Meccano Three-Engine Biplane

A FINE MODEL OF AN ARMSTRONG WHITWORTH "ARGOSY" THREE-ENGINE PASSENGER AIR LINER, AS BUILT FOR THE IMPERIAL AIRWAYS LONDON-PARIS SERVICE

SPECIAL FEATURES

The unit construction of the model renders wings, fuselage, tail, engines, etc., readily detachable. All controls work as on the actual machine. The three propellers are driven by a Meccano 4-volt Electric Motor mounted in the fuselage.

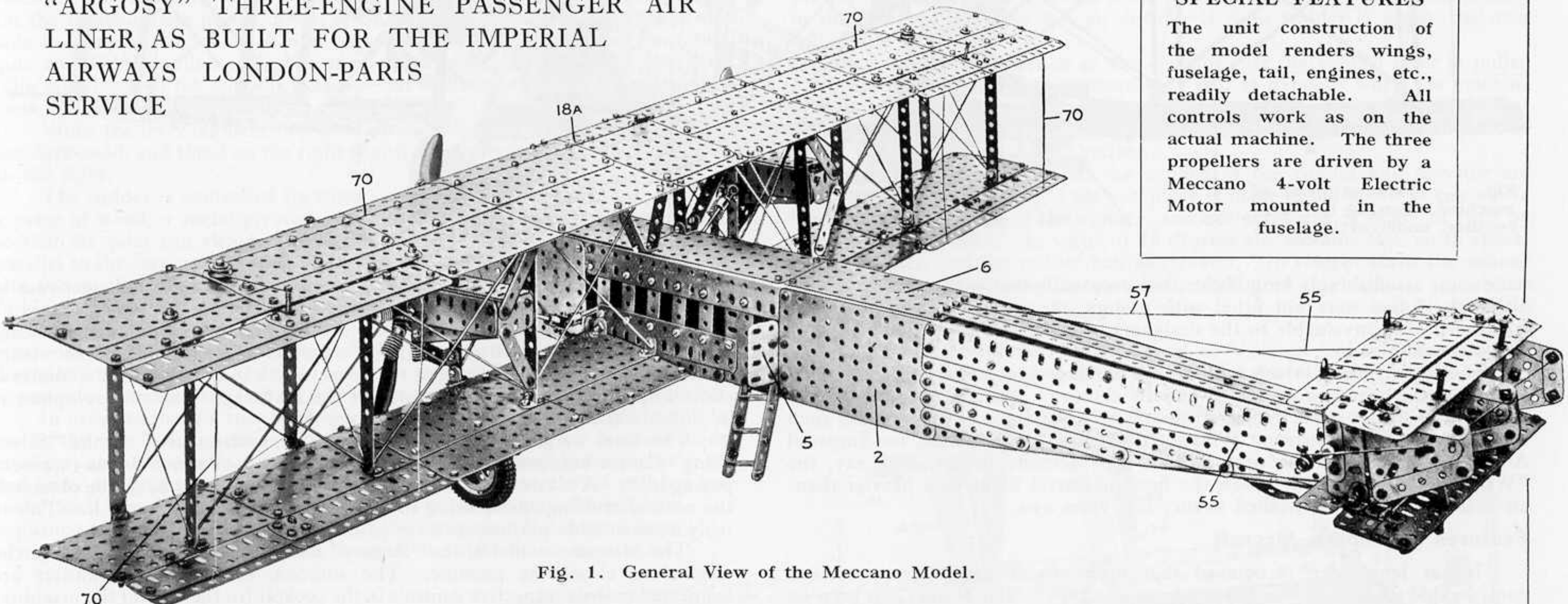

Fig. 1. General View of the Meccano Model.

THE desire to conquer the air has possessed man throughout the ages. For example, Icarus, of ancient Greek legend fame, sought to cross the Ægean Sea by fastening wings to his shoulders with wax. The sun shone so fiercely, however, that it melted the wax and Icarus forthwith did what would nowadays be described as a "nose dive," into the Ægean Sea !

Many would-be aeronauts suffered a more or less similar fate, for it was thought that successful flight could only be attained by constructing a device that imitated the actions of a bird in flight. Such machines were operated invariably by "man power," which often proved inadequate for the task and so spelt disaster !

But it was not along these lines that the conquest of the air was achieved. It was left to Lilienthal, a German who experimented with gliders, to solve successfully the problem of flight. He proved that a machine with fixed planes could be made to glide through the air. The glider was launched from a hill top or similar elevated position and flew through the air at a slight downward angle to maintain sufficient speed, making a landing some distance away. He

Published by MECCANO LTD., BINNS ROAD, LIVERPOOL
Printed in England

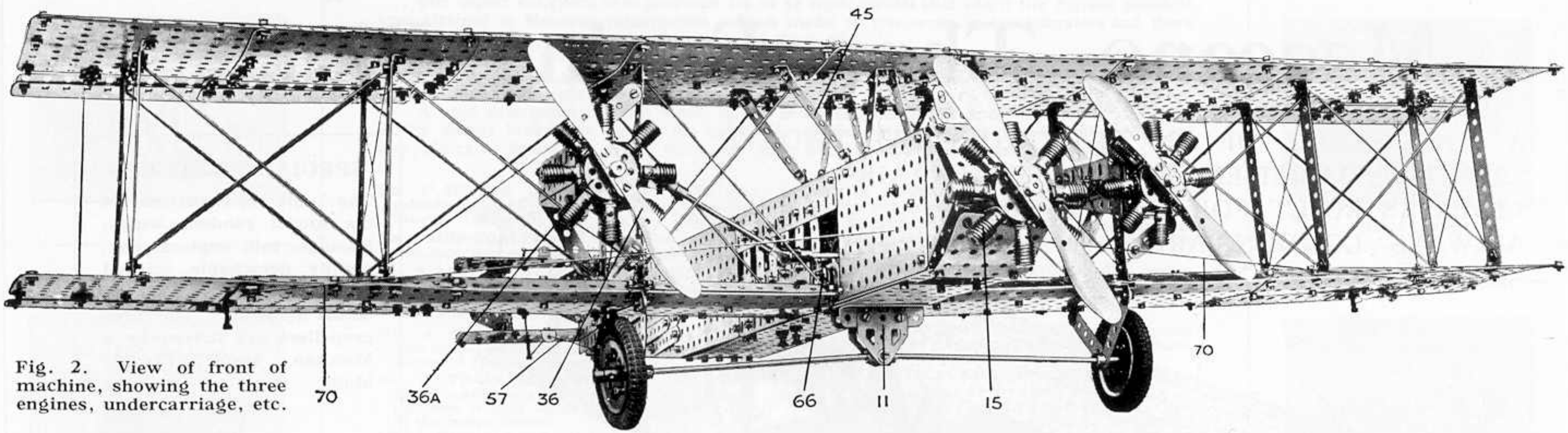

Fig. 2. View of front of machine, showing the three engines, undercarriage, etc.

made some astonishingly long flights, but eventually met with a fatal accident. Although gliders were not fitted with motors, the study of their behaviour in flight proved invaluable to the designers of the power-propelled aeroplane that was yet to come.

