FAC

0106

FAC CONSTRUCTION SYSTEM

MANUAL 0106

CONSTRUCTION METHODS

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For description of parts see catalogue 0107 »List of Parts».

FAC systems are flexible construction kits, designed to develop conventional and unconventional mechanisms, machines, structures, etc., in a rapid and easily understood 3-dimensional form. They are of great importance to not only the inventor, but to the designer, the construction engineer and to qualified engineers in general and also to the engineering student, apprentice and trainee.

Each FAC system is precision designed on a module principle and made from high quality rust-proofed Swedish steel.

A quick study of this book will indicate that each Kit is really prepacked engineering "know-how" which will inspire planning in 3-dimensions. It is a well known psychological fact that one will think better in 3-dimensions as compared with 2-dimensions and the inventor, the designer, and indeed the engineer in general has therefore much greater freedom at his disposal than given by the sketch pad and the drawing board.

Simplification of unit parts and form allow parts to be used repeatedly and for a variety of purposes.

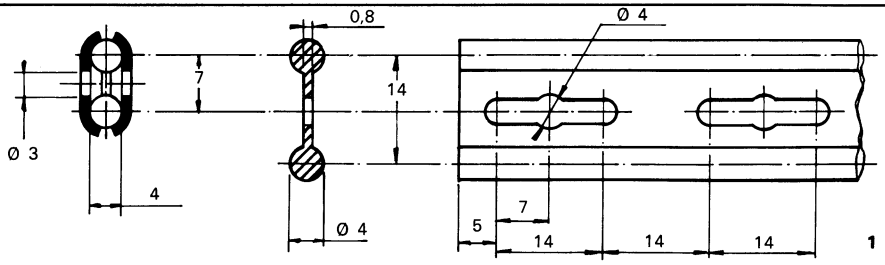
The inherent strength of FAC units allows not only a wide application for experimental working models but also makes all parts suitable equipment for industrial purposes - particularly in repetitive manufacture of machines or instruments and so on.

The outstanding features of FAC could be concentrated in a few pages but extensive presentation is given in this book not only to assist the technician but also to aid the student and the instructor together with those who engage in model mechanical engineering for the pleasure they get out of it.

It will also be found that many FAC parts can be adapted quickly and cheaply for specific purposes outside those set out in this book. These of course can be purchased separately.

Part No.	Description	Part No.	Description
10 03-40	Plain Rod	20 04-15	Shaft
11 01-10	Threaded Rod	20 38-40	Grooved Shaft
11 20	Full Threaded Rod	20 41-42	Key
11 75-82	Tapped Sleeve	20 50	Gear Shift Fork
12 01-18	Beam	20 51	Sliding Coupling
13 12-82	Tie Rod	20 61	Stub Axle
14 04-06	Distance Ring	20 70-71	Retaining Ring
14 11-13	Spacer Tube	20 80	Differential Centre
14 15-50	Hollow Shaft	21 04-06	Bushing
15 20	Corner Plate	21 11	Single Bushing Clamp
15 21-44	Plate	21 12	Twin Bushing Clamp
15 86	Baseplate	21 24	Bushing
16 01	Cranked Plate	21 34-36	Grooved Ball Bearing
16 05	Support leg	21 37	Spherical Ball Bearing
16 10-11	Flanged Strap Coupling	21 38	Axial Ball Bearing
16 12	T-Coupling	21 54	Bearing Cage
16 13	Cross Coupling	21 56	Bearing Box
16 15	Inside Angle	21 57	Retaining Clip
16 16	Outside Angle	22 01-02	Retaining Ring
16 20	Angular Coupling	22 03-04	Self-Locking Washer
16 30	Short Clamp	22 14-16	Shaft Head
16 31	Long Clamp	22 20	Split Sleeve
16 40	Plain Clip	22 30	Nylon Sleeve
16 41	End Clip	23 01	Wheel Disc
16 42	Joint Clip	23 06	Flanged Disc
16 50	Three Hole Link	23 10	Perforated Disc
16 51	Angle Link	23 20	Flanged Rim
17 03-05	Set Screw	23 30	Centreless Wheel
17 06-24	Headed Screw	23 40	Flywheel Ring
17 40	Eye Screw	23 46	Planet Wheel Disc
17 63-64	Nut	23 50	Perforated Wheel
17 70-72	Washer	23 51	Friction Disc
17 75	Locking Washer	23 61	Grooved Loose Pulley

Part No.	Description	Part No.	Description
23 62	"V" Grooved Pulley	25 61	Spring Seat
23 65-68	"V" Grooved Wheel	25 70	Hand Wheel
23 89	Rubber Tyre	25 80	Lead Screw
23 91	Plastic Cord	25 81	Lead Nut
23 92-93	O Ring	30 16-96	Spur Gear
24 06	Free Wheel Housing	31 35	Toothed Rack
24 08-09	Expansion Spring Right & Left	31 64	Gear Ring (Internal)
24 10	Coupling Ring	32 16	Spur Gear
24 20	Shaft Sleeve	33 16-24	Planet Gear
24 30	Universal Coupling	37 18-20	Bevel Gear
25 01	Sliding Crosshead	37 60	Bevel Gear Ring
25 10	Plastic Cam Disc Material	38 01-51	Worm & Worm Wheel
25 11-14	Rocker Arm	39 01	Roller Chain
25 18	Lock Plate	39 02	Roller Chain Joint
25 20	Connecting Rod End	39 10-30	Chain Sprocket
25 30	Fork Head	39 80	Chain (wire)
25 32	Tongue Head	39 84-98	Chain Sprocket
25 36	Connecting Pin (Flanged)	40 00-01	Hub
25 50	Tension Spring	08 01	Socket Key
25 60	Comp. Spring	08 02-03	Nut Key
		08 04	Allen Key
		08 06	Screw Driver



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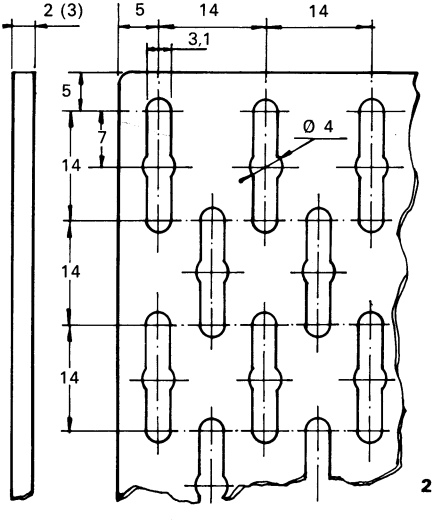

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FAC is based on the metric system but this presents no difficulty particularly as the system is standardised to a module.

MODULE

The FAC system is based on a measurement of 7 mm. derived from the sum of the diameters of the rod and screw, Fig. 1. The most common measurement 14 mm. (2 x 7 mm) is the distance between the screw holes of the coupling units, the length and pitch of the slots, "Beam" depth, etc. - see Fig. 1 and 2.

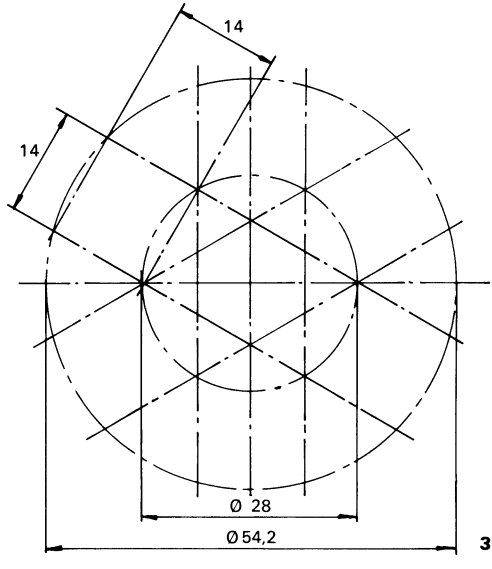
All plates - except base plates - contain a measurement of 5 mm. from slot to edge to allow edge of a beam to be placed between two plates whilst retaining the overall fixed measurement between holes.

The 14 mm. measurement also forms the basis of the dividing diagram (Fig. 3) for perforated flanges related to several of the rotary components.

Tolerances and Fits.

All measurements in mm.

Generally, screw holes and slots measure 3,1 mm. for ease of assembly. The tolerance for non-fit measurements is ± 0,1 mm. and for corresponding length measurements ± 0,5 mm. For spherical fit surfaces (holes and shafts) tolerance H8 (-0+0,018 mm.) applies to holes and h8 (+0 -0,018 mm.) to shafts.



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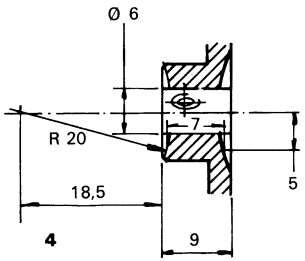

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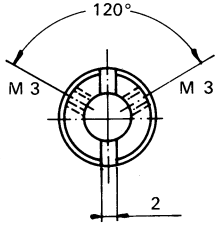

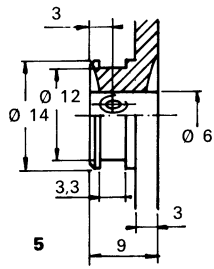

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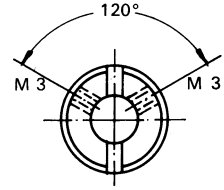

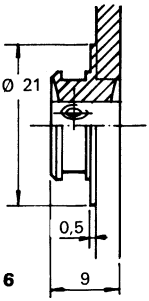

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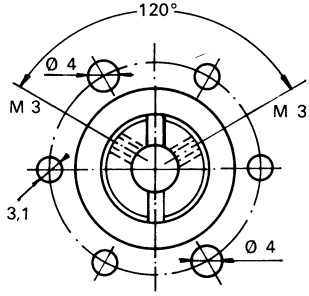

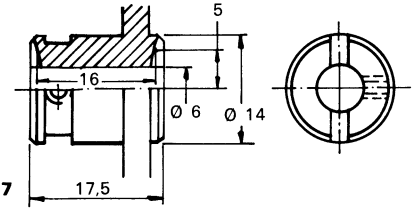

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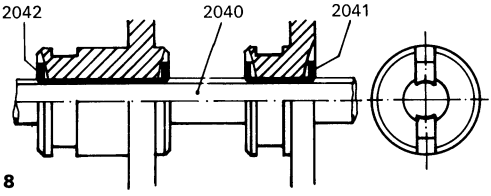

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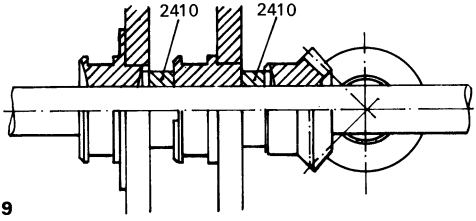


9

HUBS AND SHAFTS

The rotary components of the Fac system have been designed for four applications: a) mounted in bearings on the shaft; b) fixed on the shaft; c) running with keys on the grooved key shaft; and, d) coupled together as an assembly mounted in bearings on the shaft. By using tubes as shafts, three completely independent movements can thus have one common centre.

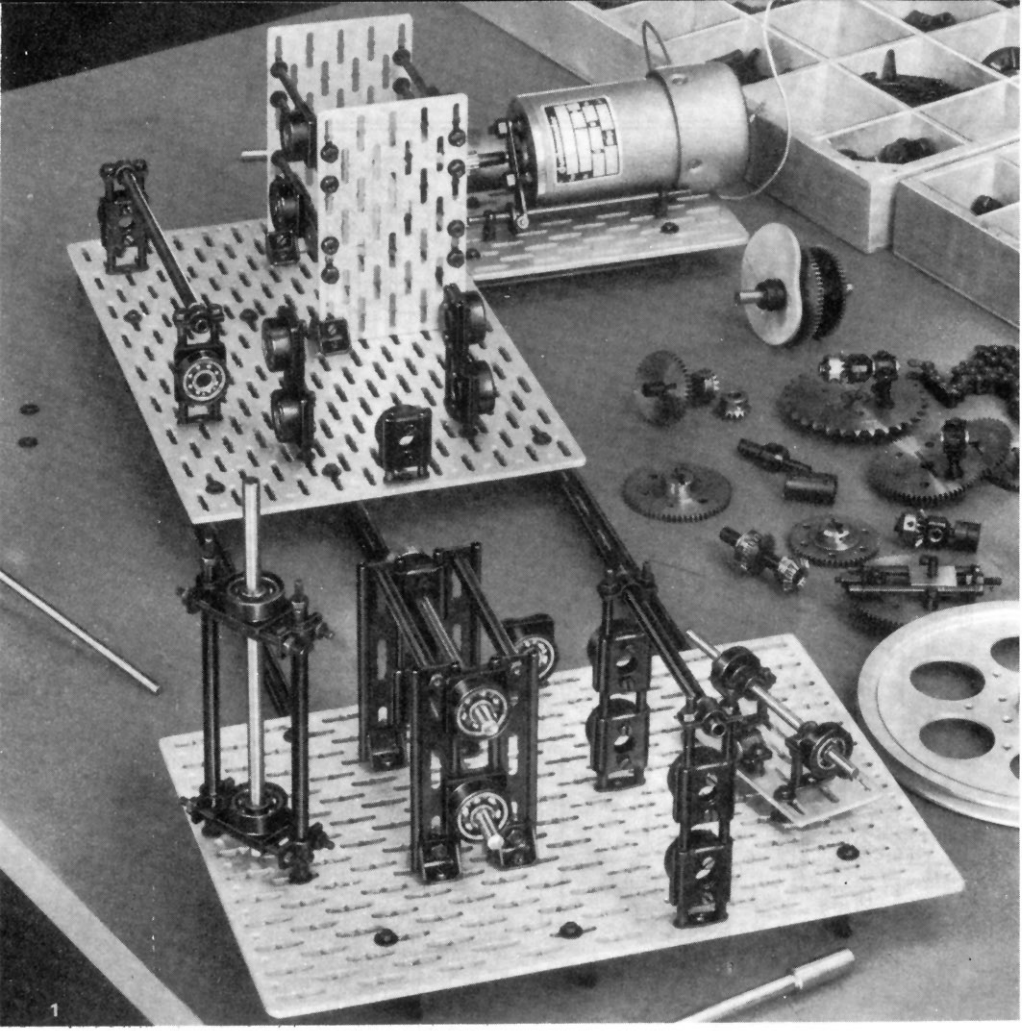
Fig. 4-9 shows different hub types and Fig. 8 and 9 two applications. All hubs of 9 mm. length have two holes for set screws placed at an angle of 120°. Most hubs also have a groove for the gear shift fork, the function of this groove being partly to allow the wheel to be moved into different gear positions, and partly to keep the wheel in position relative to the support in the case of a sliding shaft. In this latter hub application, two keys are placed in the hole with their tag ends in the grooves cut into both sides of the hub, Fig. 8. The keys fit the grooved key shaft.

Fig. 9 illustrates an assembly of wheels mounted on the shaft and axially coupled by the coupling ring.

As a rule, hubs of composite wheels with perforated flanges are fitted with centre locating stub of 21 mm. diameter.

Also, the inner circle of hubs generally includes two opposed holes that fit the stub axles used. in planetary gears, for instance.

Shafts of the Fac system are of two sizes, 4 and 6 mm. in diameter. When employing the lighter shaft, a split sleeve is first placed in the hole and compressed by means of the set screws while remaining fully centered.



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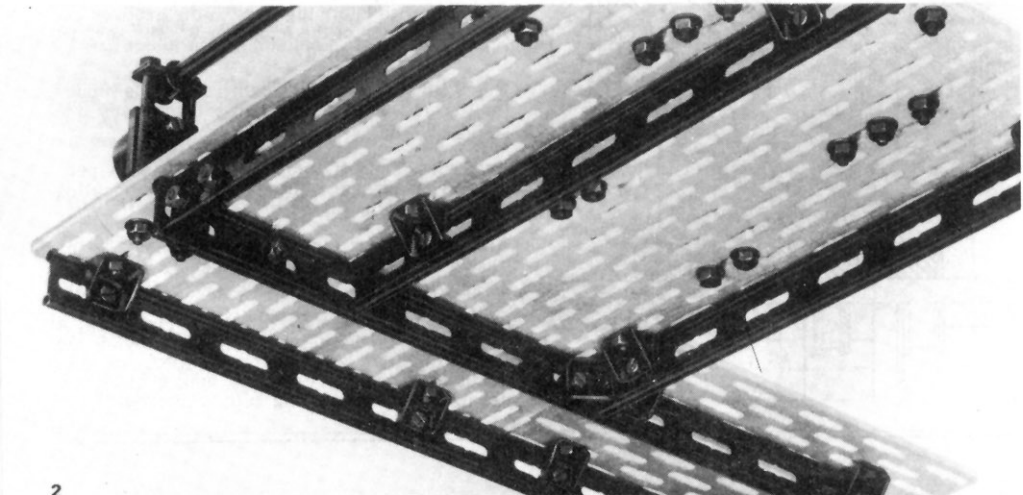

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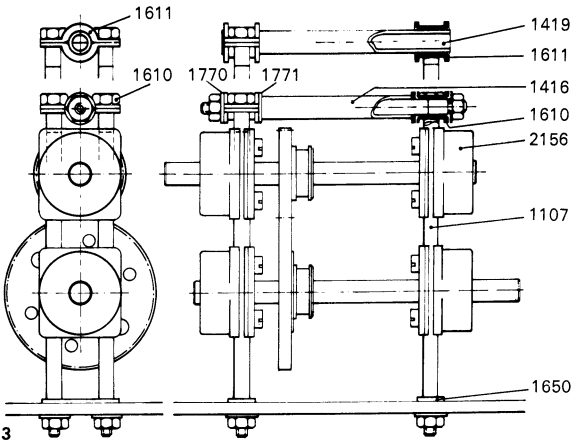

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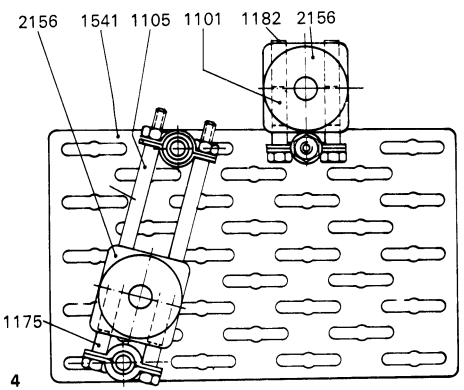

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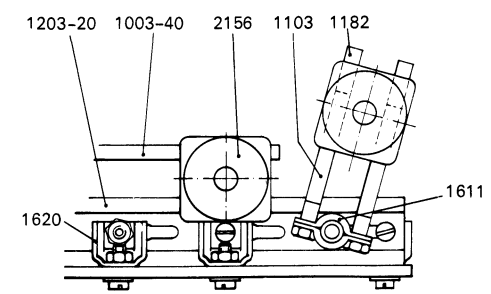

5

SUPPORTS

The bearing stand is the smallest supporting unit and consists of threaded rods, Fig. 3-5, or beams mounted in pairs. The bearing can be fitted at any point along the length of the stand. The bearing stands form part of or are combined with larger supporting units, of which there are four main types:

1. Horizontal plates, single or joined into "decks".
2. Plates mounted in opposed pairs, the bearing stands constituting the connecting elements.
3. Supports formed by coupled rods.
4. Beam supports.

The above types can be connected to form more complex supports.

In its simplest form, the bearing stand is mounted on a plate and given rigidity at the top by plain or threaded rods, or tubes in conjunction with flanged strap couplings 1610 or 1611, Fig. 3. By using couplings 1610 or 1611, the bearing stand can also be mounted parallel to the plane of the plate and the shaft centre fixed at any point of the plane by altering the angle of inclination and the length of the radius, Fig. 4. Another example of an inclined bearing stand is given in Fig. 5.

"Deck" of connected plates

A "deck" of plates can be built on a frame of beams, Fig. 2, using angular coupling 1620 to connect plates and beams. The deck can be given a form and size to allow for the desired dispersion of bearing stands and operating units. This construction has simplicity and gives accessibility although Type 1 is the simplest form of support and suitable for most mechanical applications.

