Meccano Single-Cylinder Horizontal Steam Engine

Fitted with balanced crankshaft, crosshead and centrifugal governor, etc., this model affords an interesting demonstration of the principles of a simple steam engine. It may be built with Meccano Outfit No. 6, with the addition of a Meccano Electric Motor

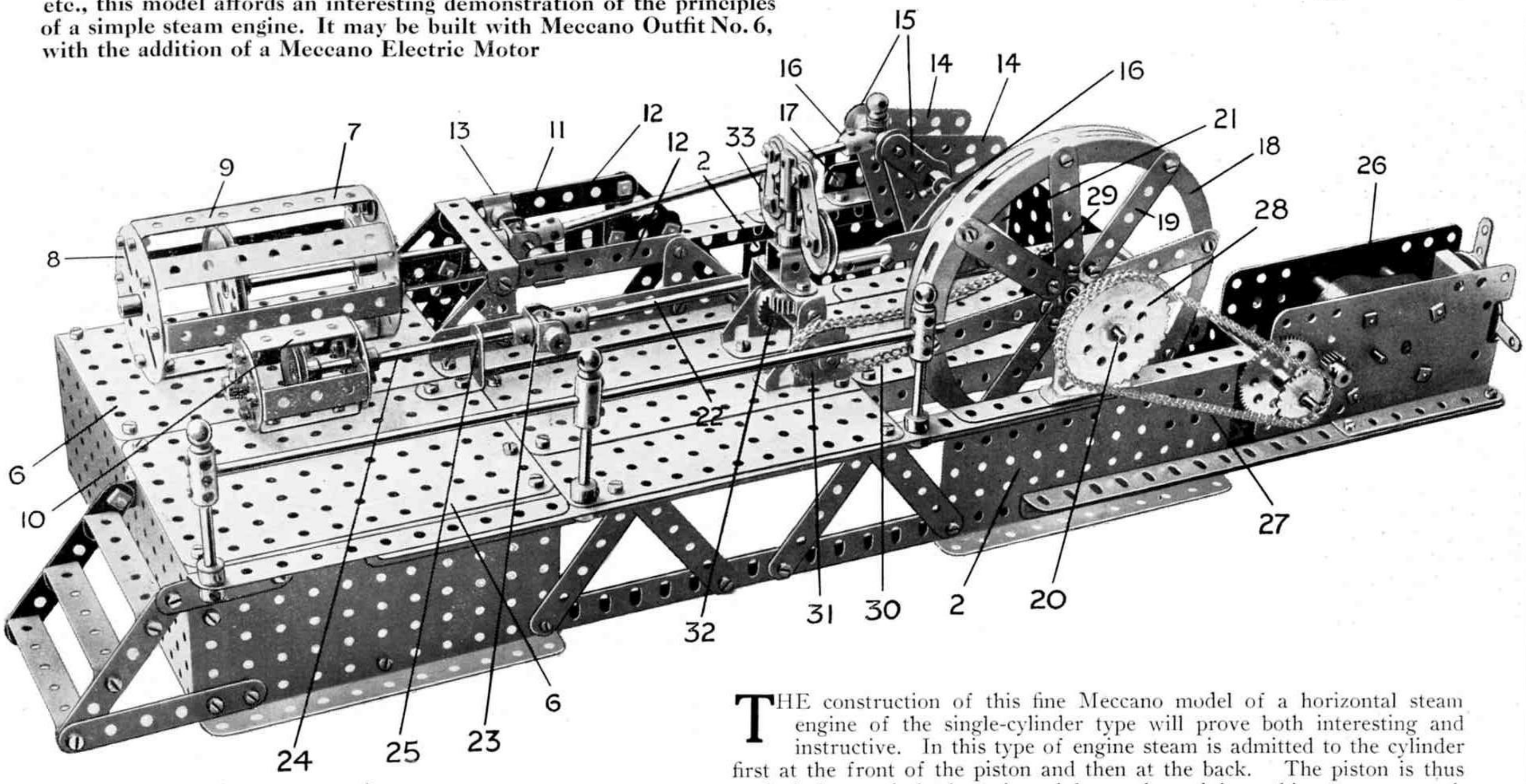

Fig. 1. General view of the Steam Engine, showing the method of coupling the Meccano Electric Motor to the crankshaft

THE construction of this fine Meccano model of a horizontal steam engine of the single-cylinder type will prove both interesting and instructive. In this type of engine steam is admitted to the cylinder first at the front of the piston and then at the back. The piston is thus pushed alternately backwards and forwards, and from this movement such engines are called "reciprocating." The type of reciprocating engine adopted as the prototype of the Meccano model is one of the simplest, and yet in spite of its simplicity the combined efforts of many inventors, spread over a long period, were necessary to produce it.