The rapidity with which aviation has developed, especially since the war, is one of the wonders of the twentieth century. Perhaps an idea of the tremendous strides made in aircraft design may be grasped by comparing such a machine as the Armstrong Whitworth "Argosy" type, made for Imperial Airways Limited and the prototype of the Meccano model, with say, the "Wright" aeroplane with which the first successful flight of a heavier-than-air machine was accomplished twenty-five years ago.

Features of Modern Aircraft

It has long been recognised that multi-engine aeroplanes possess a considerable advantage over the single-engine type. The former can keep on flying even if one engine stops : but the single engine machine has to come down in the event of engine failure.

The practical difficulties of employing multiple engines in aircraft are fast disappearing and it is evident that the multi-engine planes will be the aircraft of the future. The three-engine "Argosy" aeroplane, for instance, represents one of the finest examples in modern aircraft design. It is a very large machine, having a wing span of approximately 90 feet and accommodation for 20 passengers. The three Siddeley "Jaguar" engines develop 1,200 h.p., and each drives a tractor airscrew. Balanced ailerons and elevators are fitted, thereby permitting manœuvring to be carried out without undue fatigue to the pilot.

The fuselage and many other parts of the machine are of tubular steel construction. As modern research has proved conclusively, this method of construction is vastly superior to the old method of using wooden spars. This point will be realised from the fact that a correctly shaped steel spar is nearly 25 per cent. stronger than a wooden spar weighing 20 per cent. more.

The main passenger saloon is designed on very commodious lines, being some 30 feet long and 6 feet high. Two rows of very comfortable wicker armchairs are provided, and large windows, which may be opened if desired, allow a splendid view to be obtained of the landscape when the aeroplane is in flight, besides making the saloon very light.

The total weight of each of the Argosy machines used on the "Silver Wing" service between London and Paris, is 8 tons, of which 2 tons represent paying load. A maximum speed of approximately 110 m.p.h. can be obtained, the normal cruising speed being in the neighbourhood of 95 m.p.h. This is truly a remarkable performance for so huge a machine.

The Meccano model of the "Argosy" has been designed to resemble the original as closely as possible. The ailerons, elevators and rudders are connected to their respective controls in the cockpit (in the nose of the machine) by wires, and work as in the prototype. One 4-volt Meccano Electric Motor concealed in the fuselage drives the three propellers at the armature speed of the Motor, no reduction being found necessary.

How an Aeroplane is Controlled

At this juncture it would be well to give Meccano boys a brief description of the controls of an aeroplane and the manner in which they are used.

From the bottom of the fuselage in the pilot's seat there projects a vertical bar, called the control column, or "joystick." This is pivoted about three-quarters of the way down and can be moved backward and forward and from side to side from the pivoting point. The stick controls the elevator and ailerons. The elevator is a horizontal controlling flap set parallel to the main planes at the rear of the machine and hinged so that it can be moved upward and downward. It is connected to the control column by wires so that, when the stick is pushed forward, the elevator moves downward from its hinge, thus presenting more resistance to the air when the aeroplane is in flight and sending the nose of the machine downward. When the stick is pulled back the elevator flap is raised and the nose of the machine goes up.

The control column is also connected to the aileron flaps on each of the four wings. These flaps move upward or downward according to the movements of the control column. When the stick is moved to the left, the ailerons on the right side are pulled down, setting up an additional resistance on that side and causing that wing to rise. At the same time the ailerons on the left side are slightly pulled up, assisting the downward motion of the left wing. The movement of the ailerons is slight, but sufficient to cause the machine to bank and make an effective turn.

When the lever is pushed to the right, on the other hand, the left ailerons are depressed, and those on the right slightly raised, so that the machine banks to the right.

The rudder is controlled by wires connected to the rudder bar, which is a piece of wood or metal pivoted about its centre and arranged athwartships, so that the pilot can swing it about its centre with his feet. The rudder is parallel to the fore-and-aft line of the machine when the rudder bar is square, and the machine will then fly straight, but if one side is pushed forward the rudder is swung in the same direction. For example, if the left foot is pushed forward the rudder swings to the left, more resistance to the wind being thus given on that side, so that the tail of the machine is forced to the opposite direction and the nose of the machine turns to the left. To turn the machine to any side, therefore, the foot on that side is pushed forward on the rudder bar.

In order to make a turn, however, it is not sufficient to move the rudder bar in the required direction. If the rudder only is used the machine skids, or slips outward, an effect due to the difference in speed between the inner and outer wing tips. The aeroplane must be banked so that it will not lose speed and slip outward. Thus, to make a left-hand turn the left foot is pushed forward on the rudder and at the same time the control lever is moved to the left. When the machine is to be flown level again, the control lever is pushed across again and a little past the central position, and the right foot is pressed on the rudder. The controls are then centred so that the machine flies straight and level.

These, in brief, are the actions of the controls. It would be advisable for the reader, however, to give some consideration to the problem of what is known as the "inversion of controls."

Suppose the machine is executing a vertical turn, that is, a turn in which the aeroplane is on its side relative to the horizon. If the machine is given left rudder—which means that the left foot is pushed forward—when the aeroplane is on the turn, which we are assuming to be a left-hand one, the nose will turn toward the left wing, as it would if the machine were flying level, but, relative to the horizon, the nose will go down. If right rudder is given, the nose will go up.