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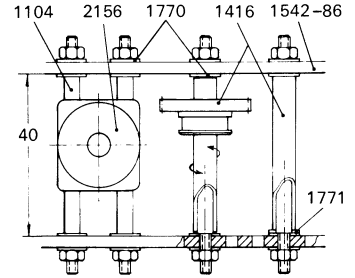

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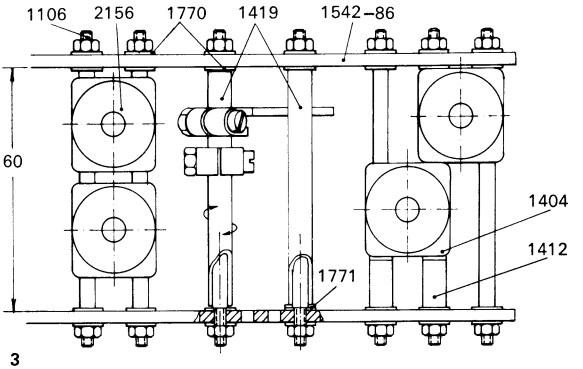

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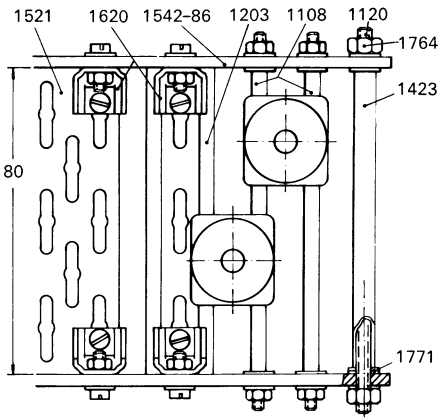

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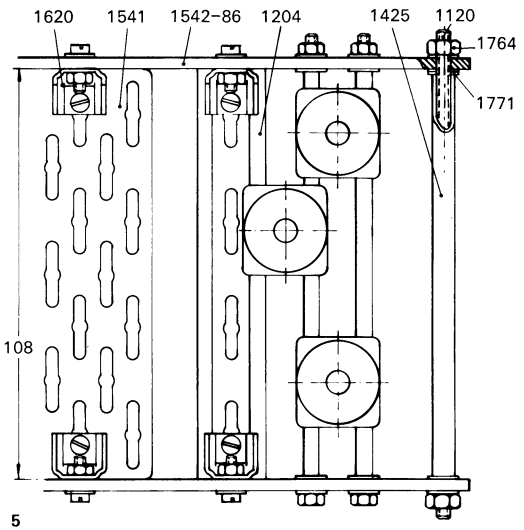

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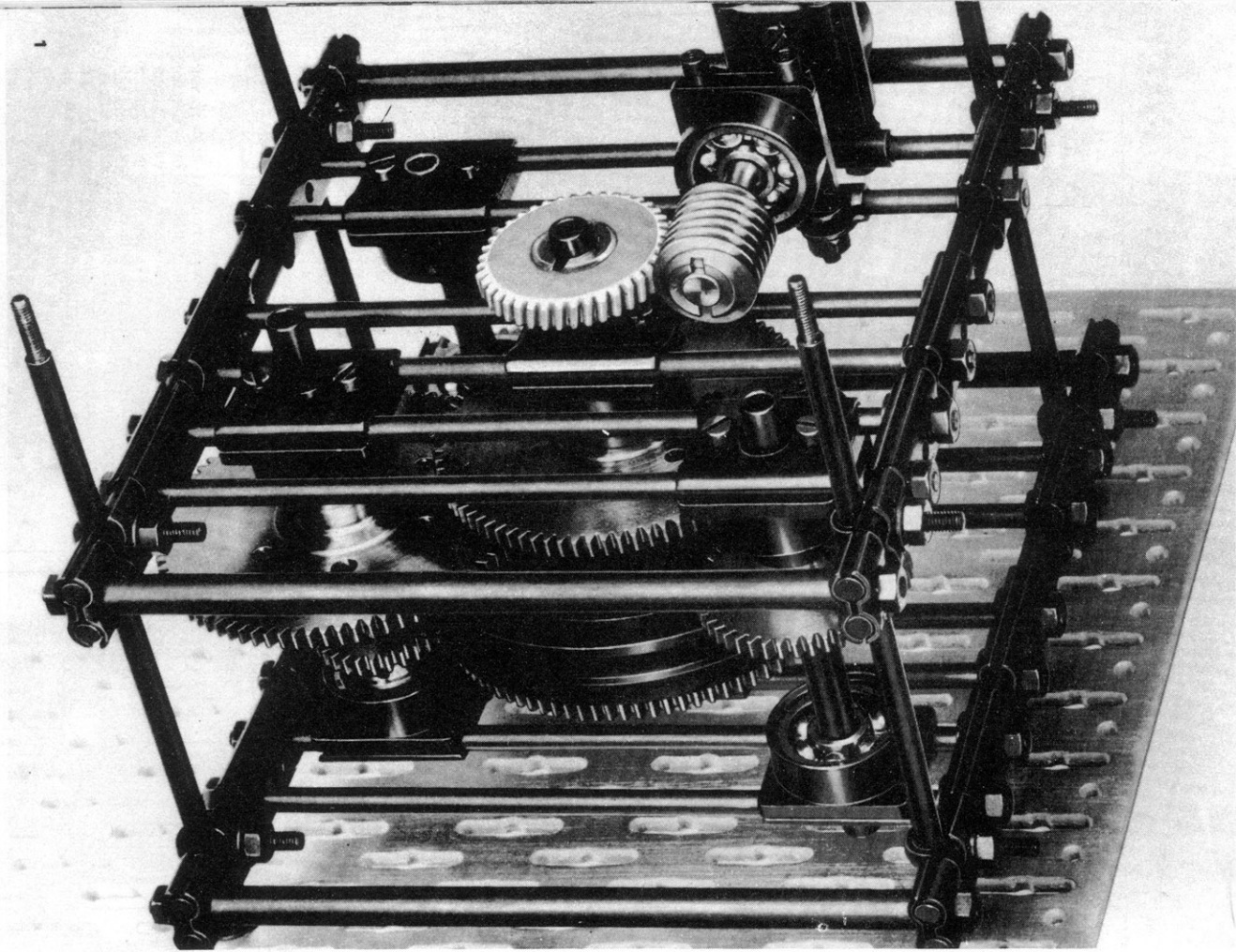
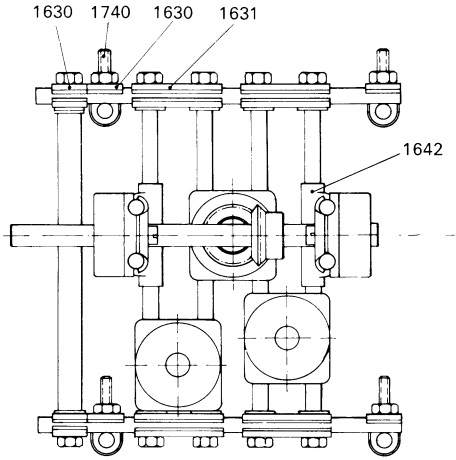
SUPPORTS OF OPPOSED PLATES

This type of support should be used where the moving elements of a mechanical unit are very compactly arranged. The bearing stands serve to unite the plates, which may also be connected by threaded rods 1101 - 1110 carrying hollow shafts 1415 - 1450 as spacer tubes.

Fig. 2 - 5 show plates arranged at varying distances from each other. The relative lengths of hollow shafts and threaded rods are adjusted so that the hollow shaft is moveable on the rod between washers 1770 and can serve as fulcrum, for rocker arms, for example. By using washer 1771, the hollow shafts will be held tight and serve as spacer tubes. The distance between plates formed by threaded rods 1108 and 1110 also provides space for beams 1203 and 1204 and for plates 1521 and 1541 (corresponding in length to threaded rods 1108 and 1110, respectively), Fig. 4 and 5.

The compact construction of mechanical units made possible by using supports of this type is illustrated in Fig. 1. The plates form protective "shields" for components. The unit has been erected on one plate only, the other plate being added as a "cover".





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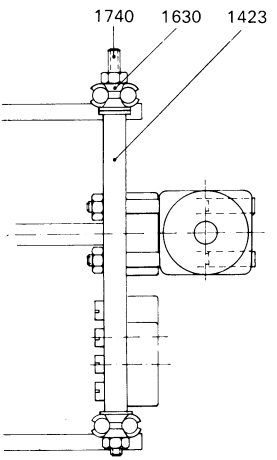

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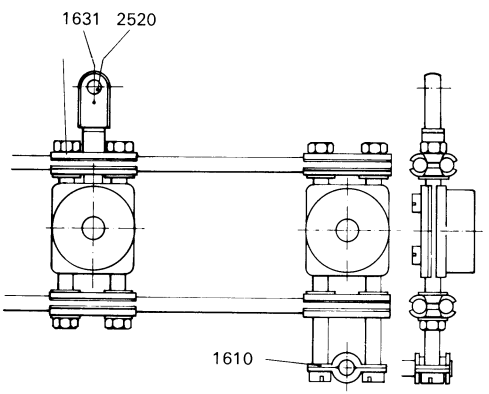

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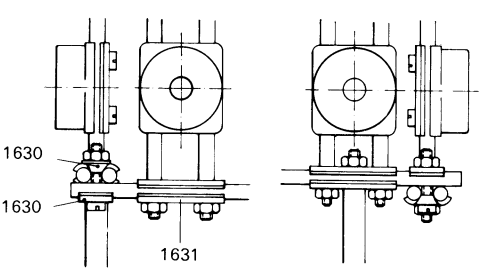

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SUPPORTS OF COUPLED RODS

Illustrated in Fig. 1 is a mechanical unit comprising planetary and worm gears mounted on a support of the above type. The rods are joined by short or long clamps 1630 and 1631, respectively, which also serve to connect the bearing stands and permit the placing of the latter at any point along the lengths of the coupled rods. The free choice as to location of the bearing on the bearing stand, as well as of the latter itself, makes it possible to place the axle centre at any point on a plane. The frame panels are connected by the couplings shown in Fig. 1-5 at optional distances from each other. The unlimited freedom of design offered by this type of support makes it the natural choice where the necessity of subsequent readjustment during erection can be anticipated. No dismantling will be necessary; the nuts are simply backed off and the bearing stands relocated. This type of support also has maximum rigidity.

Fig. 1-3 show bearing stands mounted at an angle to the frame panels by joint clips 1642. These clips are particularly suited to this purpose but must be placed on the threaded rods before these are mounted on the frame. When a bearing stand is to be connected to a frame panel without dismantling the latter, flanged strap couplings 1610 (for threaded rods) or 1611 (for spacer tubes) can be used.

Fig. 5 shows two pairs of rods coupled at right angles.

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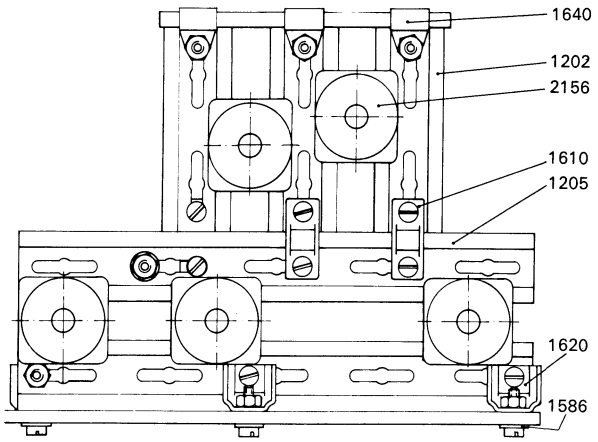

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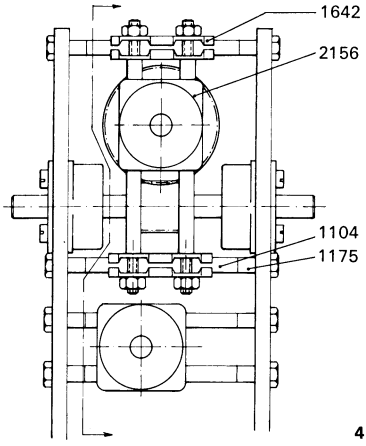

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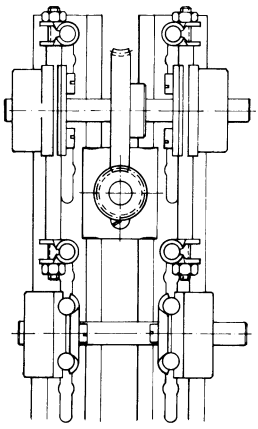

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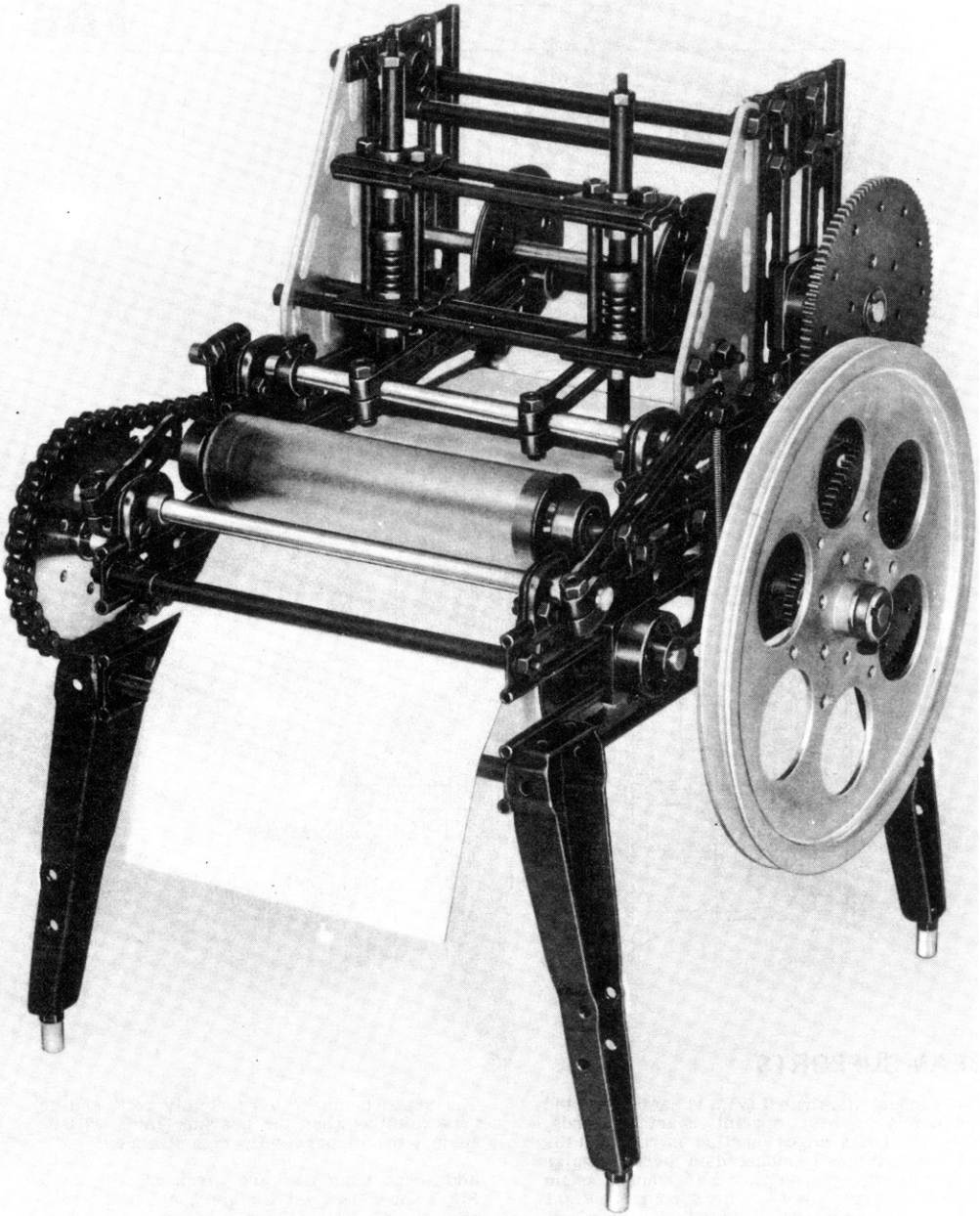
BEAM SUPPORTS

The support illustrated (Fig. 1) can be erected completely without special bearing stands, since the beam edges function as rods and the bearings can thus be mounted on these. Angular couplings 1620 are employed to connect beam frames at right angles. The support in Fig. 1 has a superstructure of standing beams secured to short horizontal beams connected, in turn, by short clamps 1630 to the lower beam frame. The type of coupling used to unite the lower frame and the superstructure will allow the latter to be located at any point along the length of the frame. The number of brackets on the beams makes supports of this type particularly suitable for carrying units with a very compact arrangement of moving components.

The support can be very rigidly built and is thus suitable when the bearing points will be subject to comparatively high stresses.

Additional examples are given in Fig. 2 - 4. Fig. 2 shows how vertical and horizontal beams are joined. If the bearing boxes 2156 are to move past the flanged strap coupling 1610, the latter should be placed on the other side of the beam with screw heads and washers on the same side as the box and secured with lock washer 1775.

Fig. 3 and 4 show a worm gear construction with bearing stands secured at right angles to the frame panels with joint clip 1642.



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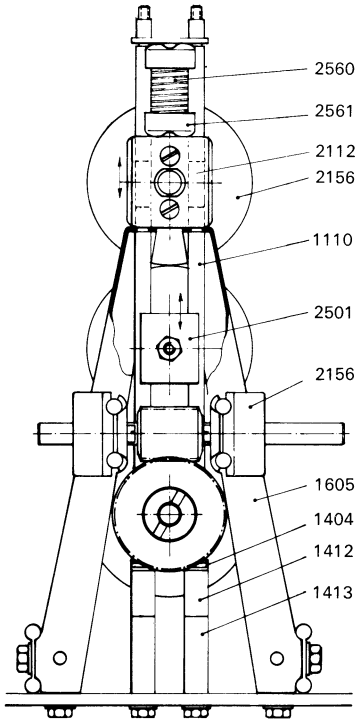

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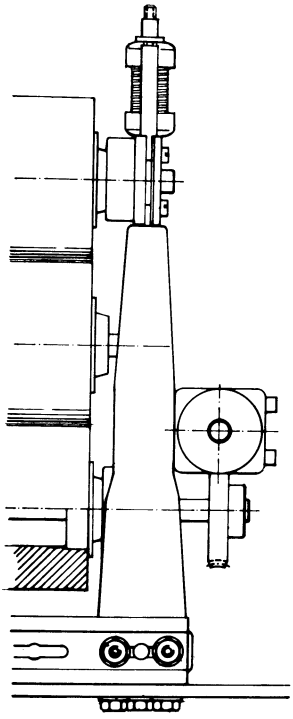

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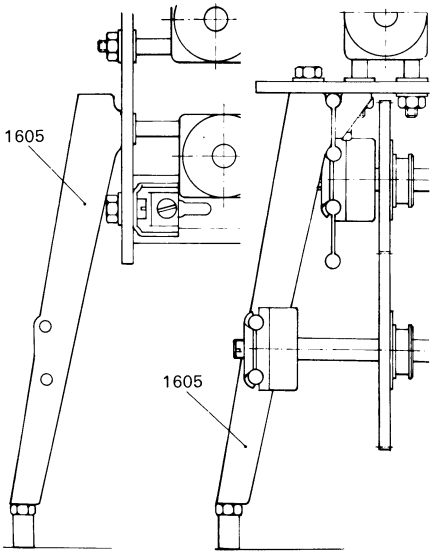


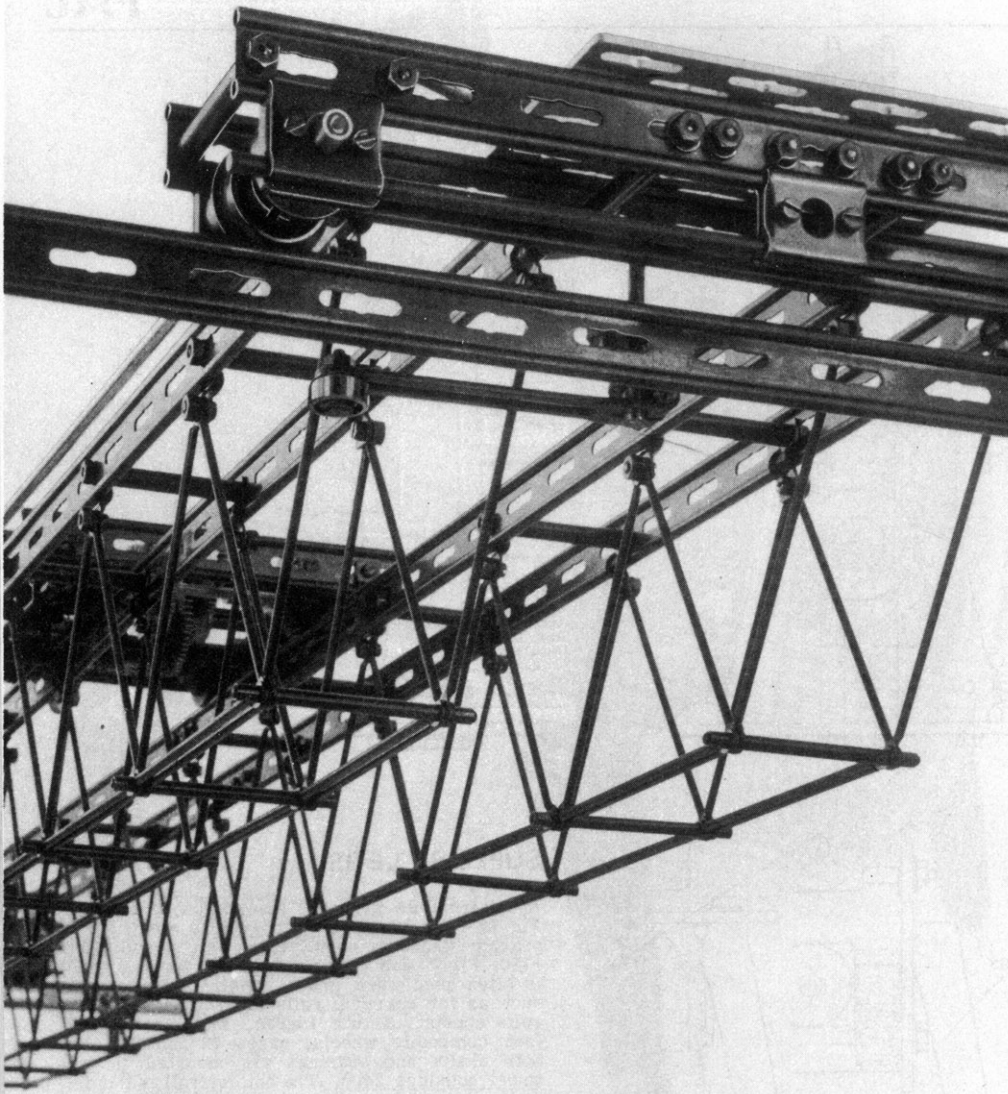
4 5

SUPPORT LEGS

Apart from its principal application as shown in Fig. 1, 4 and 5, support leg 1605 is also used in bearing stands in combination with threaded rod 1110. Fig. 2 and 3. This type of bearing stand is often used when great rigidity is necessary, such as for carrying rolls (as illustrated). The rolls consist of tube blanks, material optional (see composite wheels, pages 22 and 23), and both shafts and bearings are mounted in free wheel housings 2406. The bottom roll is the driving member (note the worm gear arrangement on the supporting legs) and the top roll is spring-loaded, while the middle roll is carried on the shaft, which is guided by sliding crossheads 2501. The top roll is thus vertically self-adjusting and the supporting legs, as illustrated, simultaneously carry the bearings and serve as guide rails for the cross heads.

