

[54] CRAFT WASHING PLANT

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134/123

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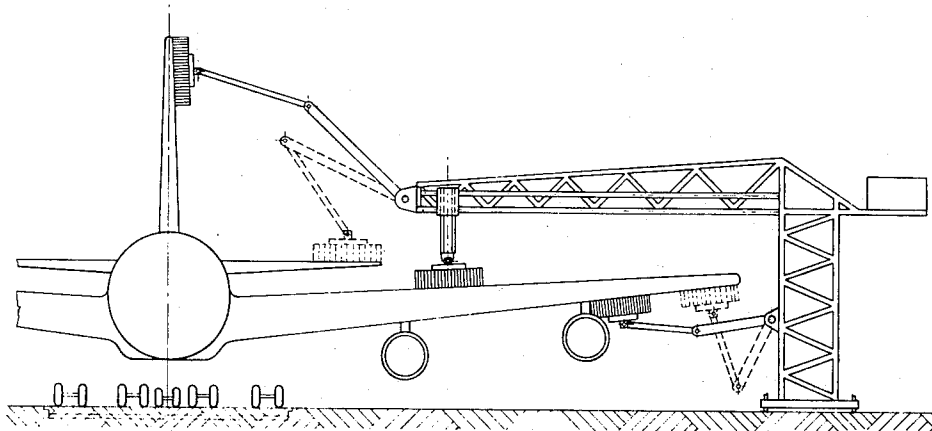
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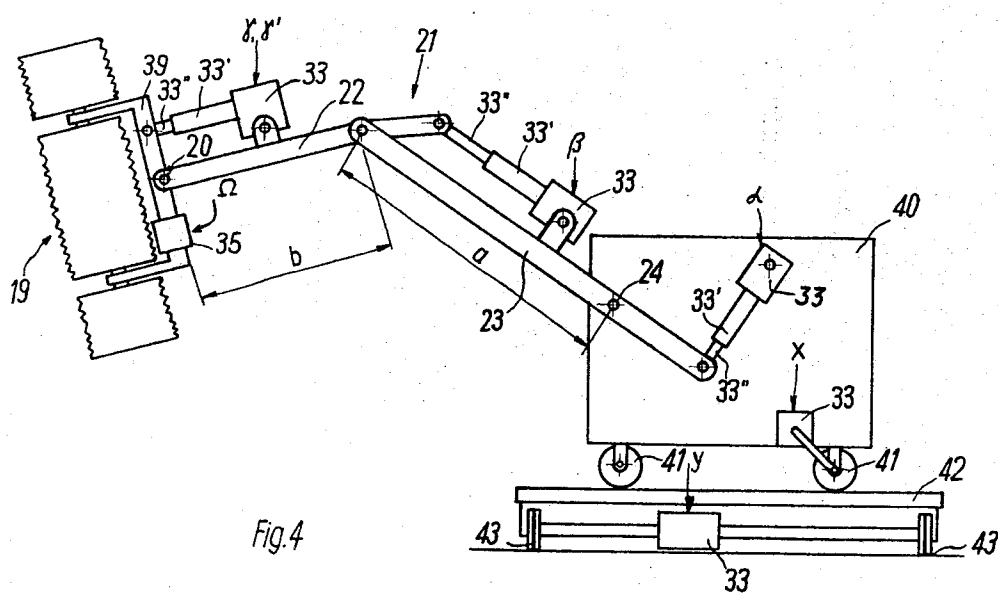
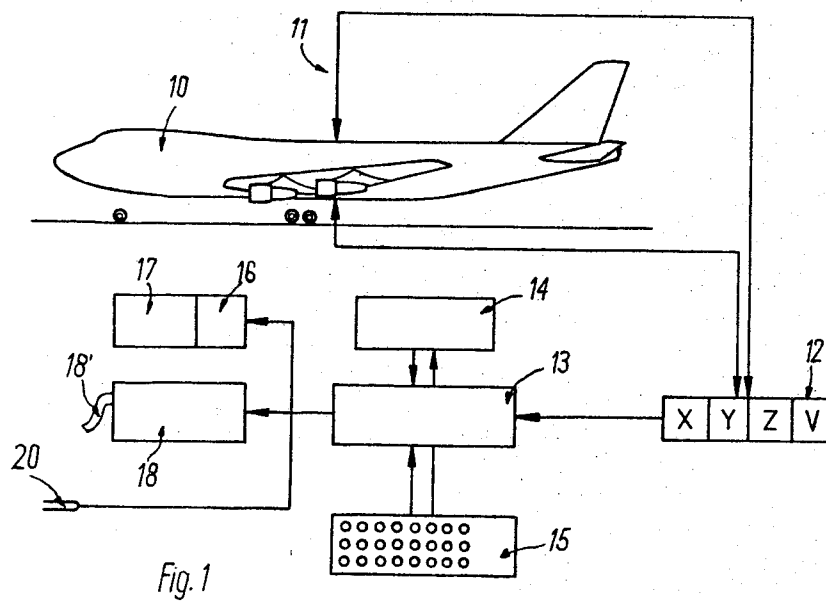
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ABSTRACT

A washing plant for craft, particularly for aircraft or marine craft, comprises one or more cleaning assemblies each comprising one or more cleaning members and an articulated support for each of said cleaning members. Each support member is such as to allow each respective cleaning member to move in three orthogonal directions from any point of a predetermined space. The movement of each washing element is effected by a plurality of servomechanisms equal in number to the degrees of freedom of the corresponding articulated support, said servomechanisms being controlled by a device adapted to read a scale and/or mathematical model of the craft to be washed and to supply said servomechanisms with parameters corresponding to positions of the corresponding cleaning member on the surface of the craft to be washed.