Now consider the action of the elevator. If the control lever is pulled back, the nose will tend to approach the tail, as happens when the machine is flying level. But, as the machine is on its side, the action of the elevator is simply that of forcing the machine to turn, as it now occupies the position of the rudder, relative to the horizon.

Thus, on a vertical bank, the actions of the rudder and elevator are reversed—that is, the nose of the aeroplane is made to fall below or rise above the horizon by means of the rudder, and the aeroplane is made to turn by means of the elevator. In turns of 45 degrees the elevator acts, so to speak, half as rudder, and the rudder half as elevator. In steeper turns the actions of the rudder and elevator become more and more reversed.

Construction of the Fuselage

The building of the body of the model, or "fuselage," should be proceeded with first. It consists essentially of four $18\frac{1}{2}''$ Angle Girders 1 with four $12\frac{1}{2}''$ Angle Girders bolted to their ends to form the sloping tail portion. Two $5\frac{1}{2}'' \times 3\frac{1}{2}''$ Flat Plates 2 are bolted at each end of the Girders 1. (In Fig. 3 the

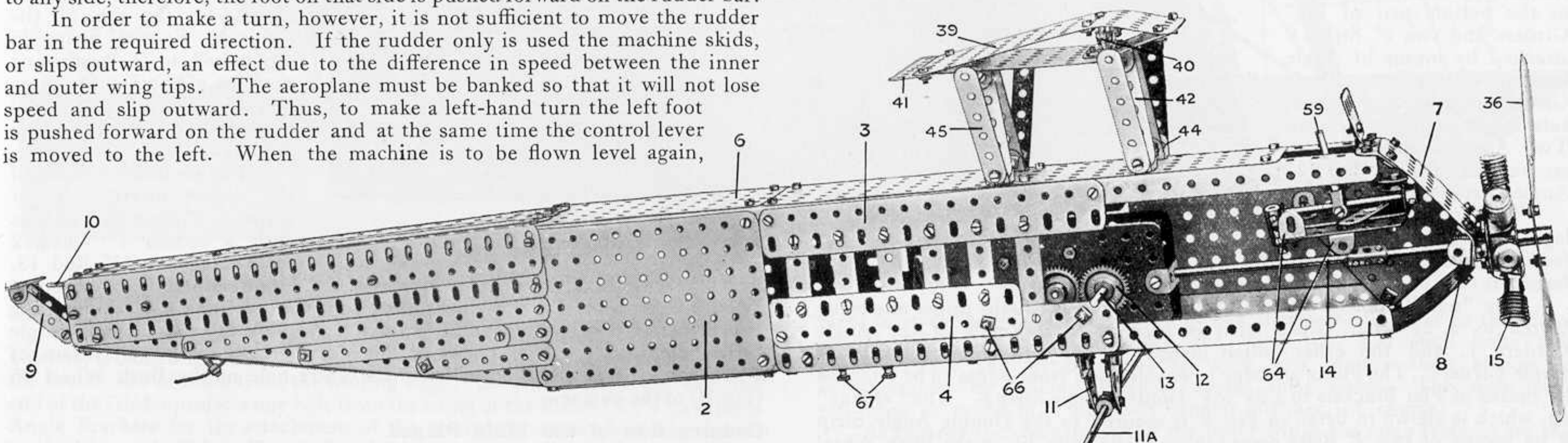

Fig. 3. Fuselage, with one side removed to show Electric Motor.

Plate at the front end has been removed to show the inside details of the fuselage). The saloon windows are represented by 2" Strips bolted to a $7\frac{1}{2}$" Flat Girder 3 and also to a $5\frac{1}{2}$" Flat Girder 4, the latter being secured to another $7\frac{1}{2}$" Flat Girder that is attached to the bottom Girder 1. The construction of the windows on the opposite side of the saloon is similar to that just described, except that a door 5 (Fig. 1) consisting of a 2" Flat Girder, is hung from the Plate 2 by means of Hinges. To accommodate the door the Flat Girders on this side are moved forward four holes and also the rearmost 2" Strip is omitted, a $3\frac{1}{2}$" Flat Girder taking its place.

The sides of the tapering tail portion of the fuselage formed by the $12\frac{1}{2}$" Angle Girders are closed in by means of $12\frac{1}{2}$" Flat Girders and Strips, disposed as indicated in Figs. 1 and 3. The upper and lower $12\frac{1}{2}$" Angle Girders have their extreme ends held together by $1\frac{1}{2}$" Angle Girders.

The top of the fuselage is composed of $5\frac{1}{2}$"$\times 2\frac{1}{2}$" Flat Plates 6 bolted to the Girders 1, a space being left at the front end for the cockpit. The top of the tapering portion consists of three $12\frac{1}{2}$" Strips bolted at the rear end to a $1\frac{1}{2}$" Angle Girder that is secured across the ends of the two top $12\frac{1}{2}$" longitudinal Girders. Another $1\frac{1}{2}$" Girder is secured to the bottom pair of $12\frac{1}{2}$" Girders and two 2" Strips 9 attached by means of Angle Brackets to this lower Angle Girder carry two Angle Brackets at the ends as shown. Two Angle Brackets 10 are secured also to the top $1\frac{1}{2}$" Angle Girder.

The bottom of the fuselage may be left open to facilitate erection, or, if preferred, it may be filled in in a similar manner to the top.