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It is interesting to go back to the early days of the steam engine and see how it has developed, step by step, from a mechanical curiosity to a practical working apparatus.

First Practical Steam Engine

James Watt is commonly regarded as the inventor of the steam engine, but as a matter of fact a number of engines using steam had been produced before his time. Watt's great work lay in developing the steam engine from a state of crude inefficiency to what may be described, comparatively, as practical perfection.

The idea of using steam in a cylinder appears to have originated with Denis Papin, a Frenchman, who, about the year 1688, constructed a working model to illustrate his idea. The first really practical engine was erected in 1710 by Thomas Newcomen, an Englishman, and it was used as a pumping engine It consisted of a vertical steam cylinder, the piston of which was connected to one end of a beam pivoted in the middle. The other end of the beam was attached to rods working the pump. Around the cylinder was a jacket, to which cold water could be supplied.

When the piston in the working cylinder was at the top of its stroke, being raised by the weight of the pump rods, steam was admitted to the cylinder so as to drive out all the air. The steam was then shut off and cold water was admitted to the outer jacket. This condensed the steam in the working cylinder so that a partial vacuum was produced, and atmospheric pressure forced the piston down, thereby raising the pump rods. Each time this occurred one stroke of the pump was made and the operation was then repeated. Newcomen's engine, improved later in some details by its inventor, was used extensively in pumping water from mines. It will be seen that the engine was not a true steam engine, for the forcing down of the piston was done by atmospheric pressure.

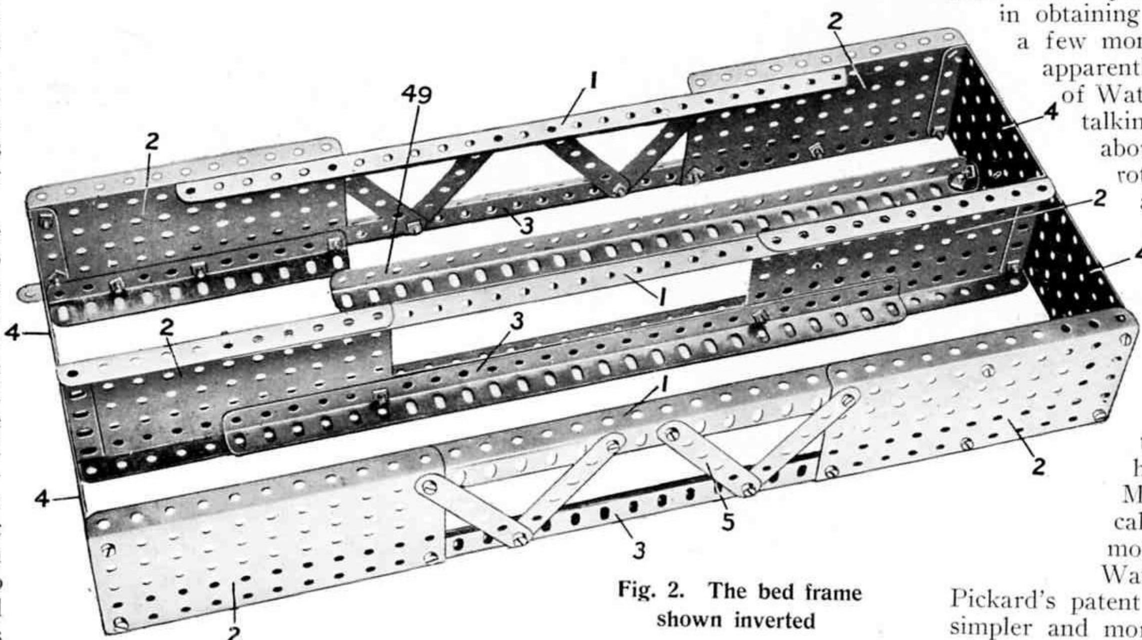

Fig. 2. The bed frame shown inverted

James Watt's Great Idea

A model of the Newcomen engine came into the hands of James Watt for repair, and while engaged on this task he hit upon the idea on which the modern steam engine is based.