10 Claims, 11 Drawing Figures





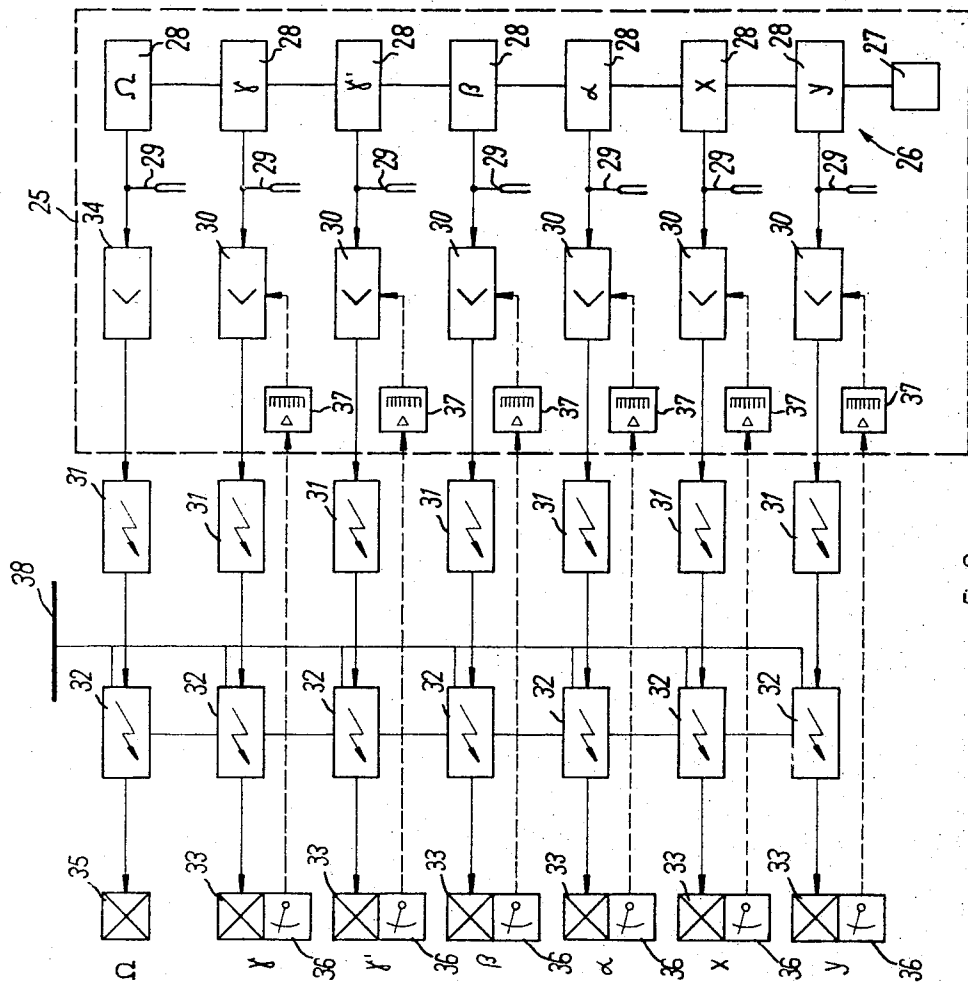


Fig. 3

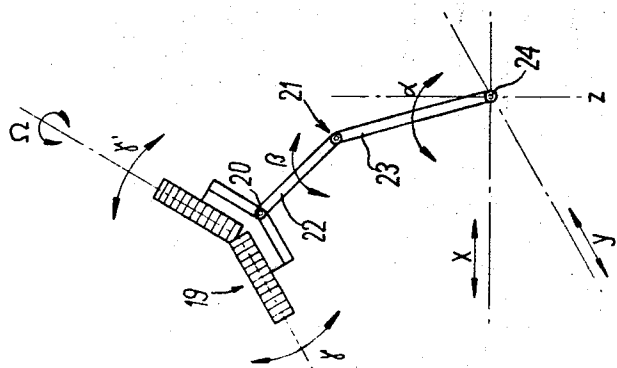


Fig. 2