The contact surfaces at the large end of the support leg are shaped to fit the beam profile and supplies additional rigidity at the base when the top is unsecured (as illustrated).

With the support legs a plate or a "deck" of plates can be raised over the base plane to provide space underneath for mechanical units and transmissions that cannot be accomodated on top, Fig. 5.



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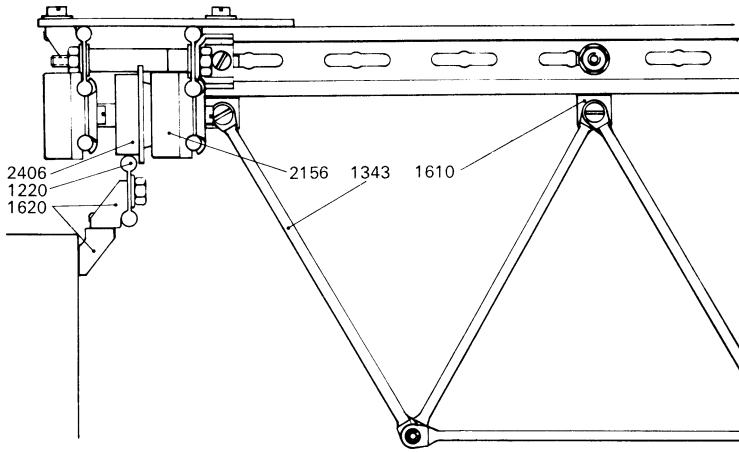

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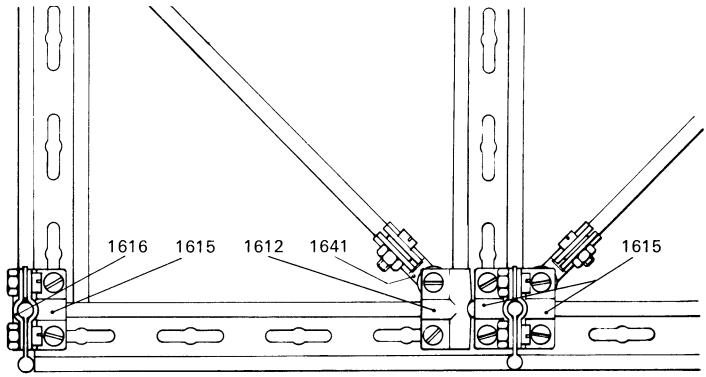
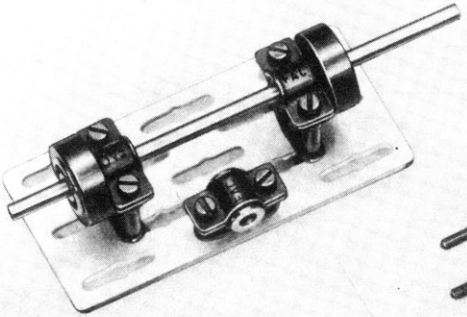


3

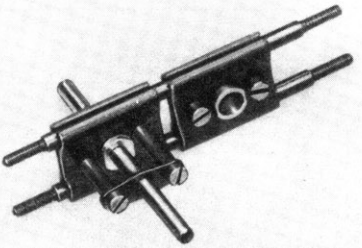
FRAMEWORK

A number of coupling components, seldom or never utilized in supports for compact mechanical units, are employed in the erection of framework models such as cranes, bridges, special trusses and masts. Framework constructions are characterized by a spacious design with rods and beams branching off in several directions from a common connecting point. Such constructions are dominated by couplings 1612 - 1620, of which only 1620 is used frequently in the machine type supports earlier described. The types of framework are so many and varied that all couplings, to a greater or lesser extent, are employed and one or two examples only will here have to represent this entire field.

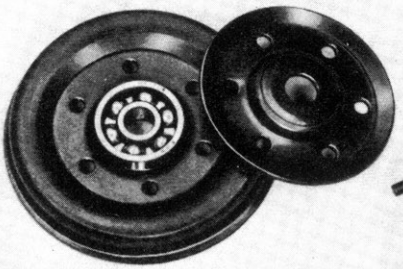
Fig. 1 and 2 show how tie rods 1312 - 1382 are used. Their lengths have been chosen so as to form the adjacent sides and hypotenuse of a right angle triangle. Framework beams can thus be constructed by using tie rods and, for instance, threaded rods only. The illustration, however, shows a travelling crane model (used for demonstrations) constructed of beams with a suspended framework of equilateral triangles, built up of tie rods. Fig. 3 shows a heavier framework of beams and rods with end clips 1641 attached. The use of couplings 1612-1616 offers a great variety of combinations of beams and rods with holes left free for diagonal bracing.



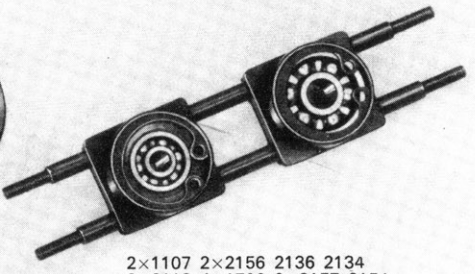
1521 2×2154 6×1611 4×1724 3×1650
2×1175 2×1715 2124 6×1763 2004
4×1182 2×2134



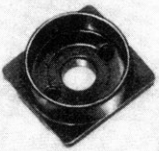
2×1106 4×2112 2104 2106 4×1710
2×1763 2×1182 1650 2×1706 2004



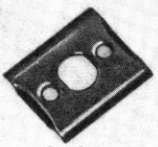
2301 2306 2136



2×1107 2×2156 2136 2134
2×2112 4×1706 2×2157 2154



2156



2112

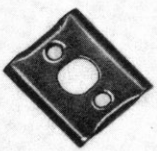
2138

2154

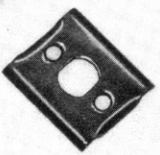
2137

2134

2136



2112



2157

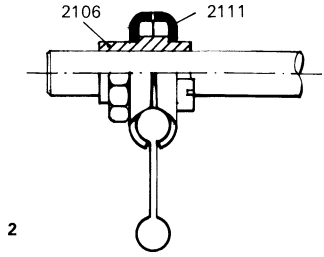
2111

2104

2106

2124

1611



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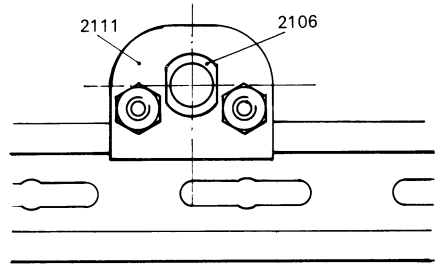

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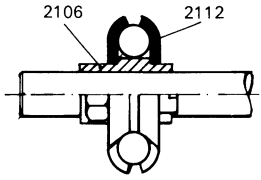

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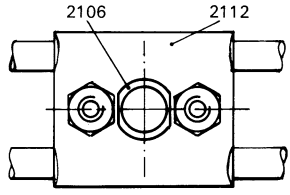

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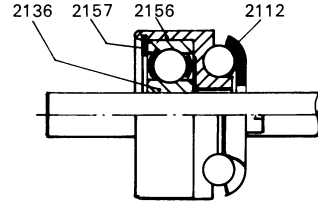

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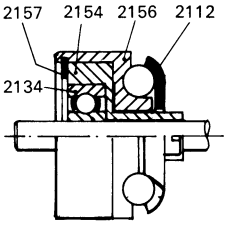

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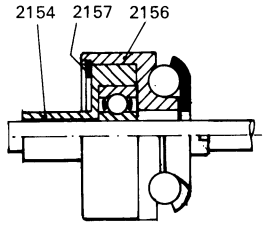

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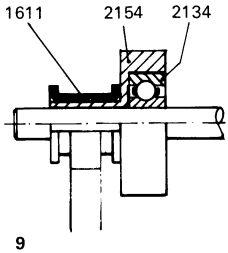

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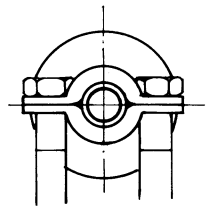

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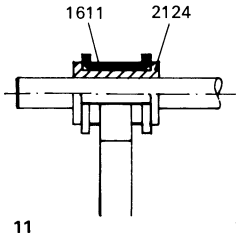

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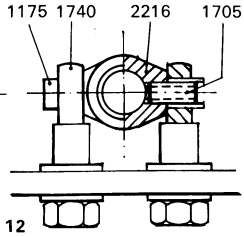


12

BEARINGS

For normal bearing arrangements, in principle, every hole can serve to carry shafts of corresponding diameter, and bearings can also be improvised when desired.

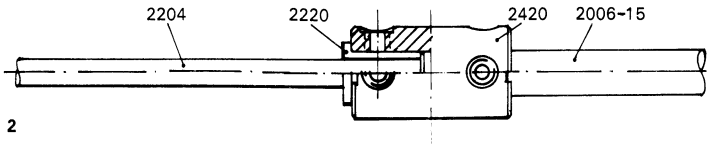
Shafts can be journalled in either sliding or ball bearings, and both require special bushing clamps. Fig. 2-6 show bushing clamps 2111 and 2112 for one and two rods (or beam edges), respectively, and bushings 2104 and 2106 for 4 and 6-mm. shafts, respectively.

Bushing 2124 can also be employed as sliding bearing for 4-mm. shafts and is then secured between two flanged strap couplings 1611, Fig. 11. Fig. 12 shows a pivoting sliding bearing for 4 or 6-mm. shafts consisting of shaft head 2214 or 2216 suspended between two eye screws 1740 with attached tapped sleeves 1175 serving as stub axles, as illustrated.

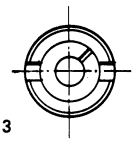
Ball bearings are carried in either bearing box 2156 for 6-mm. spherical or grooved ball bearings 2137 and 2136, respectively, or in bearing cage 2154 for 4-mm. ball bearings. The external dimensions of the latter are identical with those of 6-mm. ball bearings and these two components are thus interchangeable. Fig. 7 and 8 show the application of the bearing cage as an insert in ball bearing boxes. These are secured to the bearing stands by bushing clamp 2112, Fig. 6. A support for bearing cage 2154, employing flanged strap couplings 1611, is shown in Fig. 9 and 10.

Fig. 1 illustrates the most usual bearing arrangements referred to above and their principal components. Note how a ball bearing has been built into a wheel composed of wheel disc 2301 and flanged disc 2306. See composite wheels, pages 22 and 23.

2004
2420
2006
2430
2015
2014
2004
3718
2012
2220
1450
2010
1425
2008
1423
2006
1419
1416
2004
1415
1010
1008
2040
1007
1006
2039
1005
1004
2038
1003
2042
2041
1
2080
2071
2061
2070
2203
2204
1772



2



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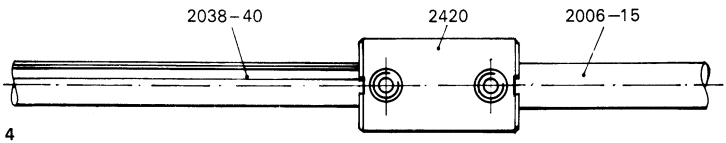

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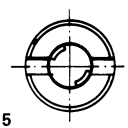

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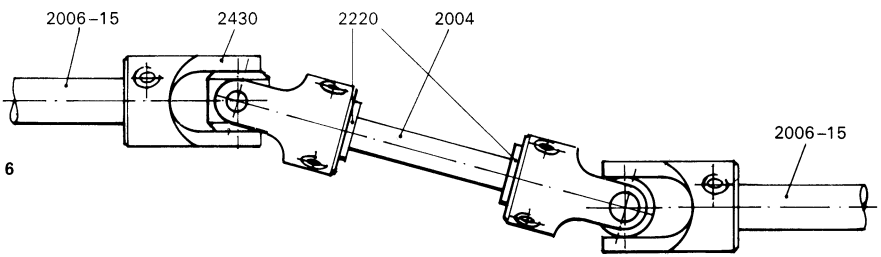

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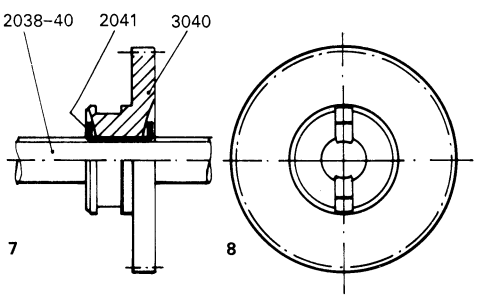

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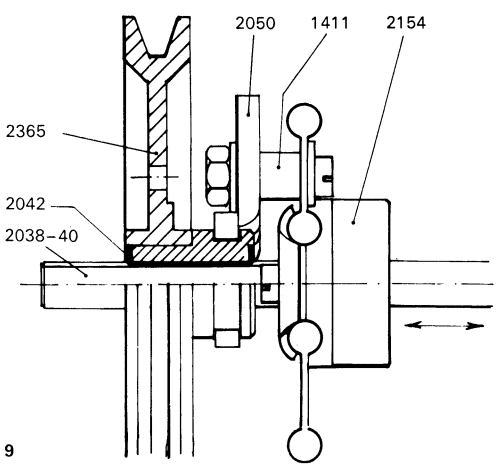
8



9

SHAFTS AND SHAFT COUPLINGS

The polished steel solid shafts 2004 (diameter 4 mm.) and 2006-2015 (6 mm.) are supplied to the closest tolerances. The 6 mm. shaft is available in such a great variety of lengths that it is hardly ever necessary to cut it into special sections. The 4-mm. shaft is only supplied in 500-mm. lengths.

Rods 1003-1040 can be used in place of 4 mm. shafts (as rocker arms, for instance) where tolerance requirements are less strict.

Hollow shafts 1415-1450 are generally employed as spacer tubes and have therefore been listed among the support components.

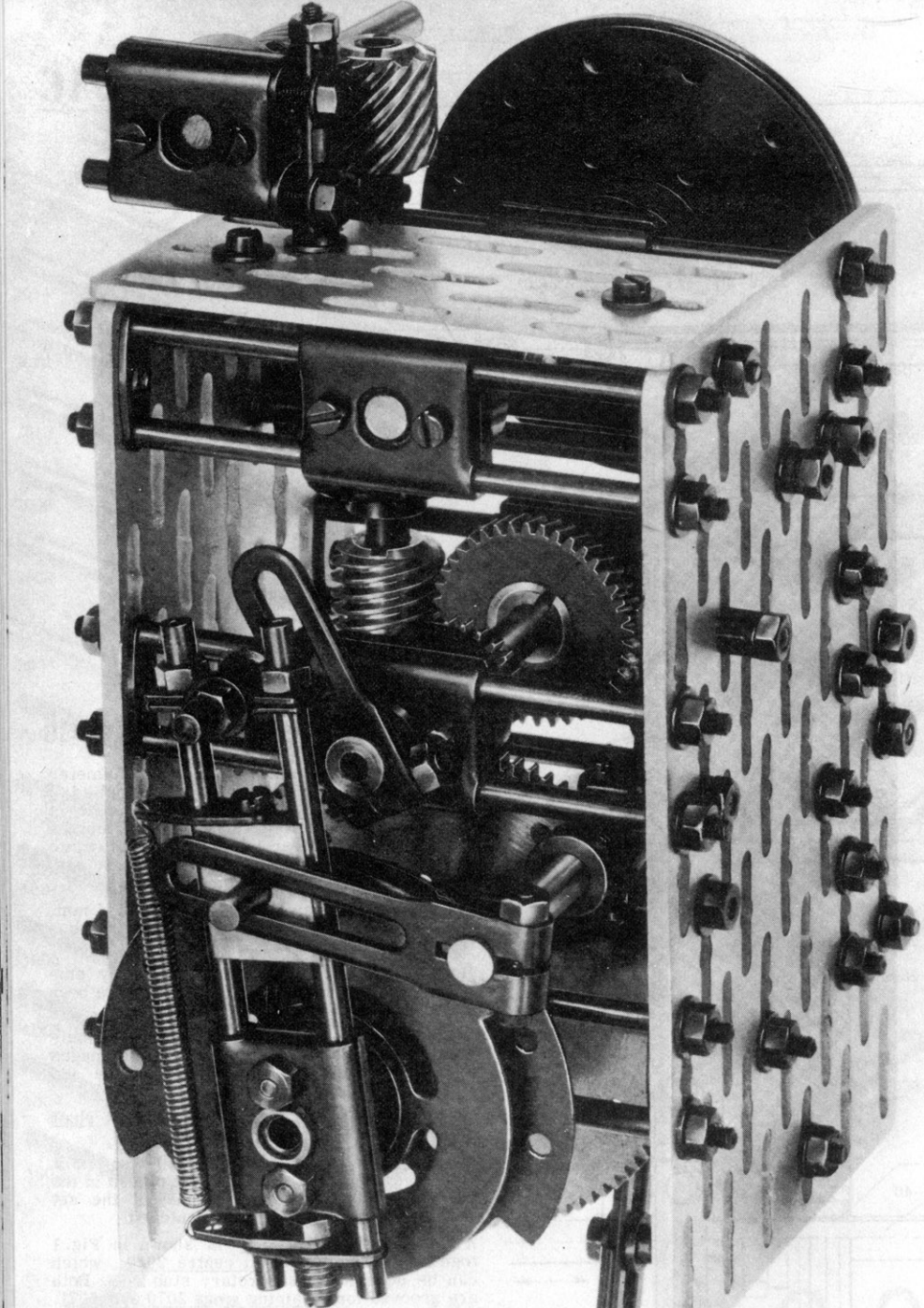
Grooved shafts 2038-2040 are used in combination with wheels fitted with keys; see pages 4-5 (Fac standards), 26-27, 38-39, 40-41 and Fig. 1, 7, 8 and 9.

All shafts can be jointed by means of shaft sleeve 2420, Fig. 1 - 5.

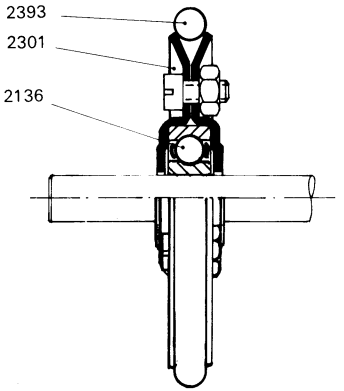
When a 4-mm. shaft is to be fitted into a 6-mm. hole, a split sleeve 2220 is first placed in the hole and compressed by means of the set screws while remaining fully centered.

A special stub axle 2061 is shown in Fig. 1 together with differential centre 2080, which can be described as a rotary stub axle. Both are grooved for retaining rings 2070 and 2071.

The shaft is held in position by retaining ring 2201 or 2202; and the latter is easily movable. Self-locking washers 2203 and 2204 take up little space and can withstand high axial pressures.



The photograph on this page illustrates a unit comprising worm gears and a spring-loaded reversing mechanism, in which perforated disc 2310 is employed as cam wheel. When the pin slides past the step in the cam and is pulled downwards, the longer of the two rocker arms triggers the reversing mechanism. This rocker arm also lifts the pin, which is then moved sideways by the shorter rocker arm, mounted on a tube shaft in the centre of the unit, and resumes its position on the wider part of the cam wheel. (Part of automatic coil winder).



