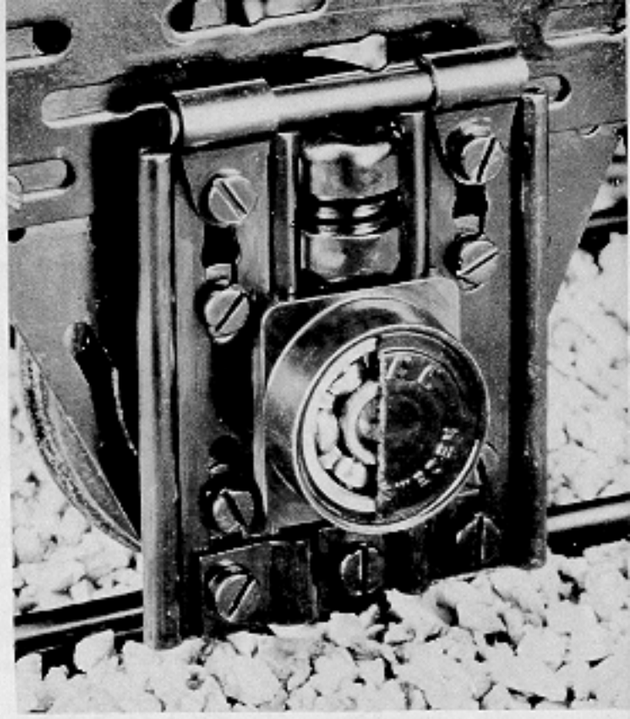


Fig. 506. — Spring-loaded Ball Bearing Box. The box is mounted on two Beams in the usual manner, but the screws are not pulled tight, allowing the box to move along the beam edges.

Fig. 507. — Spring loaded plain bearing consisting of a bronze Shaft Head fitted with a Tapped Sleeve A5-05 which slides in the center hole of a Three-Hole Link U1-02 to keep the bearing in line.

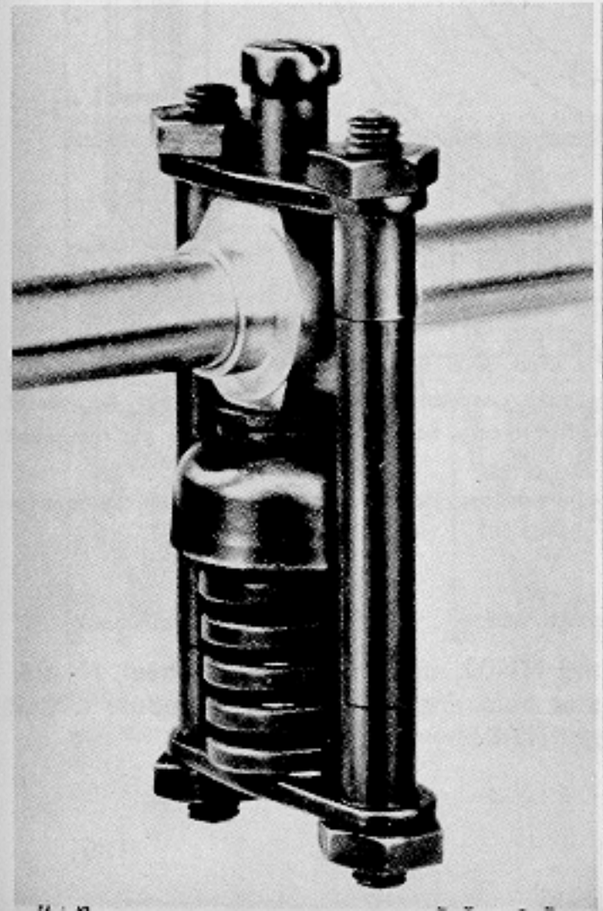
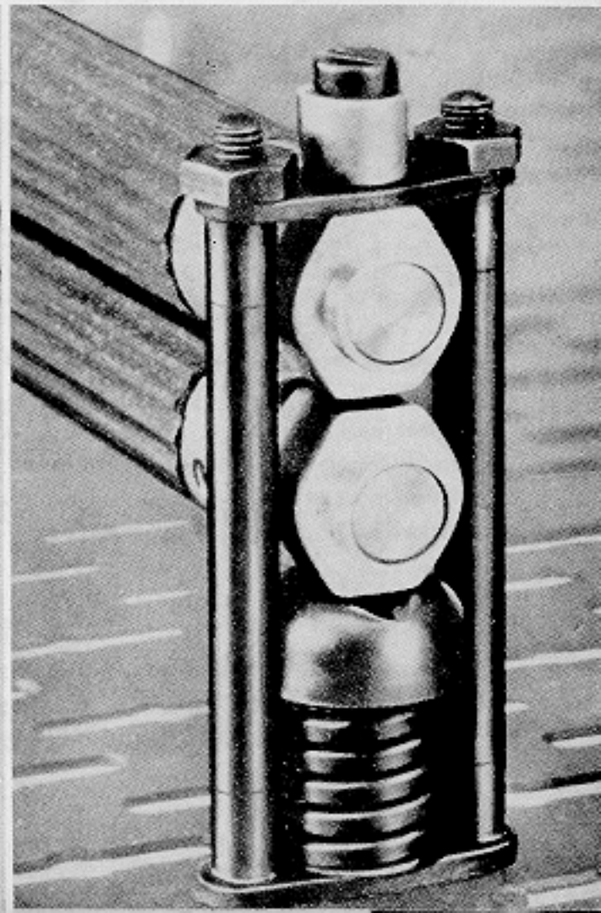


Fig. 508. — A bearing arrangement similar to that in fig. 507, but with the upper Shaft Head rigid. The rolls are made of serrated rubber tubing.



Wheels

Several types of wheels may be built from the FAC wheel parts, and can be combined in a number of ways; various measures have been taken in manufacture in order to ensure perfect matching between all wheel parts for minimum runout of the assembled wheels.

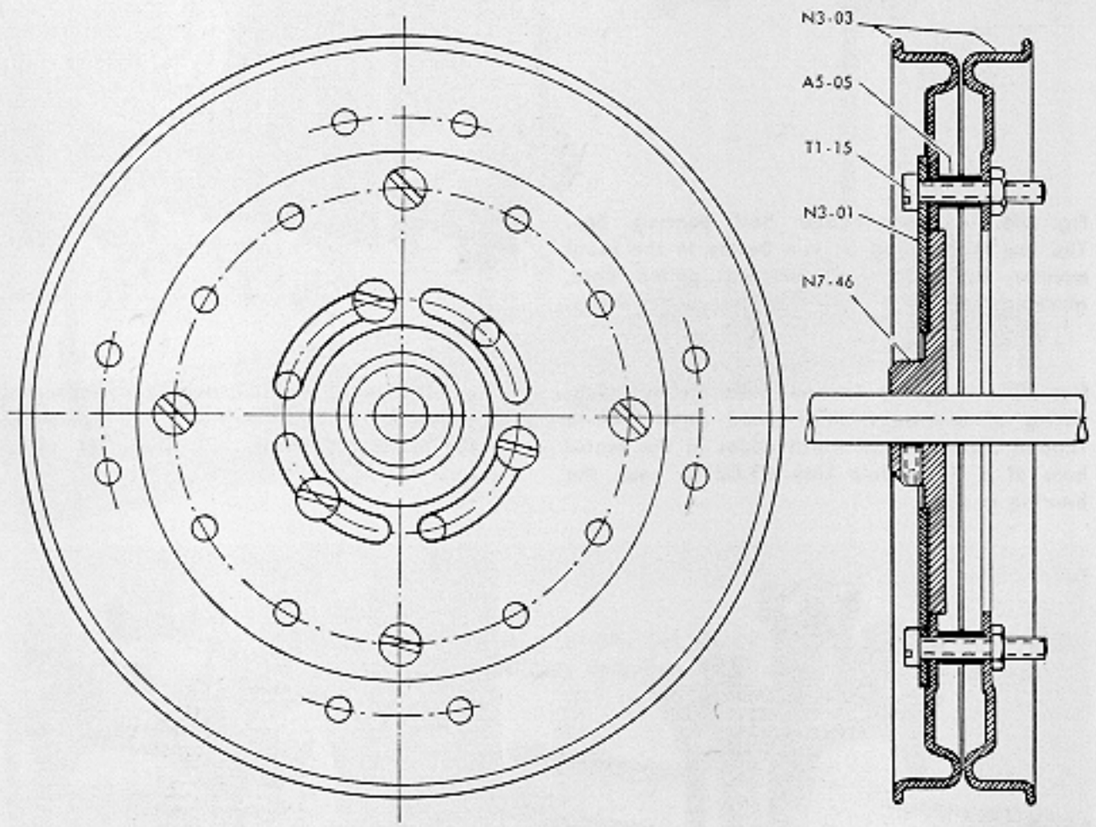


Fig. 509. — This type of assembled wheel is used as a flat-belt pulley in the ball-pen testing machine of fig. 419, and also in the crank mechanism section of the gang saw, fig. 601. Because of the great mechanical forces encountered in the latter case, both of the Flanged Rims are reinforced by Disc Webs N3-01 and Disc Hubs N7-46.
The same type of wheel build-up, although with only one Flanged Rim per wheel, will be seen in the railcar bogie, fig. 430.

The pressed Wheel Discs, N1-01 and N1-02, and the Flanged Wheel, N1-05, have dished portions around the center hole, intended to accommodate a Ball Bearing L3-06 or a Shaft Head H2-04, or H2-06.

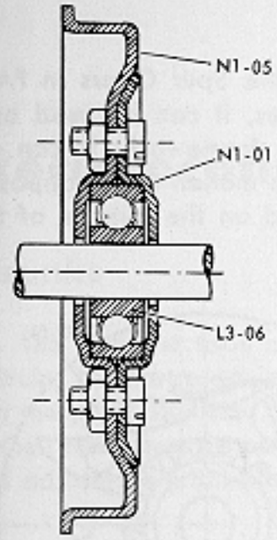


Fig. 511. — Railwheel with Ball Bearing.

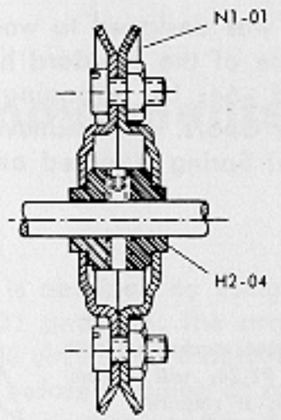


Fig. 510. — Assembled pulley for a 4 mm shaft.

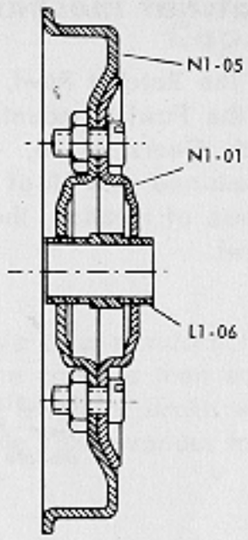


Fig. 512. — Railwheel with plain bearing, Bushing L1-06.

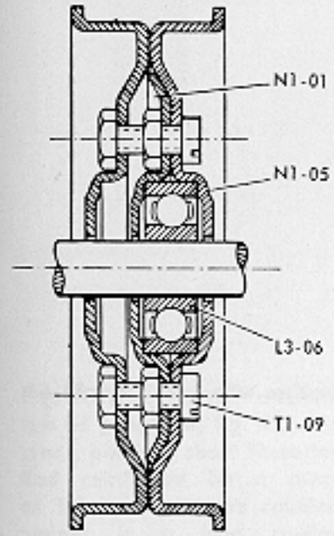


Fig. 513. — Assembled pulley with Ball Bearing.

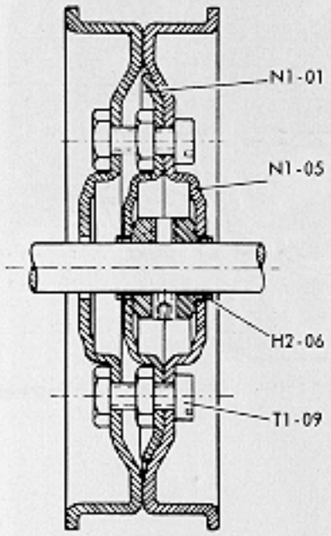


Fig. 514. — Same pulley locked on a 6 mm shaft.

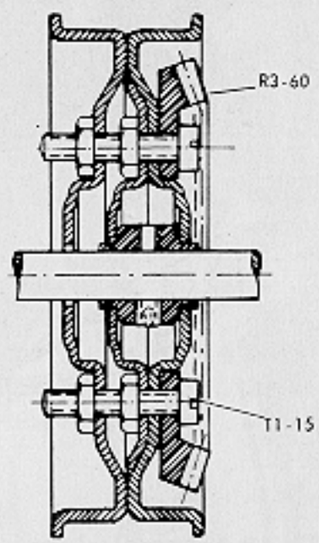


Fig. 515. — Same pulley with attached Crown Wheel.

Ratchet mechanisms

The Ratchet Pawl, U7-01, was designed to work with the Spur Gears in FAC. If the Pawl is mounted in one of the standard hole circles, it can be used only with Gears P1-16, -24, and -64; by arranging it in a framework, it can be combined with all of the Spur Gears. — To achieve a catch motion in the opposite sense of rotation, the Ratchet Spring is turned and placed on the outside of the Pawl.

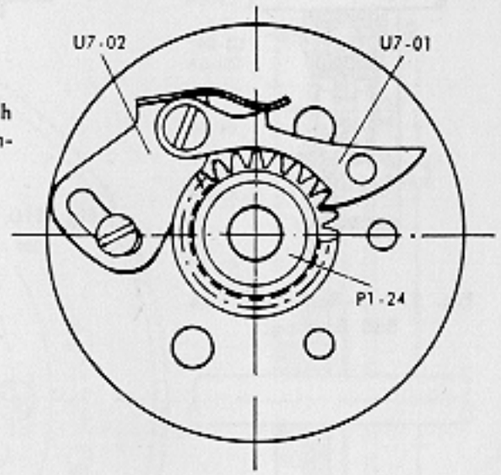


Fig. 516. — Ratchet mechanism with Gear P1-16 or P1-24; will accommodate two Pawls if required.

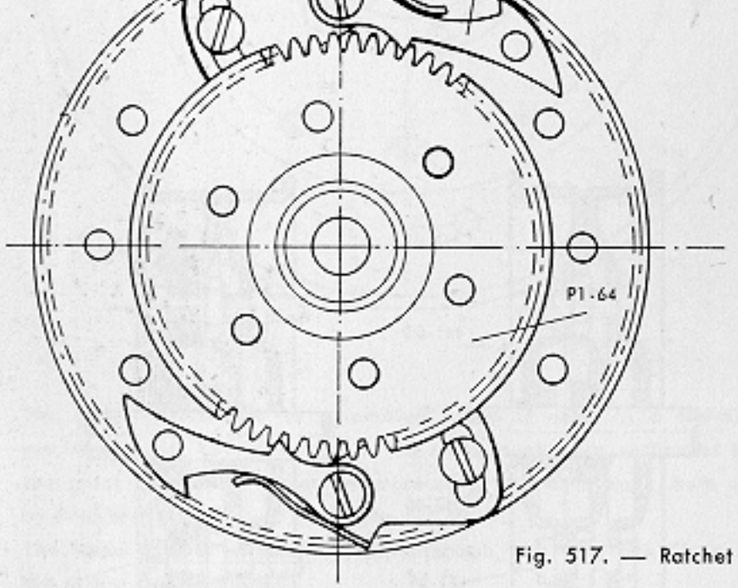


Fig. 517. — Ratchet mechanism with Spur Gear P1-64.

Gear transmissions

which properly belong under the heading, Rotary Movements, are discussed in a chapter of their own, Cap. 7.

Reciprocating movements

Cranks

The simplest form of crank is obtained by using one hole in a standard hole circle, as illustrated in figs. 601 and 605. The stroke of the crank is then equal to the pitch diameter of the hole circle. — To obtain another length of stroke, e. g. when tests must be carried out before deciding on an optimum value, various forms of adjustable cranks are possible, as shown in figs. 602-604.

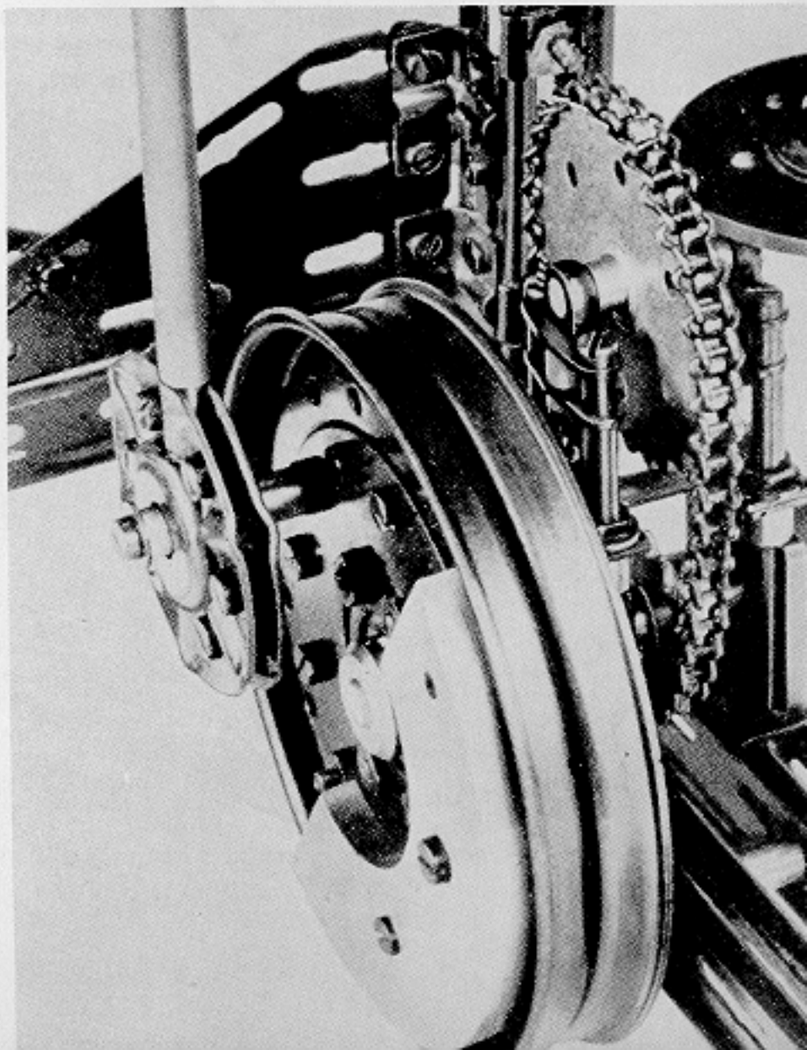


Fig. 601. — Crank mechanism of gang saw, fig. 422. The crank pin is a short Threaded Rod reinforced by a piece of Tubular Shaft; the counterweight is a lead casting specially made for the machine. — Note the sprocket shaft supports. — For a description of the crank wheel, see fig. 509.