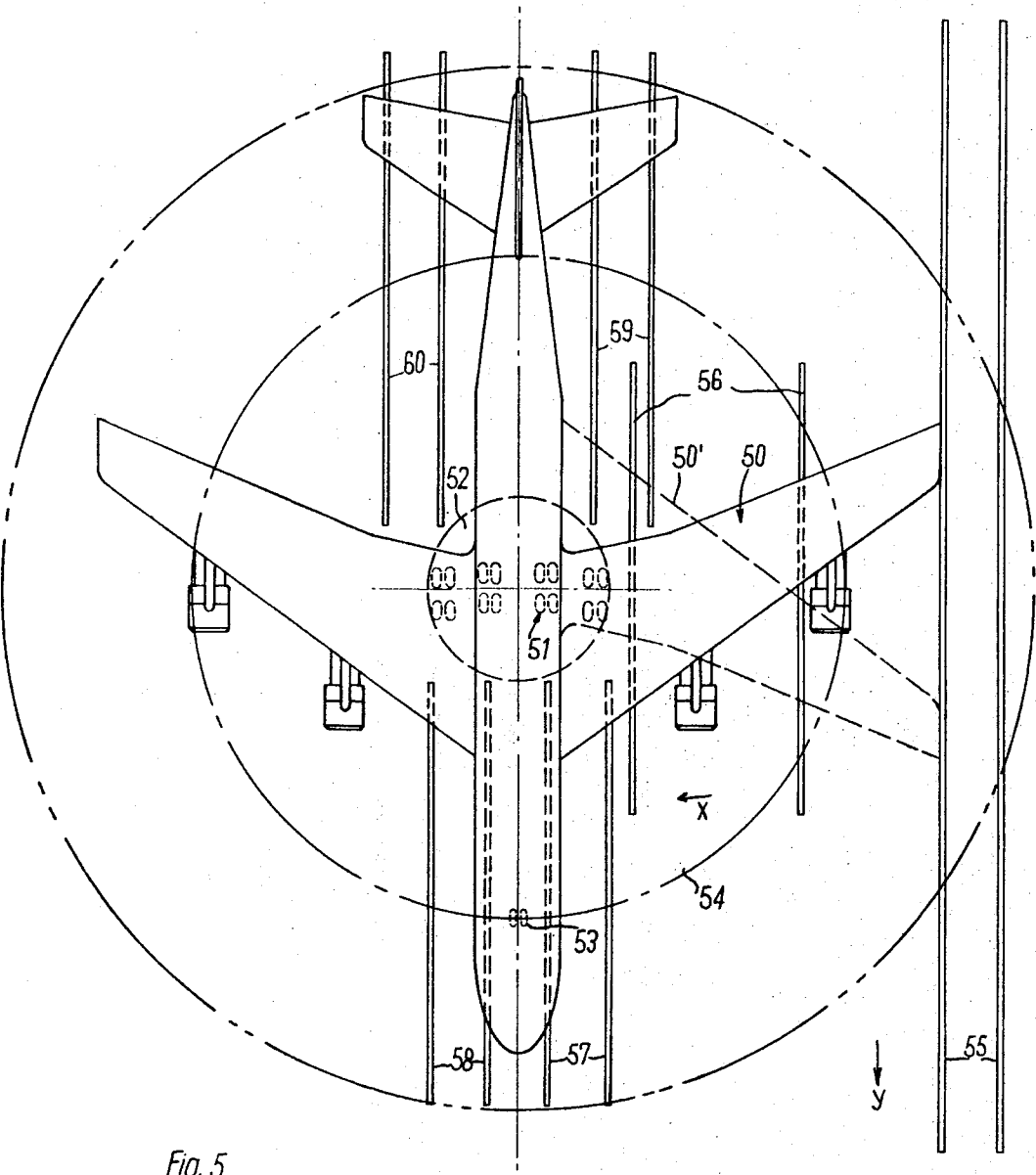
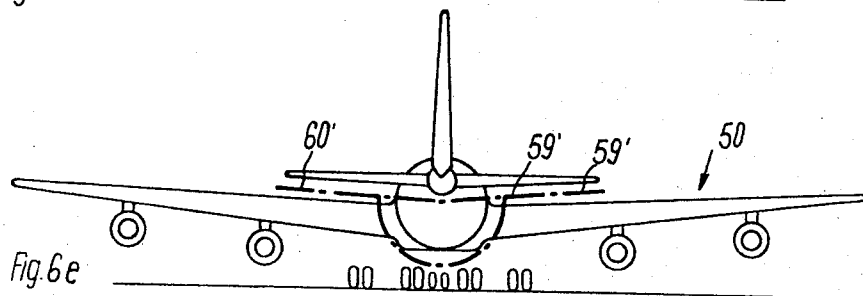
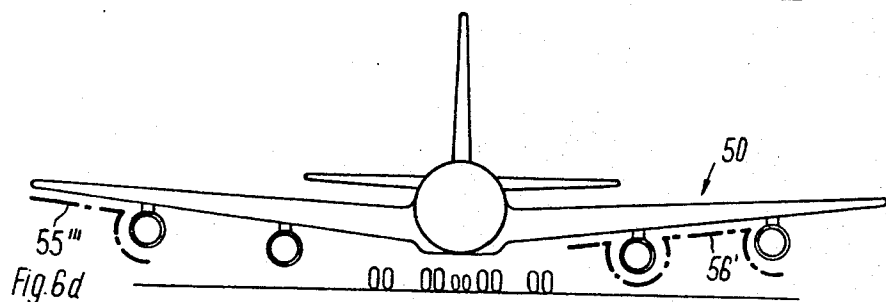
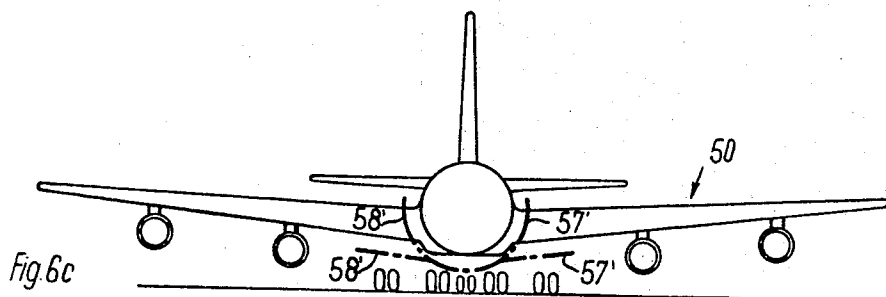