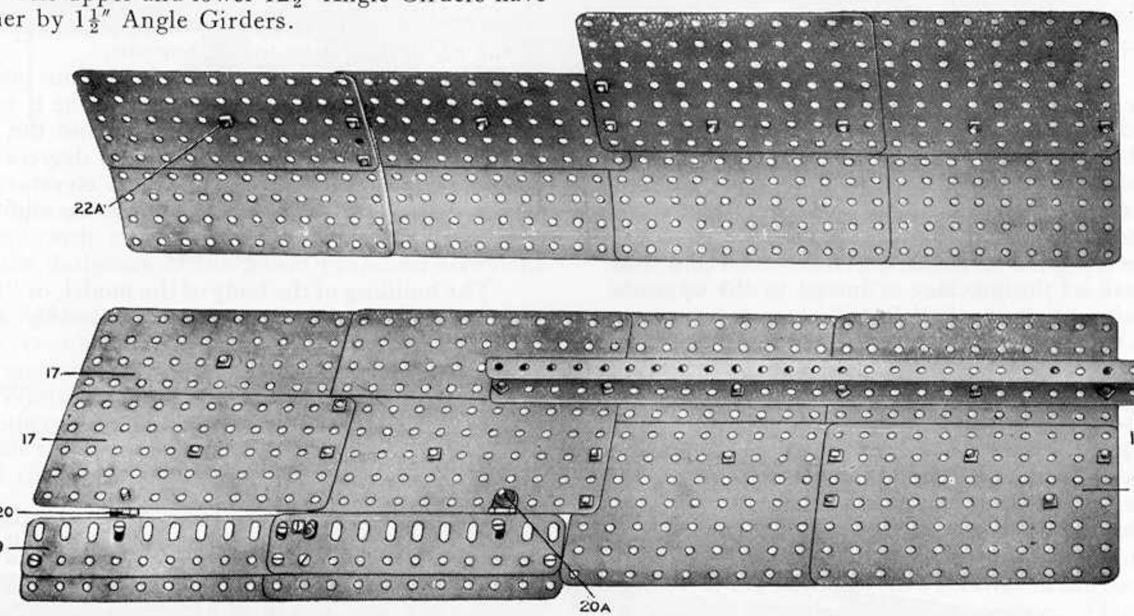

Fig. 4. Left-hand top plane "laid open" to show interior construction.

The "nose" consists of two $2\frac{1}{2}$"$\times 2\frac{1}{2}$" Flat Plates 7, the upper one being bolted to a $2\frac{1}{2}$" Flat Girder that is secured to the ends of the Angle Girders 1, and the other bolted directly to the end holes of the lower Angle Girders. The Plates are bent to enable their front edges to be attached by means of Flat Brackets to a $2\frac{1}{2}$"$\times \frac{1}{2}$" Double Angle Strip 8. The "engine" 15, which is shown in detail in Fig. 8, is secured to the Double Angle Strip 8 by means of two $\frac{1}{2}$" Bolts passed through the holes 29a in the Bush Wheel 35. A Collar on each bolt serves to space the engine away from the Double Angle Strip.

A $2\frac{1}{2}$"$\times 2\frac{1}{2}$" Flat Plate on each side of the model is bolted diagonally to the end holes of the Girders 1 and to the Double Angle Strip 8 to complete the sides of the fuselage. The controls (Fig. 6) are secured in place by means of the Angle Brackets 64 : the position in which they are bolted to the Plates 2 is shown clearly in Fig. 3.

Two Flat Trunnions 11 secured to $2\frac{1}{2}$" Angle Girders that are bolted across the bottom Girders 1 (Fig. 3) carry a Coupling, in the longitudinal bore of which two 8" Rods 11a are secured. The Coupling is secured to the Trunnion by means of bolts that are passed through the end holes of the Trunnions and inserted in the tapped centre holes of the Coupling. A Washer is placed on the shank of each bolt between the Coupling and the Trunnion, and the bolts tightened up securely.

The centre wing section (Fig. 3) is shaped to the streamline section of the main planes and consists of two $5\frac{1}{2}$"$\times 3\frac{1}{2}$" Flat Plates 39, with two $2\frac{1}{2}$" Angle Girders 40 bolted between them after the manner of the Girders 18 in Fig. 4. A $3\frac{1}{2}$" Flat Girder 41 is attached to the trailing edge of these Plates. Four $2\frac{1}{2}$" Strips 42 are bolted to two Double Brackets attached to the underside of the centre section and their other ends are bolted to two pairs of Double Brackets 44 that are secured to the top of the fuselage. Four 3" Strips 45 are bolted to the remaining portions of the Double Brackets 44. From Fig. 2 it will be seen how these Strips are arranged.

The armature spindle of the 4-volt Electric Motor carries a 1" Gear that meshes with a second 1" Gear 12 secured on the $4\frac{1}{2}$" Rod 13. The latter is journalled in the side plates of the Motor and projects an equal amount either side of the fuselage. The same Rod carries a 1" Bevel meshing with a second Bevel on the Rod 14, which is journalled in a $1\frac{1}{2}$" Double Angle Strip bolted to the side plates of the Motor and connected by means of a Coupling to a $3\frac{1}{2}$" Rod journalled in the centre hole of the Bush Wheel 35 (Fig. 8) of the engine.

Construction of the Main Planes

The construction of the main planes should next be undertaken. Fig. 4 shows the construction of the top left-hand wing, Fig. 10 the complete bottom left-hand wing, whilst Fig. 5 gives the complete right-hand bottom and top wing unit, with engine, bracing wires, and interplane struts.

To describe first the construction of the portions of the dissembled top wing shown in Fig. 4. As will be seen from the illustration it is double surfaced—a feature common to all the wings—each half consisting of six $5\frac{1}{2}'' \times 3\frac{1}{2}''$ Flat Plates and two $5\frac{1}{2}'' \times 2\frac{1}{2}''$ Flat Plates. The Plates 16 are overlapped two holes in the direction of their length and by the same amount in regard to their width. The Plates 17, however, are overlapped one hole in length and three in width. The edges of the $3\frac{1}{2}'' \times 5\frac{1}{2}''$ Flat Plates forming the leading edges of the top and bottom halves are curved slightly, so that when they are bolted together the complete wing has a streamline section as in an actual aeroplane wing. (The profile of the centre section 39, Fig. 3, gives a good idea of the shape that the main planes, in section, should present).

The two halves of the wing may now be bolted together, $\frac{3}{8}''$ Bolts being used to draw the leading edges of the Plates together whilst ordinary bolts are used for the trailing edges of the Plates 16. The aileron 19, consisting of four $5\frac{1}{2}''$ Flat Girders, is hung from the trailing edges of the $2\frac{1}{2}'' \times 5\frac{1}{2}''$ Flat Plates 17 by means of Hinges 20. It will be found that when the two halves of the wing are fitted together there is a space between the trailing edges of the Plates 17. Therefore it is necessary to place four Washers—two on each side of the Hinge—on the $\frac{3}{8}''$ Bolt 20a (see also Fig. 4). The Hinge nearest the tip is merely bolted direct to the top of the wing surface.