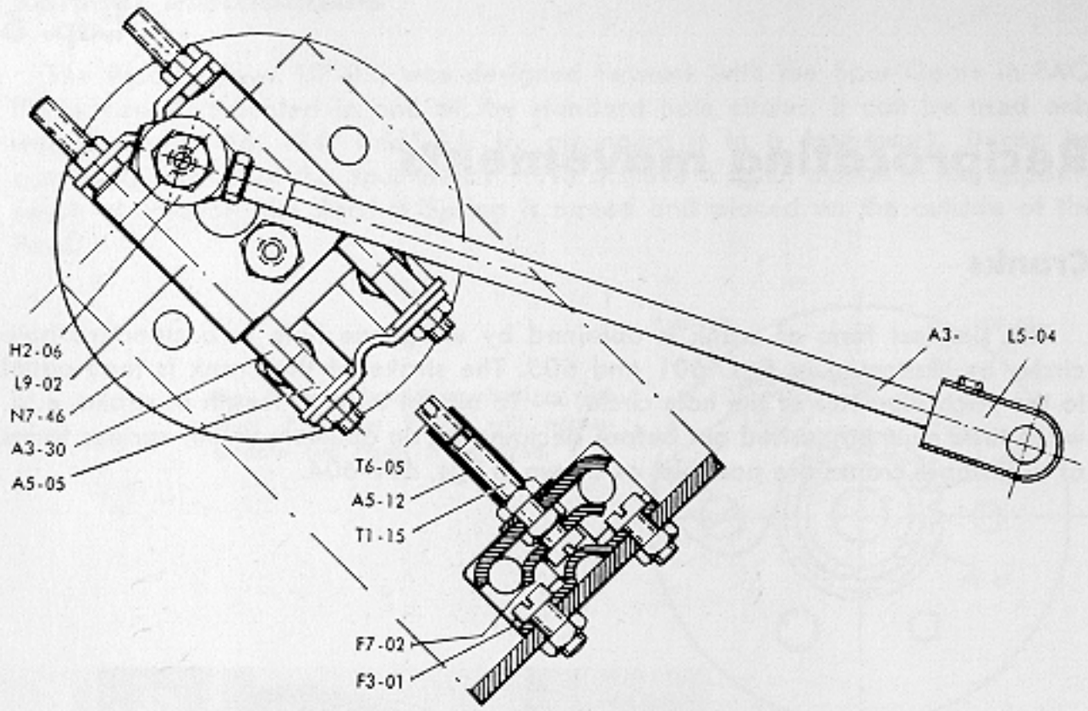


Fig. 602. — Adjustable crank.

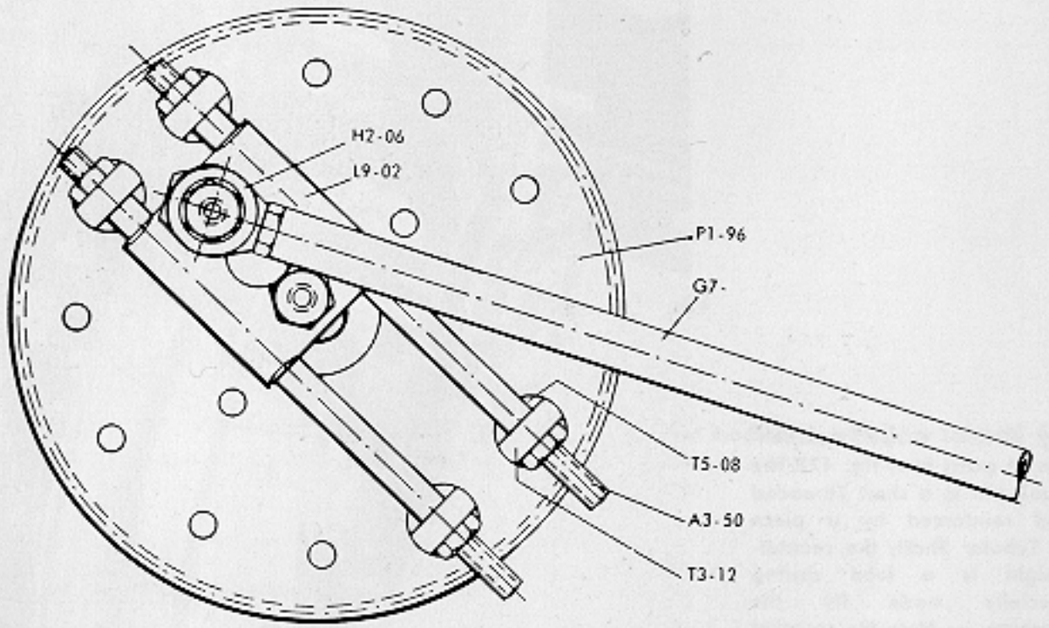


Fig. 603. — Adjustable crank, variable from zero upwards.

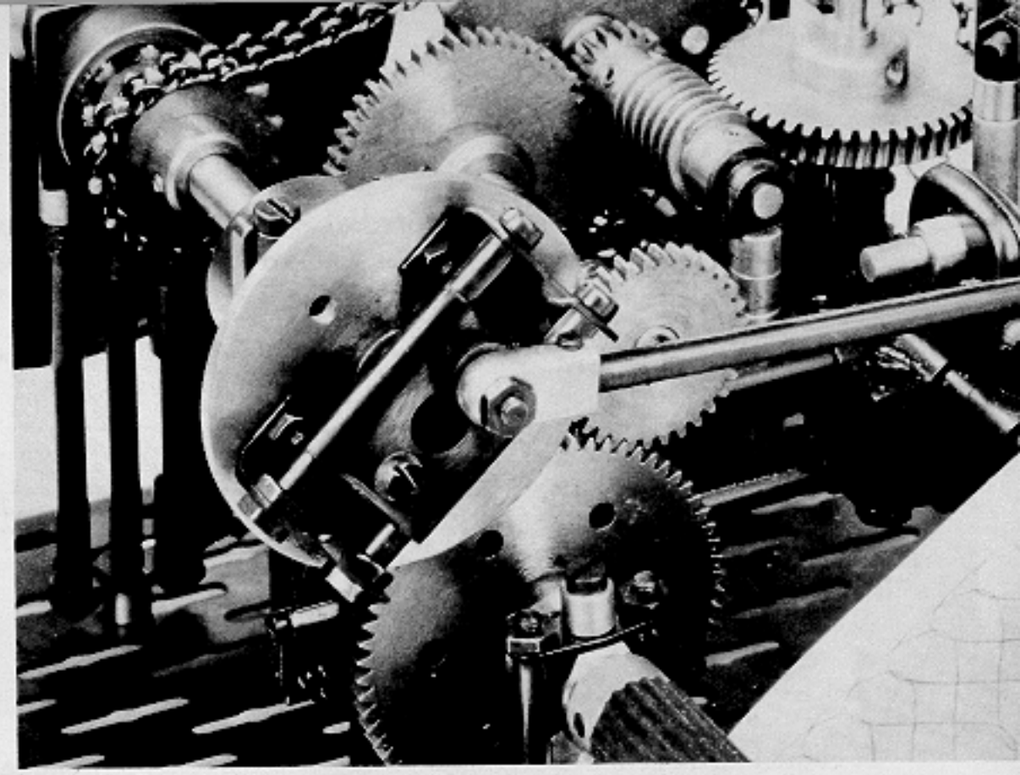
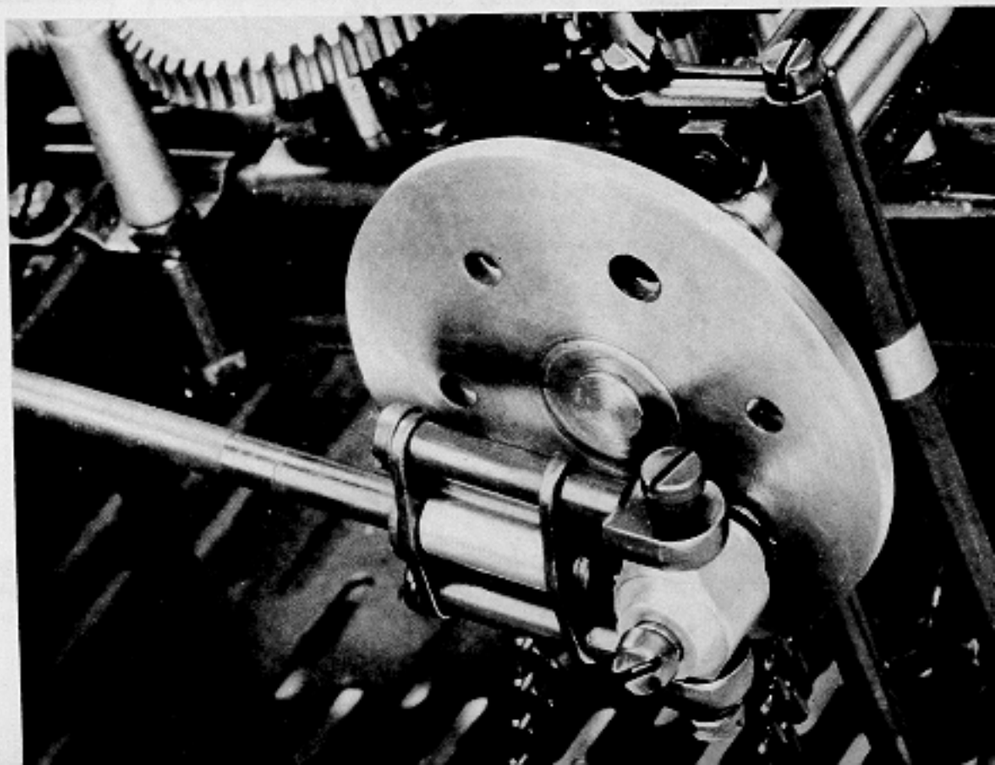


Fig. 604. — Crank with variable offset of the type shown in fig. 602, as used in a testing machine similiar to that in fig. 419.

Fig. 605. — Simple crank wheel and connecting rod with pivoted big-end bearing.



Connecting rods

The pictures and drawings in the preceding section on crank mechanisms show some simple types of connecting rods. Another useful type of rod, the forked connecting rod, is illustrated in fig. 606.

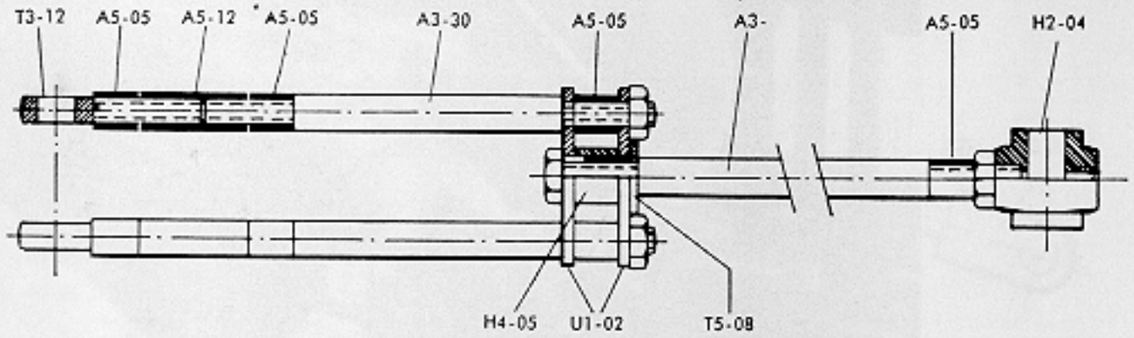


Fig. 606. — Forked connecting rod, as used in fig. 609.

In certain kinds of crank mechanisms it is sometimes an advantage if the length of the connecting rod can be varied within certain limits without going to the necessity of dismantling the rod.

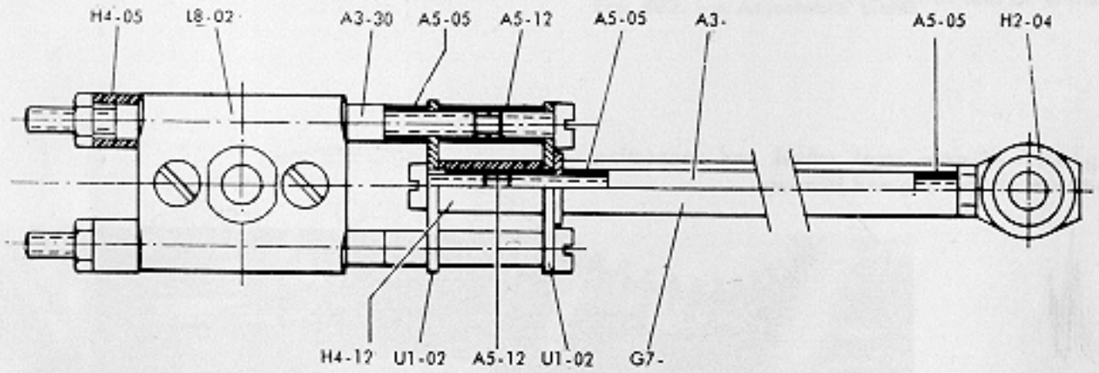


Fig. 607. — The length of this connecting rod is adjusted by moving the bearing at the forked end along the two Rods, with the help of the end Nuts, until the correct length has been found, and then pulling the bearing clamp screws tight.

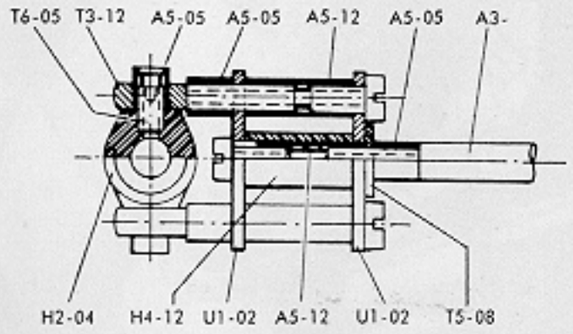
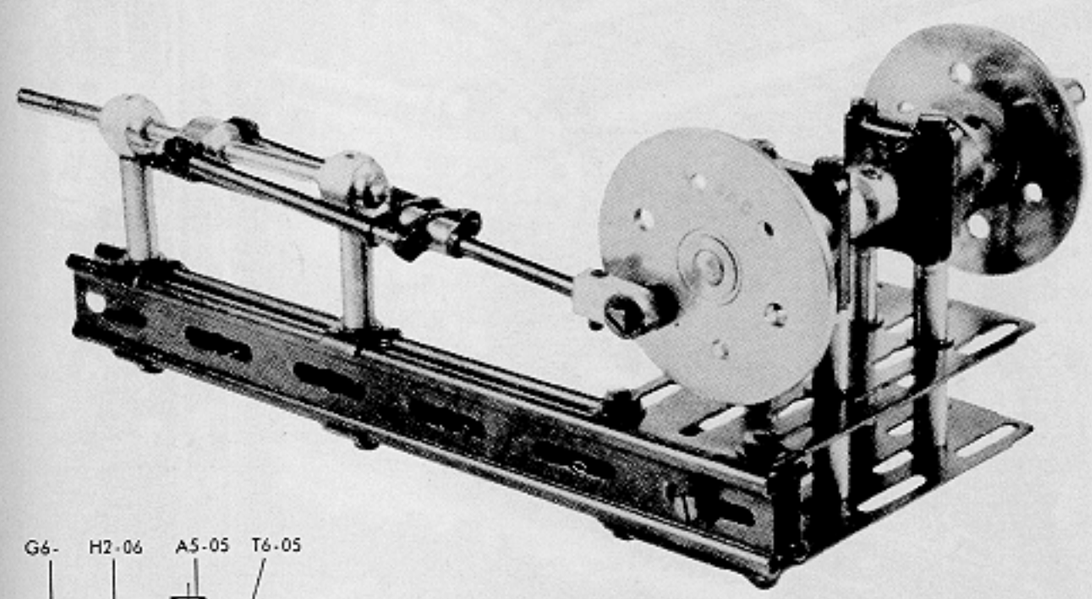


Fig. 608. — Connecting rod end with pivoted bearing according to fig. 605.

Guides

Some measure must generally be taken to guide elements of reciprocating mechanisms; one instance of this is illustrated in fig. 425 which shows a method of guiding the loose frame of the gang saw.



▲

Fig. 609. — Guiding a piston rod in two Shaft Heads, one on either side of the crosshead.

◀ Fig. 610. — Crosshead, detail of fig. 609.

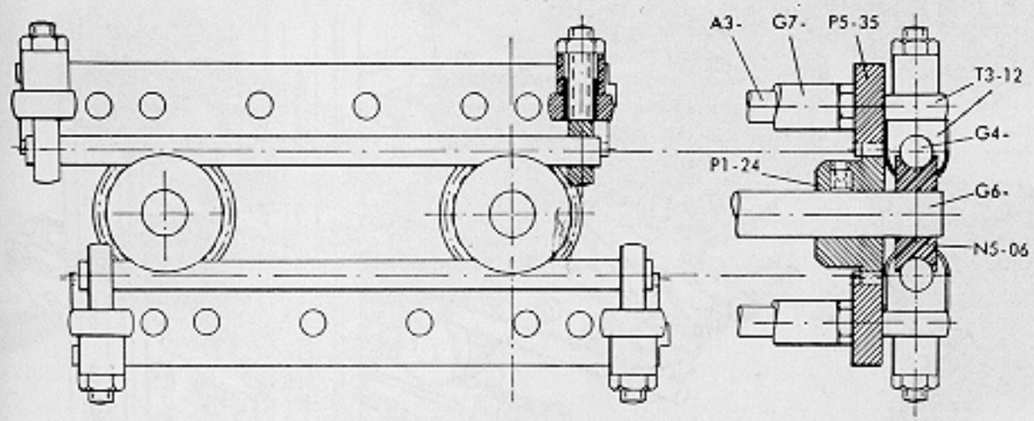


Fig. 611. — To secure a perfectly parallel movement of reciprocating tables, and the like, which might have a tendency to grip unless well guided, a system of Gears and Racks may be used, preferably supplemented by a system of Wheels and Rods to support the weight of the table.

Fig. 612. — Close-up view of a printing press table supported by a guide arrangement of the type shown in fig. 611. See also inside front cover.

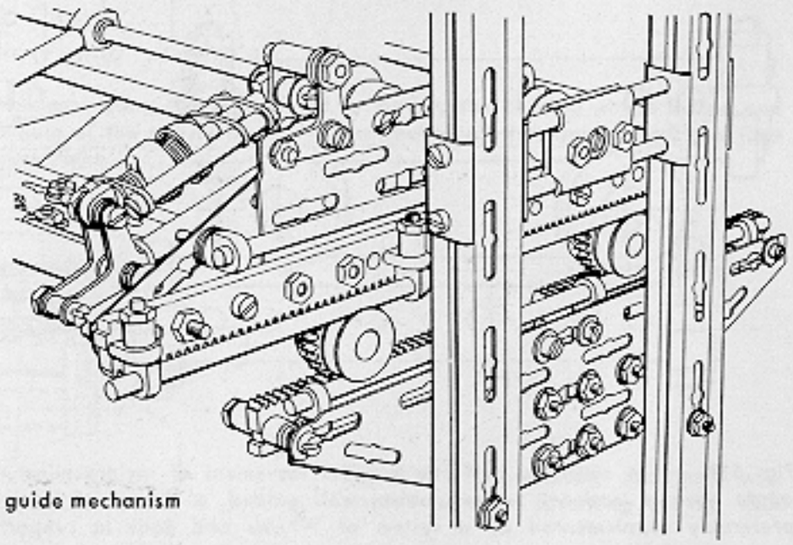


Fig. 613. — Detail showing guide mechanism in fig. 612.