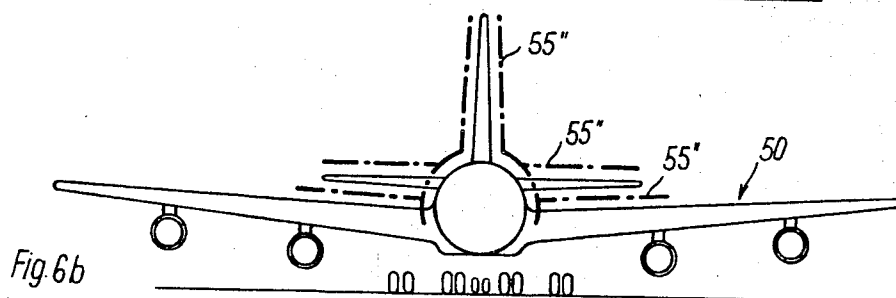
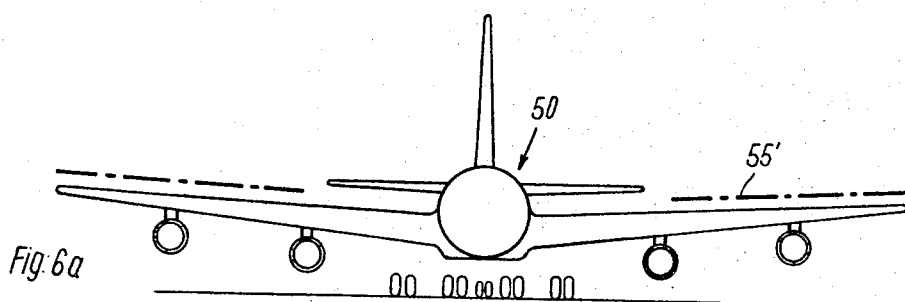
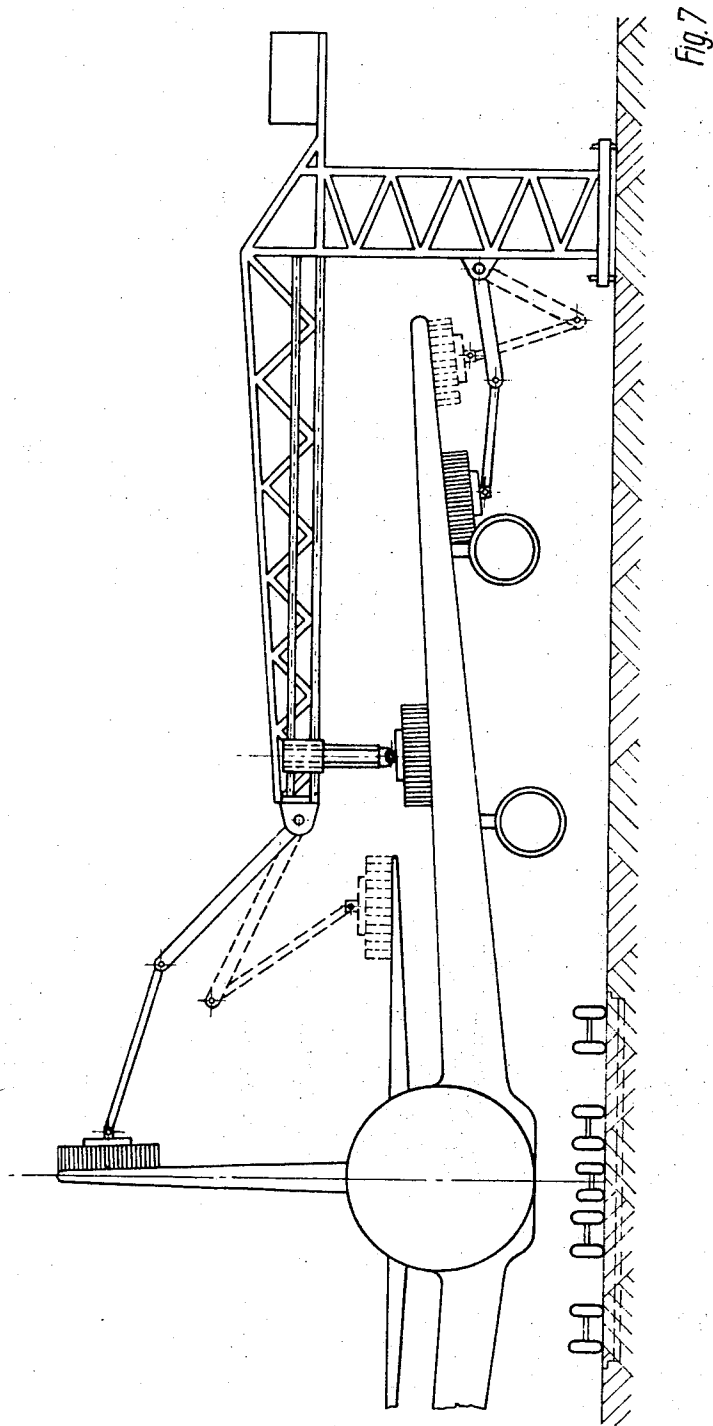