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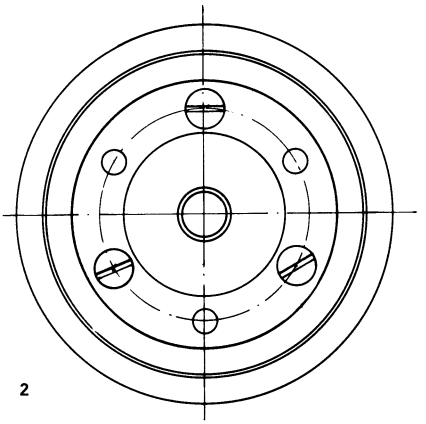

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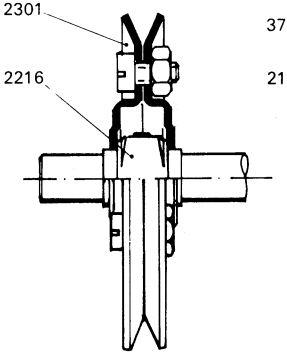

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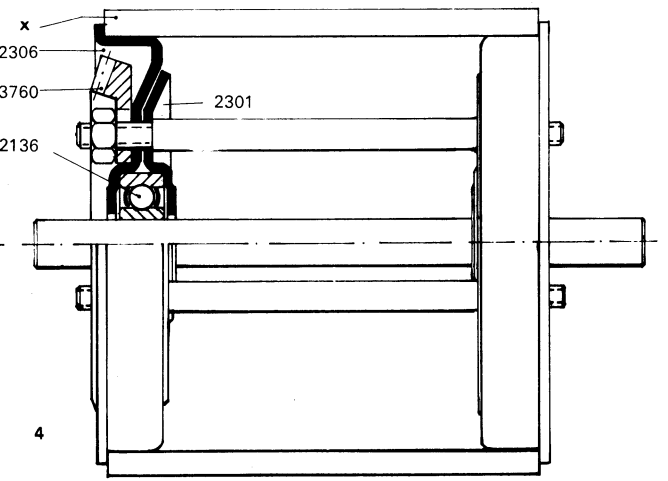

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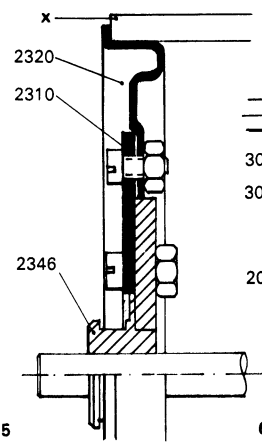

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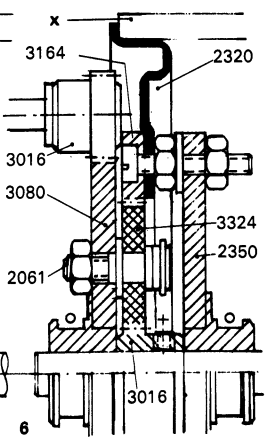
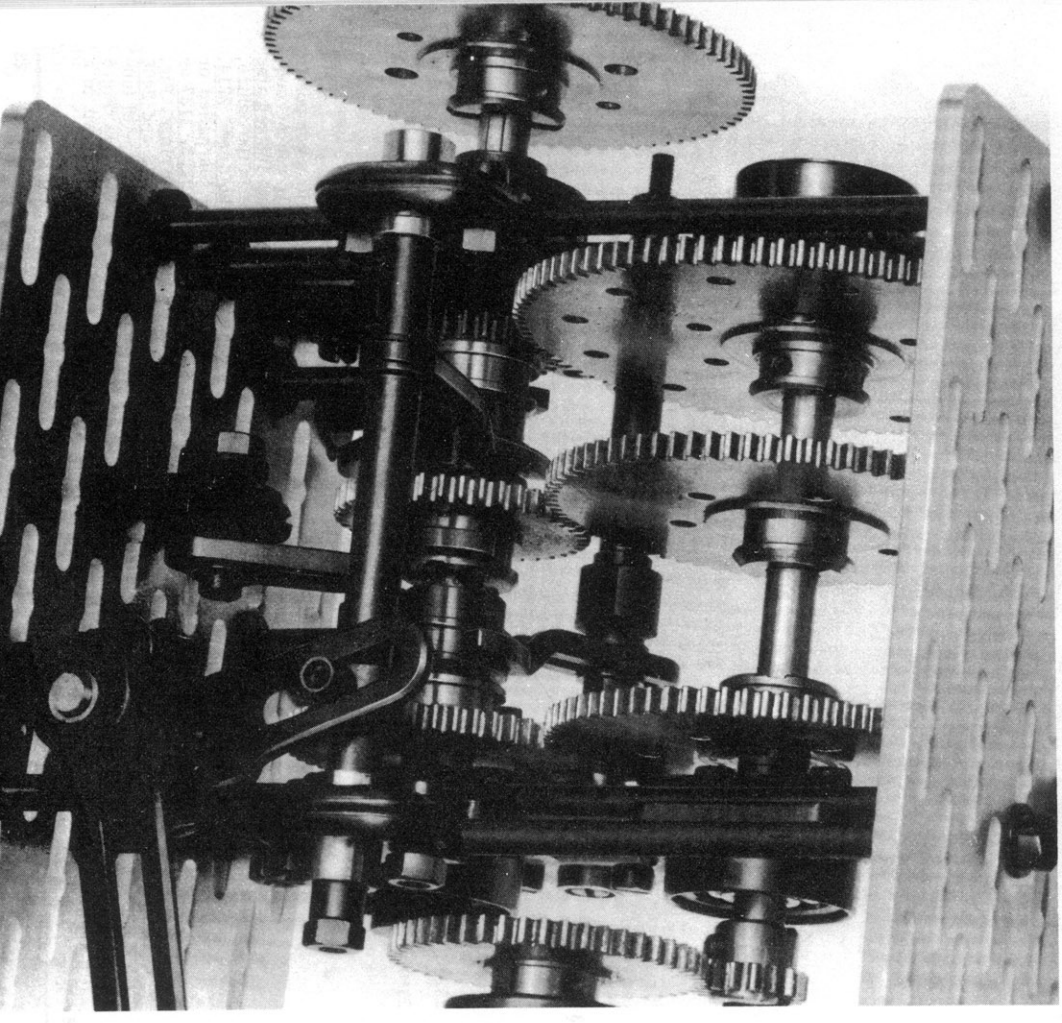
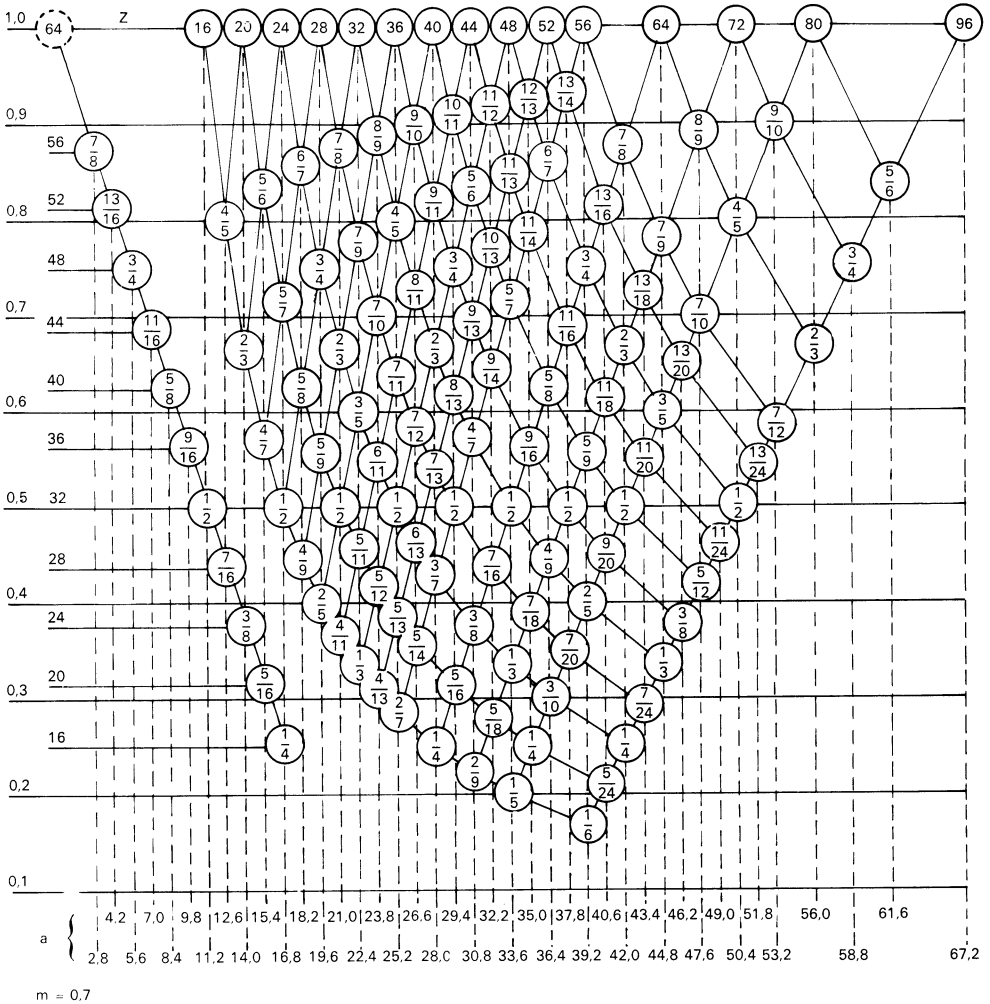


6

COMPOSITE WHEELS AND ROTARY UNITS

Fig. 1-6 give examples of various composite rotary units. Wheel discs 2301 can be connected with each other, or with flanged disc 2306, to form a closed space in the centre, in which can be fitted either shaft head 2214, 2216 (in which the shaft can be journalled or fixed), Fig. 3, or ball bearings 2136, 2137 or bearing cages for 4-mm. ball bearings, Fig. 1 and 4. Flanged discs 2306, 2320 and 2406 are suitable for carrying rolls made of tube blanks of optional material, Fig. 4-6. Fig. 6 shows a planetary gear unit enclosed in a roll. See planetary gears, pages 32-37.





m = 0,7

GEAR RATIOS

Ratios between spur gears.

The above diagram gives the ratios between the standard spur gears. The top line circles represent the gears and indicate their number of teeth. (The dotted circle represents gear ring 3164). The circles below contain fractions equivalent to the ratios between gears (circles) located along the inclined or curved lines. A vertical dotted line from each circle indicates the distance between shafts. The horizontal lines indicate ratios in decimal fractions.

Ratios between bevel gears.

The ratio between bevel gears 3718 is 1:1 and between bevel gear 3720 and bevel gear ring 3760 1:3.

Ratios between sprockets.

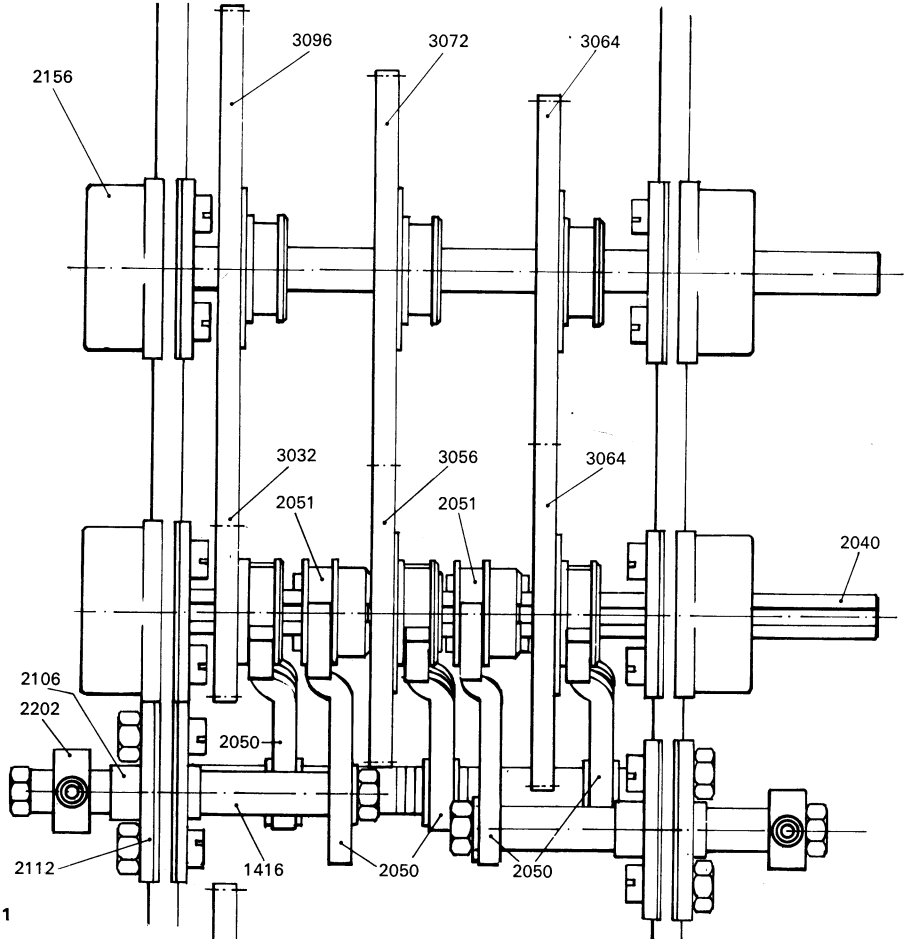
Sprockets 3910, 3915 and 3930 (roller chain) give ratios 1:1, 1:2, 1:3 and 2:3.

Sprockets 3984 and 3998 (wire chain) give ratios 1:1 and 1:2.

Ratios between worm gears.

Worm gears 3801 + 3801 = 1:1. Worm gears 3850 + 3851 = 1:5. Worm gears 3810 + 3811 = 1:10. Worm gears 3820 + 3821 = 1:20.

The gear box shown on page 24 is of the same type as in Fig. 1 and 2 on page 26.


3096
3072
3064
2156
3032
3056
3064
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2051
2040
2106
2202
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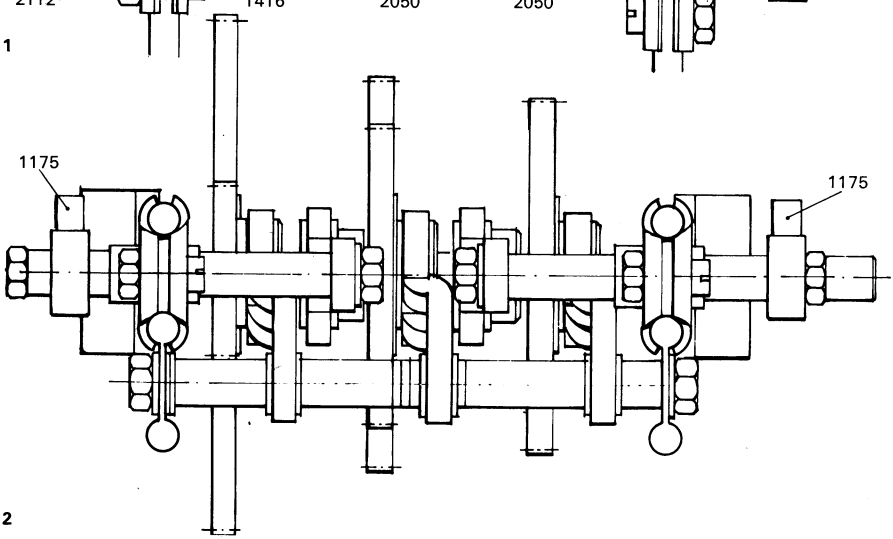
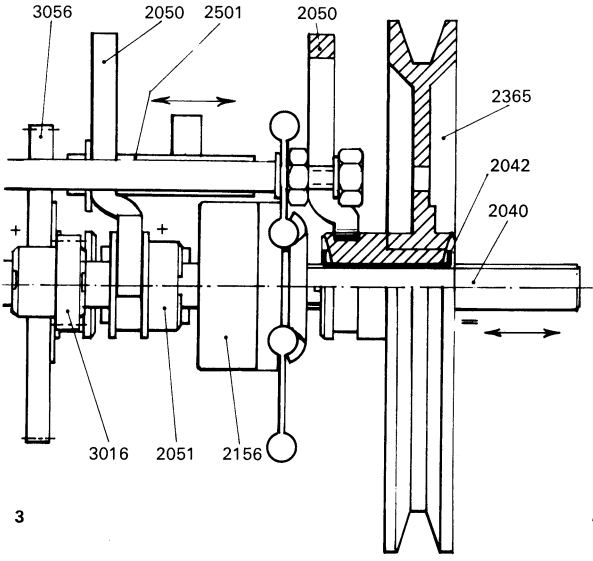
2112
1416
2050
2050

1


1175
1175

2



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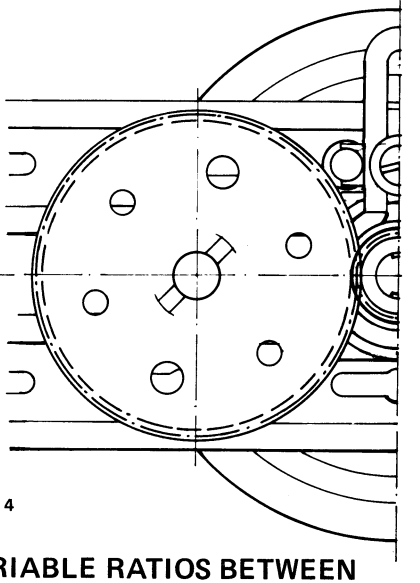

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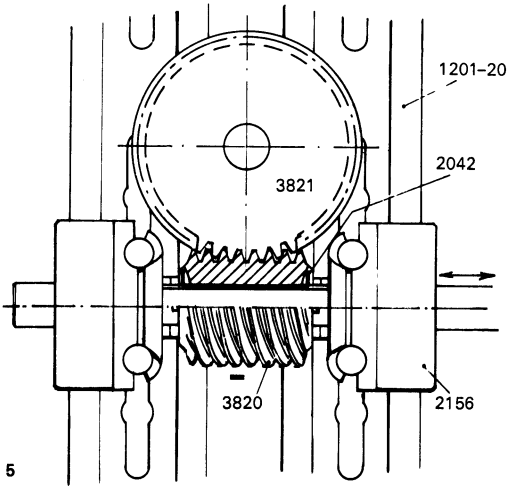

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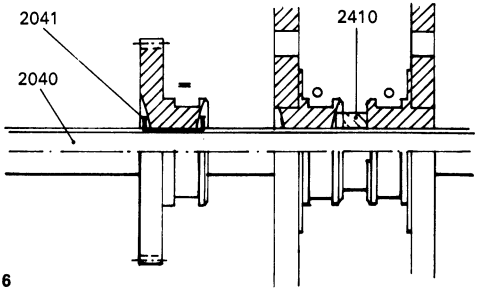


6

VARIABLE RATIOS BETWEEN SPUR GEARS

The important points as regards the construction characteristics of gear boxes have already been covered in the description of hubs and shafts given under "Fac standards", page 5; only two principal types will be illustrated here.

Gear box, constant mesh.

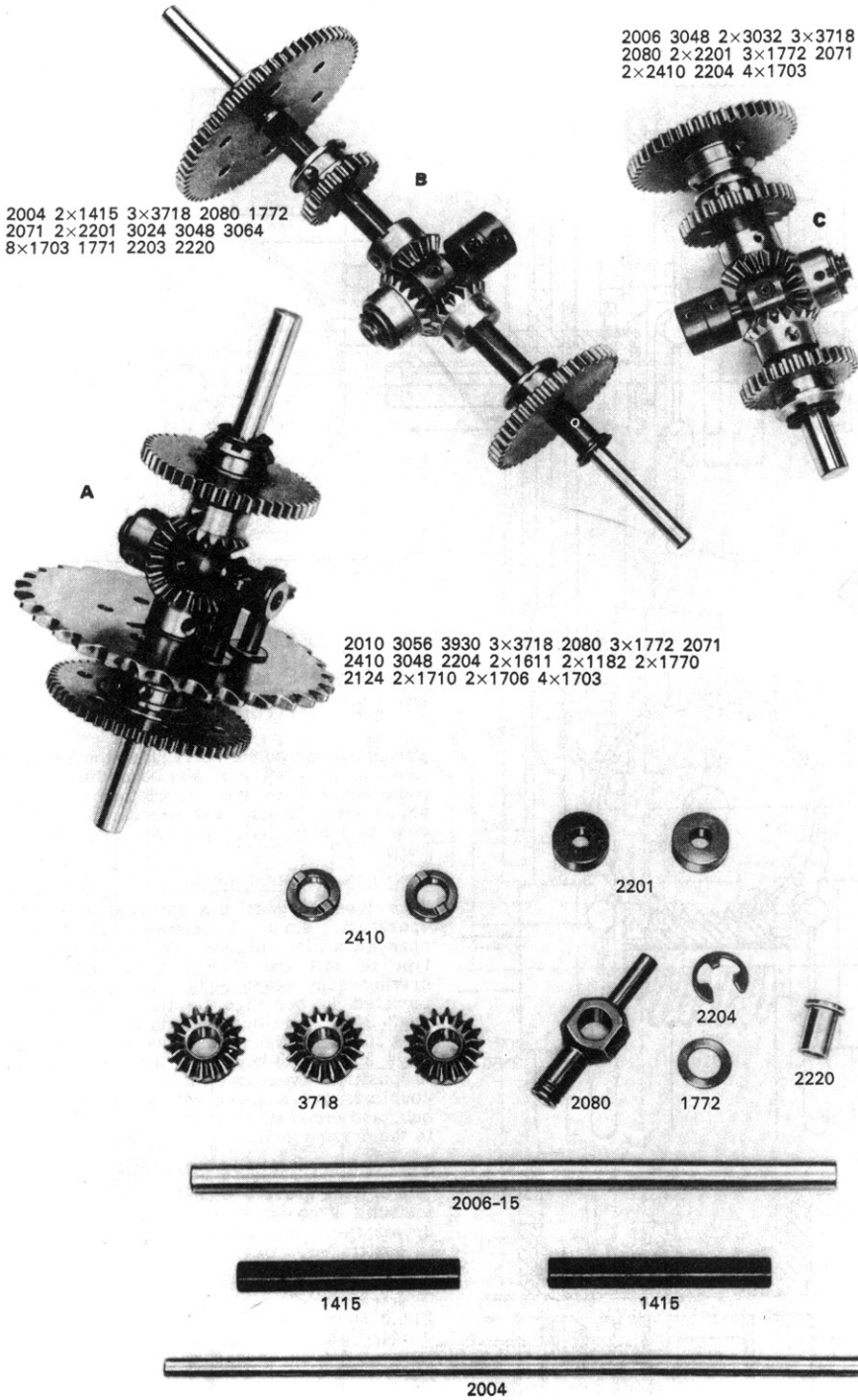
This type of gear box is most effective in operation, since it permits ratios to be changed whilst engaged. Two drawings of this type of unit are shown in Fig. 1 and 2. The driving spur gears 3032, 3056 and 3064 are mounted in bearings on the driving grooved shaft 2040 and located axially by gear shift fork 2050. Between these gears, sliding couplings 2051, with keys 2041 attached, are held in position by gear shift forks. The sliding couplings are engaged with the grooves of the hub, and the shaft movement is thus continued to the driving gears.