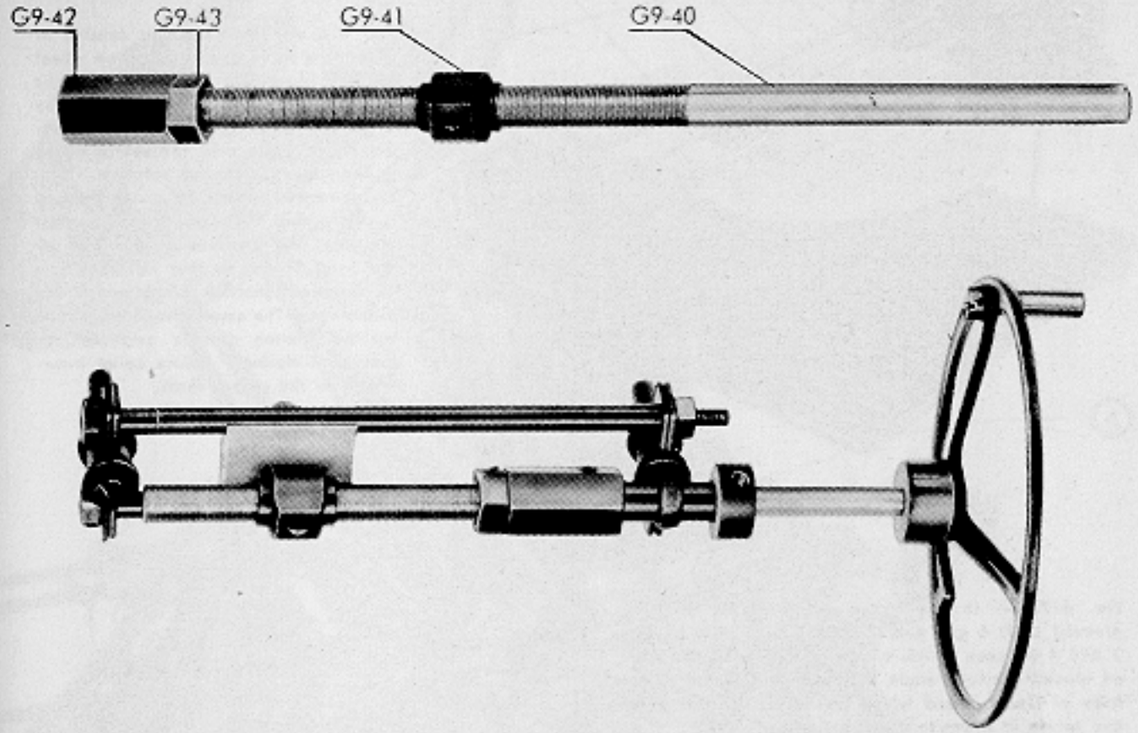
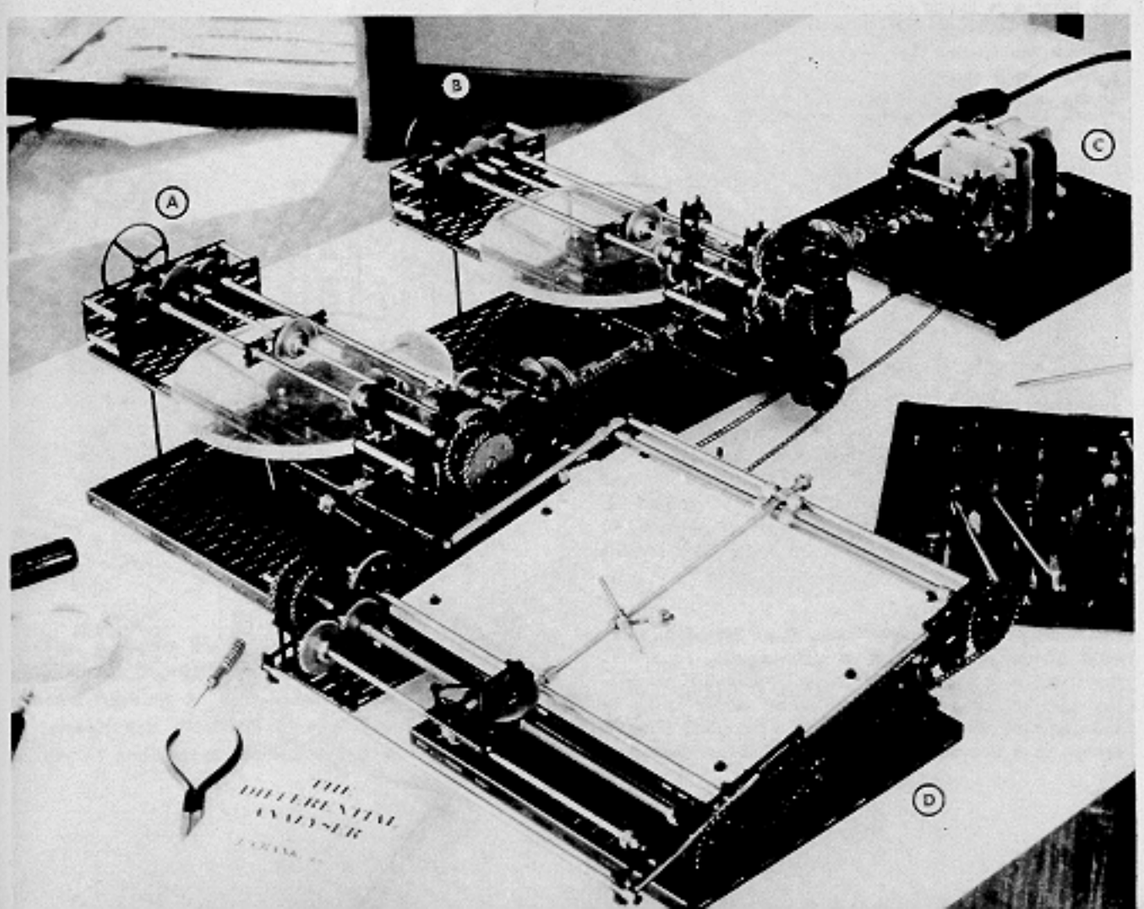


Fig. 615. — Computer for solving differential equations, consisting of integrator units A and B, motor unit C, and curve table D.



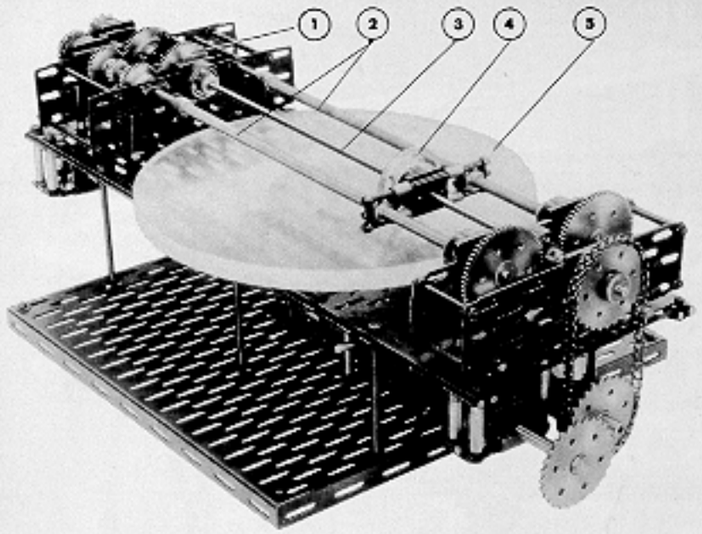


Fig. 616. — The integrator consists of a rotating table 5 and a friction wheel 4, both specially made from plastic sheet material. The wheel is moved by a pair of Lead Screws from the periphery of the table over the centre where it changes its sense of rotation.
Spring-loaded supporting ars in the bed structure hold the table pressed against the disc; the pressure is absorbed by the Lead Screws so that no force acts on Grooved Shaft 3 along which the disc moves. The small torque generated by the friction disc is amplified by torque multiplier 1 before being transmitted to the output shaft.

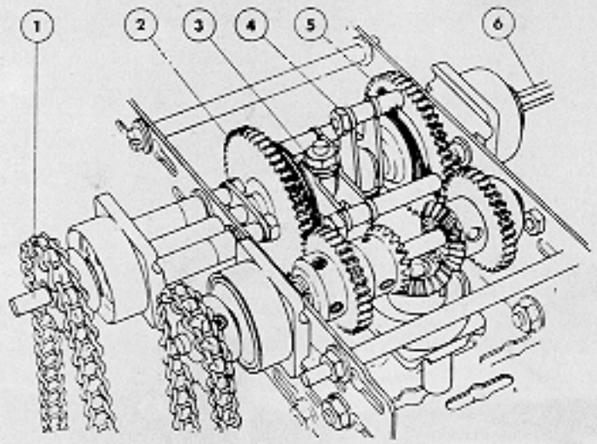
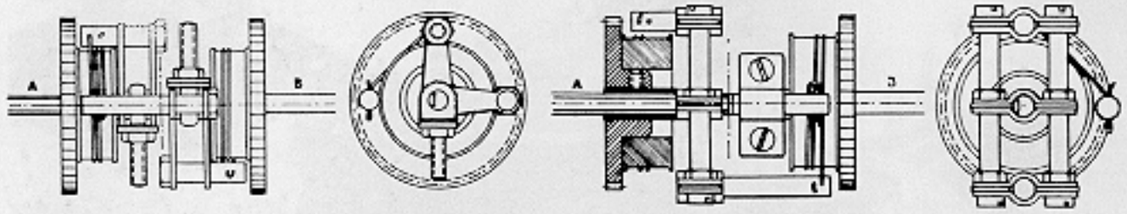


Fig. 617. — In the torque multiple, the ends of grooved shaft 6 and output shaft 1 carry wire holders 3 and 4 between which wires are suspended and coiled around specially made plastic pulleys locked to the hubs of Gears 2 and which are driven by the motor and rotate in opposite directions.
When the wire holder on the input shaft from the friction disc rotates, the wire is streched taut; it encircles the pulley that rotates in the same direction, and pulls the other wire holder — on the output shaft — with it. The power delivered by the motor is thus transferred through the friction between wire and pulleys direct to the output shaft, while maintaining the variations of the rotation of the friction disc.



Figs. 618, 619. — Two versions of the torque multiplier. The left-hand drawing is the version shown in Fig. 617, and uses Angle Links U1-05 mounted on the shafts by Eye Screws T3-12. — The right-hand type employs Strap Couplers F1-01 and Tapper Sleeves A5-12. The arms holding the wires are made from Rods A1 and Threaded Rods A3cut to length and drilled for the wires.

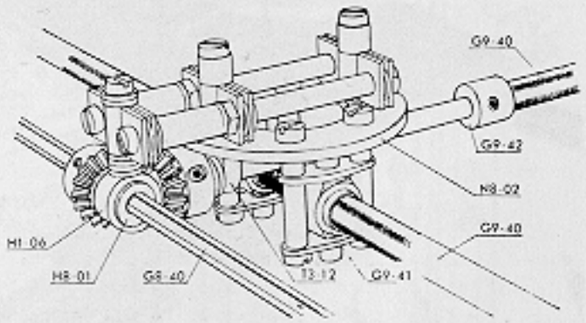


Fig. 620. — In the curve table, D in Fig. 615, three Lead Screws are arranged at right angles, supporting the stylus over the diagram paper. The entire mechanism can be lifted when the diagram paper is to be changed. The drawing shows how the travelling screw is driven by a Grooved Shaft G8-40 and Bevel Gears.

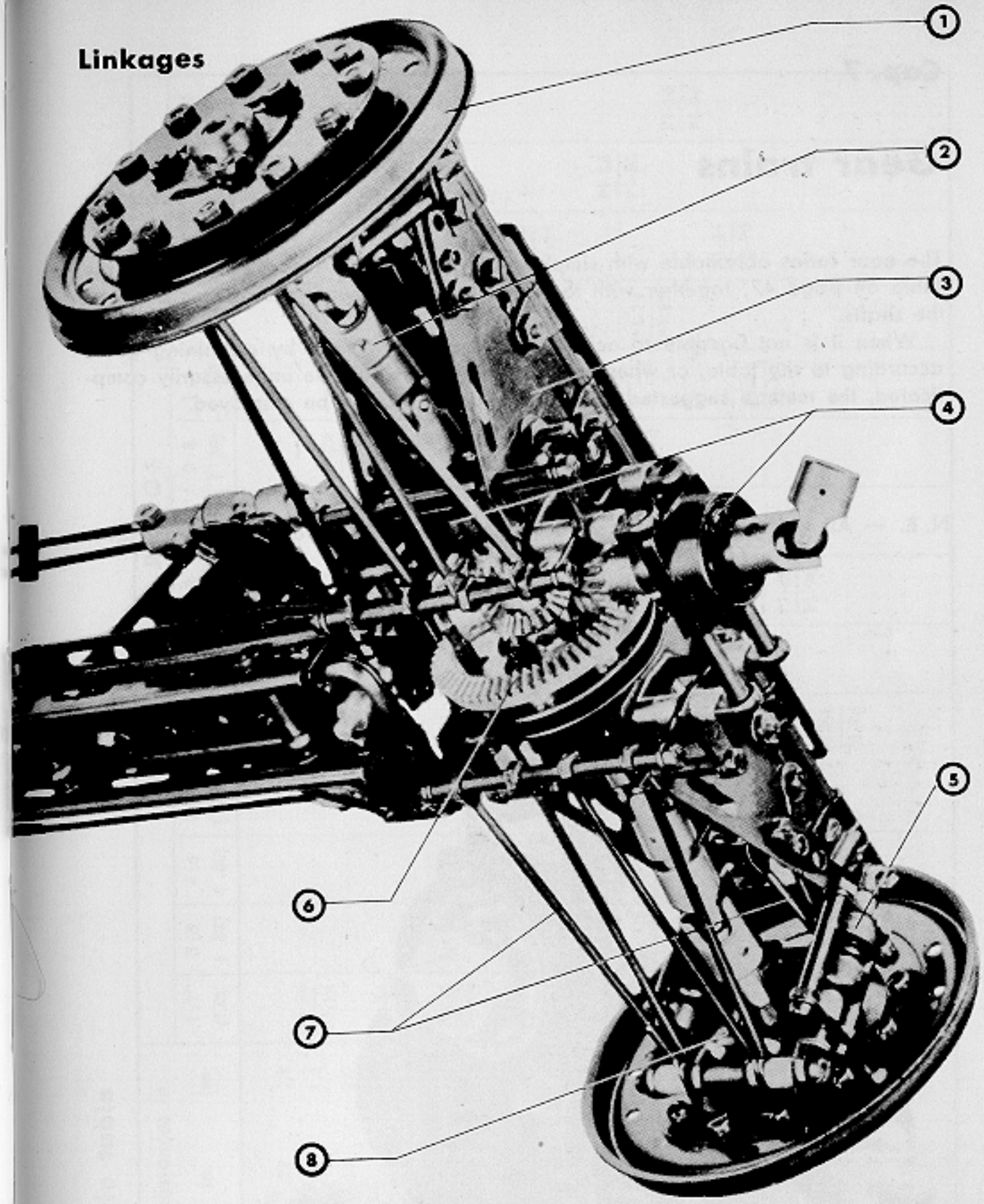


Fig. 621. — Rear end of the railcar bogie, fig. 430, underside view. — The chassis consists of a frame 3 made of Corner Plates reinforced with Rods. The differential 6, built according to fig. 712 and running in Ball Bearings 4, drives the Wheels 1 via Shafts 2 fitted with Universal Joints. The wheels are mounted on wishbone arms 7 built from Tie Rods and fitted with two Springs 5 per set of wishbones. Ball Bearing Box 8 lies in the plane of the wheel proper.

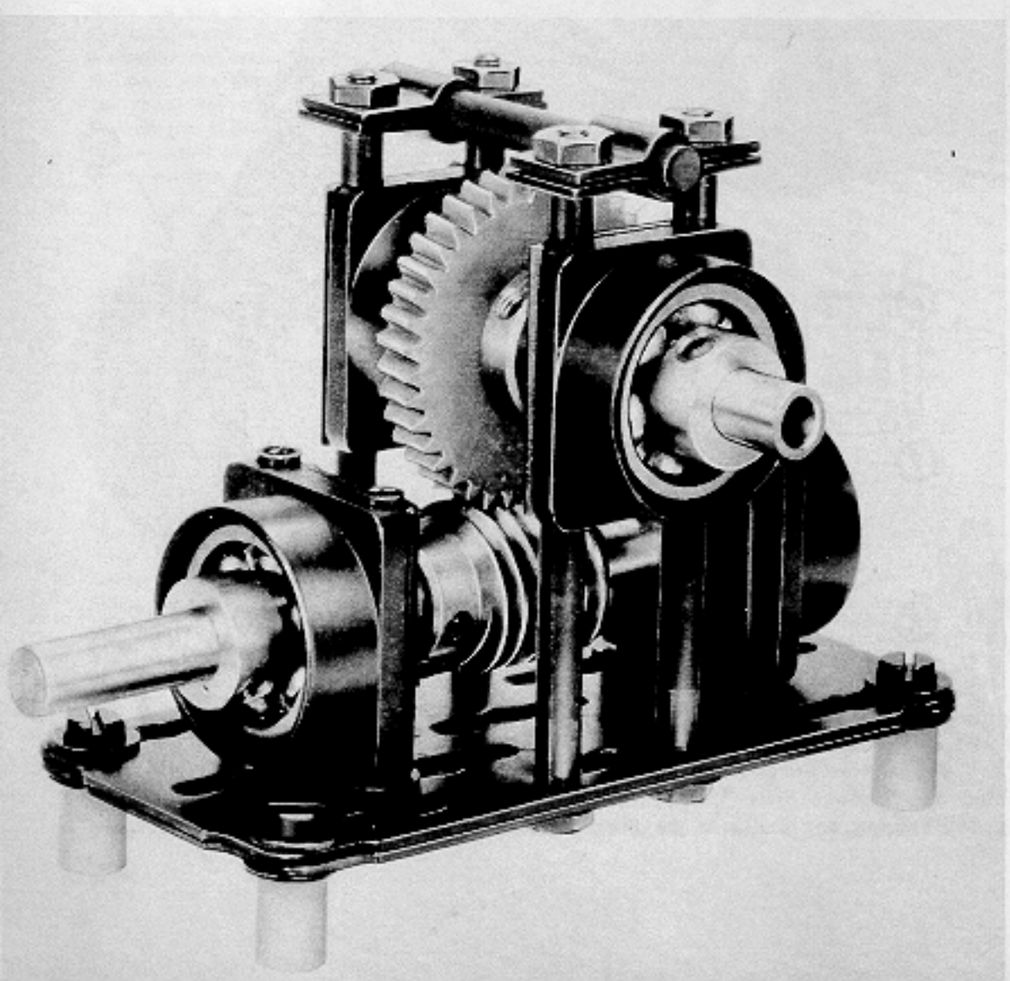
Gear trains

The gear ratios obtainable with simple pairs of FAC Spur Gears are listed in the table on page 47, together with the corresponding mounting distances between the shafts.

When it is not possible to achieve a desired gear ratio by combining gears according to the table, or when such a gear train would be unnecessarily complicated, the method suggested in figs. 715 and 716 may be employed.

N. B. — All gears which are not locked on their respective shafts, are shown without a setscrew in the drawings.

Fig. 701. — Worm gearset.