Fig. 5





CRAFT WASHING PLANT

FIELD OF THE INVENTION

The present invention relates to a washing plant suitable for use with air or marine craft and having a number of rotating cleaning members provided on holders which are movable to and fro to wash the surface of the craft.

STATE OF THE ART

Wash plants have been known as so-called "washing roads" for automobiles, in particular passenger cars.

In these washing plants the holders of the washing brushes are biased towards the surface to be washed by a more or less constant force and are passed by the contour of the surface to be washed out of their rest position against this bias. The washing brushes are thus to a certain extent supported directly on the craft to be washed.

This has certain disadvantages which considerably restrict the field of use of such washing plants. The force is to be applied by the craft to be cleaned for pushing back the washing brushes appears as contact pressure of the washing brushes on the surface to be washed and is not constant because the gyrostatic effect of the rotating washing brushes according to the direction of rotation favours either the feed bias or, the displacement force applied by the surface contour. The contact pressure of the washing brush which is variable under these circumstances together with the brush contact area fluctuations which occur in practice, lead to considerable fluctuations in the effectiveness of the washing.

These fluctuations in contact pressure have the result that the cleaning power and thus the operation of the washing brushes varies with different setting angles of the brushes. Furthermore, the contact pressure may assume such high values that the scrubbing action of the brushes not only loosens the dirt but also damages the surface being washed e.g. painted areas, sealing members, protruding parts. This is particularly the case in craft of light-weight construction, for example aircraft wherein the outer covering is often only dimensioned for the stresses which occur during normal operation.

In aircraft, washing with the conventional washing plants is not considered practicable because in addition to the problems connected with the stresses which occur there is a difficulty caused by the shape of the aircraft.

In the case of aircraft a clean outer surface is not only of aesthetic but also of considerable economic importance.

It has in fact been discovered that a present-day jumbo jet on a single Atlantic flight consumes more fuel when its surface is dirty than when it is clean. The pollution of the outer surface is a factor which considerably influences the air resistance of the aircraft. This phenomenon is of great importance in the case of large jet-propelled aircraft in a way which cannot be disregarded because in such aircraft with their engines attached on or under the wings pollution of the outer surface by the exhaust gases is practically unavoidable. Pollution of the aircraft's surface also occurs when grounded on airfields and during landing and take-off manoeuvres.

Furthermore, there is a further category of craft wherein the use of a conventional washing plant is rarely considered. These are marine craft in particular large steamers wherein it is a question of regularly cleaning the parts of the hull in contact with the water to remove dirt (algae, oil residues).

OBJECTIVES OF THE INVENTION

It is therefore an object of the invention to provide a washing plant in which, apart from the friction forces occurring through the scrubbing action of the cleaning members, practically no other forces have to be absorbed or applied by the craft to be cleaned and in which the possibilities for using the plant are not restricted either by the shape or size nor by the material of the craft to be cleaned.

This object is achieved according to the invention by the proposed cleaning plant of the kind mentioned above wherein each holder has a servomotor which is controlled by a local value transmitter in which the position coordinates of the cleaning member corresponding to the outline of the vehicle lying within the effective range of the relevant cleaning member are stored as local values in said transmitter.

The invention will now be described in more detail by way of examples, with reference to the accompanying drawings, in which:

In the drawings:

FIG. 1 is a block diagrammatic layout of equipment for devising data concerning the contour of an aircraft;

FIG. 2 is a diagrammatic illustration of a washing brush mounted on a support providing three degrees of freedom to enable the position and setting of the brushes to be fixed;

FIG. 3 is a block circuit diagram of a local value transmitter and the associated servomotor for producing the position and setting desired for the washing brush illustrated in FIG. 2;

FIG. 4 is a diagrammatic view of a washing brush assembly showing a support for a brush and a carriage for the support all of which are servomotor controlled;

FIG. 5 shows in plan a turntable on which an aeroplane ready to be washed is standing and shows also tracks used by movable carriages carrying the brushes;

FIGS. 6a - e are different front and rear views of the aircraft of FIG. 5, showing washing zones which are covered by the washing brushes which are moved on the tracks or rails of FIG. 5; and,

FIG. 7 shows a washing crane on which several brushes are assembled for wing cleaning of an aircraft.

PREFERRED EMBODIMENT

FIG. 1 shows a detecting apparatus adapted to detect the surface contour or "topography" of an aircraft to be washed. For this purpose a scale model 10 of the aircraft to be washed is used. The co-ordinate values defining the surface contour are if necessary, completed by additional boundary conditions (the nature of which will be explained later), and re-arranged in order to make them suitable for controlling the operation of washing brushes of a washing plant of which the detecting apparatus forms a part.