Gear box, controlled engagement.

The driving gears are here fixed to the axially movable grooved shaft. Only the gear that drives the shaft is fitted with keys; it is kept in position by a gear shift fork mounted on the support, Fig. 3 and 4. Note the gear shift fork mounting on the slide cross head 2501, Fig. 4.

Fig. 5 shows how a driving, axially movable grooved shaft can be connected directly to a worm gear by means of keys fitted to the latter.

Fig. 6 shows how keys are fitted to a gear wheel and the combining of wheels to an assembly using coupling rings 2410.


2006 3048 2×3032 3×3718
2080 2×2201 3×1772 2071
2×2410 2204 4×1703
C
B
2004 2×1415 3×3718 2080 1772
2071 2×2201 3024 3048 3064
8×1703 1771 2203 2220
A
2010 3056 3930 3×3718 2080 3×1772 2071
2410 3048 2204 2×1611 2×1182 2×1770
2124 2×1710 2×1706 4×1703
2201
2410
2204
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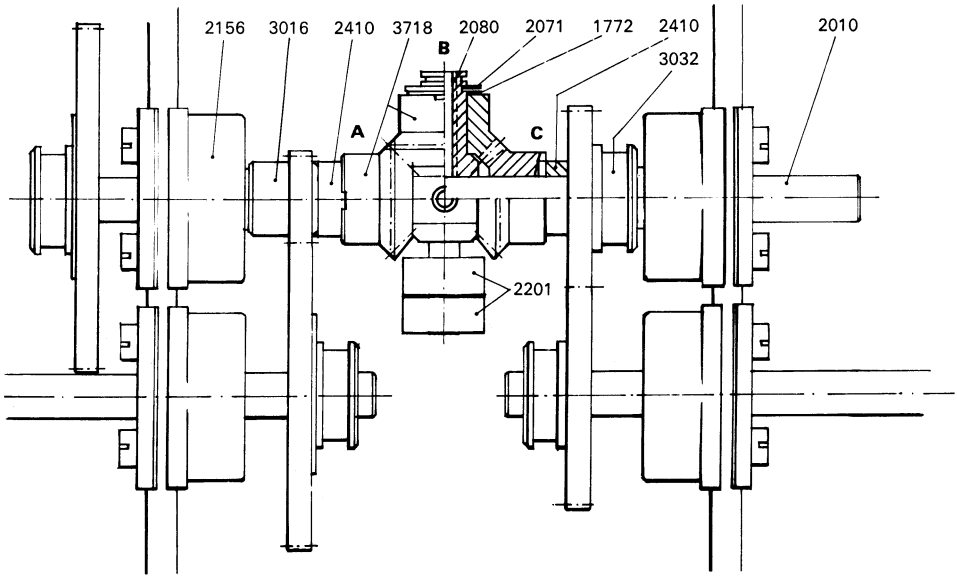
1415
1415
2004



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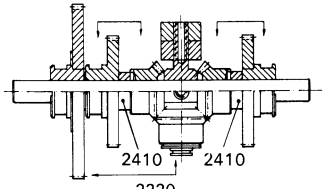

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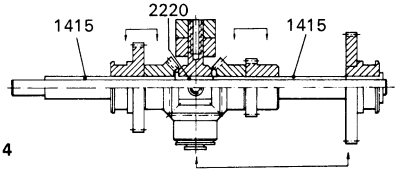

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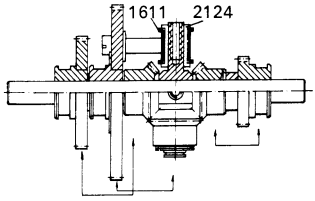

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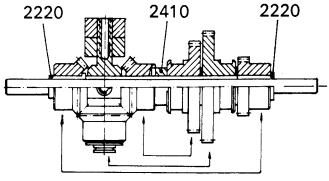


6

DIFFERENTIAL GEARING

Fig. 1 illustrates three types of differential gearing and their principal components.

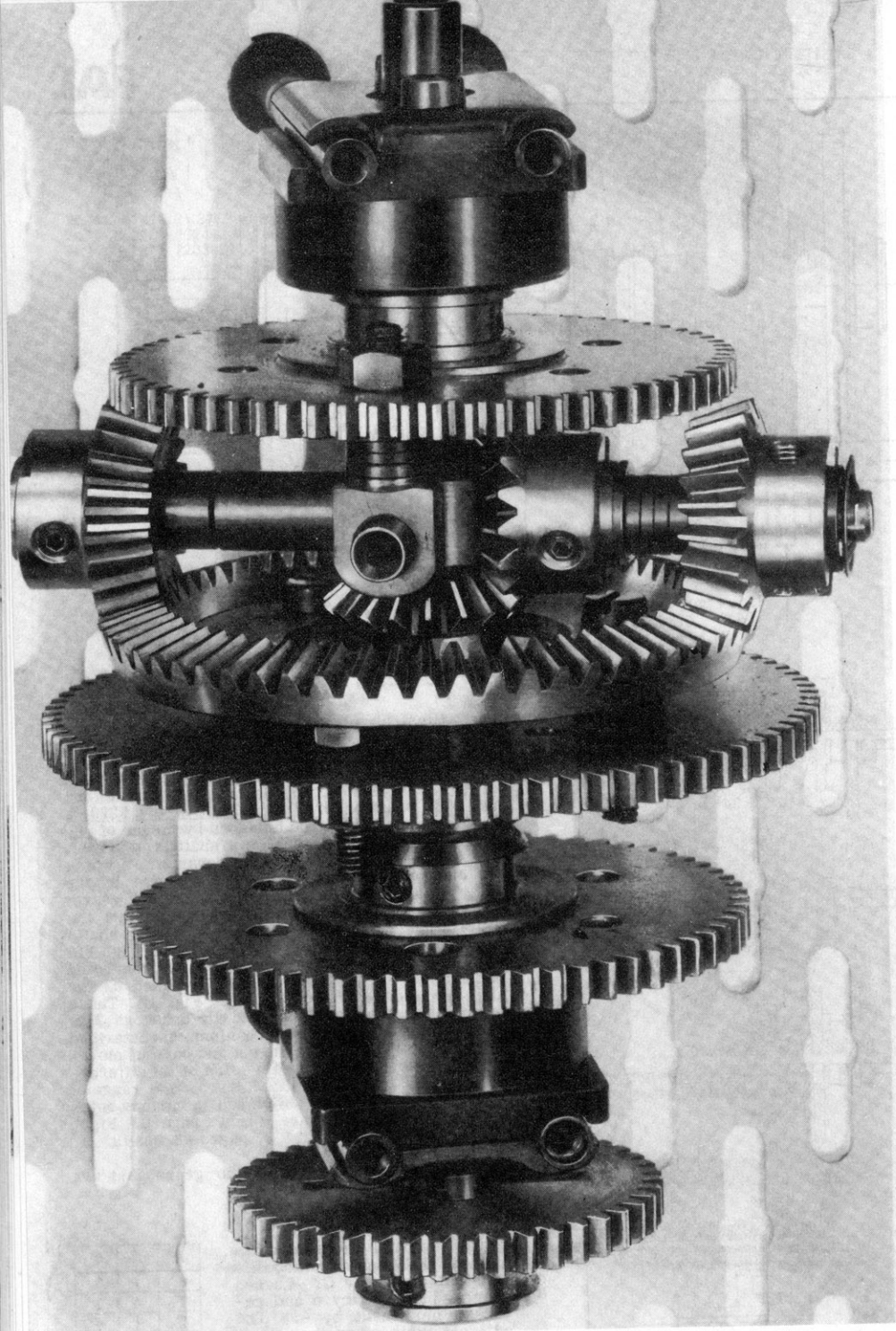
Differential centre 2080, carrying the planet wheel on its 6-mm. stub axle, can be mounted on either a 6-mm. shaft or, by fitting split sleeve 2220, a 4-mm. shaft; it can be balanced by means of retaining rings 2201. When a 6-mm. shaft is employed, the various components of the mechanism, of which the differential forms a part, are driven by the differential gears via coupling rings and gears, Fig. 2, 3 and 1C. When fitting a 4-mm. shaft, the differential gears are mounted on hollow shafts which can pass through bearings as in Fig. 1B. The differential centre can also be connected directly to a perforated wheel, mounted on the shaft, by means of coupling pins, Fig. 1A. These examples are also illustrated by drawings 2-5. Fig. 6, finally, shows a mechanism characterised by the fact that both the in-put and out-put movements are located on the same side of the differential centre. The differential has a wide range of application and can be employed in various automatic systems. Compare Fig. 1, page 8, Fig. 1 and 2, page 42, and Fig. 1-3, pages 48 and 49.

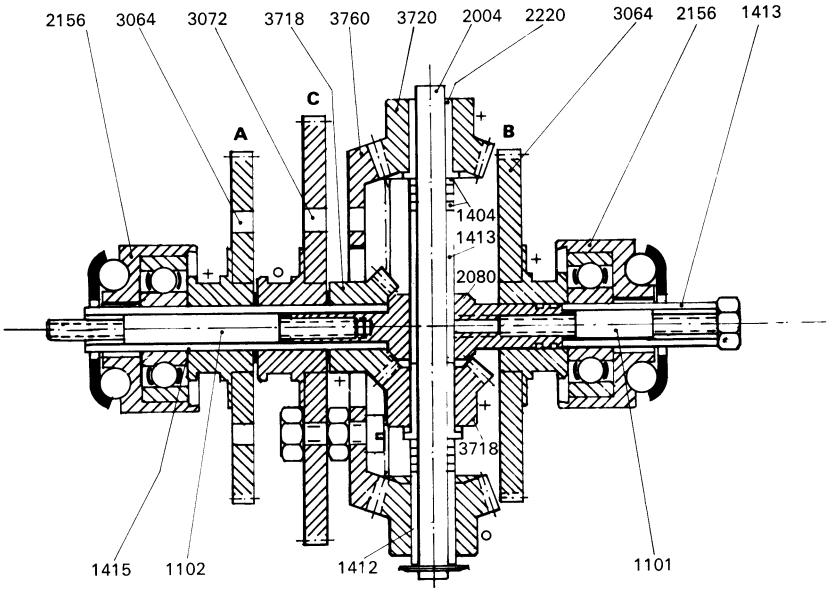
In Fig. 3-6 the arrows point to gears that are coupled together.

Ratios

The differential gears are indicated by A and B and the differential centre by C. Locked gear is indicated by o and reversed movement by -. The adjacent table gives the ratios.

A	B	C
o	1	2
1	o	-1
2	1	o





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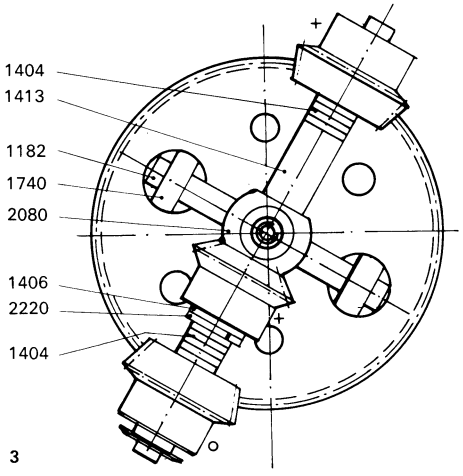


3

DIFFERENTIAL WITH 3:1 RATIO BETWEEN GEARS

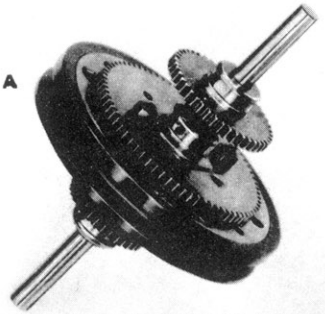
In the differential illustrated in Fig. 1-3, both differential gears are located on the same side of the centre, in which is journalled the shaft that continues the movement from one planet wheel to the other, giving a ratio of 3:1 between the differential gears; see also drawing. Fig. 2. The differential gears are indicated by A and C and the centre by B. Presuming A to be the drive gear, the movement is continued to bevel gear 3718 via shaft 1415, which is mounted on the extension of the 4-mm. differential centre stub axle formed by threaded rod 1102. Freely mounted on the same shaft, gear C is connected with bevel gear ring 3760, which constitutes the other differential gear. Planet wheels 3718 and 3720 are mounted on the diametrically opposed shaft, as illustrated, and the resultant ratio between the differential gears is thus 3:1. The differential centre is united with gear B.

Fig. 3 shows the planet wheel mounting. For increased balance and guidance, the other end of the planet wheel shaft is freely journalled in a bevel gear 3720. The construction is further illustrated by Fig. 2.

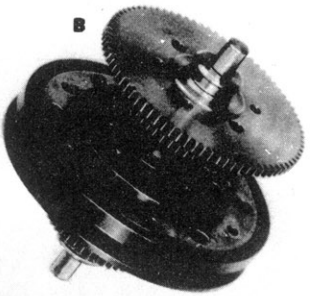
Ratios

In the adjacent table o indicates locked gear and - reversed movement.

A	B	C
o	3	4
3	o	-1
4	1	o

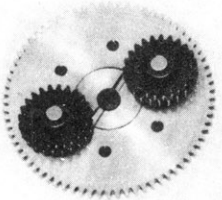


2008 3032 2350 2340 3164 3064
2×3324 2×2061 2×1404 2×1771
2×2070 1772 2202 3040 2×1763
12×1706 2410 1703

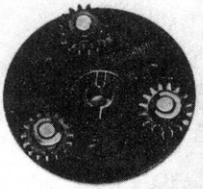


2006 2×3040 2×2410 2350
2340 3164 2346 3×2061 3×1763
3×1404 3×1771 3×2070 3×3316
3032 2×1772 3080 4×1703

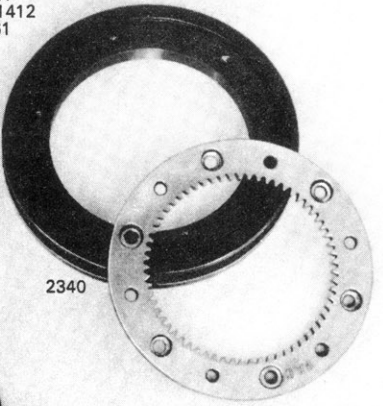
3056 3064 3016 3024 3×3324
2×1715 2×1175 4×1182 4×1412
8×1404 3×1771 2×2220 2061
2070 6×1710 2004 4×1703



3072 2×2061 2×1763
2×1404 2×1771 2×2070

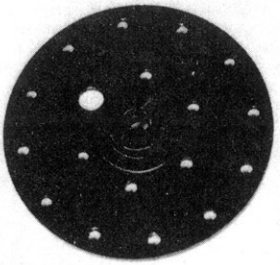


2346 3×2061 3×1763
3×1404 3×1771 3×2070



2340

3164



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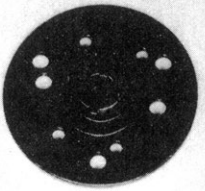

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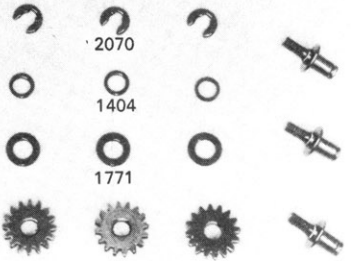


2070

1404

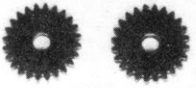
1771

3316

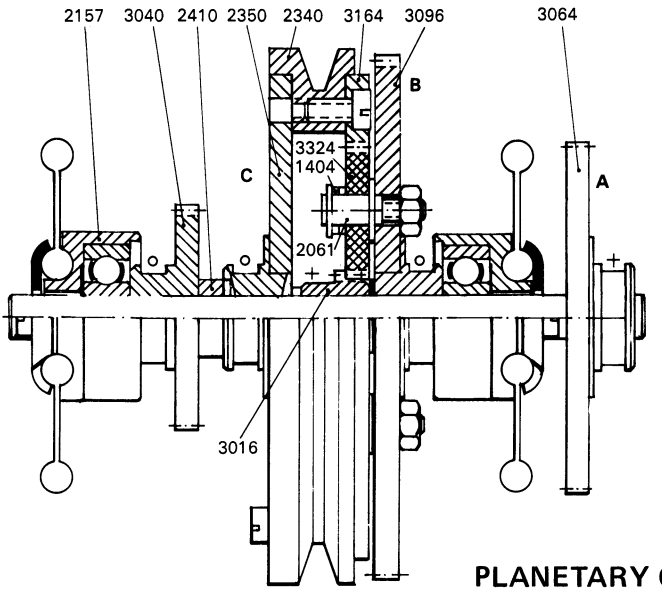
2061

3032

3016



3324



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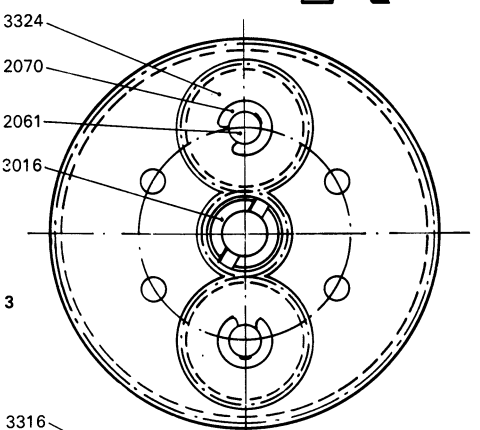

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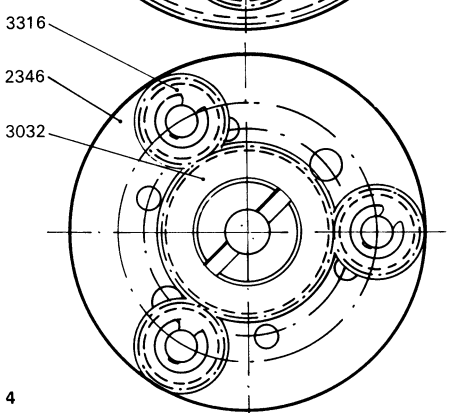


4

PLANETARY GEARS

In planetary gears comprised of spur gears, the counterpart to the differential gears consists of the sun gear and the internal gear ring; the planet gears, usually two or three, are mounted on a disc, the planet gear carrier, which corresponds to the differential centre.

Fig. 1 shows two planetary gear units, which differ in the choice of sun gear and planet gears and the number of the latter. In the one case, Fig. 3, the planet gears consist of two opposed planet wheels 3324 (fabric-reinforced bakelite) and the sun gear of the smallest spur gear 3016; the ratio between the sun gear and the internal gear ring 3164 is here 4:1. In the other case, Fig. 4, planet wheels 3316 are employed as planet gears, spur gear 3032 as sun gear and the ratio between sun gear and gear ring is 2:1.

For a gear unit with 4:1 ratio. any perforated wheel with two opposed 4-mm. holes may be employed as planet carrier. This type of unit offers a great variety of applications. For a unit giving a 2:1 ratio, planet wheel disc 2346 must be employed and the three planet gears mounted in the outer circle of holes.