It should be apparent from the various illustrations that from the end of the $12\frac{1}{2}''$ Angle Girders 18 the upper and lower wing surfaces taper towards the wing tips. In view of this, therefore, the curve on the Plates should gradually diminish toward the wing tips and such bolts that project inside the wings near the wing tips require their shanks to be shortened by placing Washers under their heads. The right-hand top wing is made in a precisely similar manner, of course.

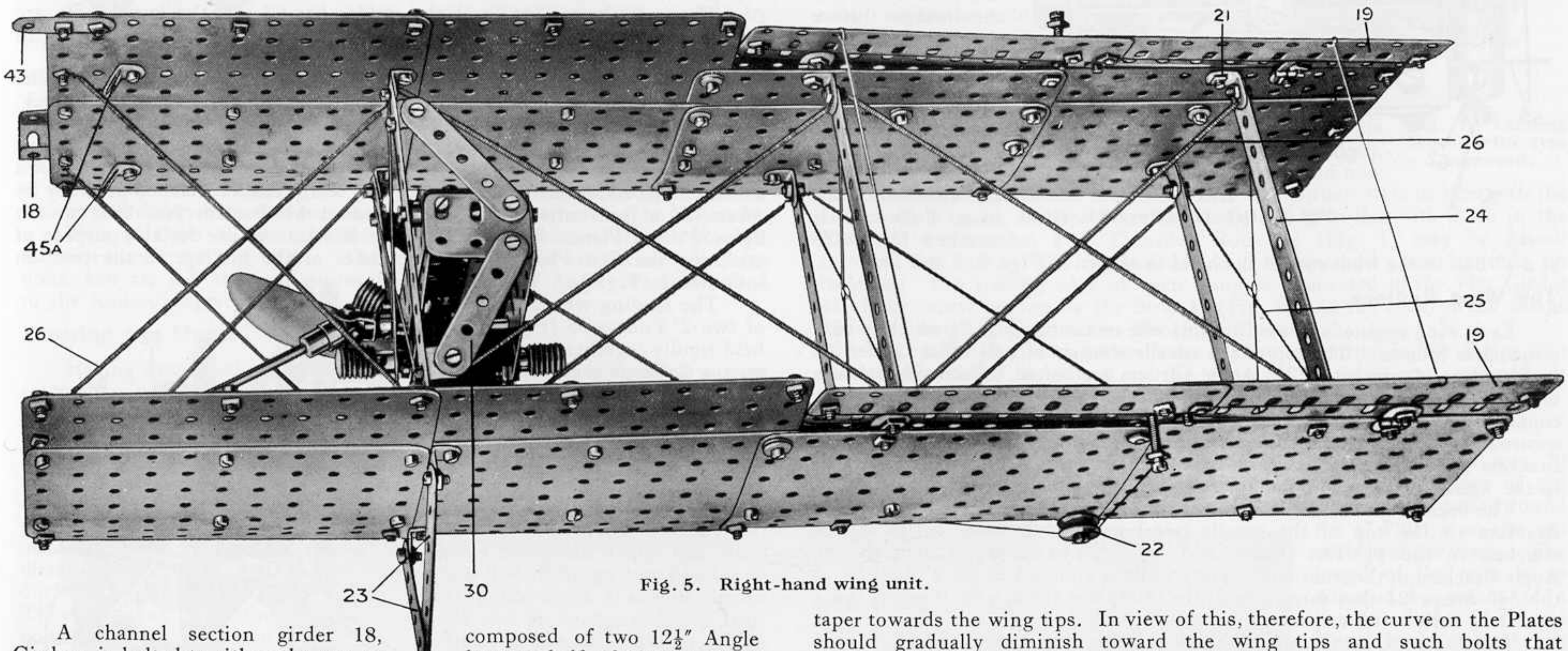

Fig. 5. Right-hand wing unit.

A channel section girder 18, composed of two $12\frac{1}{2}''$ Angle Girders, is bolted to either the top or bottom half of the wing, in the fourth row of holes from the leading edge. It will be observed that the end of the Girder projects one hole from the edges of the Plates 16. The various Angle Brackets for the attachment of the interplane struts should be bolted to the bottom half (see Figs. 1, 2 and 5 for the correct location of these Angle Brackets), and a $\frac{1}{2}''$ loose Pulley is attached to the top half by means of a $\frac{1}{2}''$ Bolt that is held in place by nuts on each side of the Plate (see Fig. 1). The Pulley is free on the bolt, of course.

As regards the construction of the lower wings the main features are the same as in the case of the top wings, but each one is only $4\frac{1}{2}''$ wide as compared with the $5\frac{1}{2}''$ of the top ones : they are also $\frac{1}{2}''$ longer. The upper and lower surface of each bottom wing consists of four $5\frac{1}{2}'' \times 3\frac{1}{2}''$ Flat Plates (Fig. 10) all overlapped one hole, thus giving the extra $\frac{1}{2}''$ in length compared with the

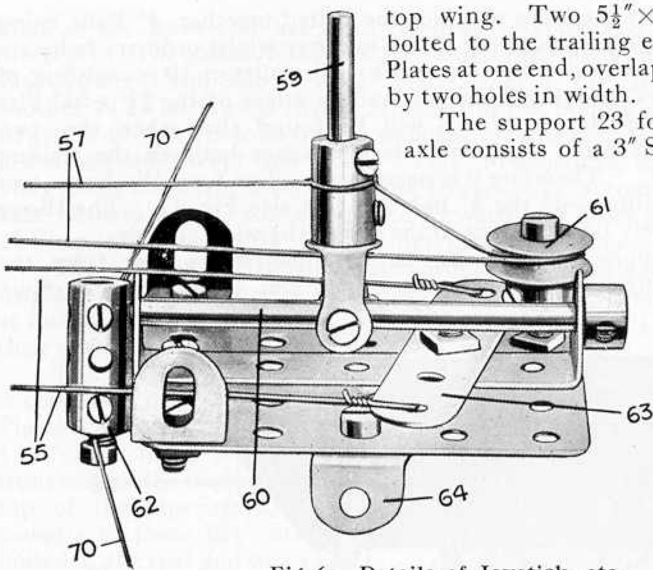

Fig 6. Details of Joystick, etc.

top wing. Two $5\frac{1}{2}'' \times 2\frac{1}{2}''$ Flat Plates are bolted to the trailing edges of the $5\frac{1}{2}'' \times 3\frac{1}{2}''$ Plates at one end, overlapping the latter Plates by two holes in width.