The detecting apparatus shown in FIG. 1 comprises a scanning device 11 adapted to scan a scale model 10

of the aircraft in three dimensions. The scanning device 11 is connected to a coding device 12 the output signals of which correspond to associated values x, y, z of the space coordinates of the outer surface of the model 10 in relation to a predetermined zero (not shown). It is obvious that the connection between the scanning device 11 and coding device 12 can have several signal lines for each scanner, wherein each signal line can be associated to a specific coordinate direction. The coding device 12 is connected to a calculator/computer 13 which re-arranges the data reaching it from the coding device 12. For this purpose the calculator 13 is connected to a store 14 in which boundary values relating to the washing plant, e.g. the boundary co-ordinates of the effective range of each individual washing brush, are stored. Furthermore, both the store 14 and the calculator 13 can be controlled or read by a manual keyboard 15; further boundary conditions particularly those conditions relating to the aircraft to be washed which cannot be detected on the model 10, can be fed to the calculator 13 or store 14 with the aid of said keyboard. The space co-ordinates of particularly sensitive parts of the aircraft, which are not covered by the cleaning members, belong to these boundary conditions. Such parts of the aircraft e.g. outside aerials, pressurizing pipes and the like are as a rule not present on model 10. Furthermore, since the co-ordinate value in the perpendicular direction depend on the degree of load (fuel, freight) of the aircraft to be washed, one of said boundary conditions to be fed in by hand consists of a correcting factor which is administered from time to time and only relates to the perpendicular co-ordinate scanner, said correcting factor can be assumed constant for a loaded aircraft to be washed for all co-ordinate values in the horizontal direction.

In general, the calculator 13 calculates the temporal sequence of control commands for each individual washing element from the contour co-ordinates x, y, z of the outer surface of the aircraft supplied to the calculator, and from all characteristic data of the washing plant (including the desired washing programme) together with the boundary conditions supplied to said calculator.

A monitor 17 is connected to the output of the calculator 13 by means of a decoder 16. The work of calculator 13 can be visually monitored or controlled by means of monitor 12 during the plotting of the data relating to one type of aircraft. A recording device 18 is connected to the output of the calculator 13 and records the values obtained from the calculator 13 on a record carrier 18' (e.g. on a magnetic tape carrier or a perforated strip). Finally, the output of the calculator 13 is coupled to a transmission line 20 which can be connected to an actual-local-value transmitter which will be described below.

Thus, as a summary it may be said that the part of the washing plant illustrated in FIG. 1 can be regarded as a store in which the spatial configuration of a type of aircraft is stored, namely either in the form of the model itself or in the form of the record carrier 18', which as a temporary storage stores this spatial configuration in the form of tridimensional co-ordinates which can be processed directly by the actual local value transmitter.

FIG. 2 shows a two-part roller brush 19 which is connected at 19' at one end of a link member 22 of an articulated support linkage 21 having a second link mem-

ber 23 which is pivotally connected to a carriage or slide (not shown at 24). This carriage forms, together with support linkage 21, a holder for roller brush 19 and is movable to and fro both in the co-ordinate direction x and in the co-ordinate direction y . The axis of articulation at 24 is parallel to the co-ordinate direction y . It follows from this that the working position of the roller brush 19 can be clearly defined by the values of the following parameters: x, y , length a of link member 23, length b of the link member 22, angle of inclination α of link member 23 in relation to the plane x, y , angle of inclination β of link member 22 relative to plane x, y as well as angle of inclination γ or γ' of the axis of the roller brush 19 relative to link member 22. Finally, parameter Ω is considered which indicates the speed and direction of rotation of the roller brush. Said parameters, with the exception of lengths a and b , are all variable and for each group of associated values x, y, z , relating to the position of one point on the aircraft to be washed, they are detected by the scanning device 11 (FIG. 1). For each group the corresponding combination of values $x, y, \alpha, \beta, \gamma$ and γ' can be calculated. These values which, as mentioned, are determined by the calculator 13 and recorded by the recording device 18 on a record carrier 18', thus form correlated local value components which are supplied to each individual element of a servo drive of the washing brush 19 so that the latter describes a path which corresponds exactly to the contour of the aircraft to be washed as determined by the scanning device 11.

A local value transmitter and the servo drive for the holder of washing brush 19 will now be described with reference to the circuit diagram of FIG. 3. The local value transmitter is shown by the chain-dotted line 25 in FIG. 3. This transmitter has a programme transmitter 26 which is driven by a timing pulse generator 27 and has a reader 28 for the recording carrier 18'. The reader 28 has many output channels from which one output channel is allocated for each value $y, x, \alpha, \beta, \gamma', \gamma$, and Ω . To each of these output channels is connected a connector plug 29 to which — if desired — the transmission line 20 illustrated in FIG. 1 can be directly connected by means of a series parallel transformer (not shown). It follows that, if the transmission line 20 is connected to the connector plug 29, the recording carrier 18 is not used because in this case the calculated values for the servo drive are supplied directly from the calculator 13 to the servo drive. The output channel of each reader 28, except the reader relating to parameter Ω , leads to one input of a respective differential amplifier 30 whose output controls a respective servomotor 33 by means of two stages 31 and 32.

Each servomotor 33 is operated in accordance with the actual value of the parameter corresponding to its channel. The output channel of the reader 28 associated with the value Ω is connected to a simple amplifier 34 whose output controls a driving motor 35 of the washing brush 19 by means of two relay stages 31, 32.

A position transmitter 36 coupled to each of the servomotors 33 issues an output signal corresponding to the actual position of the respective servomotor 33 and feeds said signal to the second input of the associated differential amplifier 30 by means of a code converter 37. It follows from this that the servomotors 33 only react to alterations of the values read off by the reader 28. Thus, it is ensured that the servomotors remain in

operation until the occupied position corresponds to that value which is predetermined by the programme transmitter 26.