Ratios

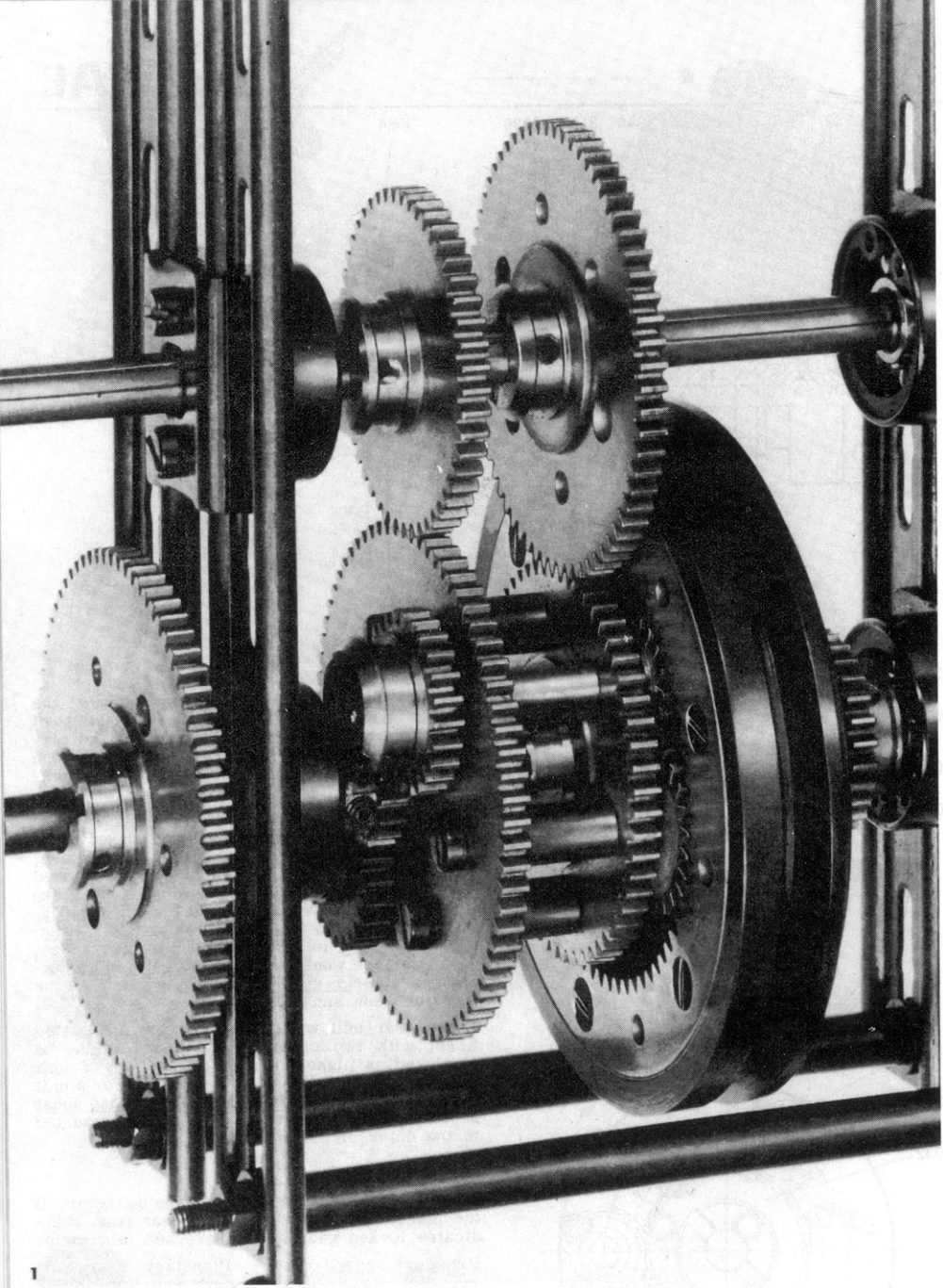
In the tables below, A indicates the sun gear, B the planet wheel disc and C the gear ring. o indicates locked gear and - reversed movement.

Planetary gear unit with sun gear 3016 and planet gears 3324

A	B	C
o	4	5
4	o	-1
5	1	o

Planetary gear unit with sun gear 3932 and planet gears 3316

A	B	C
o	2	3
2	o	-1
3	1	o



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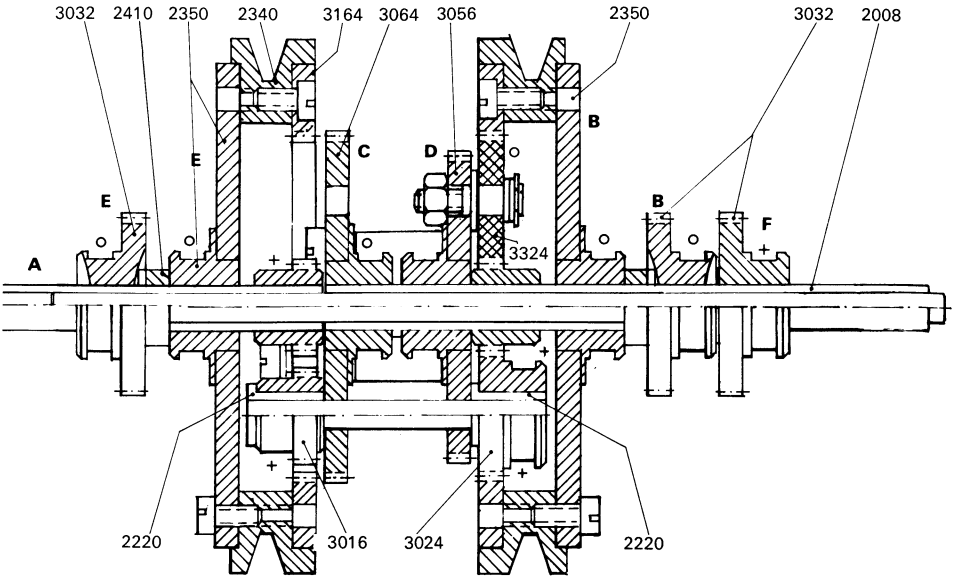

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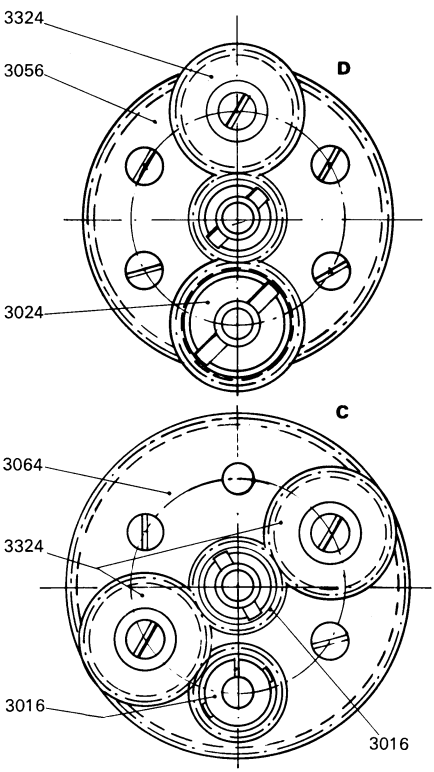


3

4

DOUBLE PLANETARY GEARS

The planet wheel discs of the two identical units shown here are united and mounted on the same shaft, which continues the movement from the planet gear of one unit to that of the other. Fig. 1 and 2 show different designs. In Fig. 1 one of the gear rings has been removed to show clearly the combined planet wheel disc. The input and output shafts are indicated by letters A, B, CD, E and F, Fig. 2. CD indicates the combined planet wheel discs and the construction is further illustrated by Fig. 3 and 4.

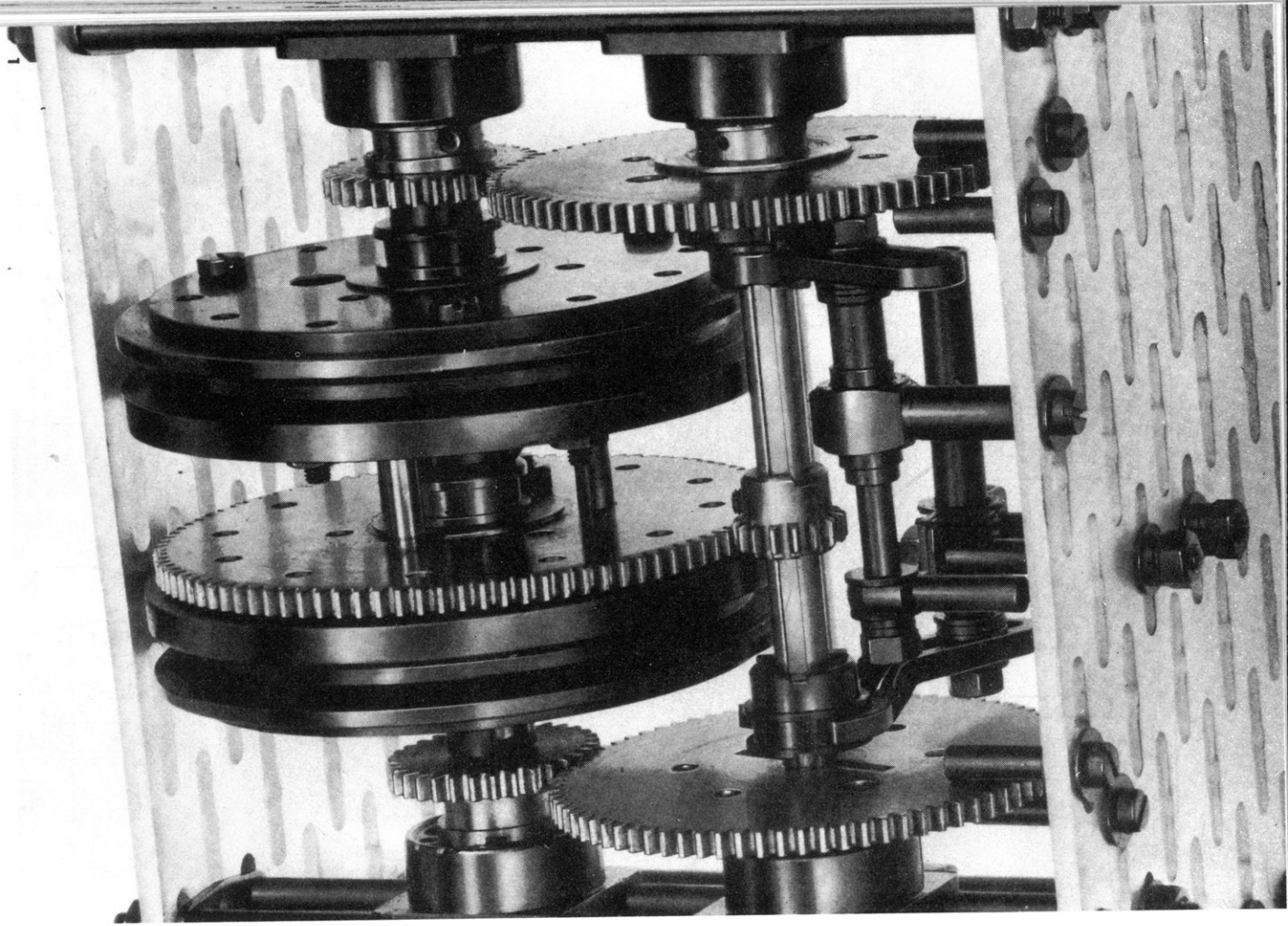
Two spur gears 3016 and 3024 are located on the shaft connecting the planetary gear units. Spur gear 3024 serves as planet gear in the right hand unit and spur gear 3016 is in mesh with the left hand unit planet gear 3324. The ratio between these gears is 3:2.

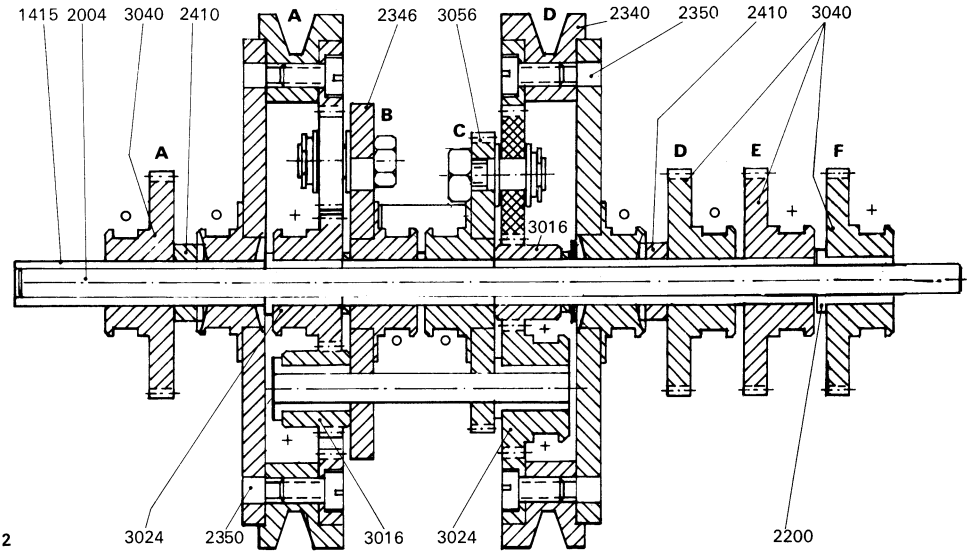
All gears are mounted on hollow shafts carried by a 4-mm. through shaft. Note the connection points of the hollow shafts and which gears are journalled or fixed on those.

In the adjacent table o indicates locked shaft and - reversed movement.

A	B	CD	E	F
o	10	12	15	20
10	o	-2	-5	-10
12	2	o	-3	-8
15	5	3	o	-5
20	10	8	5	o

The shaft with the highest ratio of revolutions compared with the output shaft should be chosen as input shaft.





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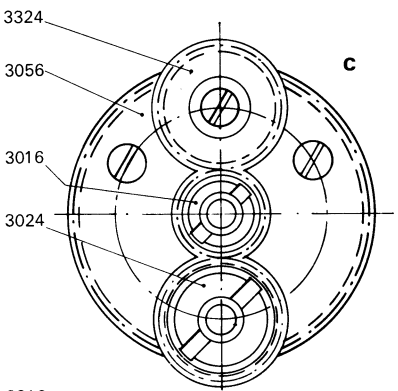

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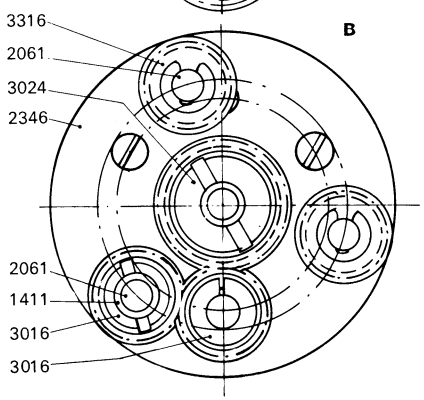


4

DOUBLE PLANETARY GEARS

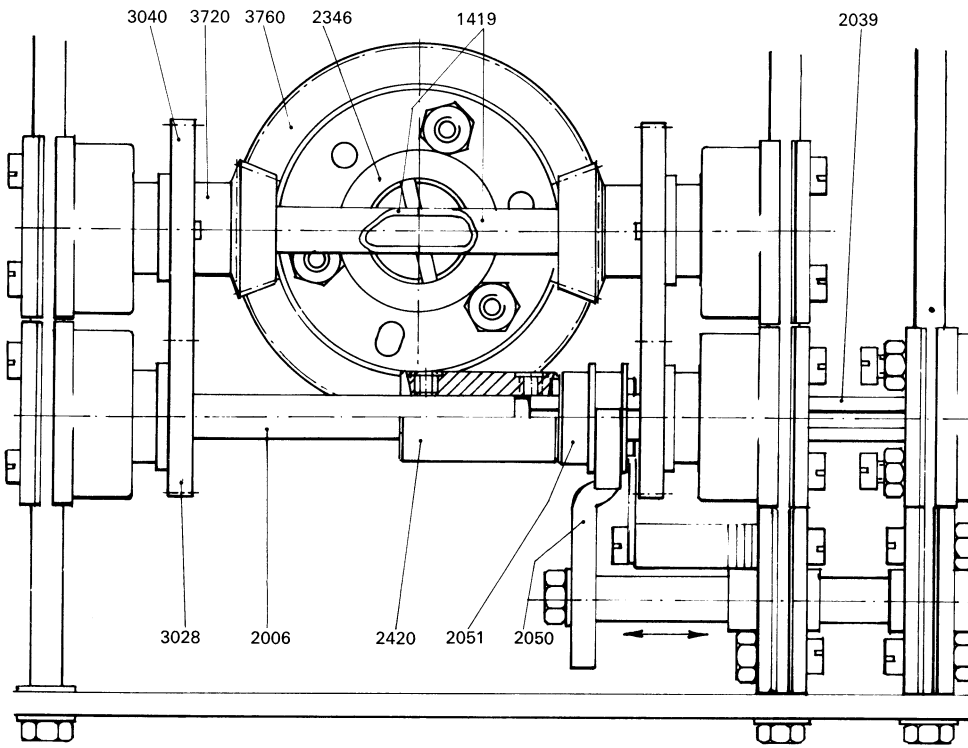
In the example here described. the right hand gear unit comprises sun gear 3016 and planet gears 3024 and 3324 (fabric-reinforced bakelite). The left hand unit comprises sun gear 3024 and planet gears 3316 (fabric-reinforced bakelite) and 3016. Sun gear and planet gears are connected via spur gear 3016, which is located on the shaft combining the two planetary gear units and continues the drive to the right hand unit planet gear 3024 located on the same shaft, Fig. 3 and 4. The shafts, both input and output, are given the letters A, BC, D, E and F. Gear A is connected with the left hand gear ring by means of a tube shaft and coupling rings. Sun gear 3024 in this unit is connected with gear F via the 4-mm. through shaft. Planet wheel discs BC are located on a tube shaft (spacer tube 1413) journalled on the same shaft, and the right hand unit sun gear D, united with a gear wheel by a coupling ring, is mounted on a tube shaft which connects the sun gear of this unit with gear wheel E.

Ratios

In the adjacent table o indicates locked gear and - reversed movement.

E	F	A	BC	D
o	20	30	36	45
20	o	-10	-16	-25
30	10	o	-6	-15
36	16	6	o	-9
45	25	15	9	o

The shaft with the highest ratio of revolutions compared with the output shaft should be chosen as input shaft.



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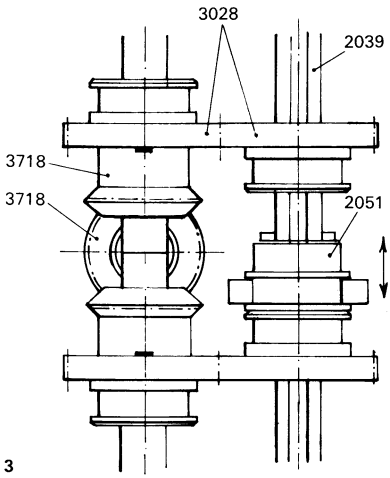


3

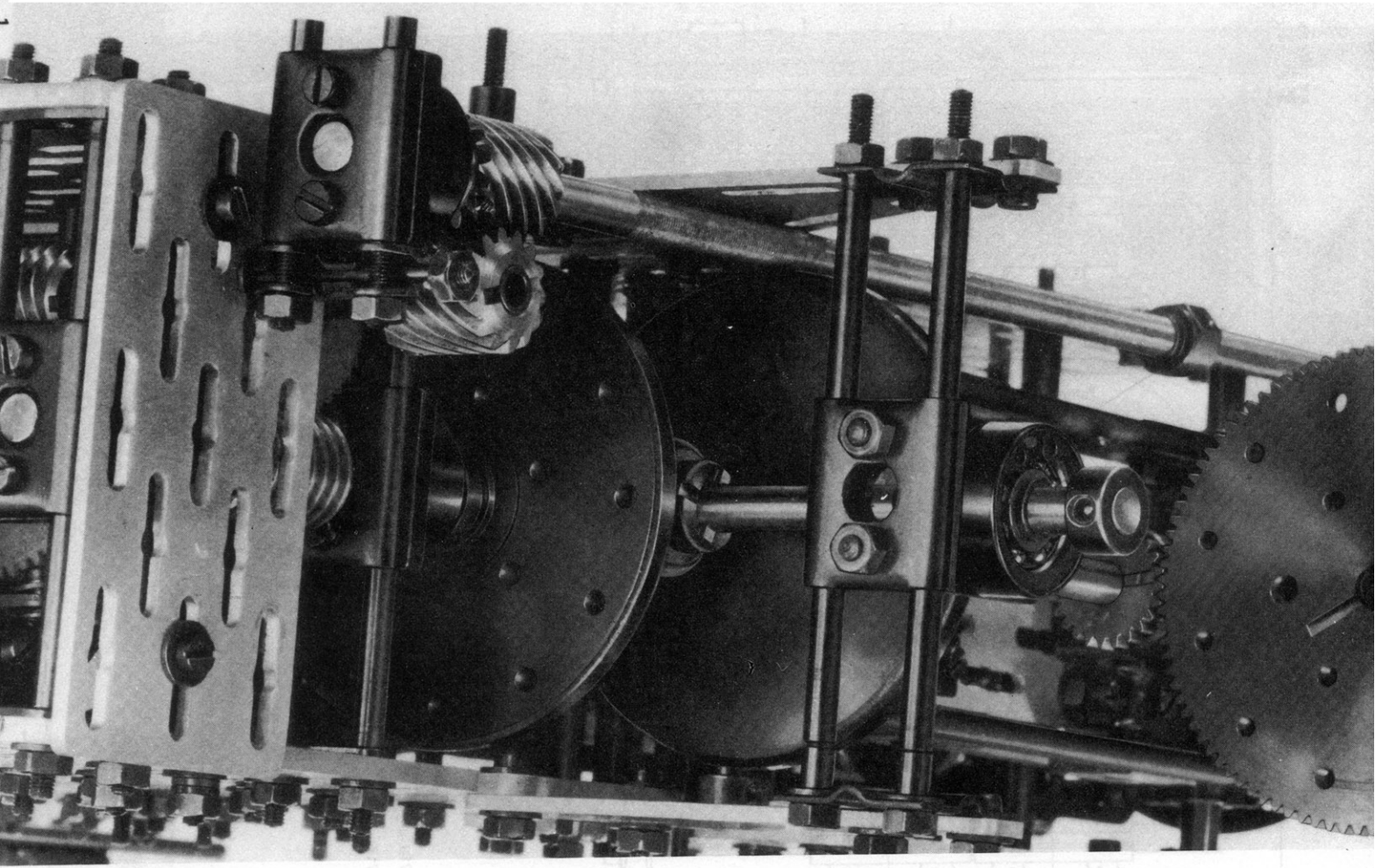
SLIDING COUPLING. Forward – reverse

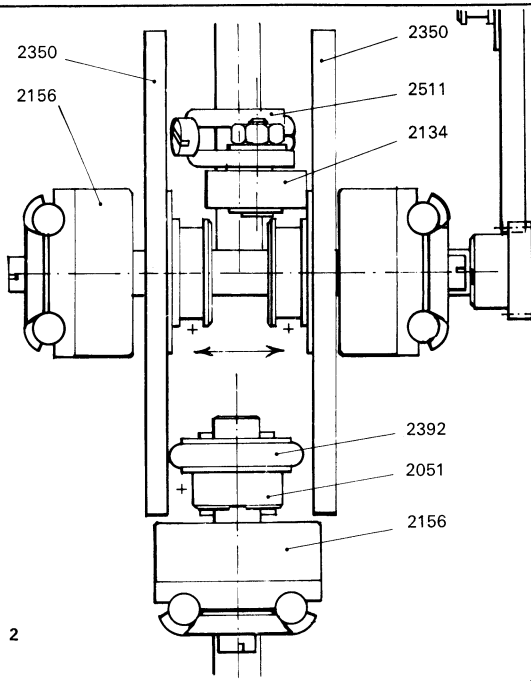
Fig. 1 and 2 show a device for quick shifting between forward and reverse. Bevel gear ring 3760 is in mesh with the two bevel gears 3720, each of which is connected with a spur gear 3040 and mounted on hollow shafts 1419 guided by a 4-mm. through shaft. Two axially parallel shafts 2006 and 2039 are located below, solid shaft 2006 being mounted in one ball bearing only and carried by grooved shaft 2039 by means of shaft sleeve 2420. Spur gears 3028 are located on these parallel shafts, in mesh with corresponding gears on the adjacent tube shafts. Sliding coupling 2051 is located on the grooved shaft, between the spur gear and the shaft sleeve, sliding on keys 2041 and guided by gear shift fork 2050. The grooved shaft is the driving shaft. Reversal of the movement direction of the other gears in the unit is actuated by the engagement of the sliding coupling with either the shaft sleeve or the spur gear.