In the Newcomen engine the working cylinder was first heated by steam and then cooled by water to condense the steam. Watt saw that this alternate heating and cooling resulted in a great waste of energy, and endeavoured to find some means of keeping the cylinder at an even temperature. It took him a long time to solve the problem, but at last he succeeded by condensing the steam in a separate vessel, instead of in the working cylinder itself.

Talkative Workman Causes Trouble

Watt's improved engine, patented in 1769, was used entirely for pumping as Newcomen's had been. In 1781 Watt took out another patent for an engine in which the reciprocating motion of the piston was converted into rotary motion, so that ordinary machinery could be driven. Watt had intended to obtain this rotary motion by means of the now familiar crank and flywheel, but he found himself prevented from doing so because a Birmingham button-maker named James Pickard has succeeded in obtaining a patent for this device a few months previously. Pickard apparently got the idea from one of Watt's workmen, who had been talking too freely and bragging about the great things that the rotary engine was going to accomplish. Watt was very angry when he found what had happened, and for a while he was puzzled to overcome the difficulty thus created. He determined not to be beaten, however, and after trying various schemes he decided to use a device invented by his best workman, William Murdock. This device was called the "sun-and-planet" motion, and was utilised on Watt's rotary engines until Pickard's patent expired, after which the simpler and more efficient crank and fly-wheel were substituted. "Sun-and-planet" mechanism may easily be reproduced with Meccano (see detail No. 279 in the later editions of the Standard Mechanisms Manual).

Watt's Final Improvements

Up to this time Watt's engines were "single acting"—that is to say the cylinder was connected to the condenser only on one side of the piston, so that work was only performed during one stroke of the piston. In 1782 Watt took out a patent for connecting the cylinder to the condenser both back and front of the piston, thus making the engine "double acting," and consequently much more efficient.

In the same year he obtained another patent for a method of securing greater economy in the use of steam. The principle involved in this final improvement was that of shutting off steam from the cylinder when the piston had only travelled part of its journey, and leaving the rest of the thrust to be carried out by the expansion of the steam.

The brilliant inventions we have briefly described were Watt's chief contributions towards the perfecting of the steam engine. Watt found the engine a clumsy mechanism, very inefficient and wasteful of fuel, and only capable of working a pump. Through his inventions it became efficient and economical, and capable of working machinery of almost every kind.

The Meccano Model: The Bed Frame.

It will be seen on glancing at the model that no reversing device is fitted to the engine. Usually engines of this kind are equipped with some valve motion that is capable of reversing the direction of rotation of the crankshaft as required. There are instances, however, where an engine is required to run in one direction only and reversing valve motion is therefore unnecessary. By suitably arranging the positions of the main piston in relation to the valve piston the action of a simple steam engine can clearly be understood.

The working portions of the engine are mounted on a raised bed-frame. This frame is shown inverted in Fig. 2, the covering plates 6 having been removed. The construction of the framework is as follows. The 12½" Angle Girders 1 in the base, are bolted at each end to the 5½" by 2½" Flanged Plates 2 and the 12½" Angle Girders 3 are attached to the top flanges of the Plates 2. The ends of the bed-frame consist of four 2½" by 3½" Flanged Plates 4, their flanges being bolted to the Plates 2. Each long side of the framework is braced with four 3" Strips 5.