In the illustrated example six servomotors and one driving motor are present. The number of servomotors depends on the type of construction of the holder of the washing brushes and, basically, one servomotor is required for each degree of freedom which this holder has. Both hydraulic and electric motors can be provided as servomotors so long as they are able to convert energy supplied into the necessary amount of mechanical motion. In FIG. 3 the power source for feeding both the servomotors 33 and the driving motor 35 is indicated at 38. Source 38 can, if the servomotors 33 and the drive motor 35 are electric motors, be the mains. In this case the stages 32 consist of contactors controlled by respective relay stages 31. If on the other hand the servomotors 33 and driving motor 35 are hydraulic motors, then source 38 is a pressure source and the stages 32 are suitable valve arrangements which are controlled by respective relay stages 31.

FIG. 4 illustrates the construction of a rotary washing brush 10 with its holder. The washing brush 19 is shown as rotatably positioned with its fixed axis on a fork 39. The fork 39 is in turn pivoted at the point 19' to the free end of link member 22 of the articulated support linkage 21. The other link member 23 is connected at 24 to a carriage 40 which is provided with wheels 41 for movement to and fro on a second carriage 42. The second carriage 42 runs on wheels 43 in the direction at right angles to the drawing plane of FIG. 4. A servomotor 33 is associated with each movable part of the holder of the washing brush 19, namely the fork 39, links 22 and 23 and carriages 40 and 42, the position of the relevant movable part of the holder being adjusted by means of said servomotor 33 which is controlled by local-value transmitter 25. Thus, the servomotor 33 associated with the fork 39 is intended for adjustment of values γ and γ' , the servomotor 33 associated with the link 22 for adjustment of inclination β , the servomotor 33 associated with link 23 for adjustment of the angle α of inclination, and the servomotors 33 associated with the carriages 40, 42 for adjustment of values x and y . The driving motor 35 for the washing brush 19 is installed on the fork 39 and drives the washing brush 19 by means of a chain gear unit (not shown).

Linear actuator motors each comprising a driven nut 33', which is driven in rotation but is secured against axial displacement, and a rod 33'', which is fixed against rotation and is axially displaceable by nut 33' are particularly suitable as servomotors for altering the inclinations. This design has the advantage that a potentiometer can be used as transmitter 36 (cf FIG. 3), said potentiometer being connected to the rod of said servomotor 33 directly or by means of a reduction gear, and the tapped voltage of said potentiometer being an analogue signal indicating the actual position of the free end of rod 33''.

Several washing brush holders movable on separate carriages are provided for covering the entire surface of an aircraft.

METHOD OF USE OF PREFERRED EMBODIMENT

FIG. 5 is a plan view of an aircraft 50 which stands with its main undercarriage 51 on a rotatable platform

52. This platform 52 is rotatable by a servo drive (not shown in detail) about a perpendicular axis. On rotating the platform 52, the aircraft 50 is obviously also rotated and the nose wheel 53 of the aeroplane thereby describes a circle marked 54. Several pairs of rails 55, 56, 57, 58, 59 and 60 are mounted on the region of the expanse of the aeroplane 50 in its position on the platform 52, at least one carriage (not shown in FIG. 5), being positioned on each pair of rails, said carriage corresponding in principle to the carriage 42 of FIG. 4. From the plurality of pairs of rails 55 - 60 it follows that the washing brushes present on the carriages positioned on these rails are thus intended only to cover a specific zone of the surface of the aircraft 50. Thus, the design of the roller-brush holder mounted on the carriage located on the individual pairs of rails can be readily derived from the shape of an aircraft which is basically always the same, namely fuselage, lifting surfaces, rudder and tail planes.

Various front and rear views of the aeroplane 50 are shown in FIGS. 6a - 6e wherein the washing zones to be covered by the washing unit on the various pairs of rails are indicated by the thick chain dotted lines. Thus, for example, on the left in FIGS. 6a, 6b and 6d, three different washing zones 55', 55'' and 55''' are indicated which are covered by washing brushes mounted on a carriage positioned on the rails 55. Washing zones 55' extends along the upper surface of the wing from the wing tip to the engine unit nearer the fuselage. Washing zone 55'' includes one side of the rudder assembly, the upper side of the tail plane, the upper side of the wing from the wing root to the engine unit nearer the fuselage, and the upper side of the fuselage. Washing zone 55''' includes the lower side of the wing from the wing tip to the furthest engine unit. The washing zone 57' and the washing zone 58' include the underside of the fuselage from the nose to the level of the landing gear as well as a part of the underside of the wing. The washing zone 56' (on the right of FIG. 6d) comprises the lower side of the wing adjoining the washing zone 57' up to the beginning of washing zone 57'''. Finally, washing zones 59' and 60' include the underside of the fuselage from the back to the landing gear as well as the underside of the tail plane. The shape of the carriages which are movable on the different pairs of rails 55 - 60 of FIG. 5 is evident from the division described of the outer surface of the aircraft 50 into various washing zones.