A similar construction is illustrated by Fig. 3, but this application involves longer travel of the sliding coupling.

The gear shift fork should be spring loaded so that it is held firmly in the end positions.

Fig. 1 shows a model of the unit built according to Fig. 2 (part of an automatic coil winder; the winding direction of each wire layer is reversed).





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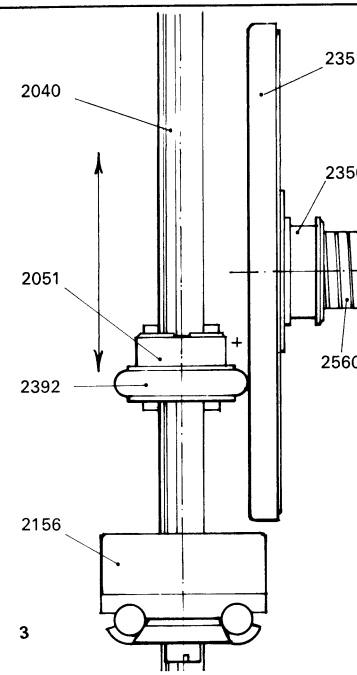

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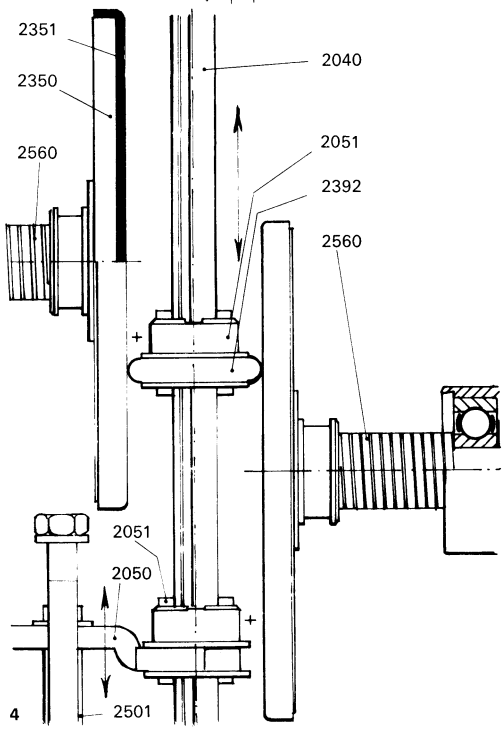


4

STEPLESS GEAR RATIOS – FORWARD–REVERSE

Stepless gear ratios can be obtained by friction drive using the perforated wheel with attached friction disc, 2350 + 2351, and the sliding coupling with fitted O-ring, 2051 + 2392, as driving wheel. The sliding coupling is mounted on a one-piece or jointed grooved shaft 2040. This shaft, fitted with keys 2041, is axially movable in the driving wheel, which is held in position relative to the support by means of a fixed gear shift fork 2050 attached to the support.

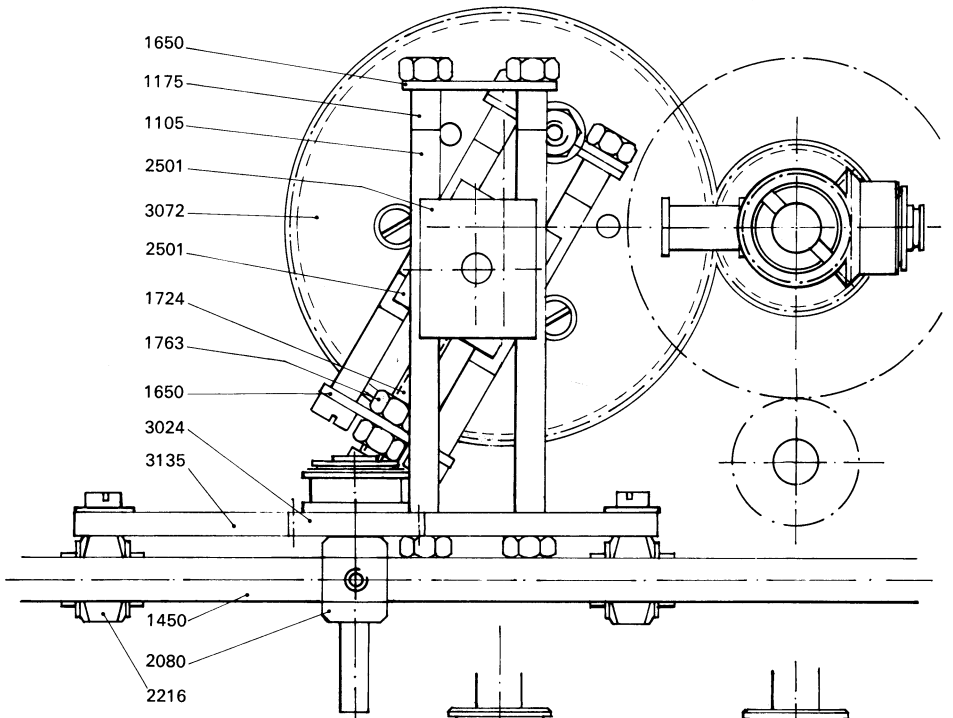
Fig. 3 shows a common device giving variable gear ratios in both directions. Compare Fig. 1 and 2, pages 50 and 51.

In the unit in Fig. 4, the driving wheel, 2051 + 2392, actuates two mechanisms with mutually variable gear ratios in one direction only. Compare Fig. 1.

Fig. 2 shows a simple reversing unit, in which the driven wheels are allowed an insignificant axial movement, limited to the maximum combined lateral movement permissible for two gears, which facilitates the further transmission of power.

Fig. 1 shows an variable speed transmission in accordance with Fig. 4.

As a rule, the above types of gear units function best in connection with comparatively light torque. Where connected units are subject to heavier loads, a considerable reduction in gearing is recommended. If this is not possible, a torque booster should be employed. See Fig. 1 and 2, pages 50 and 51.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1105
2501
3072
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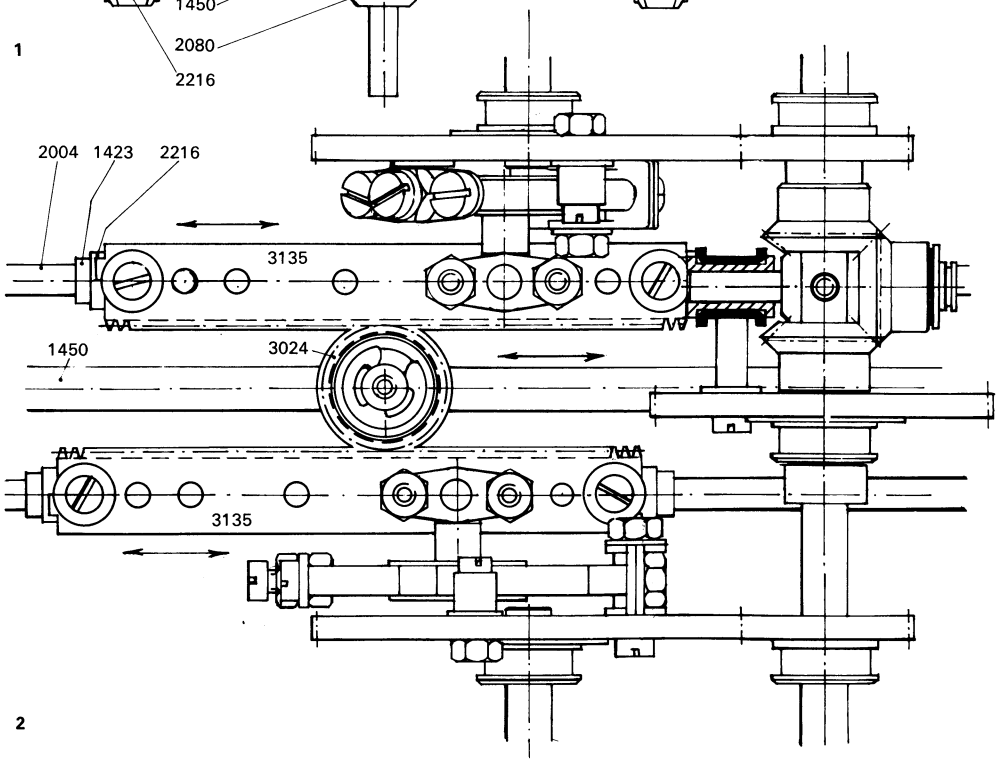
1724
1763
1650
3024
3135
1450
2080
2216

1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1423
2216
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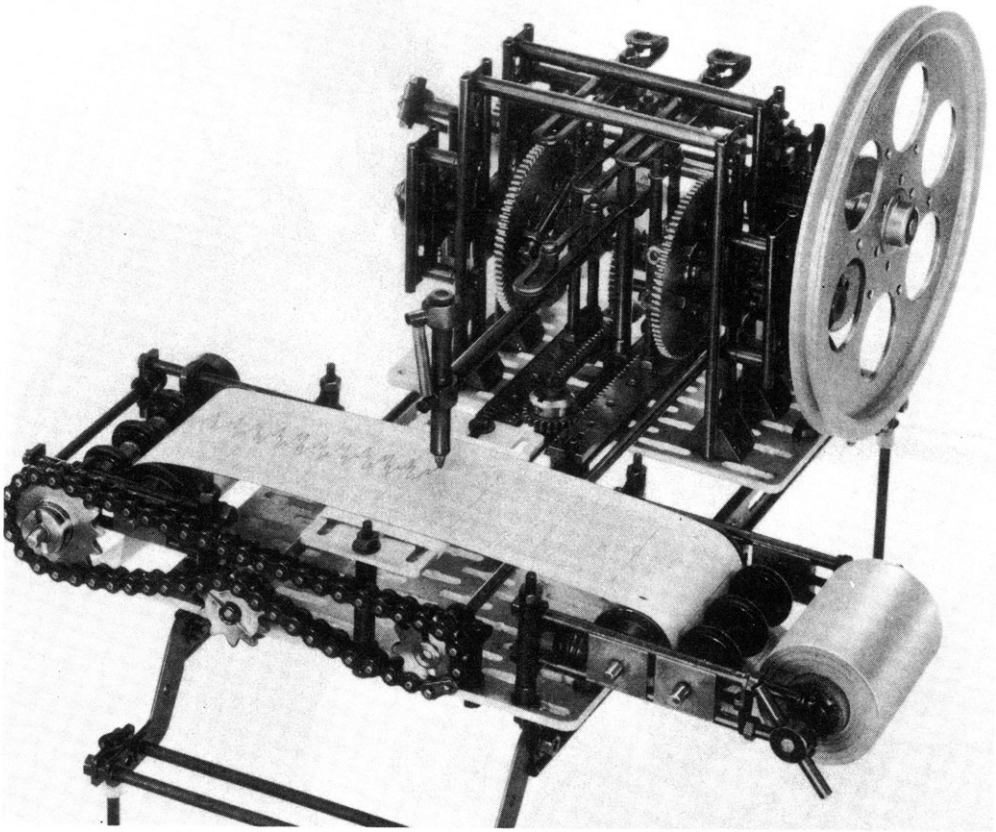
1450
3024
3135

2

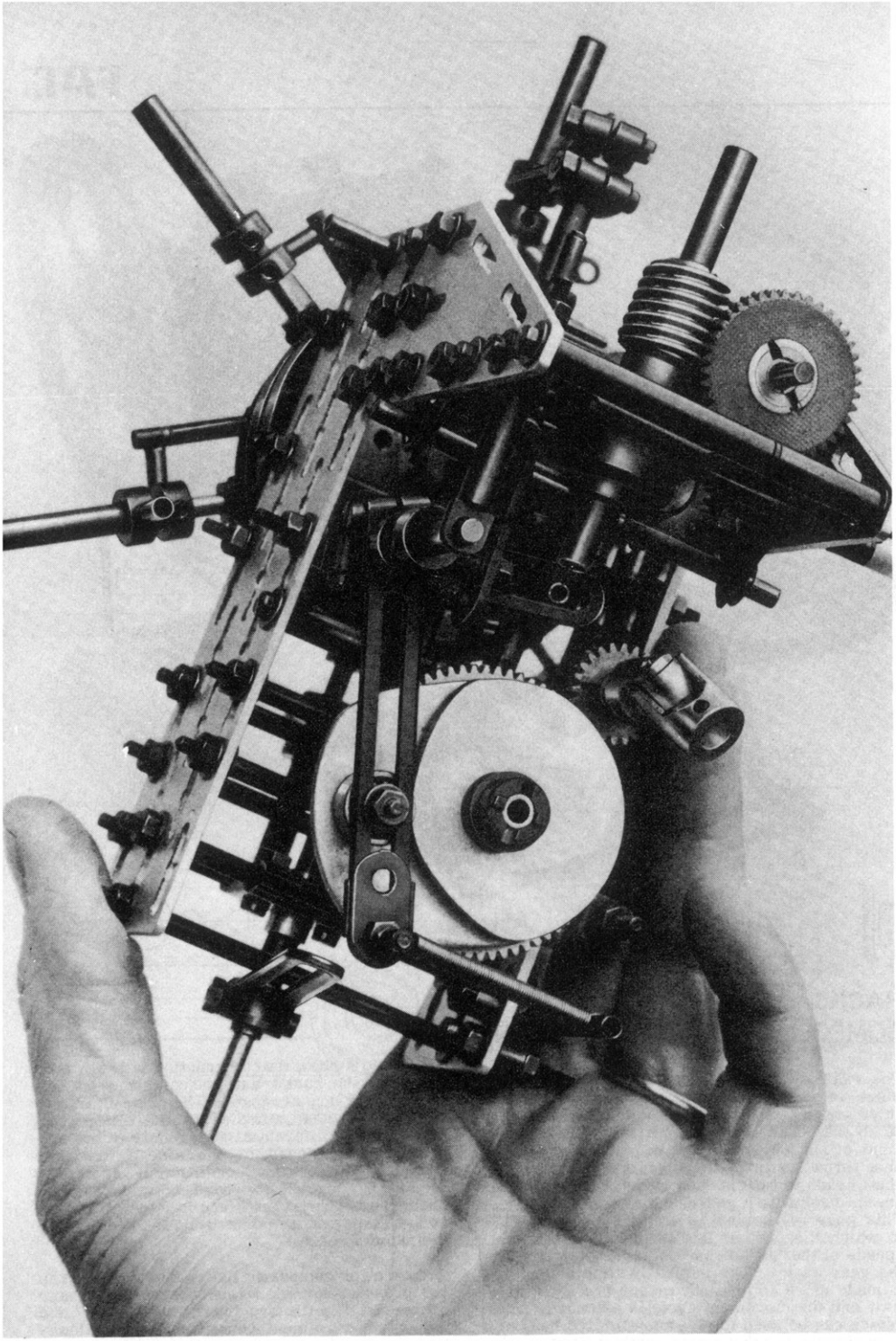


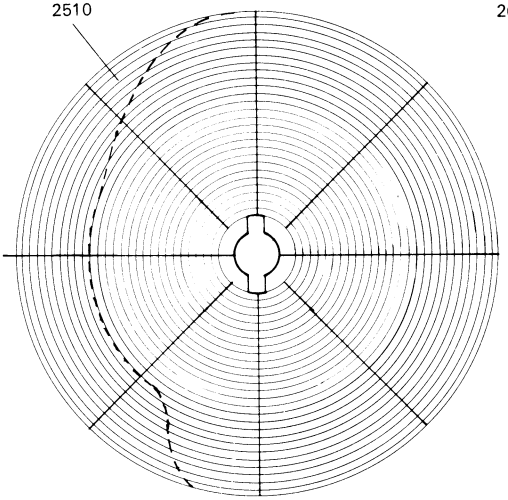
RACKS.
COMPOSITE LINEAR MOVEMENT

The example shown in Fig. 3 above is a device which records a diagram on a moving cross-ruled paper strip, the speed of which is adjusted to that of the complex reciprocating movement of the scriber. Two cranks with adjustable throw continue the movement via sliding shaft heads to two opposed racks, both of which are in mesh with a gear located between them. This gear is carried by an axially guided rod to which the scriber is attached. The relative speeds of the cranks can be altered by changing the gear ratios. The basically simple gearing is made more complex by means of a differential, and the movement cycle is extended. This device can be used to test an unlimited number of reciprocating movement combinations.

Fig. 1 and 2 show the construction of the cranks and how the racks and the gear moving between them are arranged. The drive is transmitted by a gear attached to the differential centre. The differential gear shafts (tubes and 4-mm. shafts) pass to one side of the unit (compare differential construction according to Fig. 6, page 29), where they carry exchangeable gears which are in mesh with corresponding gears mounted on a gear plate (not shown).

A device for composite linear movement, as in the present example, can be called a "linear differential" with two input movements, and one output movement constituting the arithmetic mean of the two former.