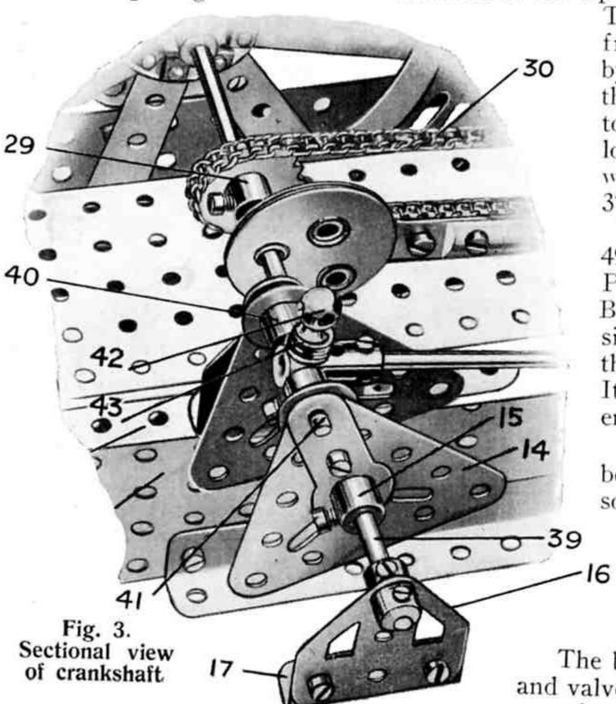

Fig. 3. Sectional view of crankshaft.

The 12½" Angle Girder 49 fastened to one of the Plates 4 by an Angle Bracket, forms one side of the slot in which the flywheel 18 turns. It is fastened at its other end to the Flat Plates 6.

These Plates 6 should be secured in place as soon as the bed frame is completed. Three 5½" by 3½" and two 5½" by 2½" Flat Plates are used, as shown in Fig. 1.

The building of the cylinder and valve-casing should next be completed. The cylinder 7 is constructed from two Face Plates 8 and 3½" by ½" Double Angle Strips 9. The valve-casing 10 consists of two Bush Wheels and four 1½" by ½" Double Angle Strips, a 1" fast Pulley Wheel being placed in the casing prior to fastening the Strips to the Bush Wheels. The casing is secured to the bed plate by nuts and bolts.

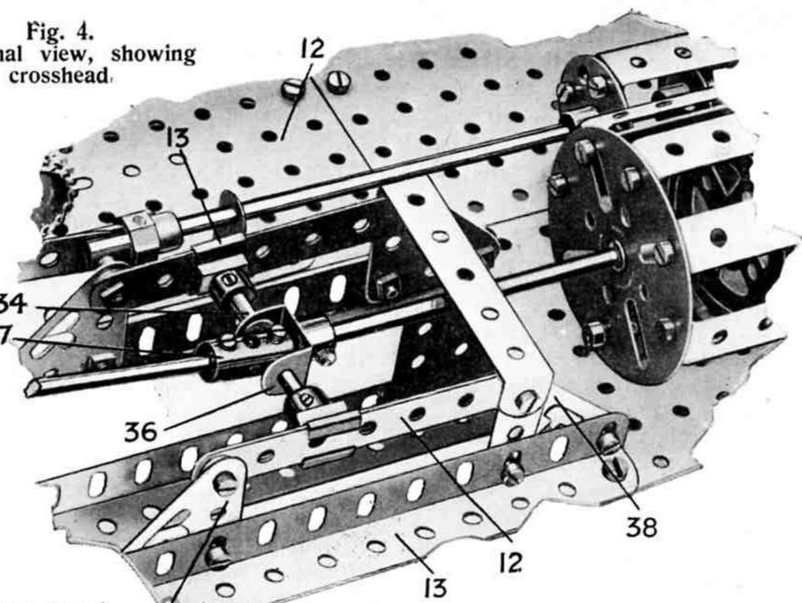

Fig. 4. Sectional view, showing crosshead.

The Crosshead

The crosshead 11 should next be built up. It is shown in detail in Fig. 4. The slide-bars are supported at their ends by Corner Brackets 38, which are bolted to 5½" Angle Girders placed one on each side of the opening in the bed frame, as can be seen in Fig. 1. The crosshead framework is strengthened at the end nearest the cylinder by means of a 2½" by ½" Double Angle Strip bolted to two of the Corner Brackets 38.

To the slide-bars 12 is attached the slidable portion of the crosshead. This consists of a Large Fork Piece 36 fastened to the end of the piston rod, and a Coupling 37 pivoted in the end of the Fork Piece by means of a 2" Rod 34. When passing the Rod 34 through the Fork Piece and Coupling two Washers should be slipped on each side of the Coupling to retain it in the correct position in the centre of the Fork Piece. Eye Pieces with Bosses are next fitted on to each end of the Rod 34 and arranged to engage the slide-bars 12.