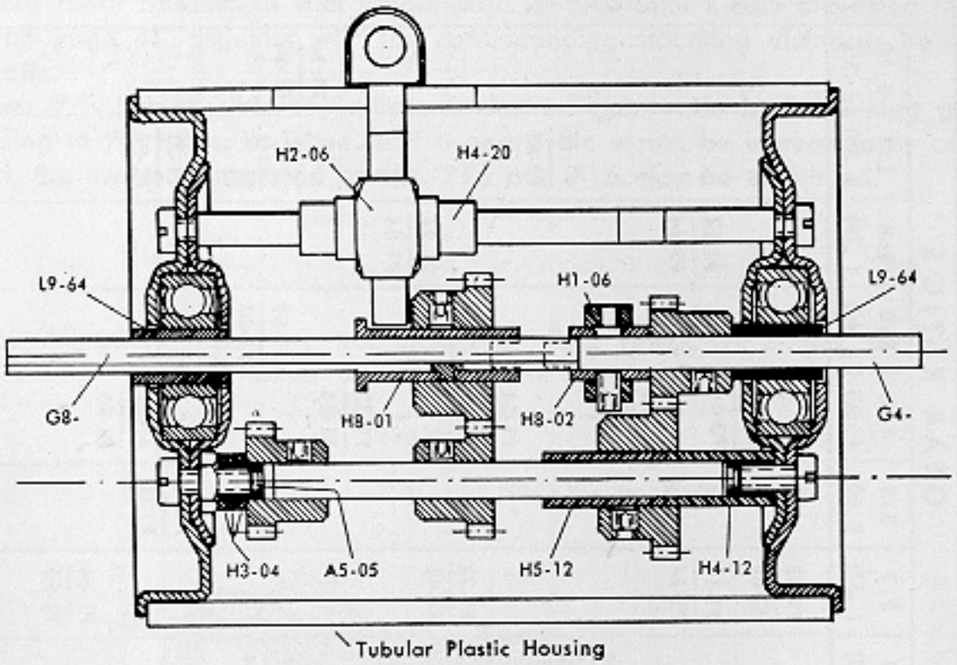


Gear ratio table

Centre distances in mm	in.	m	GEAR RATIOS 1:1 (1.0)	5:6 (.83)	4:5 (.80)	3:4 (.75)	2:3 (.67)	3:5 (.60)	1:2 (.50)	2:5 (.40)	3:8 (.38)	1:3 (.33)	3:10 (.30)	1:4 (.25)	1:5 (.20)	1:6 (.17)
5.6	.22	0.8					P1-48 / P3-64		P1-32 / P3-64		P1-24 / P3-64			P1-16 / P3-64		
11.2	.44	1.6	P1-16 / P1-16				P1-16 / P1-24		P1-16 / P1-32							
14.0	.55	2.0					P1-24									
16.8	.66	2.4	P1-24 / P1-24			P1-24 / P1-32			P1-24 / P1-48			P1-16 / P1-48				
19.6	.77	2.8	P1-32 / P1-32											P1-16 / P1-64		
22.4	.88	3.2									P1-24 / P1-64				P1-16 / P1-80	
25.2	.99	3.6					P1-32 / P1-48		P1-32 / P1-64				P1-24 / P1-80			P1-16 / P1-96
28.0	1.10	4.0								P1-32 / P1-80						
30.8	1.21	4.4	P1-48 / P1-48			P1-48 / P1-64		P1-48 / P1-80	P1-48 / P1-96			P1-32 / P1-96		P1-24 / P1-96		
33.6	1.32	4.8					P1-64 / P3-64									
36.4	1.43	5.2					P1-16 / P1-24									
39.2	1.54	5.6				P1-48 / P1-64							P1-32 / P1-64			
42.0	1.65	6.0						P1-64 / P1-80								
44.8	1.76	6.4	P1-64 / P1-64		P1-64 / P1-80		P1-64 / P1-96									
50.4	1.98	7.2	P1-80 / P1-80	P1-80 / P1-96												
56.0	2.20	8.0														
61.6	2.43	8.8	P1-96 / P1-96													
67.2	2.65	9.6														

Gearboxes

Gearboxes for speed selection can, of course, be arranged in a number of ways; our illustrations show two forms with the power input and take-off shafts in-line, and consequently suitable for self-propelled vehicles of various kinds.



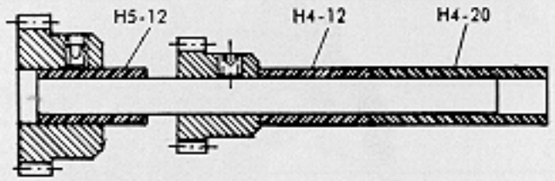


Fig. 702. — Gearbox with two forward and one reverse speed, reduction ratios 1 : 1, 4 : 9, and 8 : 27, respectively. In designing this gearbox, use has been made of the fact that the center distance between Gears P1-16 and P1-24 is 2 **m**, i. e. equal to the radius of the inner hole circle of Wheel Parts, so that the ends of the gearbox can be made from Wheel Discs and Flanged Wheels. The input and output shafts can then be arranged in Ball Bearings; countershaft and backshaft run on Tapped Sleeves A5-05 mounted in the hole circles.
The end of the input shaft, G4- , carries a Fixed Dog H8-02 locked with a Collar H1-06 which serves as a pilot bearing for output shaft G8- , on which Sliding Dog H8-01 with attached Gear P1-24 is mounted.
The shaft shown at the bottom of the drawing is the reverse shaft which is journalled on Tapped Sleeves in the same manner as the countershaft.
The gearbox is surrounded by a plastic tube — not a standard FAC part — making it possible to fill the box with oil level with the lowest free holes in the hole circles.
N. B. — Split Sleeve H5-12 used in this gearbox has been discontinued; it is superseded by Split Sleeve H5-10.

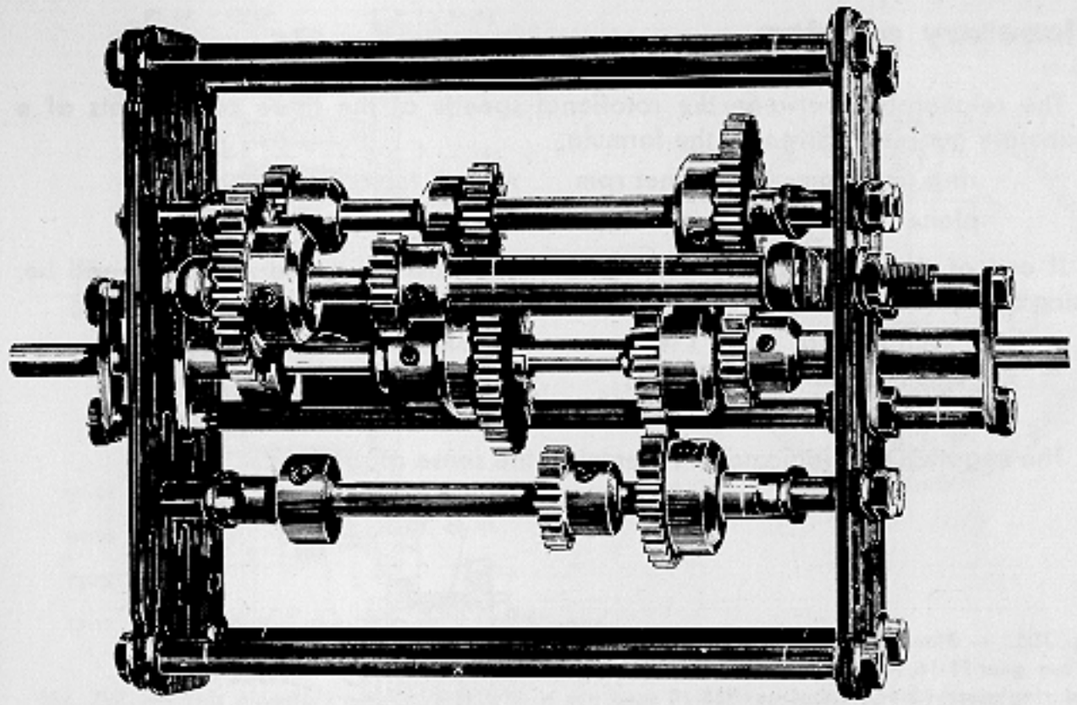


Fig. 703. — Gearbox with three forward speeds and one reverse, with reductions 1 : 1, 1 : 2, 1 : 4, and reverse 1 : 8, using Gears P1-16, -24, and -32. Two countershafts are employed; Plates C2-52 are used as end plates.

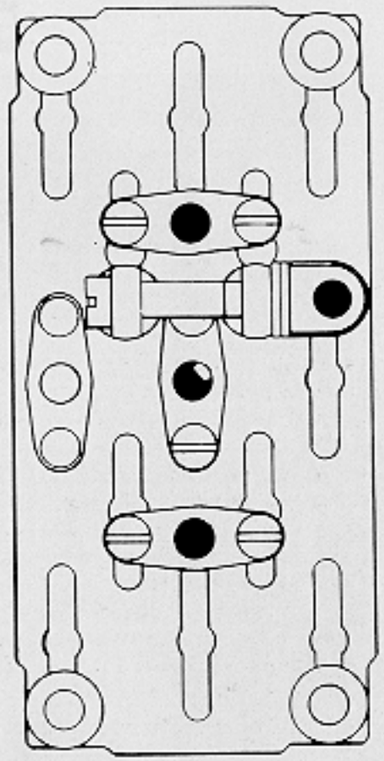


Fig. 704. — Shaft arrangement of the gearbox in fig. 703. Only the input and output shafts are through shafts, carried in Three-Hole Links. The center distance between all shafts is 2.4 **m**, and the supports of all other shafts must therefore be constructed. The countershafts are installed between Three-Hole Links, and the reverse countershaft by means of Eye Screw supports.

Planetary gearing

The relationship between the rotational speeds of the three components of a planetary gearset is given by the formula,

$$\frac{\text{ring gear rpm} - \text{planet rpm}}{\text{planet rpm} - \text{sun gear rpm}} = \frac{\text{no. of teeth, ring gear}}{\text{no. of teeth, sun gear}} = N$$

If one of the three systems is stationary, the possible speed reductions will be, using the symbol N as above,

sun to ring	− 1 : N	with planet system stationary
sun to planet	1 : (N+1)	with ring gear stationary
planet to ring	N : (N+1)	with sun gear stationary

The negative sign indicates a reversal of the sense of rotation.

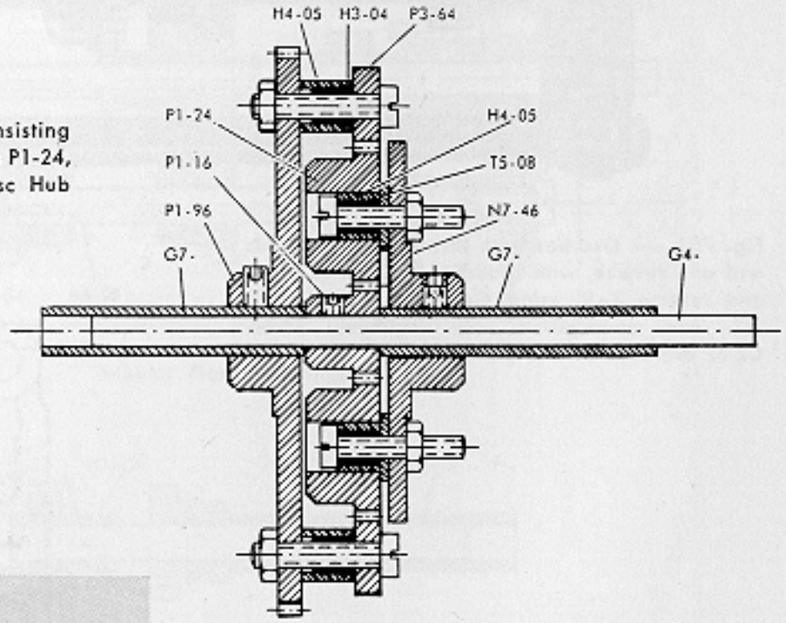
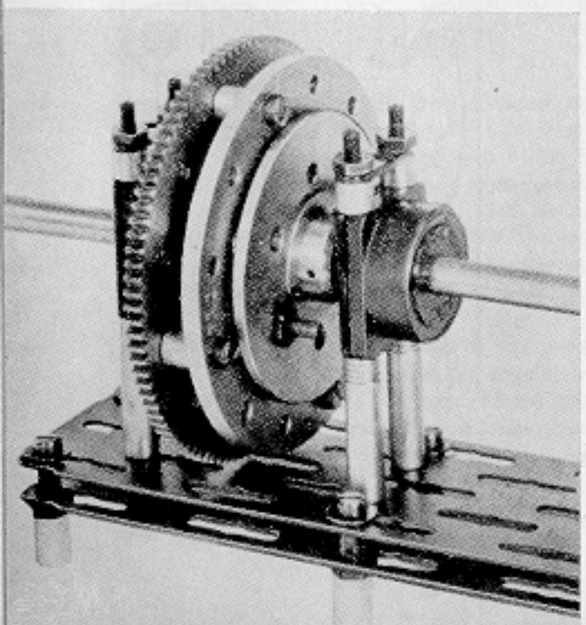
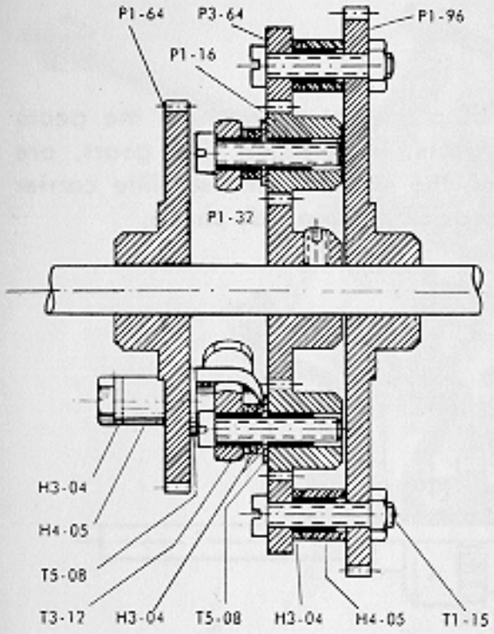


Fig. 705. — Planetary gear consisting of sun gear P1-16, two satellites P1-24, and ring gear P3-64, with Disc Hub N7-46 as satellite carrier.



For the planetary gear of figs. 705 and 706, the above formulas give a reduction of -1 : 4 from sun to ring gear, with satellite carrier stationary, and 1 : 5 from sun gear to planet system, with ring gear immobilized.

Fig. 706. — Photo of the gear of fig. 705; note extremely close mounting possible.



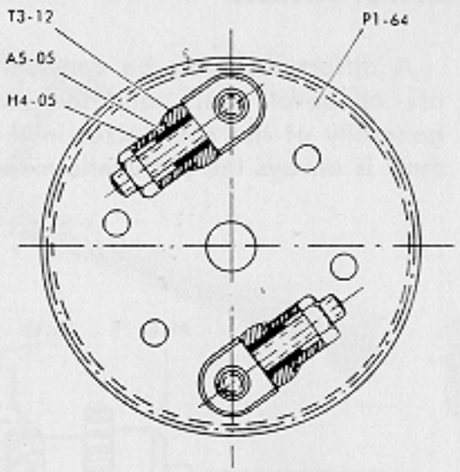
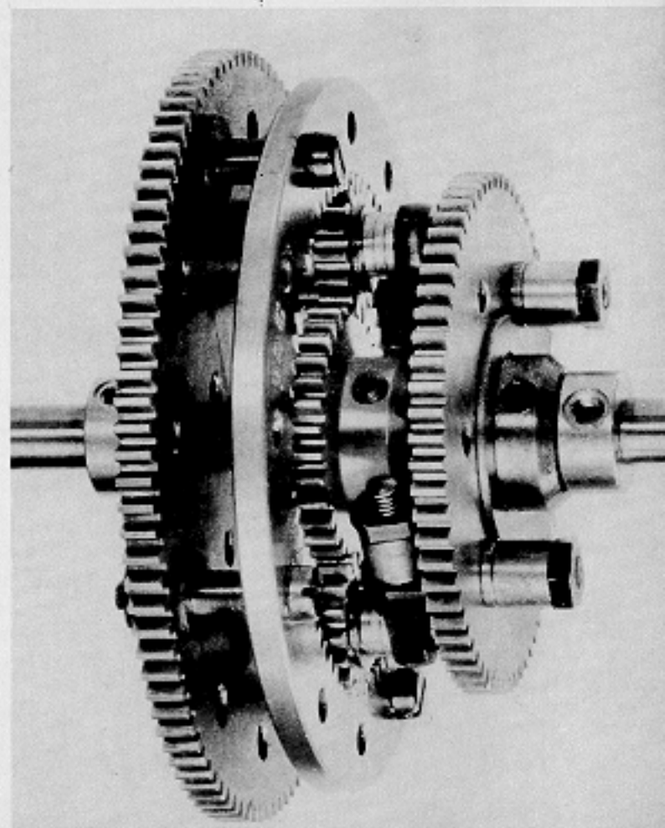


Fig. 707. — This planetary gear is built with a sun gear P1-32, two satellites P1-16, and a ring gear P3-64. As the orbit of the satellite-shafts does not coincide with the standard hole circle of the supporting gear — in this case a Spur Gear P1-64 — the shafts have been mounted in Eye Screws as shown on the right.

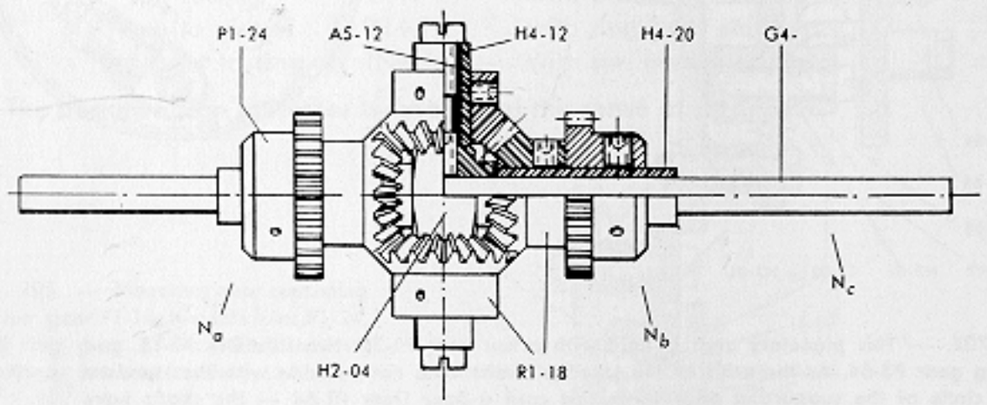
Fig. 708. — Photo of planetary gear of fig. 707.



Differentials

A differential may be considered a form of planetary gear where the gears are all bevel gears, and the sun and ring gears, here called side gears, are generally of the same size. In this differential, the speed of the satellite carrier shaft is always the arithmetic mean of the speeds of the two side shafts,

$$N_c = \frac{N_a + N_b}{2}$$



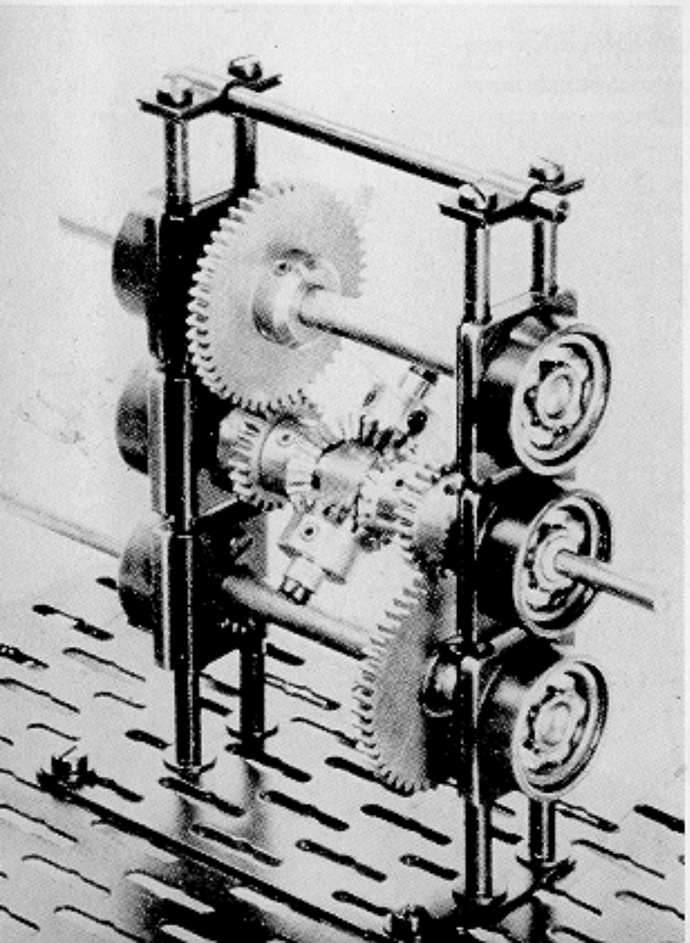


Fig. 709. — Differential with four Bevel Gears R1-18. The two Setscrews in the Shaft Head are lengthened into a satellite shaft by screwing on Tapped Sleeves A5-12, on which the satellites are running on bushings made of Sleeves H4-12. Power is taken off from the side gear shafts by means of Spur Gears locked on the same Sleeves H4-20, or Tubular Shafts G7- , as the side gears.

Fig. 710. — Differential of the type shown in fig. 709 mounted on Ball Bearings in a rack.