The support 23 for the landing wheel axle consists of a $3''$ Strip and a $2\frac{1}{2}''$ Strip, and is attached by $\frac{1}{2}'' \times \frac{1}{2}''$ Angle Brackets to the bottom surface of the wing. The Angle Brackets must be bolted to the wings before the latter are closed up, of course, a fact that should be borne in mind also with regard to the Angle Brackets to which the interplane struts are attached. The loose Pulley 22 is attached by means of a $\frac{1}{2}''$ Bolt in the front row of the holes as shown in Figs. 2, 5 and 10.

The Wing Engines

Each wing engine is housed in a nacelle or casing (Fig. 7) which is constructed as follows. The top of the nacelle consists of a $3\frac{1}{2}''$ Flat Girder 27, to the edges of which two $3\frac{1}{2}''$ Angle Girders are bolted. Each side consists of $3\frac{1}{2}''$ Flat Girders arranged in the manner shown, the bottom edges being connected together by a $1\frac{1}{2}'' \times \frac{1}{2}''$ Double Angle Strip. An Angle Bracket is secured to the centre hole of this Double Angle Strip, and two further Angle Brackets are secured to the front edges of the side Flat Girders as indicated in the figure. Three $\frac{3}{8}''$ Bolts 29 are bolted to these Angle Brackets.

The back of the nacelle is formed by a $1\frac{1}{2}''$ Flat Girder attached by Angle Brackets to the top of the nacelle (see Fig. 5). Two $2\frac{1}{2}''$ Strips 30 are attached to the $1\frac{1}{2}''$ Flat Girder, and two $2''$ Strips 32 are secured also by Angle Brackets to the front end. The nacelle is attached by the $\frac{3}{8}''$ Bolts 31 to the $5\frac{1}{2}''$ Strips 24 that form two of the interplane struts, two Washers being placed on each bolt for spacing purposes.

The $2''$ Rod 33 is journalled in the Flat Girders composing the sides of the nacelle, and carries a $\frac{7}{8}''$ Bevel 34, which is intended to mesh with a second Bevel that is secured to a $1\frac{1}{2}''$ Rod journalled in the centre hole of the Bush Wheel 35 (Fig. 8). Eight Angle Brackets are arranged round the periphery of the Bush Wheel and carry the Worms representing the cylinders, which are attached to the Angle Brackets by $\frac{3}{8}''$ Bolts. A Bush Wheel 36a (Fig. 2) is secured to the $1\frac{1}{2}''$ Rod close to the Angle Brackets and, lastly, the propeller 36, consisting of two Propeller Blades bolted to a Double-arm Crank, is secured in position on the Rod. The $\frac{3}{8}''$ Bolts 29 bolted to the Angle Brackets on the nacelle are passed through the holes 29a in the Bush Wheel 35, nuts holding the latter in place. The left-hand wing engine nacelle is shown in Fig. 7 : the other for the right-hand wing is exactly similar.

Having made all the wings and also the two engine nacelles it remains only to assemble them into a complete unit as shown in Fig. 5. The interplane struts 24 are attached to the Angle Brackets 21 by nuts and bolts, the latter serving also to secure the various "bracing wires." The Loom Healds 25 prevent fore and aft movement of the struts, whilst the Spring Cord 26 is intended to brace the planes in a vertical direction. The complete unit should now appear as in Fig. 5.

The Controls

The controls, consisting of the rudder bar 63 and the joystick 59, are mounted together on a $2\frac{1}{2}'' \times 2\frac{1}{2}''$ Flat Plate for convenience in fixing them in the fuselage.

The joystick is a $1\frac{1}{2}''$ Rod held in the boss of a Swivel Bearing. The latter's "spider" is secured to the $3''$ Rod 60, which is journalled in a $2\frac{1}{2}'' \times \frac{1}{2}''$ Double Angle Strip bolted to the Flat Plate and carries a Coupling 62 secured to one of its ends. The $\frac{1}{2}''$ loose Pulley 61 is journalled on a $\frac{3}{4}''$ Bolt attached to the Plate by two nuts, and is retained in position on the bolt by means of a Collar. The rudder bar 63 consists of a $2\frac{1}{2}''$ Strip that is attached pivotally by means of a lock-nutted bolt (see Standard Mechanism No. 262) to the $2\frac{1}{2}'' \times 2\frac{1}{2}''$ Flat Plate. The $\frac{1}{2}'' \times \frac{1}{2}''$ Angle Brackets 64 are for the purpose of attaching the Flat Plate to the side Plates of the fuselage in the position indicated in Fig. 3.

The landing wheels each consist of two $2''$ Pulleys 65 (Fig. 9) that are held rigidly together by $\frac{1}{2}''$ Bolts and nuts, a Collar on each bolt spacing the Pulleys the required distance apart. The Wheels are shod with two $2''$ Dunlop Tyres, which are sprung in the groove formed between the two Pulleys

The Tail Unit

As will be seen from Fig. 11, both the upper and lower elevators (fixed and moving) of the tail unit are exactly similar in construction : therefore the description of one should suffice to make the whole clear. The fixed portion of the elevator consists of a $7\frac{1}{2}''$ Flat Girder 47 and another Flat Girder 46 $8\frac{1}{2}''$ in length (obtained by bolting

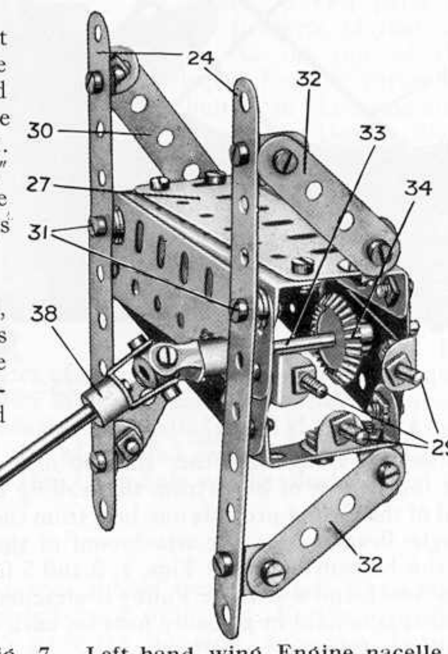

Fig. 7. Left-hand wing Engine nacelle.