The Crankshaft.

The next portion to be assembled is the crankshaft and flywheel. The bearings for the crankshaft consist of Flat Trunnions 16 secured to 1½" Angle Girders 17, which, in turn, are bolted to the flanges of the Plates 2. The flywheel consists of a Circular Girder 18 connected by means of 2½ Strips 19 to a Bush Wheel fastened to the shaft 20. (A Hub Disc will serve equally well for the flywheel.) The Bush Wheel is adjusted so that the edge of the Circular Girder has plenty of room to turn freely in its slot.

A detailed view of the crankshaft is shown in Fig. 3. Each crank arm consists of two Cranks 15 and 40 bolted one on each side of a 2½″ Triangular Plate 14. The inner end of the 2″ Axle Rod 39 is secured in the Crank 15, and the inner end of the 5″ Rod 20 is gripped in the boss of the corresponding Crank 15 on the other crank arm.

The crank pin consists of a 2″ Axle Rod 41 secured in the bosses of Cranks 40. The end bearing of the connecting rod consists of a Coupling that is free to turn about the Rod 41, the set-screw in its end having been removed. A Handrail Support 42 is inserted in place of the set-screw, four Washers 43 being placed on its shank to prevent the latter touching the crank pin 41. By removing the Handrail Support the crank pin may be lubricated. The purpose of balancing the crankshaft by securing the Triangular Plates 14 to the crank arms is to ensure smooth rotary motion of the engine.

It will be realised that every time the crankshaft completes a half revolution the crank arms, connecting rod, and piston rod all come into alignment. Hence in this position, which is known as the "dead point," there is a tendency for the whole mechanism to come to rest unless some means is devised to carry it round until the piston can again exert its force. The heavy fly-wheel overcomes the tendency by storing up energy during the piston stroke, which energy can be expended in carrying the crankshaft over the "dead centre."

A 1″ Sprocket Wheel 29 on the Axle Rod 20 is connected by an endless Sprocket Chain 30 to the 1″ Sprocket Wheel 31, which drives the governor mechanism. A Triple-throw Eccentric is also fastened to the Rod 20, the ¾″ throw being used. This Eccentric provides the reciprocating motion that actuates the piston valve rod, to which it is joined in the following manner. A Strip Coupling is pivoted on a ⅜″ Bolt passed through the end hole of the Eccentric arm, and a 5½″ Rod 22 is fastened to the Strip Coupling. The Rod 22 has a Coupling attached to its other end, and this Coupling is pivoted to a large Fork Piece 23 by means of a 1″ Axle Rod held in place by two Collars. A Washer is placed on each side of the Coupling in order to eliminate side play.

The valve rod 24 is fastened in the boss of the Large Fork Piece 23 and is attached to the 1″ Pulley Wheel which represents the piston valve in the casing 10. The Rod 24 is guided in a 1″ by 1″ Angle Bracket 25 bolted to one of the Flat Plates 6.

The Centrifugal Governor

A separate view of the centrifugal governor is shown in Fig. 5. Its support is built up from Trunnions 48, bolted to one of the base Plates 6, and 1½″ Strips 47. A 1½″ by ½″ Double Angle Strip is fastened to the Strips 47 by means of ⅜″ bolts, Washers being placed between the Double Angle Strip and the Strips 47 to obtain the correct spacing. A 1″ Sprocket Wheel 31 and ¾″ Contrate Wheel 32 are fastened on a 2″ Rod journalled in the centre holes of the Strips 47, and a ¾″ Pinion 46 meshes with the Contrate 32.

The Pinion 46 is secured to a 2″ Axle Rod journalled in the 1½″ by ½″ Double Angle Strip and also in the Double Bent Strip 45. A Strip Coupling 44 attached to the upper end of the Rod carries in its slot the 1½″ Strip that supports the governor arms. The latter consist of 1½″ Strips pivoted at their upper ends by bolts and lock-nuts and carrying at their lower ends the weights, which consist of 1″ loose Pulley Wheels 33 fastened to the Strips by means of ⅜″ Bolts and Nuts. When the 1″ Sprocket Wheel 31 is rotated by means of the Sprocket Chain 30 and the 1″ Sprocket Wheel 29 (Fig. 1), the vertical 2″ Rod carrying the governor arms is set in motion and the weights 33 will rise higher and higher as the speed of the engine increases, owing to centrifugal force.