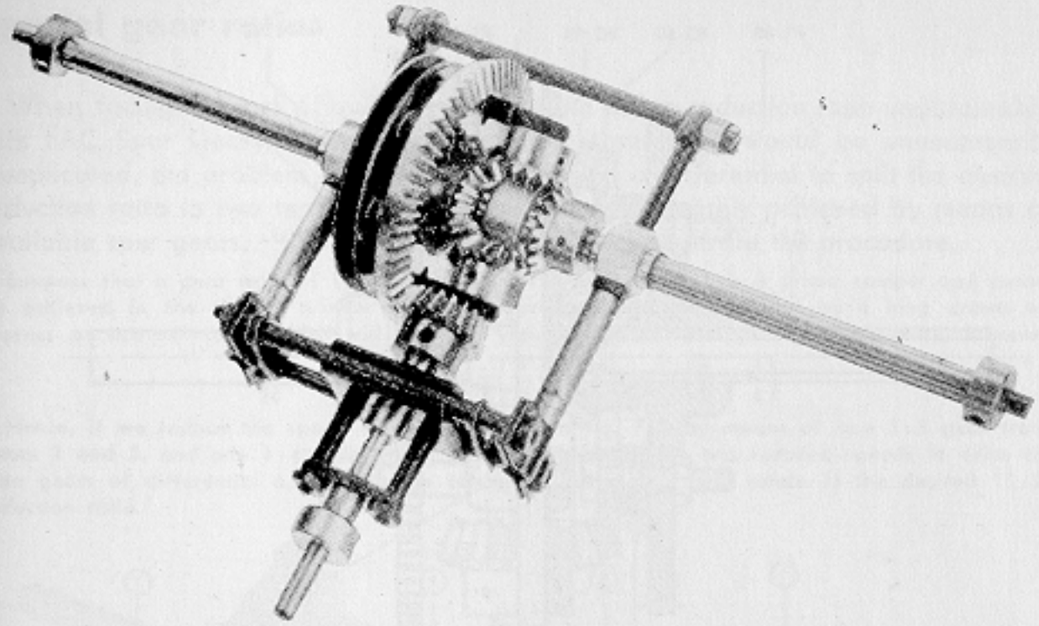


Fig. 711. — Bevel gear drive and differential suitable for self-propelled vehicles, as used in the railcar bogie of figs. 430 and 618.

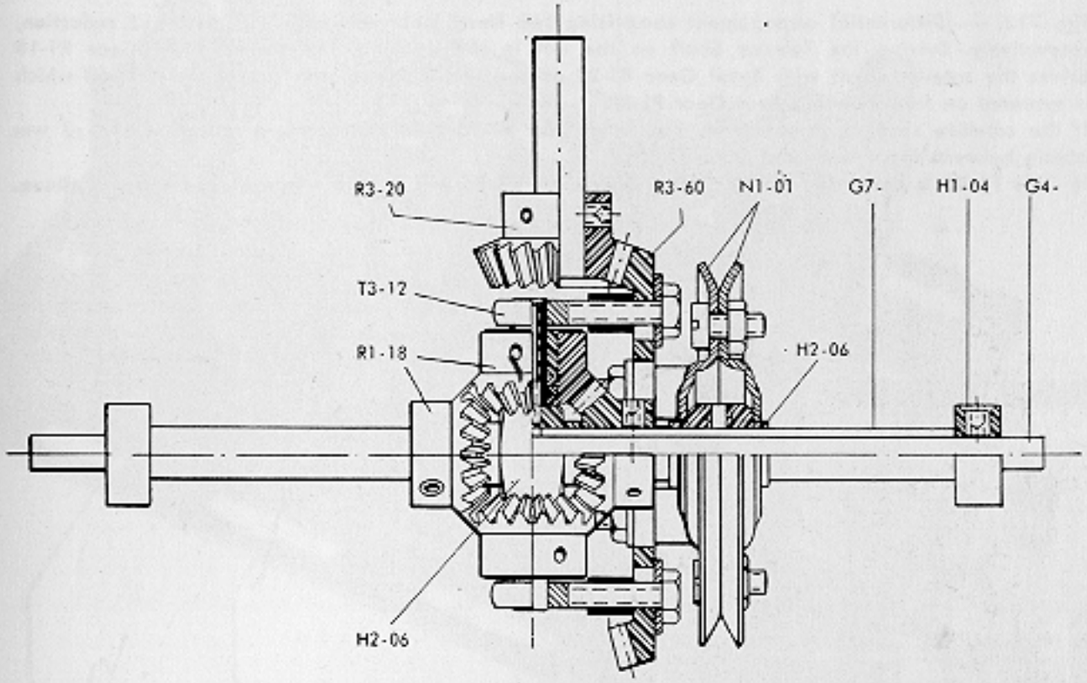


Fig. 712. — To build the differential in fig. 711, begin by assembling Wheel Discs N1-01 and Shaft Head H2-06; then install four Screws T1-15 fitted with Tapped Sleeves A5-05, and use Sleeves H4-05 and Rings H3-04 as spaces between Wheel and Crown Gear. Take care that the wheel is correctly mounted on the shaft and does not wobble. Then mount Crown Gear complete with satellite shafts. The satellites are fitted with a Sleeve H4-05 and three Rings H3-04 each, serving as bushings. When mounting the Eye Screws holding the satellite shafts, check that the Tapped Sleeves A5-05 do not touch the gears.

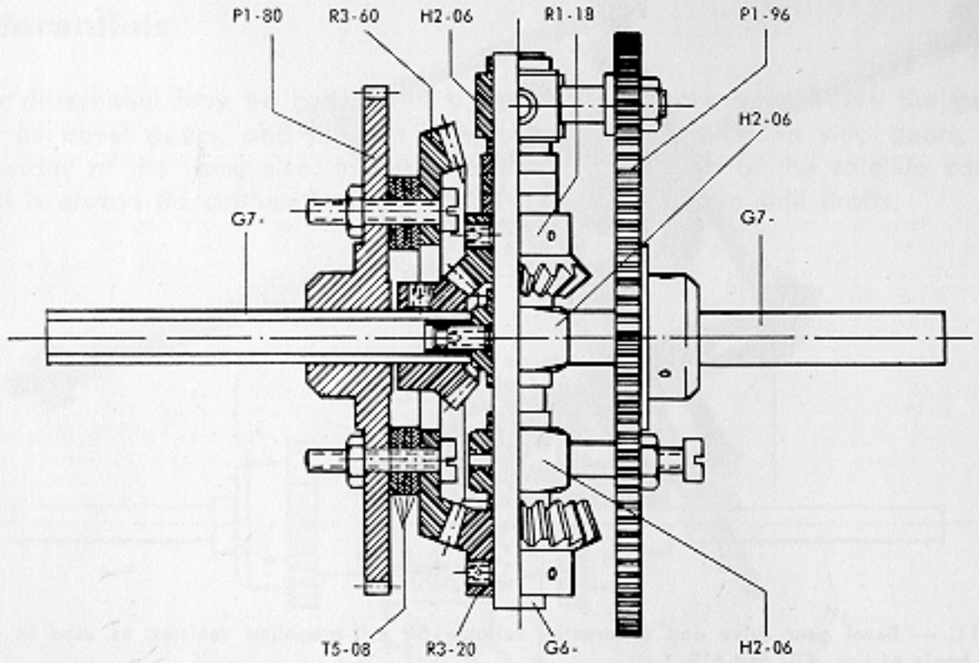


Fig. 713. — Differential arrangement comprising two bevel gear sets with 1 : 1 and 1 : 3 reduction, respectively. Driving the Tubular Shaft on the left in the drawing, the central Bevel Gear R1-18 drives the satellite shaft with Bevel Gear R3-20 at one end meshing with Crown Gear R3-60 which is mounted on free-wheeling Spur Gear P1-80.
If the satellite shaft is immobilized, i. e. Spur Gear P1-96 held stationary, a reduction of 1 : 3 will obtain between input shaft and Gear P1-80.
If Gear P1-80 is prevented from rotating, Spur Gear P1-96 will instead rotate at 1 : 4 reduced speed.

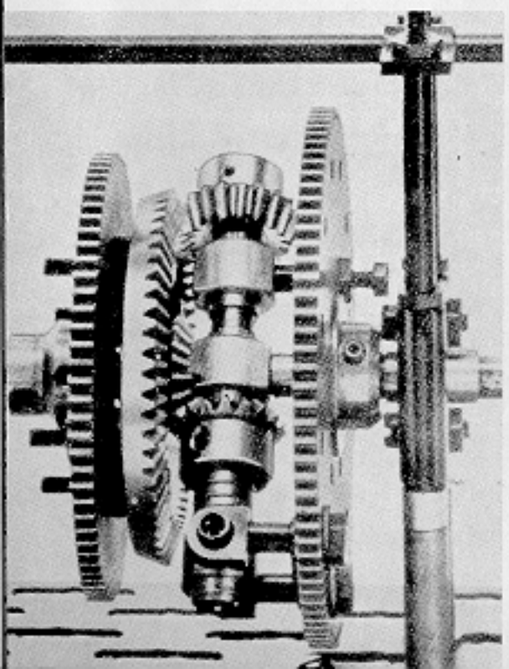


Fig. 714. — Photo of the differential.

Special gear ratios

When facing the task of building a gear train with a reduction ratio unobtainable with FAC Spur Gears, or when the resulting gear train would be unnecessarily complicated, the problem can be solved by using a differential to split the desired reduction ratio in two terms, both of which may be readily achieved by means of available spur gears. — Two examples will serve to illustrate the procedure.

Suppose that a gear ratio of 11 : 24 is desired. The numerator 11 is a prime number and cannot be achieved in the normal manner with the spur gears available except by a long drawn out process of approximation which will still not yield an exact result. — We can write, however,

$$\frac{11}{24} = \frac{1}{2} \cdot \frac{8+3}{12} = \frac{1}{2} \cdot \left(\frac{8}{12} + \frac{3}{12}\right) = \frac{1}{2} \cdot \left(\frac{2}{3} + \frac{1}{4}\right)$$

Hence, if we reduce the speed of input shaft 1 in fig. 715 by means of one 2 : 3 gear train, gears 2 and 5, and one 1 : 4 train, gears 4 and 3, and use the two reduced speeds to drive the side gears of differential 6, the satellite carrier output shaft 7 will rotate at the desired 11 : 24 reduction ratio.

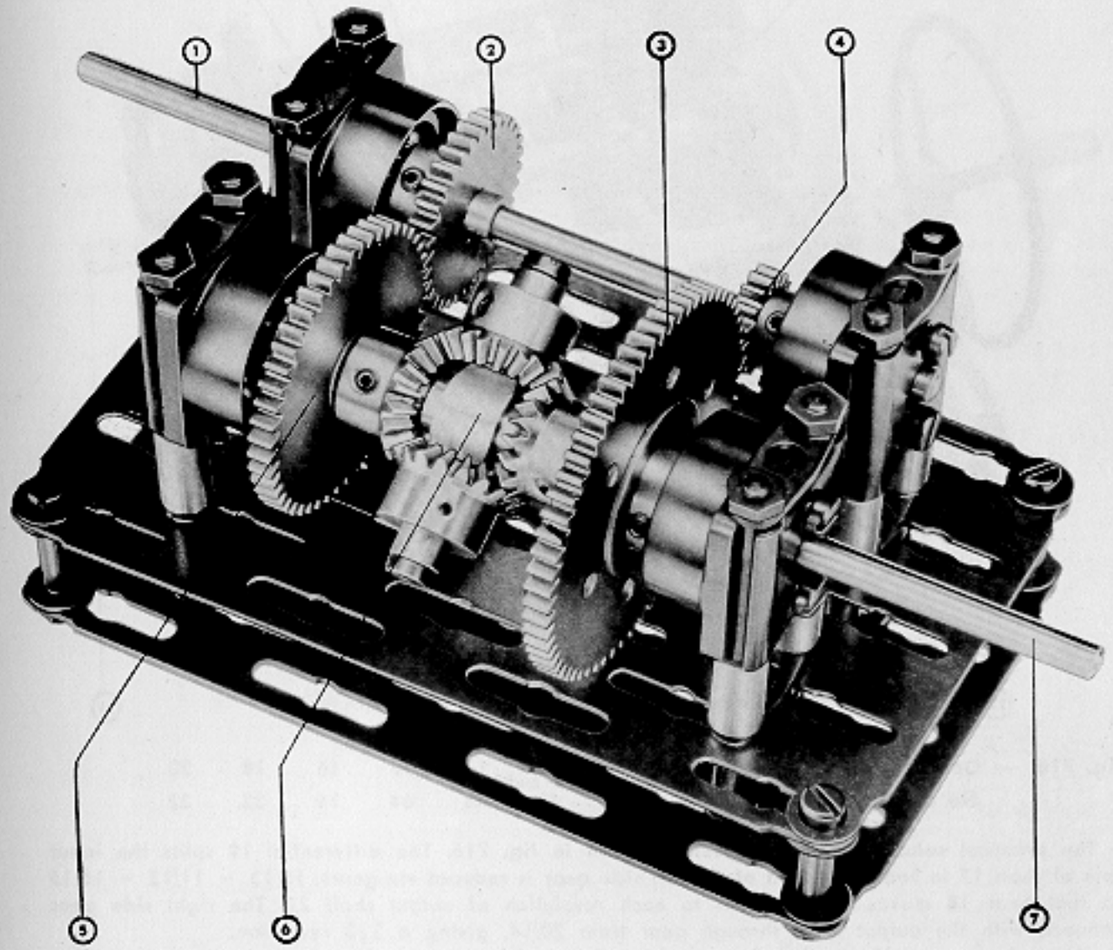


Fig. 715. — Special reduction gearset.

Gear no.	2	3	4	5
No. of teeth	32	64	16	48

Another possibility of splitting the desired ratio would be,

$$\frac{11}{24} = \frac{1}{2} \cdot \frac{12-1}{12} = \frac{1}{2} \cdot \left(\frac{1}{1} - \frac{1}{12}\right)$$

In this case, one side gear shaft can be used as input shaft without reduction, and the other side gear coupled to it via a 1:12 gear train which must also *reverse* the sense of rotation, e. g. two stages with reduction 1:3 and 1:4 plus an idler gear.

To take another example, let us design a gearset to give a 1:12.75 speed reduction. In this case we may write, among other possibilities,

$$12.75 = \frac{51}{4} = \frac{1}{2} \cdot \left(\frac{48}{2} + \frac{3}{2}\right) = \frac{1}{2} \cdot \left(24 + \frac{3}{2}\right)$$

i. e. the problem dissolves into constructing two gear trains of 1:24 and 2:3 reduction, respectively, and having the same direction of rotation.

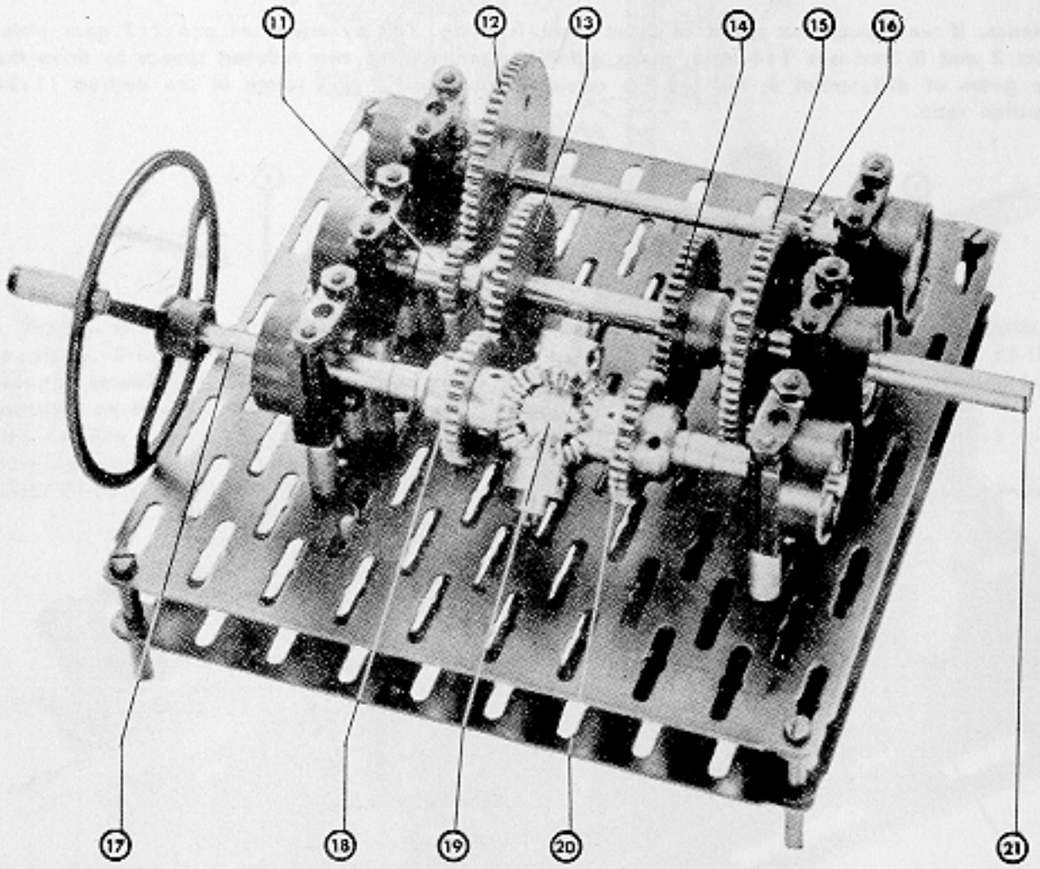


Fig. 716. — Gear no.	11	12	13	14	15	16	18	20
No. of teeth	16	64	48	48	64	16	32	32

The practical solution of this gearset is shown in fig. 716. The differential 19 splits the input rpm of shaft 17 in two; the speed of the left side gear is reduced via gears: 18/13 – 11/12 – 16/15 so that gear 18 makes 24 full turns to each revolution of output shaft 21. The right side gear connects with the output shaft through gear train 20/14, giving a 2:3 reduction.

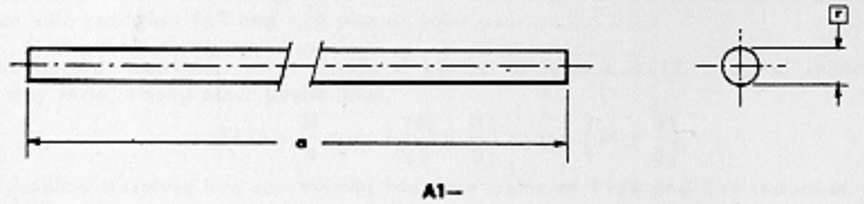
By using a differential in combination with conventional spur gears in the manner described above, practically any desired gear ratio may be realized with a resonable number of gears.

PARTS DRAWINGS

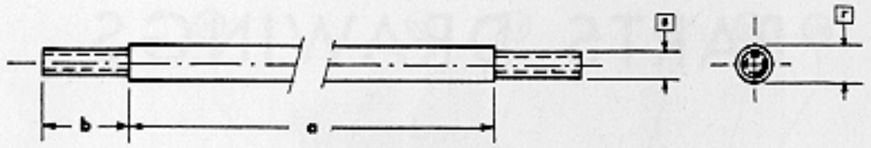
and

TABLES

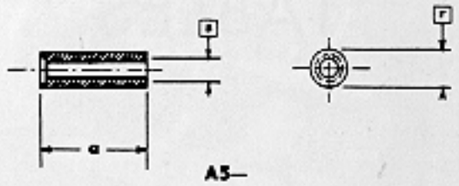
N. B. — The manufacturer reserves all rights to change dimensions, tolerances or material of FAC parts without preliminary notice. — FAC is a living system in the sense that parts may be discontinued or replaced, and new ones added when required.