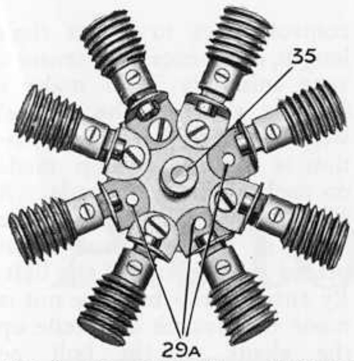

Fig. 8. One of the three Engines.

a 1½″ Flat Girder to one end of a 7½″ Girder). The two Girders are connected together at each end by means of Flat Brackets, a 1½″ Strip lending additional support in the centre. The longer Girder 46 overlaps the shorter one by one hole at each end.

The movable portion of each elevator consists of a 9½″ Flat Girder with 2″ Flat Girders bolted at right angles to its ends. It is attached to its respective fixed portion by Hinges 49. The two units—consisting of one fixed and moving plane—are spaced apart by 2½″ Flat Girders 50 attached by means of ½″×½″ Angle Brackets to the Flat Girders 47. Bolted to the Flat Girders 50 are Hinges to which the rudders 51 are attached. The rudders each consist of a 2½″ Triangular Plate, along the edges of which two 2½″ Strips and a 1½″ Strip are bolted.

Double-arm Cranks 53 are bolted to the two outside 2½″ Flat Girders 50, and Collars 54 are secured on the ends of 1½″ Rods held in the bosses of the Double-arm Cranks. The rudder wires 55 are to be taken round the shanks of ordinary bolts that are inserted in the set-screw holes of the Collars 54.

Two ¾″ Bolts 56 are attached to the moving portion of each elevator at the extreme trailing edge. The control wires 57 are secured to these bolts, and are led through guides 58 consisting of Angle Brackets bolted to the leading edges of the Flat Girders 46.

Erecting the Model

Having completed the various portions of the model it remains now to erect them in their respective positions. The first step is to attach the tail unit to the fuselage. It is bolted firmly to the Angle Brackets on the ends of the Strips 9 and to the Angle Brackets 10 at the end of the fuselage (Fig. 3) and should appear as in Fig. 1. Two wires 55 are now fixed to the rudder bar (one at each end), led along inside the fuselage for some distance, and then passed out through each side. They are taken round the bolts on the Collars 54 and attached to the rudders 51, the wires connecting all three together so that the movement of the rudders synchronise.

Short lengths of wire 57 are passed through the guides 58 and secured to the ¾″ Bolts 56 on each elevator plane. The other ends of each pair of wires are connected together (see Fig. 1). Another length of wire is clamped to the joystick between the boss of the Swivel Bearing and the Collar (see Fig. 6). One end of this wire is led round the Pulley 61 (Fig. 6) and thence out through the top of the fuselage and connected to the wire yoke 57 of the upper elevator (see Fig. 1), while the other end is taken directly to the yoke of the lower elevator. If the length of the wire 57 is adjusted correctly by means of "strainers" the elevators will rise and fall in accordance with the movements of the joystick. The elevators cause the actual machine to rise or dip whilst the rudders direct its course to left or right.

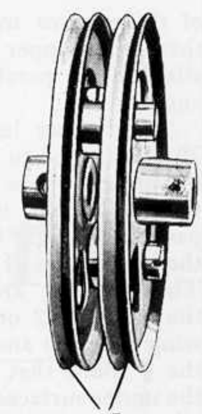

Fig. 9. Landing Wheel with tyre removed.

Attaching the Wing Units to the Fuselage

Each bottom wing has two ½″×½″ Angle Brackets bolted to its upper surface at the end nearest the side of the fuselage. These Brackets are slipped on to the ⅜″ Bolts 66 bolted to the side of the fuselage (see Figs. 2 and 3). The projecting end of the Girder 18 (Fig. 5) should now be pushed into the centre section so that the Girder 18 is in line with the Girder 40 (Fig. 3), and the holes in the Girder 18 in line with those in the Plates 39 in order that a 1″ Threaded Rod 18a (Fig. 1) may be passed through the holes. The Threaded Rod is retained in place by nuts on its ends. The trailing edge of each wing is connected to the Flat Girder 41 of the centre section by the Strip 43 (Fig. 5), and the ends of the Strips 45 bolted to the Angle Brackets 45a (Figs. 2, 3 and 5).

The ends of the landing wheel axles 11a are supported in the Strips 23: the landing wheels are placed on the ends of the axles and retained in place by Collars.

Fixing the Aileron Controls

The top wing ailerons are connected together by a length of wire 70 (Fig. 1) that is attached to ¾″ Bolts secured to the trailing edges of the ailerons and passed round the ½″ Pulleys on the top surface of the wings. The length of the wire is so adjusted by means of a "strainer" that it is taut when both ailerons are perfectly level in relation to the main plane surface.

The upper ailerons are connected by short lengths of wire 70 to the lower ailerons, to transmit the motion of the former to the latter. The length

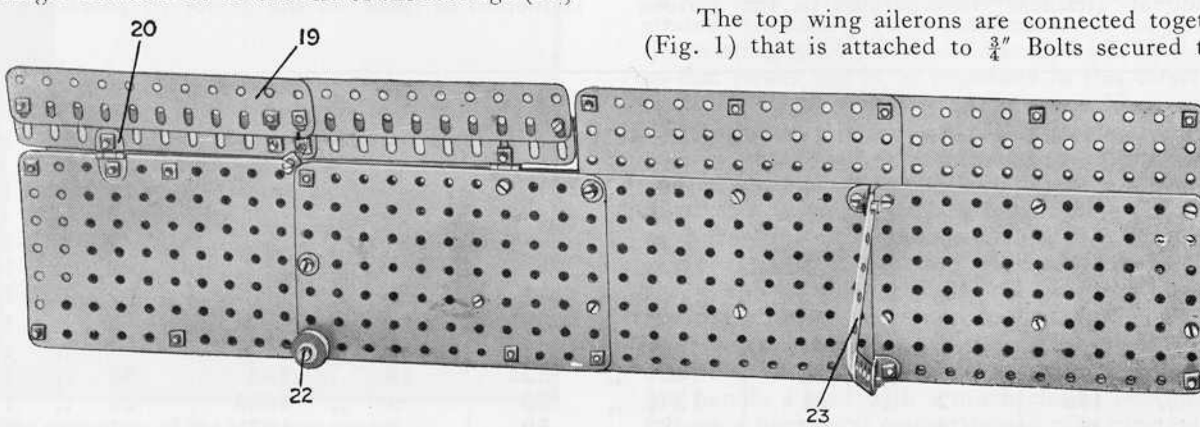

Fig. 10. Underside of left-hand bottom plane.