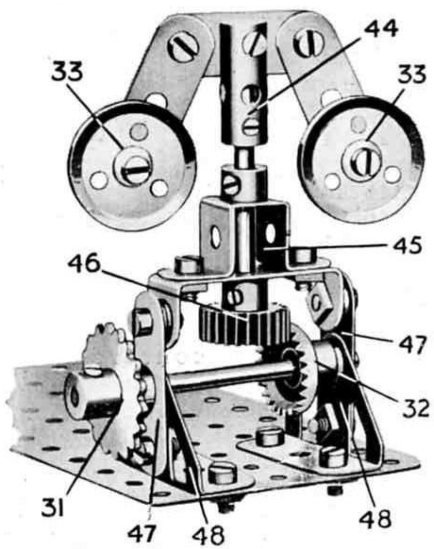

Fig. 5. The Centrifugal Governor

In the actual engine the weights 33 are coupled to a collar sliding on the vertical shaft of the governor, and the movement of this collar is caused to actuate the valve that controls the supply of steam to the cylinder. If the engine's speed exceeds a certain limit the rising weights commence to close the supply valve, thus diminishing the amount of steam passing through the cylinder, and the speed of the engine drops accordingly.

The model is completed by fixing the Electric Motor in position and coupling it to the crankshaft. The Motor is attached to the engine bed by means of a 9½″ Angle Girder at one side and by an Angle Bracket at the other side. The drive from the armature shaft is led through reduction gearing and a Sprocket Chain drive to the crankshaft. The gear train consists of a ½″ Pinion on the armature shaft engaging with a 57-teeth Gear Wheel on a secondary shaft and another ½″ Pinion on this shaft meshing with a second 57-teeth Gear Wheel, which may be seen in Fig. 1. A 1″ Sprocket Wheel on the shaft of the latter Gear Wheel is connected to the 2″ Sprocket Wheel 28 by means of the endless Chain 27.

This gearing is designed for use with the 6-volt Motor, and if assembled exactly as described the model will work easily at a fair speed. If an old type high-voltage Motor is used, a reduction of speed will be necessary. This can be effected, of course, by adding to the number of gears in the transmission gear train.

To ensure smooth running of the engine special care should be taken to see that all the bearings are in correct alignment and are kept properly lubricated.

List of Parts Required to Build the Horizontal Engine

2 of No. 3	1 of No. 8a	2 of No. 12	2 of No. 16	3 of No. 24	4 of No. 48	14 of No. 59	26″ of No. 94	2 of No. 126
11 ,, ,, 4	3 ,, ,, 9	1 ,, ,, 12a	2 ,, ,, 16a	3 ,, ,, 26	4 ,, ,, 48a	4 ,, ,, 62	1 ,, ,, 95	3 ,, ,, 126a
8 ,, ,, 5	1 ,, ,, 9d	1 ,, ,, 13	5 ,, ,, 17	2 ,, ,, 27a	6 ,, ,, 48b	6 ,, ,, 63	3 ,, ,, 96	4 ,, ,, 133
1 ,, ,, 6	3 ,, ,, 9f	2 ,, ,, 14	2 ,, ,, 18a	1 ,, ,, 29	2 ,, ,, 50a	2 ,, ,, 63b	2 ,, ,, 109	3 ,, ,, 136
5 ,, ,, 6a	4 ,, ,, 10	1 ,, ,, 15	1 ,, ,, 20a	160 ,, ,, 37	7 ,, ,, 52	3 ,, ,, 70	2 ,, ,, 116	1 6-volt Elec. Motor
7 ,, ,, 8	2 ,, ,, 11	1 ,, ,, 15a	1 ,, ,, 22	20 ,, ,, 38	2 ,, ,, 52a	2 ,, ,, 76	1 ,, ,, 118	
			2 ,, ,, 22a	1 ,, ,, 45	4 ,, ,, 53			