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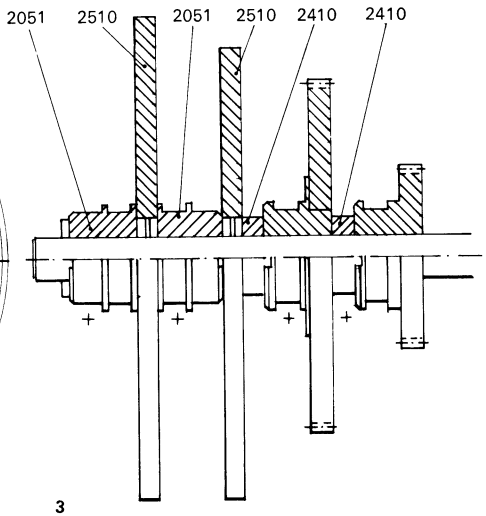

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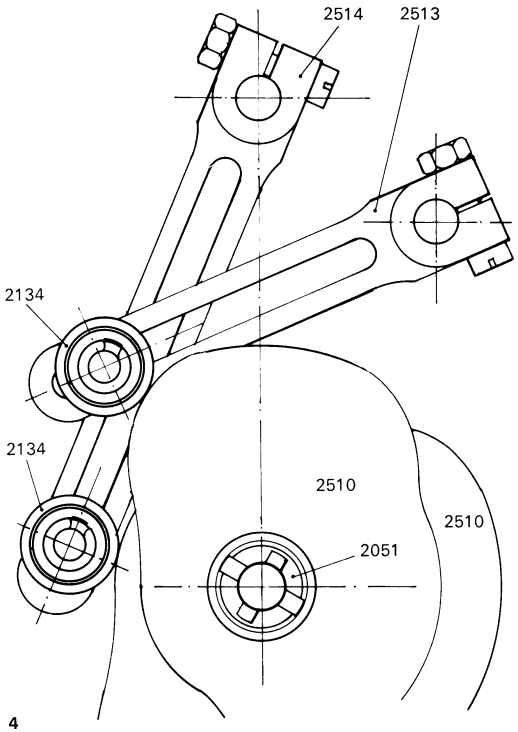
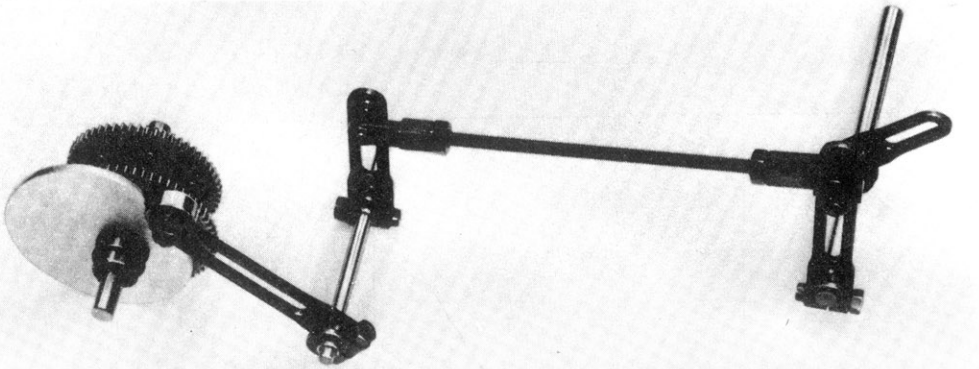


4

CAM DISCS

Aluminium cam disc material 2510 can be cut and filed to any desired profile, which is first calculated and drawn. Cam plattern 2510 is metrically graduated in concentric circles with radial lines forming 45° angles. The finished cam disc is mounted on the shaft using sliding couplings 2051 as hubs. By means of sliding couplings and coupling rings 2410, "assemblies" of cam discs and driving gears can be built, Fig. 3. Fig. 4 shows a combination of cam discs, rocker arms 2511-2514, and rollers consisting of 4-mm. ball bearings 2134. Spacer tube 1411 can also be used as roller. The rollers are mounted on stub axles 2061.

Fig. 1 shows a unit comprising two cam discs in an "assembly". The cam discs turn half a revolution in one direction, and half a revolution in the other, while the rocker arm moves axially at the turning points and alternately follows first one cam and then the other. The rocker arm movement is continued to a tube on a 4-mm. shaft, sliding the tube inwards from its centre position, and back, and outwards and back to its centre position. The tubes are fitted to a revolving turret holding 6 tubes and the movement is transmitted to the tube in working position (part of automatic coil winder).



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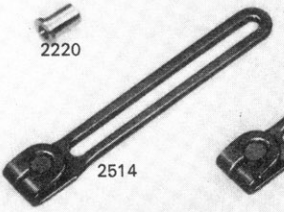
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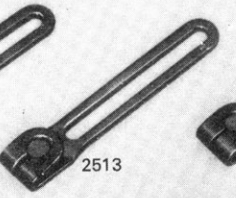
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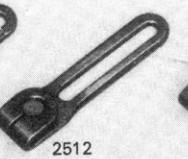
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2511

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2061

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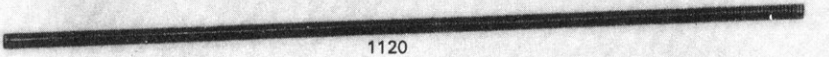
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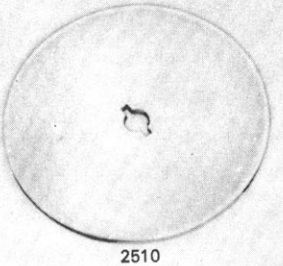
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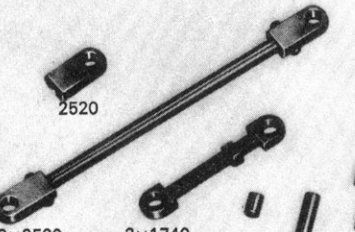
2051

2520

2410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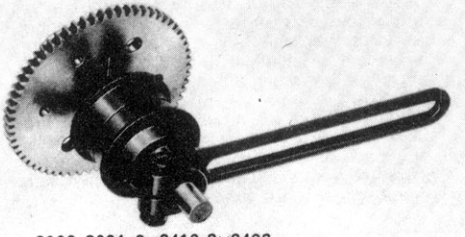
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2408 (2409) 1715 1763 2514

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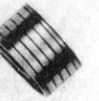
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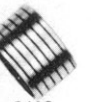
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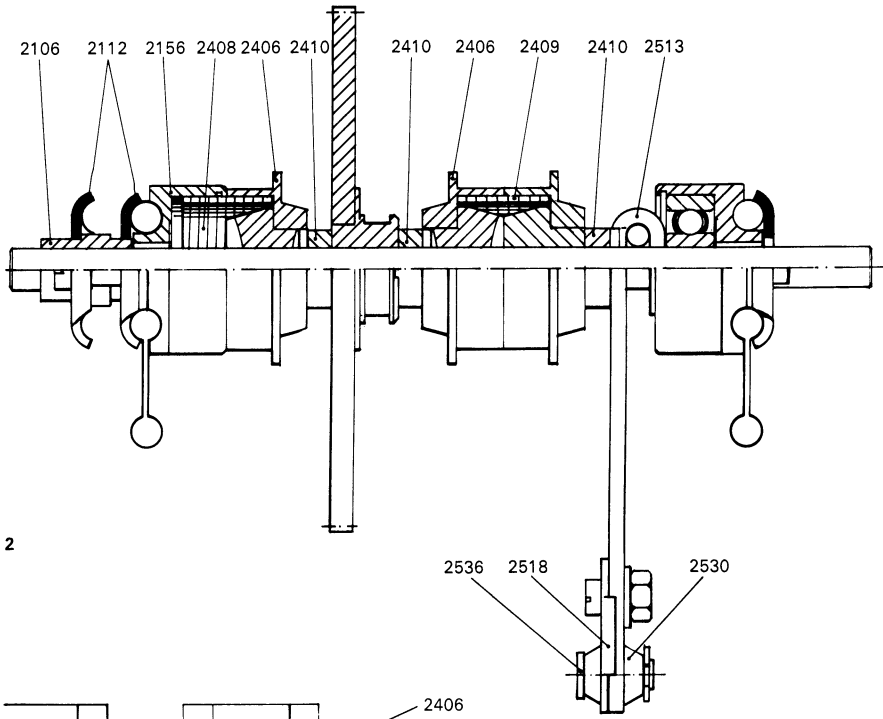

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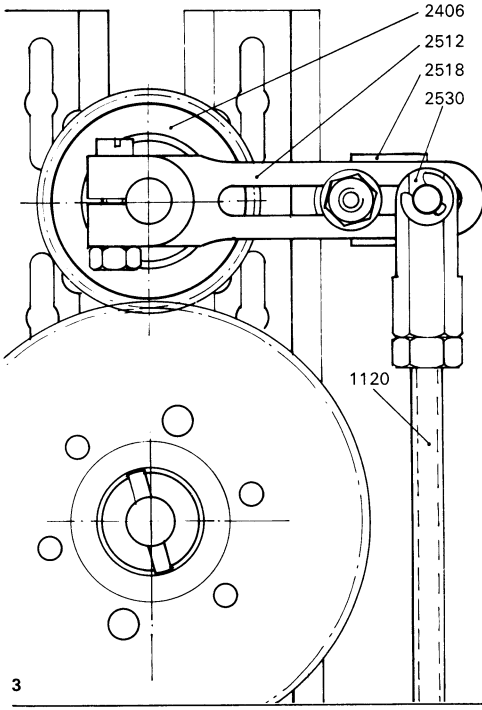
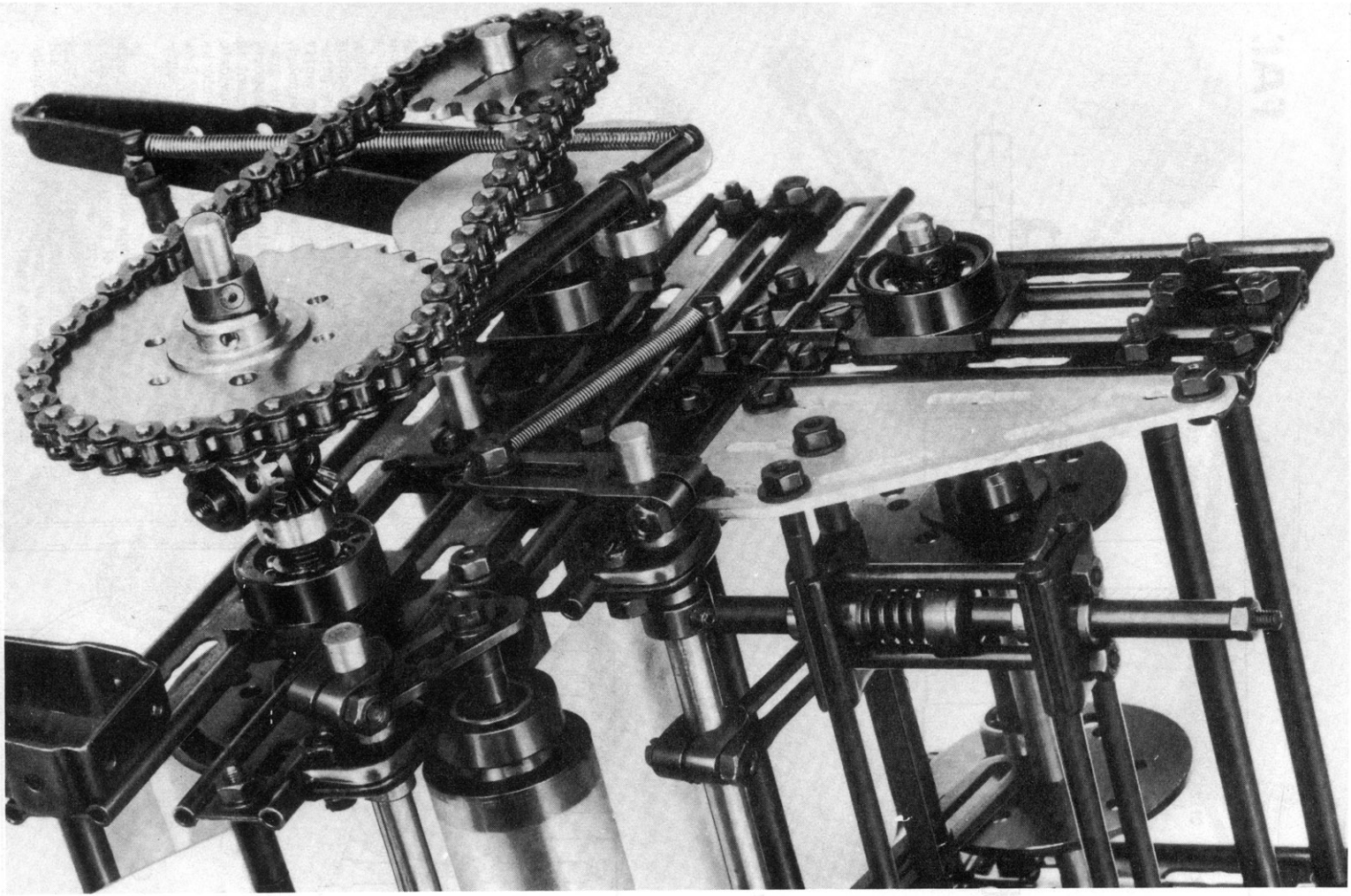


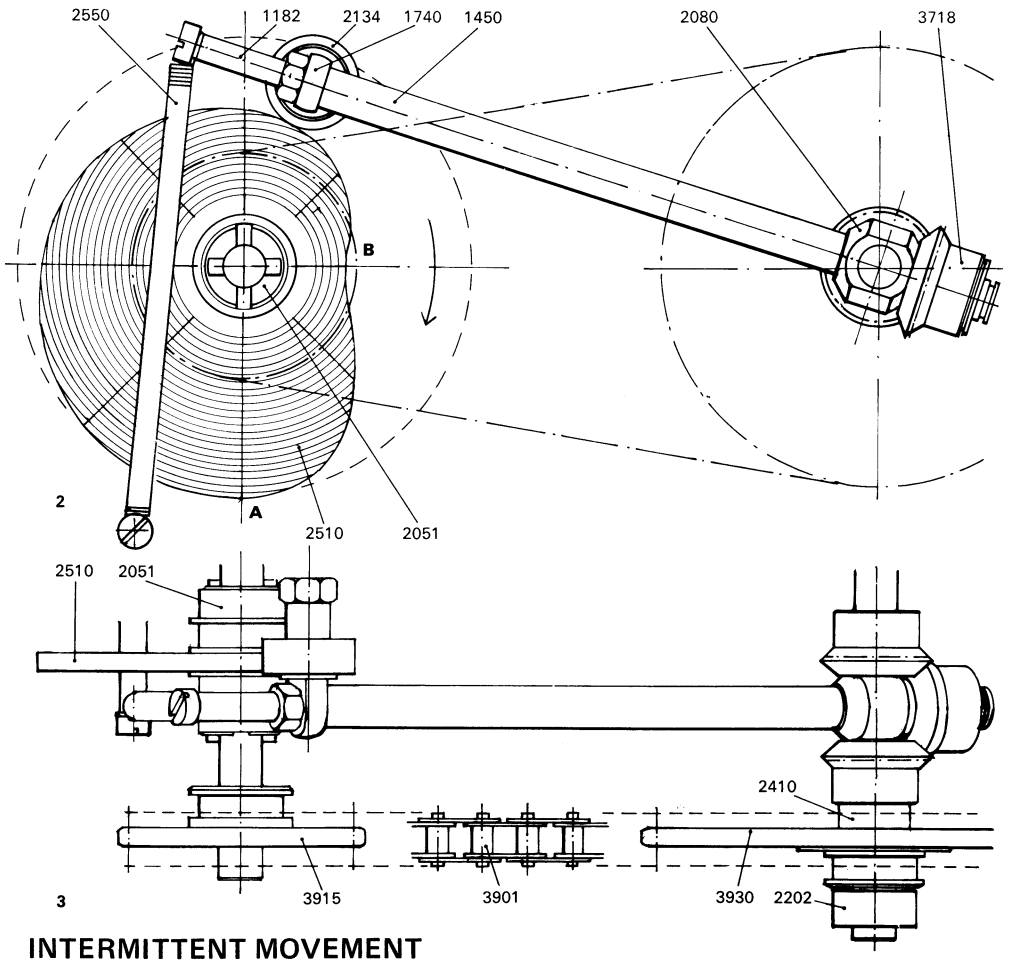
3

LOCKING DEVICES, FREEWHEEL, LINKAGES

A freewheel is constructed by combining two free wheel housings 2406 containing expansion spring 2408 or 2409, the former with right-hand winding, the latter with left-hand winding. A freewheel can thus lock in either direction, depending upon the choice of spring. A locking device can be constructed on the same principle using a free wheel housing and an empty bearing box 2156 mounted on the support. Fig. 2 shows a unit in which a wheel is gradually turned counter-clockwise. The support-mounted locking device blocks movement in the opposite direction. Via the intermeidate freewheel, the wheel is turned counter-clockwise by rocker arm 2513 while remaining free in the opposite direction. A similar arrangement is shown in Fig. 3.

Fig. 1 shows a unit comprising a cam disc with a linkage consisting of rocker arms 2511-2514 full threaded rod 1120, which may be cut to the desired length. This rod will fit fork head 2530 and tongue head 2532 whose internal 4M threads, 8 mm. in length, will permit adjustment of the rod length.

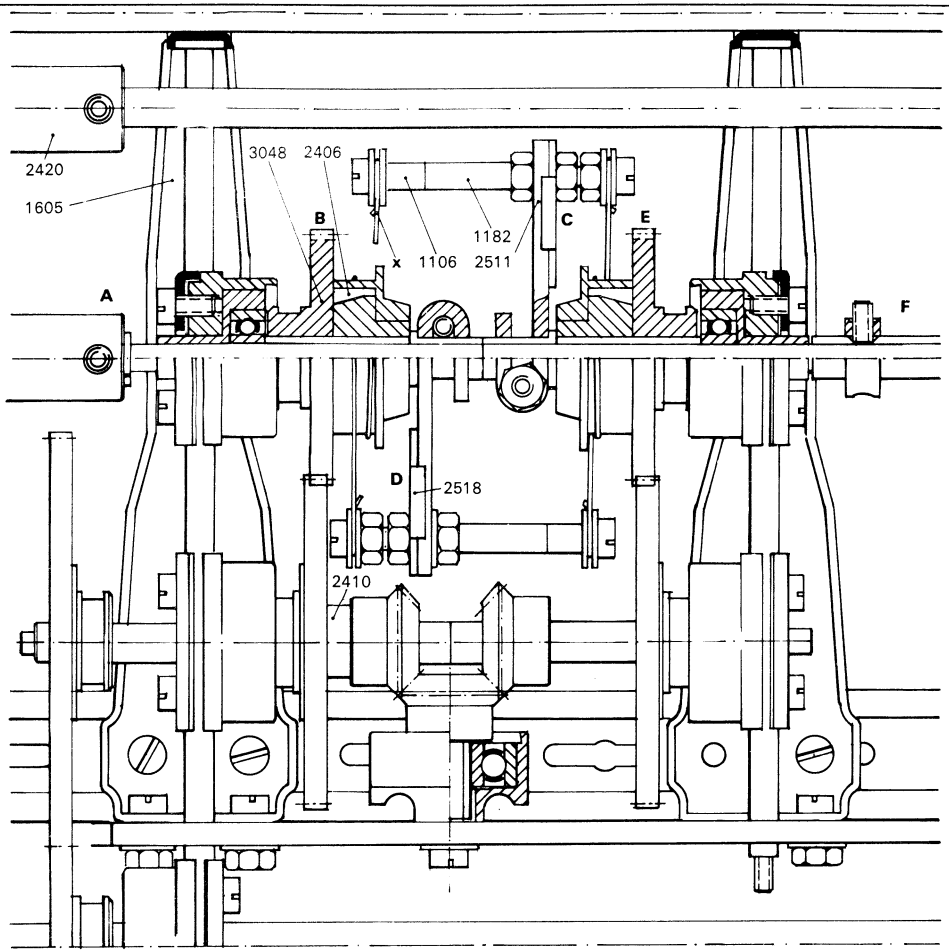




INTERMITTENT MOVEMENT

The example in Fig. 1 is a printing machine which presses a stamp against roll-driven paper strip. While the stamp is applied, the movement of the paper is interrupted. This intermittent movement of the paper (i. e. of the rolls) is effected by a differential and cam disc arrangement located on one side of the machine. Intermittent movements of this type have many applications and only the differential and cam disc mechanism will be described here.

In the drawing, Fig. 2, cam disc 2510 is located on the driving shaft and graduated in concentric circles
A-B and B-A trace two curves. From B the curve describes a spiral to its apex, at A, and then takes a sharp dip to B. The driving shaft actuates the paper feeding roll by a chain drive (giving a ratio of 2:1) and a differential, which is located between the driven sprocket and the support and reverses the movement direction. The 4-mm. stub axle of the differential centre is extended to a rocker arm, which carries a roller resting on the cam disc. As this roller travels from B to A, the differential centre is turned thus increasing the speed of the feeding roll. At A the roller starts to move quickly towards the cam disc centre causing the differential centre to turn in the opposite direction at a speed adjusted to stop the differential gear that drives the roll until the rocker arm roller resumes its travel along the spiral B-A. Once the transmission ratio (and thereby the number of working stations per revolution) and the length of the rocker arm are determined, the latter can be made to trace the desired curve A-B on the cam disc 2510 by locking the driven differential gear (or, for instance, the feeding roll). The spiral B-A is then easy to draw in.



TORQUE BOOSTER

The integrator in Fig. 1 contains a large rotating translucent plastic disc, which drives a friction roller, diametrically movable across the disc surface. The roller is controlled by lead screw 2580, which guides a sliding unit of corner plates 1520 along a fixed 6-mm. shaft 2015. Gear shift fork 2050 continues the movement to the friction roller consisting of a spur gear 3024 fitted with a plastic disc; disc and roller are both specially made components. The sharp edge of the roller disc travels against the cushioned main disc. To ensure that the force transmitted to the roller by the friction against the main disc is sufficient to drive other mechanisms (other integrators, etc.), it must be increased by means of a torque booster, the construction of which is described in Fig. 2. Input shaft A connects with output shaft F at the centre of the torque booster. Rocker arms 2511 are located on the shaft tips and fitted with wire clamps, as illustrated. Both shafts must be carried in two bearings. Input shaft A is journalled at the other end of the unit (not visible) and the bearings for the output shaft are shown in Fig. 1. Behind wire clamps C and D, drums (composed of parts 3048 and 2406) are freely mounted on the shafts and driven directly by the motor, in opposed directions, at a speed exceeding the maximum speeds of shafts A and F. Wires run between the clamps and are wound once, in different directions, round their respective drum.

When shaft A turns, the wire wound in that direction tightens round its drum, which turns correspondingly pulling along the wire and thus also the other wire clamp located on the output shaft. When shaft A turns in the other direction, the process is repeated, but centered on the drum turning in the opposite direction. This mechanism will thus supply additional driving force without affecting established transmission ratios.

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