ALTERNATIVE EMBODIMENT

FIG. 7 illustrates a second embodiment in which the carriage 42 of FIG. 4 is designed as a gantry crane or movable bridge on which several washing units are mounted. The carriage shown in FIG. 7 is adapted to be mounted on the rails 55 (see FIG. 5) for washing zones 55', 55'' and 55'''. This carriage serves as support for three brush holders which in turn are individually displaceable analogous with the brush holder of FIG. 4 so that on passing along the entire stretch of the rails 55 said holders follow the outer contours of the aeroplane 50 and only become operative when the corresponding washing brush enters a washing area. It follows that the carriage illustrated in FIG. 7 is movable to and fro repeatedly in direction y (cf. FIG. 5) wherein on each journey of the carriage the washing brushes occupy a different delivery position (in FIG. 5 generally marked x).

In FIG. 5 a pair of rails 55 and 56 is only illustrated on one side of the platform 52. The arrangement of the rails as in FIG. 5 is thus asymmetrical relative to the axis of rotation of the platform 52. This arrangement has therefore been developed in order to make do with a minimum number of carriages with washing brushes by using the symmetry of the aeroplane 50 to be washed. In FIG. 5 it is seen that after washing the half of the aeroplane 50 on the left, seen in the flight direction, the aeroplane is rotated 180° by means of the platform 52 so that the right wing enters into the position indicated by chain-dotted line 50'. In this position the right-hand half of the aeroplane 50, seen in the direction of flight, can be washed with the same programme, but with the partly reversed signs of the local values, and by the same washing carriages.

MODIFICATIONS

Whereas in the present example only washing brushes are described as cleaning members it is obvious that the cleaning members can be basically adapted to the dirt to be removed, so that for example for cleaning ships' hulls wire brushes or even grinders may be used as the cleaning members.

I claim:

1. A washing plant for craft, comprising locating means for said craft, washing equipment comprising at least one rotatable cleaning member, means for displacing said member within a predetermined space in three dimensions, first drive means for rotating said member, second drive means for positioning said member, readout means providing from a model of said craft surface to be washed data significant of the surface contour, and control means controlled by said readout means data and actuating said second drive means whereby said cleaning member follows a cleaning path determined by the sequential read-out of said data and thus the craft contour itself.

2. Plant as set forth in claim 1, in which the member displacement means comprises an articulated arm, actuators control the extent and direction of articulation of said arm, and said control means act to determine operation of said actuators.

3. Plant as set forth in claim 1, said equipment includes carriages, tracks supporting said carriages, articulated supports carried by said carriages and carrying respective cleaning members, and turntable means supporting said craft; said displacing means and first and second drive means being controlled by said control means which also control the carriage positioning on said tracks.

4. Aircraft washing plant comprising a turntable for said aircraft; means for turning said turntable; tracks extending parallel to one another and asymmetrically arranged with respect to said turntable; wash carriages mounted on said tracks; an articulated arm carried by each said carriages; a washing member carried at an end of said arm; separate drive means for moving said member, for controlling said arm articulation, positioning said carriage on one of said tracks, and turning said turntable; a master record of the aircraft surface contour; readout means obtaining from said master record parameters in three dimensions of points along a prescribed washing path to be followed by said washing member; means deriving from said readout means analogue electrical signals; and connections for feeding said analogue electrical signals to said drive means in

a predetermined sequence representing the order of washing of zones of the surface contour of the aircraft.

5. Plant as claimed in claim 4, in which one of said carriages comprises a gantry structure having mounted thereon independently operable articulated arms individually carrying rotary brush cleaning members.

6. Aircraft washing plant as set forth in claim 4, including a plurality of servomechanisms constituting drive means controlling movement of each of said articulated arms, said servomechanisms being equal in number to the degrees of freedom of said arm, and a local-value transmitter means having outputs equal in number to the degrees of freedom of said articulated arm and said cleaning member; each of at least part of said outputs being connected to a respective servomechanism provided for movement of said at least one cleaning member, said outputs being adapted to supply said servomechanisms with reference input signals indicative of corresponding position co-ordinates of said cleaning member, and means for changing said position coordinates in a programmed washing sequence to alter the position of said cleaning member on the craft contour being washed.

7. A washing plant as claimed in claim 4, wherein a local value transmitter for each degree of freedom of movement of each of said articulated arms comprises means for reading recording carrier means on which the coordinates of the surface contour of the craft to be washed are stored, and controlling said arm articulation drive means in accordance with said co-ordinates.

8. A washing plant for craft, comprising articulated support means, a cleaning member supported by said means and movable thereby in three orthogonal directions a servomechanism positionally controlling said support means for moving said cleaning member along a predetermined cleaning path, said servomechanisms being equal in number to the degrees of freedom of said cleaning member, a control unit for controlling the operation of said servomechanisms, a three-dimensional model scanning device in said control unit, a three-dimensional model of the craft to be washed, a calculator/computer connected to the output of said scanning device, and a keyboard for manually feeding the calculator/computer with boundary data relating to additional features of the craft's surface contour and to limitations dictated thereby and existing within a cleaning space within which said one cleaning member is movable; said calculator/computer being adapted to transform position co-ordinate data relative to said feature positions into control parameters which are fed to the corresponding servomechanism as reference input signals together with co-ordinate data obtained from said model scanning device.

9. A washing plant as claimed in claim 8, wherein the output of the calculator/computer is further connected to recording means adapted to record said control parameters on recording carrier means.

10. A washing plant as claimed in claim 8, including a turntable for supporting said craft, linear track adjacent said turntable, carriages mounted on said tracks and controllable positioned thereon, and means on said carriages for supporting said cleaning member and said support member.

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