A1—



A3—



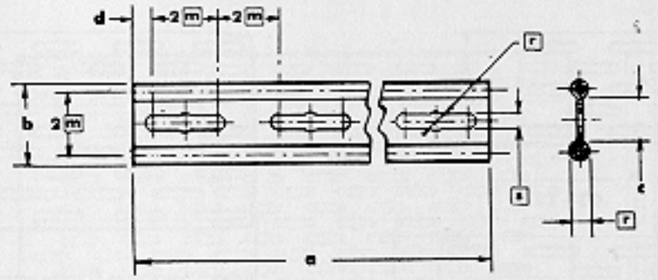
A5—

Drawn in scale 1:1

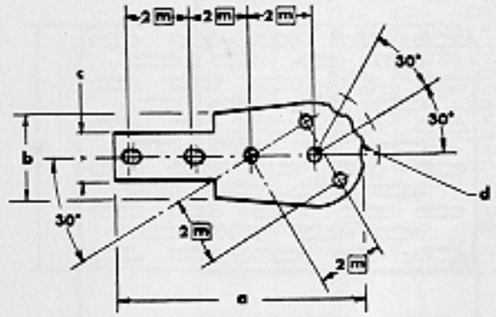
Part No.	Part name	Dimensions in millimeters		Dimensions in inches	
		a	b	a	b
A1—02	**Rod**	24		.95	
A1—03	**Rod**	38		1.50	
A1—04	**Rod**	52		2.05	
A1—05	**Rod**	66		2.60	
A1—06	**Rod**	80		3.15	
A1—07	**Rod**	94		3.70	
A1—08	**Rod**	108		4.25	
A1—10	**Rod**	136		5.35	
A1—40	**Rod**	500		21.89	
A3—10	**Threaded Rod**	10	10	.394	.40
A3—20	**Threaded Rod**	20	10	.787	.40
A3—30	**Threaded Rod**	30	10	1.181	.40
A3—40	**Threaded Rod**	40	10	1.574	.40
A3—50	**Threaded Rod**	50	10	1.968	.40
A3—60	**Threaded Rod**	60	10	2.362	.40
A3—70	**Threaded Rod**	70	10	2.756	.40
A5—05	**Tapped Sleeve**	5.2		.205	
A5—12	**Tapped Sleeve**	12.2		.480	

Material: steel, 4 mm diameter (.16 in.).

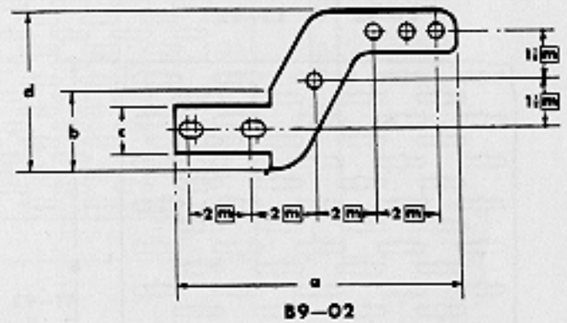
Re symbols r s m v w x y z and dimensional tolerances see page 76.



B1—



B9—01



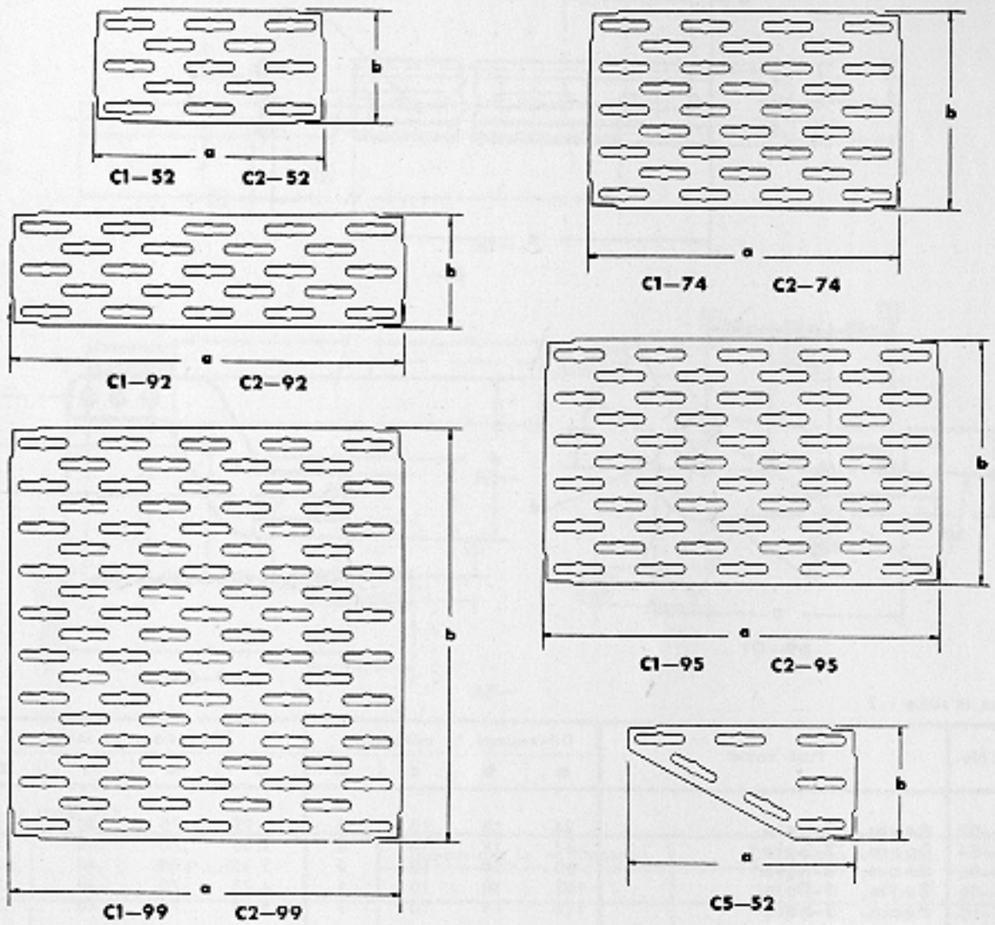
B9—02

Drawn in scale 1:2

Part No.	Part name	Dimensions in millimeters				Dimensions in Inches			
		a	b	c	d	a	b	c	d
B1—02	**Beam, 1-hole**	24	18	10	5	.95	.70	.40	.20
B1—04	**Beam, 2-hole**	52	18	10	5	2.05	.70	.40	.20
B1—06	**Beam, 3-hole**	80	18	10	5	3.15	.70	.40	.20
B1—08	**Beam, 4-hole**	108	18	10	5	4.25	.70	.40	.20
B1—10	**Beam, 5-hole**	136	18	10	5	5.35	.70	.40	.20
B1—12	**Beam, 6-hole**	164	18	10	5	6.46	.70	.40	.20
B1—14	**Beam, 7-hole**	192	18	10	5	7.56	.70	.40	.20
B1—16	**Beam, 8-hole**	220	18	10	5	8.66	.70	.40	.20
B1—18	**Beam, 9-hole**	248	18	10	5	9.76	.70	.40	.20
B1—20	**Beam, 10-hole**	276	18	10	5	10.86	.70	.40	.20
B1—22	**Beam, 11-hole**	304	18	10	5	11.97	.70	.40	.20
B1—24	**Beam, 12-hole**	332	18	10	5	13.07	.70	.40	.20
B1—26	**Beam, 13-hole**	360	18	10	5	14.17	.70	.40	.20
B1—28	**Beam, 14-hole**	388	18	10	5	15.28	.70	.40	.20
B1—30	**Beam, 15-hole**	416	18	10	5	16.38	.70	.40	.20
B1—32	**Beam, 16-hole**	444	18	10	5	17.48	.70	.40	.20
B1—34	**Beam, 17-hole**	472	18	10	5	18.58	.70	.40	.20
B1—36	**Beam, 18-hole**	500	18	10	5	19.69	.70	.40	.20
B1—38	**Beam, 19-hole**	528	18	10	5	20.79	.70	.40	.20
B1—40	**Beam, 20-hole**	556	18	10	5	21.89	.70	.40	.20
B9—01	**Beam End Plate** steel 1 mm (.04 in.)	56	18	10	4	2.20	.70	.40	.16
B9—02	**Beam Offset Plate** steel 1.5 mm (.06 in.)	69	18	10	35	2.71	.70	.40	1.38

Material: steel, thickness .8 mm (.03 in.), unless otherwise stated.

Re symbols r s m v w x y z and dimensional tolerances see page 76.

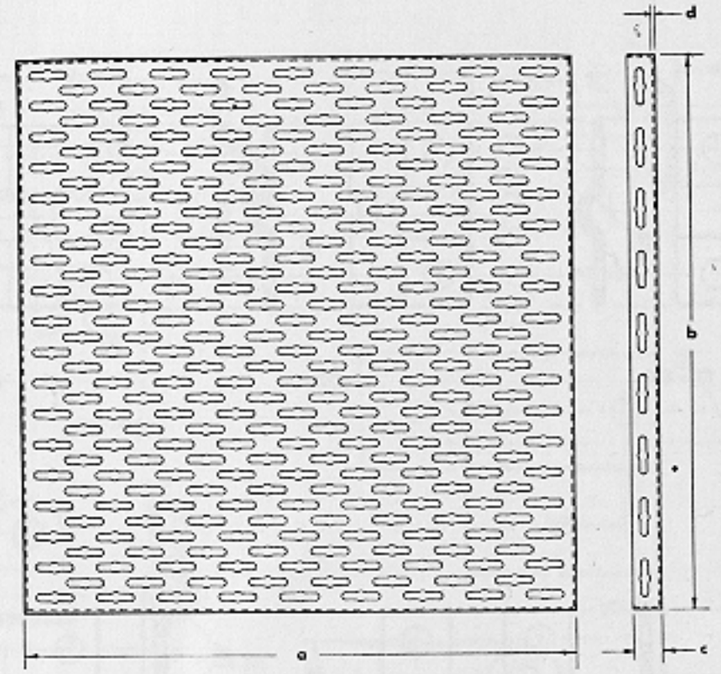


Drawn in scale 1:3

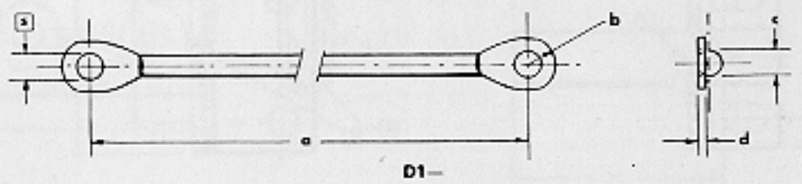
Part No.	Part name	Dimensions in millimeters a	b	Dimensions in inches a	b
C1—52	**Plate,** thickness .6 mm (.024 in.)	80	38	3.15	1.50
C1—74	**Plate,** thickness .6 mm (.024 in.)	108	66	4.25	2.60
C1—92	**Plate,** thickness .6 mm (.024 in.)	136	38	5.35	1.50
C1—95	**Plate,** thickness .6 mm (.024 in.)	136	80	5.35	3.15
C1—99	**Plate,** thickness .6 mm (.024 in.)	136	136	5.35	5.35
C2—52	**Plate,** thickness 1 mm (.040 in.)	80	38	3.15	1.50
C2—74	**Plate,** thickness 1 mm (.040 in.)	108	66	4.25	2.60
C2—92	**Plate,** thickness 1 mm (.040 in.)	136	38	5.35	1.50
C2—95	**Plate,** thickness 1 mm (.040 in.)	136	80	5.35	3.15
C2—99	**Plate,** thickness 1 mm (.040 in.)	136	136	5.35	5.35
C5—52	**Corner Plate,** thickness .6 mm (.024 in.)	79	38	3.11	1.50

Material: steel.

Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



Drawn in scale 1:4

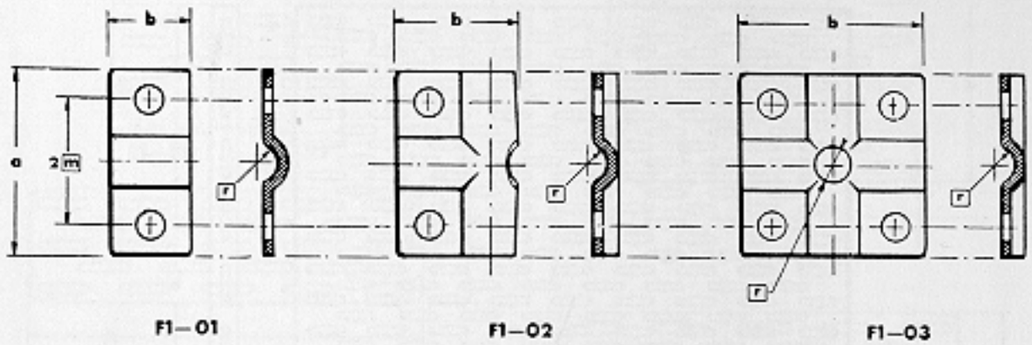


Drawn in scale 1:1

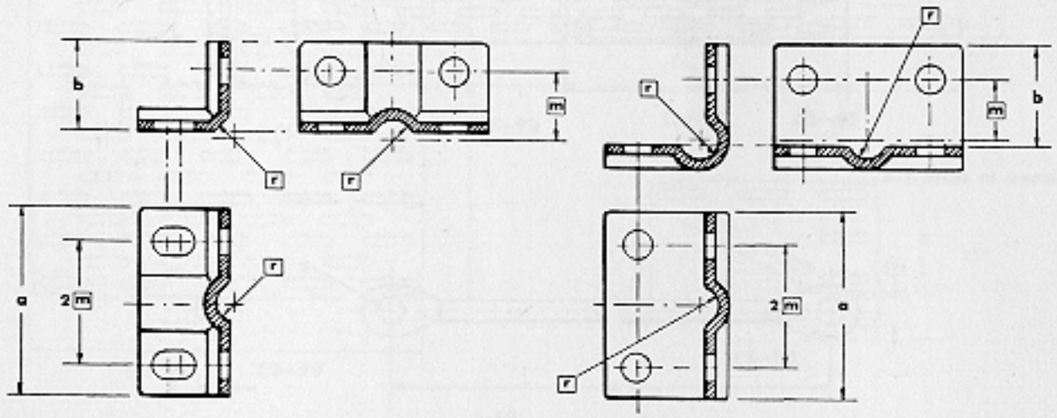
Part No.	Part name	Dimensions in millimeters a	b	c	d	Dimensions in inches a	b	c	d
C9—17	**Flanged Plate**	252	252	13	1	9.92	9.92	.50	.04
D1—12	**Tie Rod**	19.8	3	2.5	.8	.779	.12	.10	.03
D1—13	**Tie Rod**	24.3	3	2.5	.8	.955	.12	.10	.03
D1—20	**Tie Rod**	28.0	3	2.5	.8	1.102	.12	.10	.03
D1—22	**Tie Rod**	39.6	3	2.5	.8	1.559	.12	.10	.03
D1—23	**Tie Rod**	48.5	3	2.5	.8	1.909	.12	.10	.03
D1—40	**Tie Rod**	56.0	3	2.5	.8	2.205	.12	.10	.03
D1—42	**Tie Rod**	79.2	3	2.5	.8	3.117	.12	.10	.03
D1—43	**Tie Rod**	97.0	3	2.5	.8	3.819	.12	.10	.03
D1—80	**Tie Rod**	112.0	3	2.5	.8	4.409	.12	.10	.03
D1—82	**Tie Rod**	158.4	3	2.5	.8	6.235	.12	.10	.03

Material: steel.

Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



F1—01 F1—02 F1—03



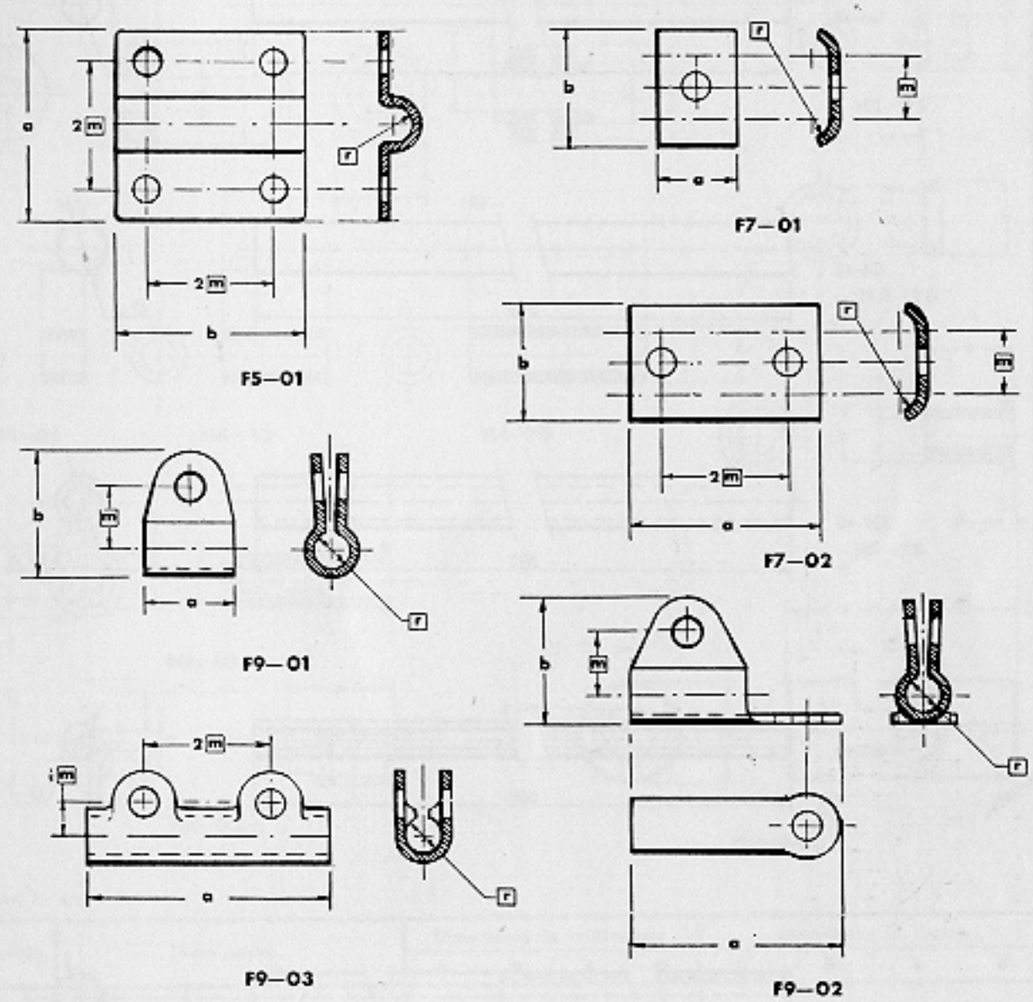
F3—01 F3—02

Drawn in scale 1:1

Part No.	Part name	Dimensions in millimeters a	b	Dimensions in inches a	b
F1—01	**Strap Coupler**	21	9	.83	.35
F1—02	**T-Coupler**	21	13.5	.83	.53
F1—03	**Cross Coupler**	21	21	.83	.83
F3—01	**Inside Angle**	21	10	.83	.40
F3—02	**Outside Angle**	21	11	.83	.44

Material: steel, thickness 1 mm (.04 in.).

Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



F5—01 F7—01 F7—02 F9—01 F9—03 F9—02

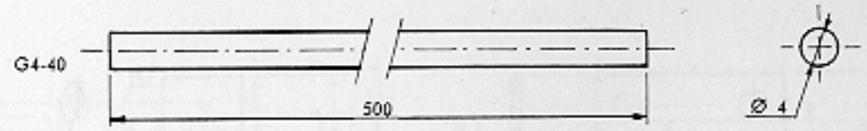
Drawn in scale 1:1

Part No.	Part name	Dimensions in millimeters a	b	Dimensions in inches a	b
F5—01	**Saddle Coupler**	21	21	.83	.83
F7—01	**Short Clamp**	9	13	.35	.51
F7—02	**Long Clamp**	21	13	.83	.51
F9—01	**Plain Clip**	10	13.5	.40	.53
F9—02	**End Clip**	23	13.5	.90	.53
F9—03	**Joint Clip**	27		1.06	

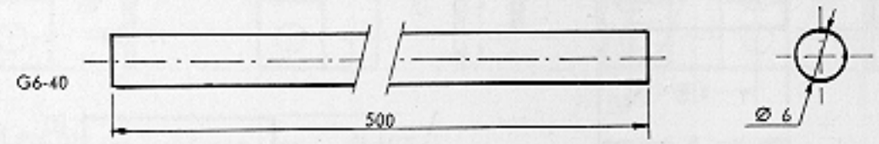
Material: steel, thickness 1 mm (.04 in.).

Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.

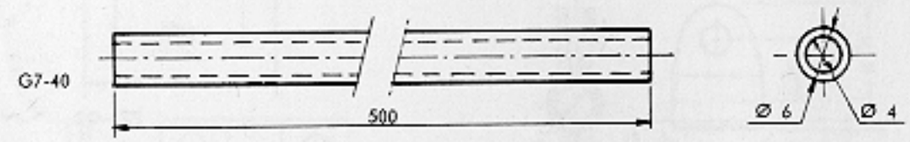
G4-40



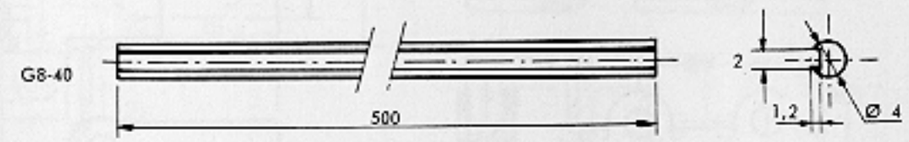
G6-40



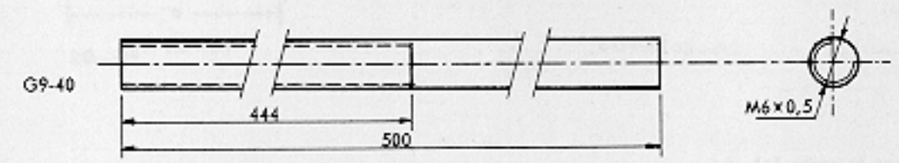
G7-40



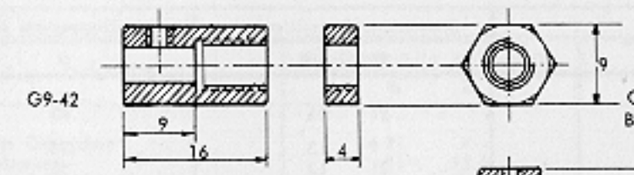
G8-40



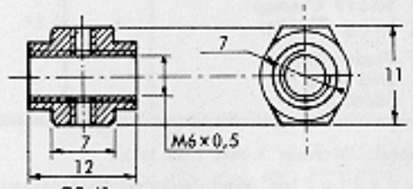
G9-40



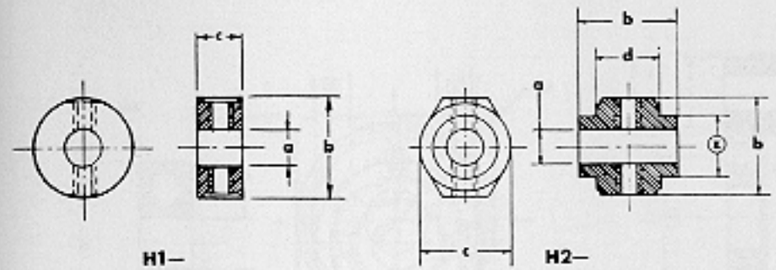
G9-42



G9-43
Bronze



G9-41
Bronze

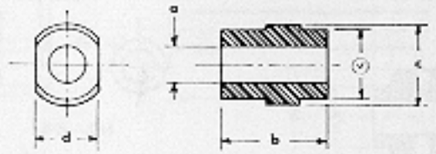


Drawn in scale 1:1

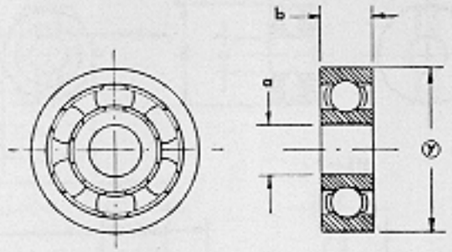
Part No.	Part name	Dimensions in millimeters a	b	c	d	Dimensions in inches a	b	c	d
H1—04	**Collar**	4[H9]	11	5		.1581	.433	.196	
H1—06	**Collar**	6[H9]	11	5		.2368	.433	.196	
H2—04	**Shaft Head**	4[H9]	10.8	9.9	7	.1581	.425	.390	.275
H2—06	**Shaft Head**	6[H9]	10.8	9.9	7	.2368	.425	.390	.275
H3—04	**Ring**	4[H11]	6	1		.159	.235	.039	
H3—16	**Ring**	6[H11]	8	1		.238	.315	.079	
H4—05	**Sleeve**	5	6	4		.196	.235	.159	
H4—12	**Sleeve**	12	6	4		.472	.235	.159	
H4—20	**Sleeve**	19.8	6	4		.780	.235	.159	
H5—10	**Split Sleeve,** steel	10	6[h8]	4[H8]	1	.394	.2358	.1579	.04
H8—01	**Sliding Dog,** steel	18	6[h8]	4[H8]	8	.709	.2358	.1579	.315
H8—02	**Fixed Dog ,** steel	12	6[h8]	4[H8]		.472	.2358	.1579	
H9—06	**Universal Joint,** steel	6[H9]	11	13		.2368	.433	.52	

Material: bronze unless otherwise stated.

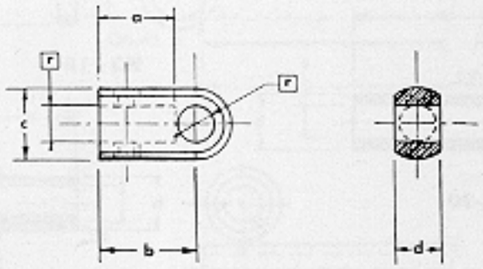
Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



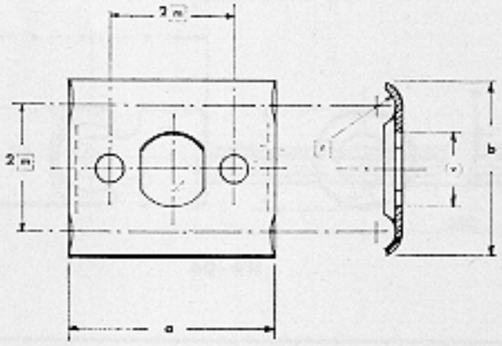
L1—



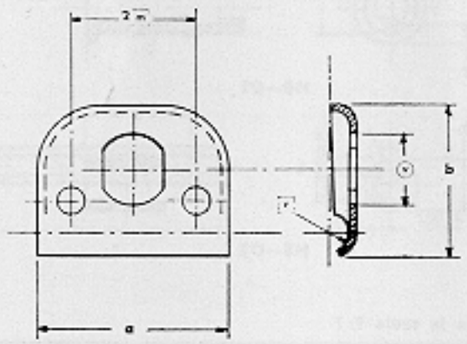
L3—06



L5—04



L8—02



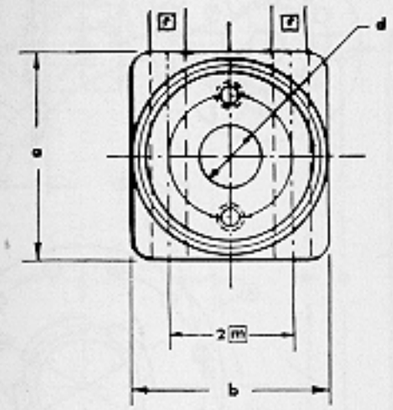
L8—01

Drawn in scale 1:1

Part no.	Part name	Dimensions in millimeters				Dimensions in inches			
		a	b	c	d	a	b	c	d
L1—14	**Bushing,** bronze	4[E9]	12	9		.1589	.472	.315	
L1—16	**Bushing,** bronze	6[E9]	12	9		.2376	.472	.315	
L3—06	**Ball Bearing** steel, SKF, internat. standard dim.	6	6			.2361	.234		
L5—04	**Rod End,** bronze	7	11	8	5	.28	.433	.315	.196
L8—01	**Bushing Clamp, single rod** steel, thickness 1 mm (.04 in.)	21.5	17			.85	.67		
L8—02	**Bushing Clamp, twin rod** steel, thickness 1.2 mm (.05 in.)	23.5	20			.93	.79		

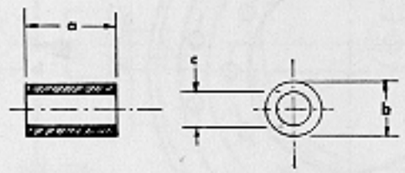
Material: as stated.

Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



L9—06

L9—60



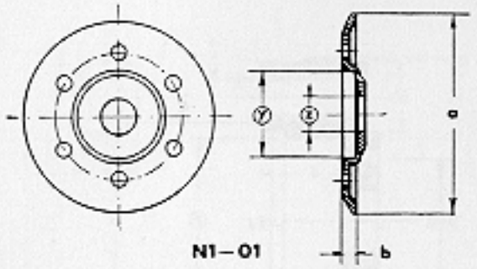
L9—64

Drawn in scale 1:1

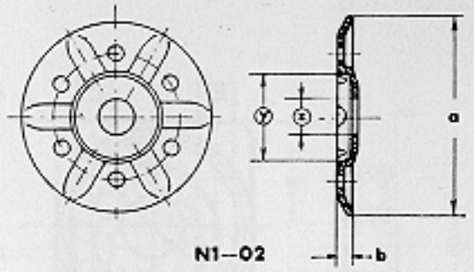
Part No.	Part name	Dimensions in millimeters				Dimensions in inches			
		a	b	c	d	a	b	c	d
L9—06	**Ball Bearing Box** bronze or aluminum	23.5	22	12.4	7	.93	.87	.48	.28
L9—60	**Bearing Box Cover** cellulose acetate	20	8.2	6.2	4.2	.79	.32	.24	.17
L9—64	**Ball Bearing Insert,** nylon	10	6	4		.40	.237	.157	

Material: as stated.

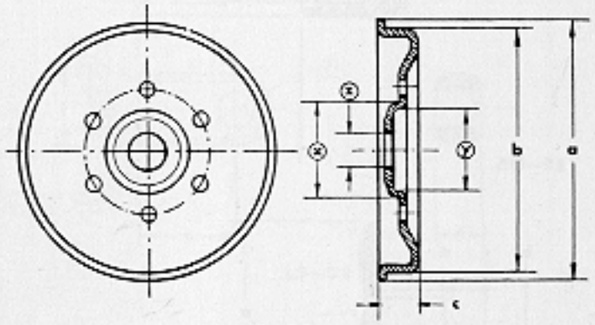
Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



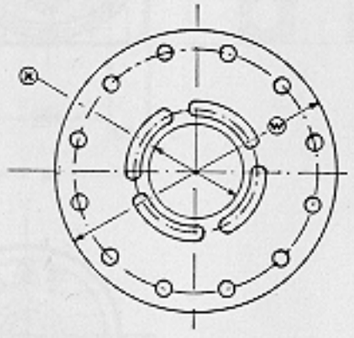
N1—01



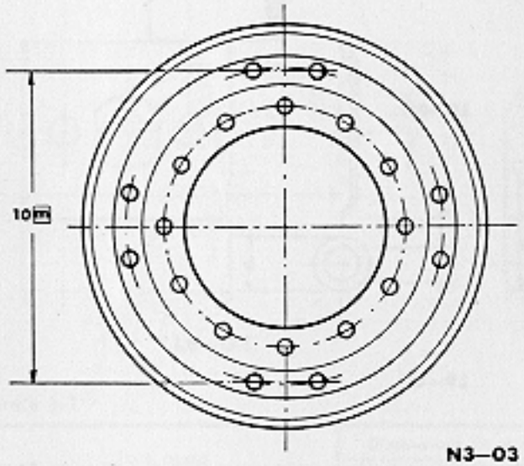
N1—02



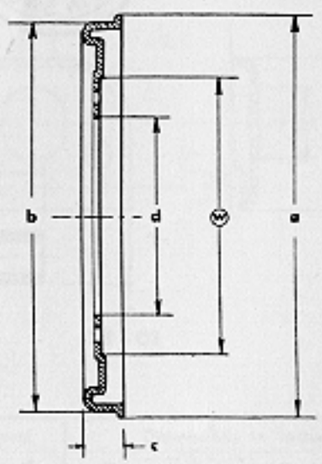
N1—05



N3—01



N3—03

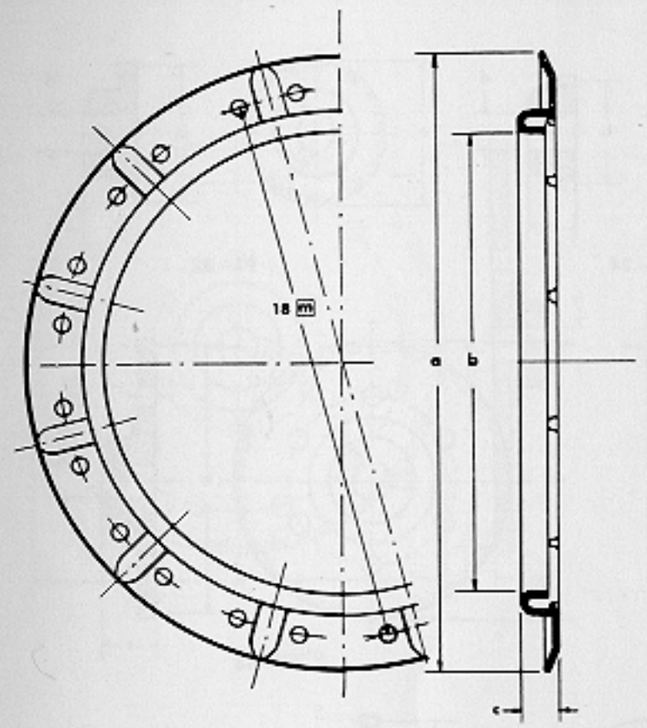


Drawn in scale 1:2

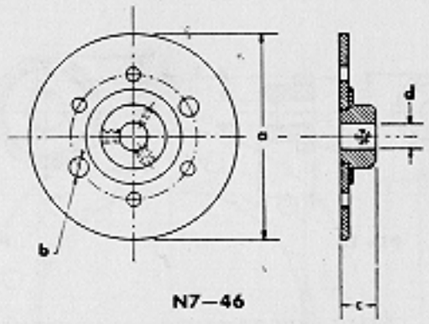
Part No.	Part name	Dimensions in millimeters				Dimensions in inches			
		a	b	c	d	a	b	c	d
N1—01	**Wheel Disc**	42.5	2.6			1.67	.10		
N1—02	**Wheel Spoke Disc**	42.5	2.6			1.67	.10		
N1—05	**Flanged Wheel** steel 1.2 mm (.05 in.)	57.5	54	8.5		2.25	2.13	.33	
N3—01	**Disc Web**								
N3—03	**Flanged Rim**	91	87.8	7.8	46.2	3.58	3.46	.31	1.83

Material: steel, thickness 1 mm (.04 in.) unless otherwise stated.

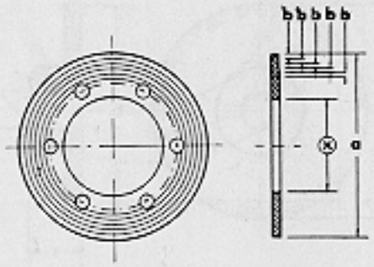
Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



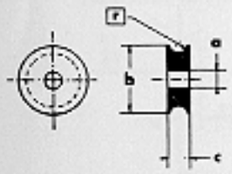
N3—05



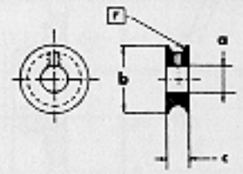
N7—46



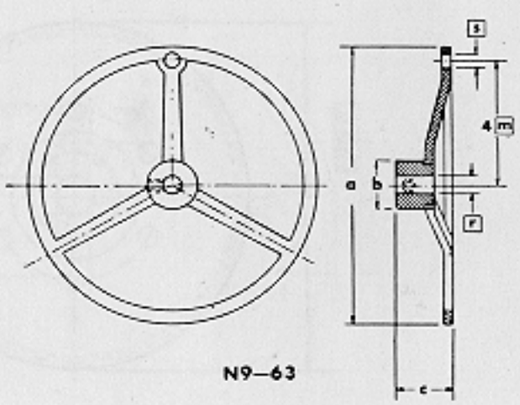
N8—42



N5—04



N5—06



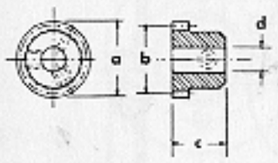
N9—63

Drawn in scale 1:2

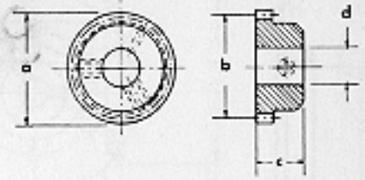
Part No.	Part name	Dimensions in millimeters				Dimensions in inches			
		a	b	c	d	a	b	c	d
N3—05	**Slewing Ring** steel, 1 mm (.04 in.)	142	106	7.8		5.59	4.17	.31	
N5—04	**Loose Pulley,** bronze	4[H9]	15.6	5		.1581	.61	.196	
N5—06	**Fixed Pulley,** bronze	6[H9]	15.6	5		.2368	.61	.196	
N7—46	**Disc Hub**	46.2	4	8	6[H8]	1.818	.1581	.315	.2366
N8—42	**Cam Blank**	42	1			1.654	.0394		
N9—63	**Handwheel**	63	11	12.5		2.48	.43	.49	

Material: steel, thickness 2 mm (.08 in.) unless otherwise stated.