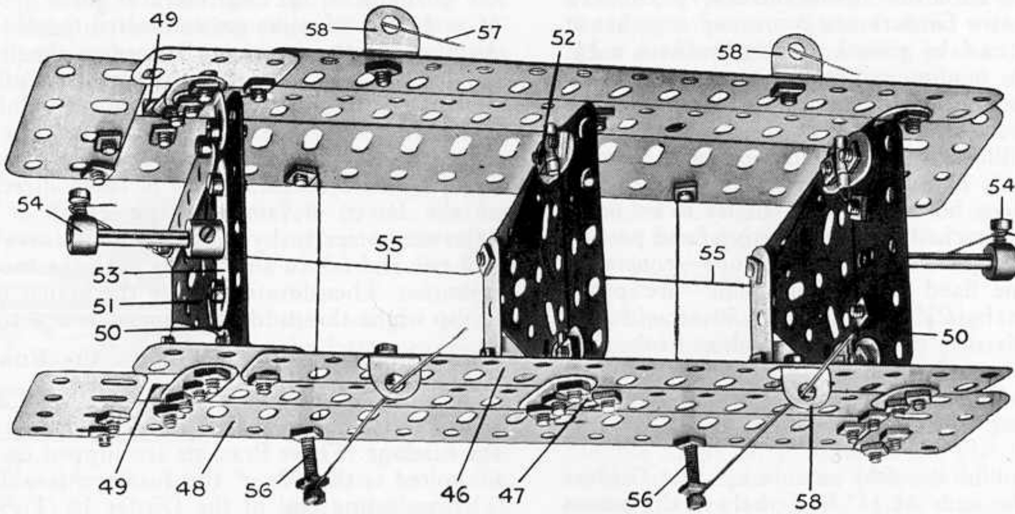

Fig. 11. Tail, showing hinged Rudders and Elevators, etc.

of these wires must be such that the upper and lower ailerons are parallel with one another.

A further length of wire 70 is attached to the bolt held in the end of the Coupling 62 (Fig. 6) and its ends are passed through the holes in the side Plates of the fuselage. Thence they are led round the Pulleys 22 on the bottom wing (Fig. 2) and fastened to the $\frac{3}{4}''$ Bolts that are bolted to the under surfaces of the lower ailerons. The length of the wires must be so adjusted by means of the strainers incorporated in each of them, that when the joystick is in a vertical position, the ailerons are level with the main plane surfaces. Therefore any side-to-side movement of the joystick should result in an up and down movement of the ailerons—those on one side of the machine moving downward whilst those on the opposite side move upward simultaneously.

The fact that one aileron is inclined downward and the other upward produces a couple that tends to roll the actual machine about its longitudinal axis. This is known as "banking," a manoeuvre that is neccessary when turning the machine in either direction. It is also necessary to operate the ailerons frequently while the machine is in flight, in order to maintain equilibrium and counteract sudden gusts of wind, etc.

Mention has been made of "strainers" incorporated in the various control wires to adjust their length, and hence their tension, very minutely. To make a suitable strainer, the control wire requiring such an addition is cut and a loop made on each of the cut ends. A $\frac{1}{2}''$ Bolt is passed through the loops of the wire and a nut placed on the end of the bolt. By turning the bolt the nut is made to advance or recede up the shank of the bolt, so altering the tension of the control wire.

Thin wire obtained from any ironmongers or stores for an inconsiderable sum is used for all the control wires on this model. Meccano Cord is not suitable, as it stretches considerably and would prevent satisfactory working of the model.

To connect up the drive from the Electric Motor to the wing engines, the Universal Couplings 38 (Fig. 7) are secured to each end of the Rod 13 (Figs. 2, 3). All three propellers are driven at the speed of the armature of the Motor, as the ratios existing between the various gears is unity.

Two terminals 67 are provided on the bottom of the fuselage (see Fig. 3) to form a convenient means of attaching the leads from a 4-volt Meccano Accumulator. The shanks of the terminals are 6 B.A. Bolts (part No. 304) secured to and insulated from the fuselage by 6 B.A. Nuts (part No. 305) with Insulating Bushes and Washers (parts Nos. 302 and 303). The terminals are connected to those on the Motor by short lengths of wire.

Parts required to build the Three-Engine Biplane

6 of No.	1	4 of No.	9b	2 of No.	16a	489 of No.	37	5 of No.	62b	11 of No.	103d	4 of No.	140
2 ,,	1a	4 ,,	9d	1 ,,	16b	74 ,,	37a	3 ,,	63	4 ,,	103f	1 ,,	165
14 ,,	2	2 ,,	9f	2 ,,	17	2 ,,	37b	22 ,,	70	5 ,,	103g	2 ,,	302
2 ,,	3	12 ,,	10	3 ,,	18a	42 ,,	38	5 ,,	72	3 ,,	103h	2 ,,	303
6 ,,	4	6 ,,	11	4 ,,	20a	6 ,,	41	3 ,,	76	7 ,,	103k	2 ,,	304
20 ,,	5	86 ,,	12	5 ,,	23	3 ,,	48	2 ,,	82	9 ,,	111	2 ,,	305
18 ,,	6	2 ,,	13a	6 ,,	24	2 ,,	48a	12 ,,	101	3 ,,	111a	2 ,,	306
10 ,,	6a	1 ,,	14	6 ,,	30	46 ,,	52a	18 ,,	103	56 ,,	111c	8 ,,	312
4 ,,	7a	2 ,,	15a	2 ,,	31	15 ft. ,,	58	2 ,,	103a	20 ,,	114	1 Electric	
12 ,,	8	3 ,,	16	24 ,,	32	8 ,,	59	4 ,,	103b	2 ,,	126a		Motor