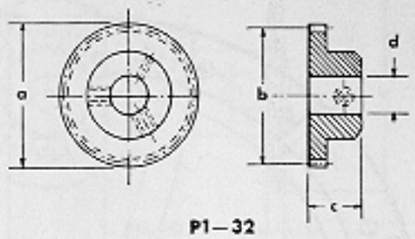
Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



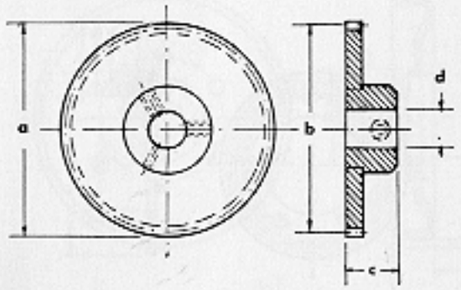
P1—16



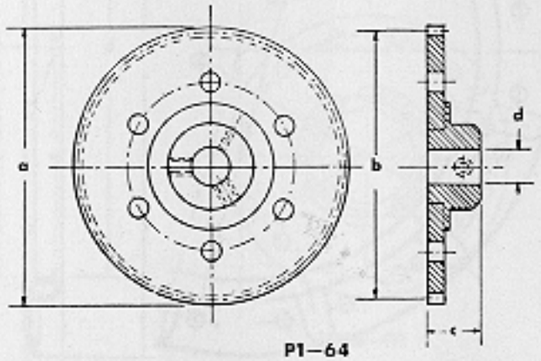
P1—24



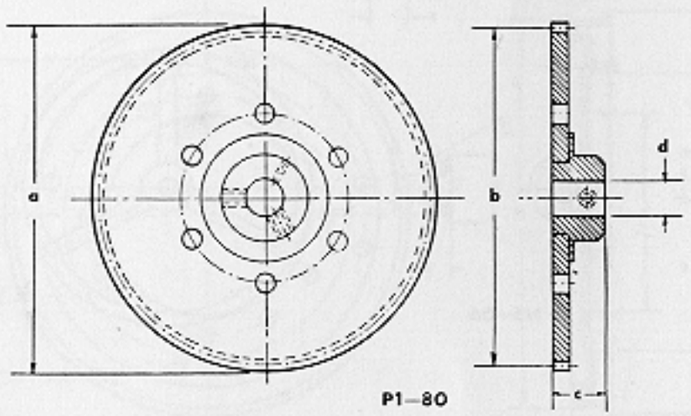
P1—32



P1—48



P1—64



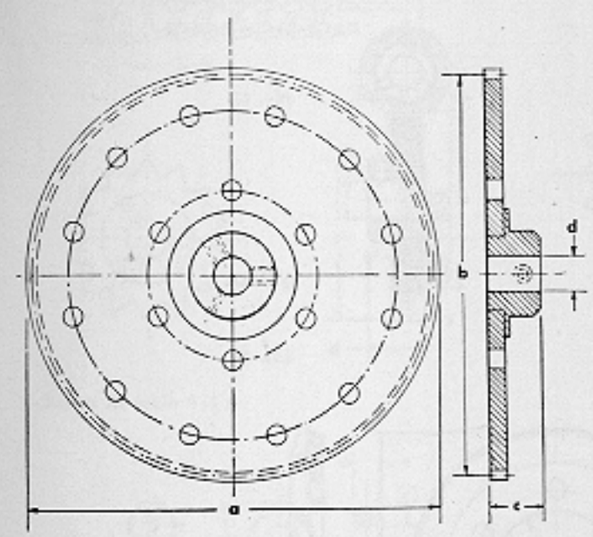
P1—80

Drawn in scale 1:1.5

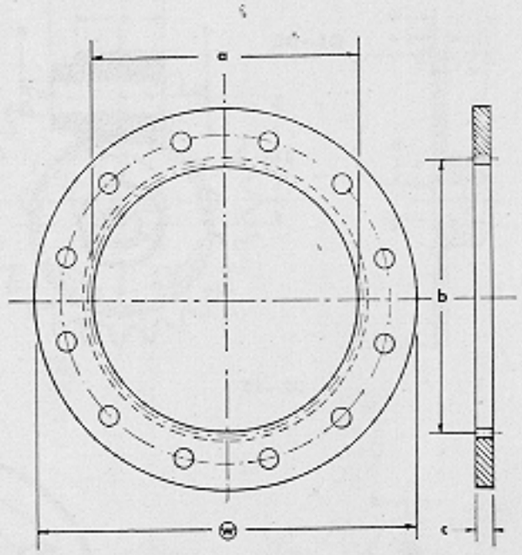
Part no.	Part name	Dimensions in millimeters a	b	c	d	Dimensions in inches a	b	c	d
P1—16	**Spur Gear, 16 teeth**	12.6	11.2	9	4 [H8]	.496	.4409	.354	.1579
P1—24	**Spur Gear, 24 teeth**	18.2	16.8	9	6 [H8]	.717	.6614	.354	.2366
P1—32	**Spur Gear, 32 teeth**	23.8	22.4	9	6 [H8]	.937	.8819	.354	.2366
P1—48	**Spur Gear, 48 teeth**	35.0	33.6	9	6 [H8]	1.378	1.3228	.354	.2366
P1—64	**Spur Gear, 64 teeth**	46.2	44.8	9	6 [H8]	1.819	1.7638	.354	.2366
P1—80	**Spur Gear, 80 teeth**	57.4	56.0	9	6 [H8]	2.260	2.2047	.354	.2366

Material: steel.
Module: 0.7 = DP36 approx.
Pressure angle: 20°. Gear tooth width 3 mm (.118 in.).

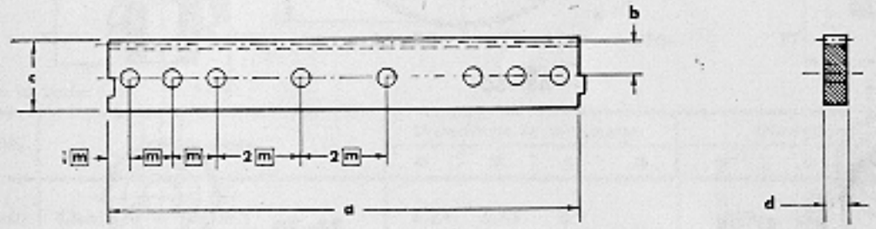
Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



P1—96



P3—64



P5—35

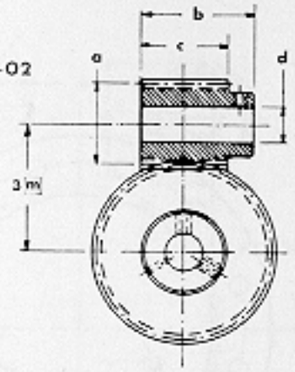
Drawn in scale 1:1.5

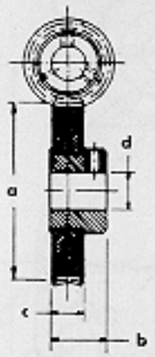
Part No.	Part name	Dimensions in millimeters a	b	c	d	Dimensions in inches a	b	c	d
P1—96	**Spur Gear, 96 teeth**	68.6	67.2	9.5	6 [H8]	2.701	2.6457	.37	.2366
P3—64	**Internal Spur Gear, 64 teeth**	43.4	44.8	3		1.709	1.7638	.118	
P5—35	**Rack, 35 teeth**	77.0	5.6	11.8	4	3.032	.2205	.465	.157

Material: steel.
Module: 0.7 = DP36 approx.
Pressure angle: 20°. Gear tooth width 3 mm (.118 in.).

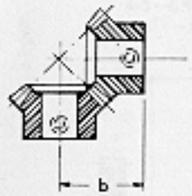
Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.

Q1—02

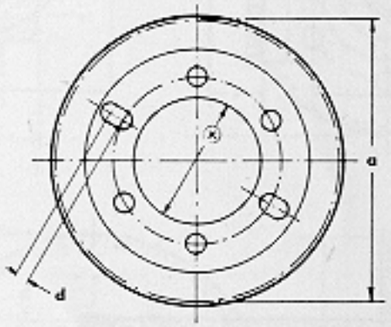




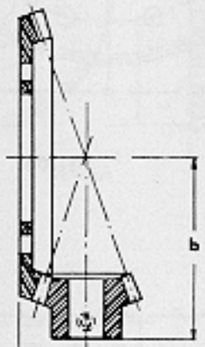
Q1—40



R1—18



R3—60



R3—20

Drawn in scale 1:1.5

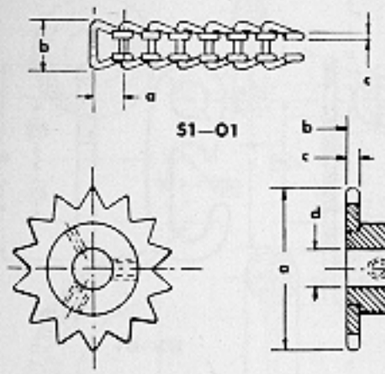
Part. No	Part name	Dimensions in millimeters				Dimensions in inches			
		a	b	c	d	a	b	c	d
Q1—02	**Worm, R.H. double thread,** steel	14	19	14	6 [H8]	.551	.748	.551	.2366
Q1—40	**Worm Gear, 40 teeth** fabric base laminate with steel hub	28	9	5	6 [H8]	1.102	.354	.197	.2366
R1—18	**Bevel Gear, 18 teeth,** bronze	15.5	13.7	6 [H8]		.61	.54	.2366	
R3—20	**Bevel Gear, 20 teeth,** bronze	17.5	29.8	11.4	6 [H8]	.69	1.17	.45	.2366
R3—60	**Bevel Gear, 60 teeth,** bronze	48.5	29.8	11.4	2	1.91	1.17	.45	.08

Material: as stated.

Worm Gears: Pressure angle 20°. Module: 0.7 = DP36 approx.

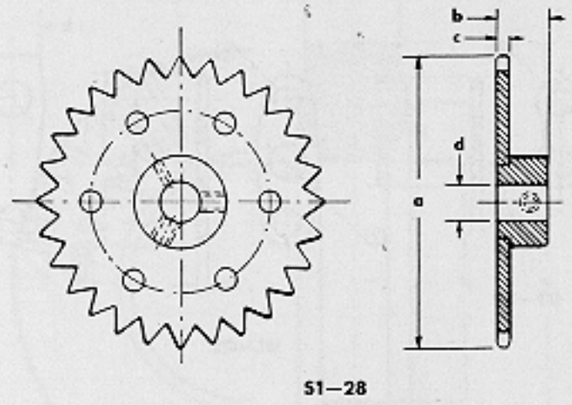
Bevel Gears: Module: 0.8 = DP32 approx.

Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



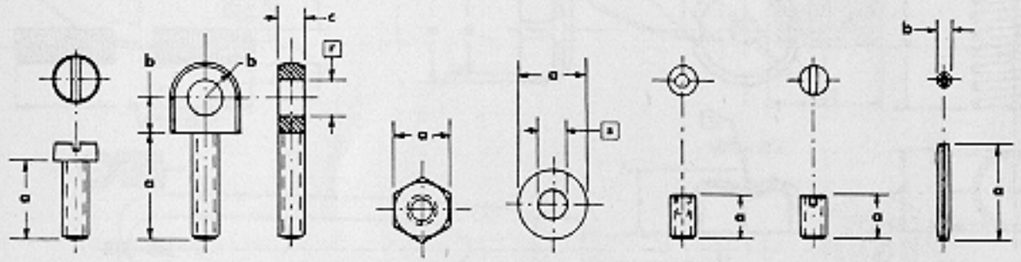
S1—01

S1—14



S1—28

Drawn in scale 1:1.5



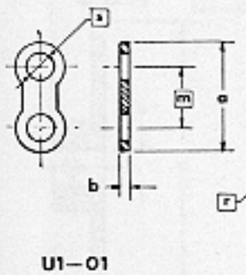
T1— T3—12 T4—02 T5—08 T6— T7— T9—

Drawn in scale 1:1

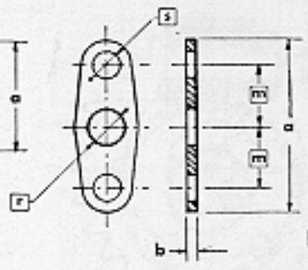
Part No.	Part name	Dimensions in millimeters				Dimensions in inches			
		a	b	c	d	a	b	c	d
S1—01	**Chain,** 1 m (40 in.)	4.54	6.75	0.9		.179	.27	.035	
S1—14	**Sprocket, 14 teeth**	24.8	8	2	6 [H8]	.98	.32	.08	.2366
S1—28	**Sprocket, 28 teeth**	44.8	8	2	6 [H8]	1.76	.32	.08	.2366
T1—06	**Screw,** cheese head	6				.24			
T1—09	**Screw,** cheese head	9				.35			
T1—15	**Screw,** cheese head	15				.59			
T1—24	**Screw,** cheese head	24				.95			
T3—12	**Eye Screw**	12	4	3		.47	.16	.12	
T4—02	**Nut,** thickness 2 mm (.09 in.)	6				.24			
T5—08	**Washer,** thickness .8 mm (.03 in.)	8				.31			
T6—03	**Setscrew,** Allen type	2.75				.11			
T6—05	**Setscrew,** Allen type	5				.20			
T7—03	**Setscrew,** slotted type	2.75				.11			
T7—05	**Setscrew,** slotted type	5				.20			
T9—09	**Roll Pin**	9	1.7			.35	.07		
T9—12	**Roll Pin**	12	1.7			.47	.07		

Material: steel.

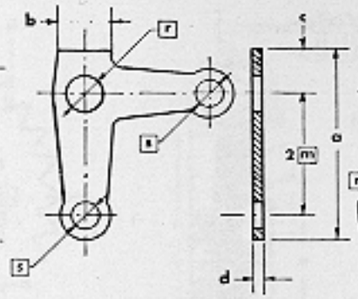
Re symbols [r] [s] [m] (v) (w) (x) (y) (z) and dimensional tolerances see page 76.



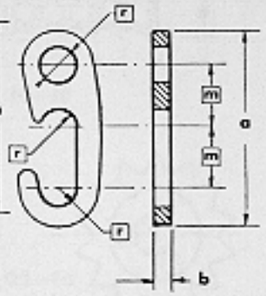
U1—01



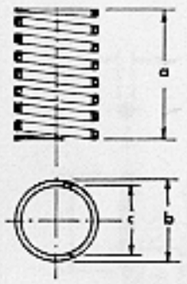
U1—02



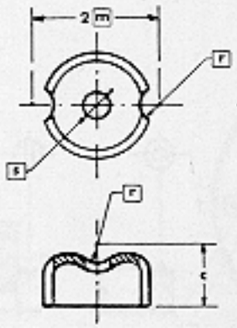
U1—05



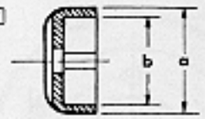
U3—01

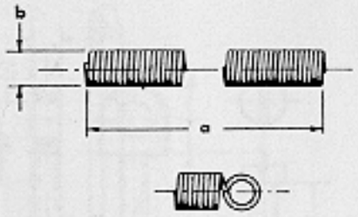


U5—01

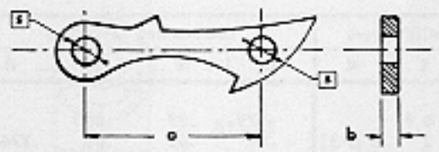


U5—02

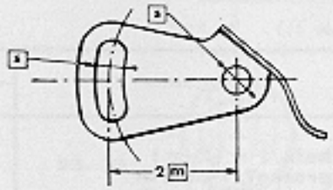




U5—05



U7—01



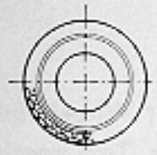
U7—02

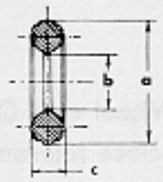
Drawn in scale 1:1

Part No.	Part name	Dimensions in millimeters a	b	c	d	Dimensions in inches a	b	c	d
U1—01	**Two Hole Link**	12.5	1.2			.49	.05		
U1—02	**Three Hole Link**	19.2	1.2			.77	.05		
U1—05	**Angle Link**	21.8	6	5	1.2	.86	.24	.20	.05
U3—01	**Hook**	22.5	2			.89	.08		
U5—01	**Thrust Spring**	15	9.8	7.8		.60	.386	.307	
U5—02	**Spring Seat**	12	10	7		.47	.39	.28	
U5—05	**Tension Spring** ends may be formed as shown	278	4			11	.157		
U7—01	**Ratchet Pawl**	19.2	2			.756	.08		
U7—02	**Ratchet Spring,** phosphor bronze								

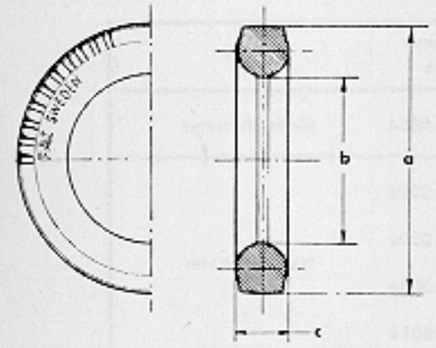
Material: steel, unless otherwise stated.

Re symbols r s m v w x y z and dimensional tolerances see page 76.

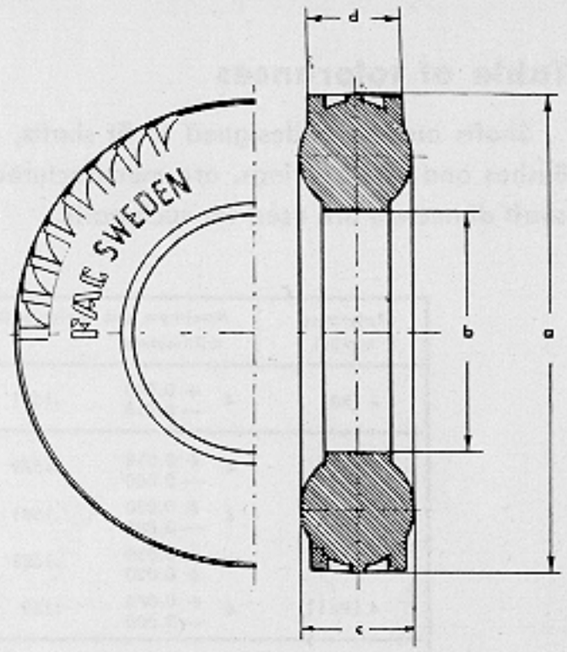




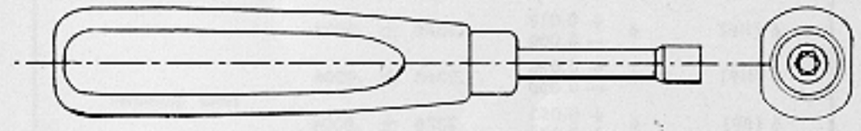
W1—01



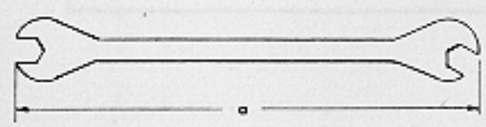
W1—02



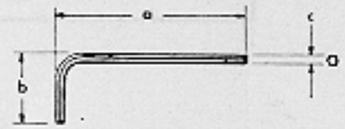
W1—03



W9—01



W9—02



W9—03

Drawn in scale 1:2

Part No.	Part name	Dimensions in millimeters a	b	c	d	Dimensions in inches a	b	c	d
W1—01	**Rubber Tire,** vehicle type fits N5—04 or N5—06	26	12.5	7.5		1.00	.50	.30	
W1—02	**Rubber Tire,** vehicle type fits a pair of N1—01 or N1—02	60	37	11		2.40	1.50	.45	
W1—03	**Rubber Tire,** vehicle type fits a pair of N1—05	104	53.5	25	20	4.10	2.10	1.00	.80
W9—01	**Socket Wrench**								
W9—02	**Open End Wrench** steel, thickness 2 mm (.08 in.)	105				4.10			
W9—03	**Allen Wrench**	43	16	1.27		1.70	.63	.05	

Material: as stated.

Re symbols r s m v w x y z and dimensional tolerances see page 76.

Table of tolerances

Shafts and parts designed to fit shafts, such as Wheel and Gear Wheel Hubs, Bushes and Ball Bearings, are manufactured to very close tolerances. Two nominal shaft diameters are used for such parts.

Tolerance symbol	Maximum and Minimum Diameters millimeters	inches	Notes
4 [h8]	4 $^{+\ 0.000}_{-\ 0.018}$	.1571 ± .0004	Shaft diameter
4 [H8]	4 $^{+\ 0.018}_{-\ 0.000}$	.1579 ± .0004	Hole diameter
4 [H9]	4 $^{+\ 0.030}_{-\ 0.000}$	.1581 ± .0006	
4 [E9]	4 $^{+\ 0.050}_{+\ 0.020}$	.1589 ± .0006	
4 [H11]	4 $^{+\ 0.075}_{-\ 0.000}$	.159 ± .0014	
6 [h8]	6 $^{+\ 0.000}_{-\ 0.018}$	.2358 ± .0004	Shaft diameter
6 [H8]	6 $^{+\ 0.018}_{-\ 0.000}$	.2366 ± .0004	Hole diameter
6 [H9]	6 $^{+\ 0.030}_{-\ 0.000}$	.2368 ± .0006	
6 [E9]	6 $^{+\ 0.050}_{+\ 0.020}$	.2376 ± .0006	
6 [H11]	6 $^{+\ 0.075}_{-\ 0.000}$	.238 ± .0014	

List of symbols

[m] = 7 mm = appr. .28 in.
[r] = 4 mm = appr. .16 in.
[s] = 3 mm = appr. .12 in.
(v) = 8 mm = appr. .315 in.
(w) = 63.3 mm = appr. 2.49 in.
(x) = 21 mm = appr. .84 in.
(y) = 19 mm = appr. .75 in.
(z) = 7 mm = appr. .28 in.

These are nominal dimensions only; actual dimensions are modified to obtain a suitable fit.

Alleenverkoop voor de Benelux:

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