March 18, 1969 L. J. RODGERS 3,432,911

METHOD AND APPARATUS FOR INSTALLING JET ENGINES

Filed Jan. 19, 1966 Sheet 1 of 3

Fig. 1.

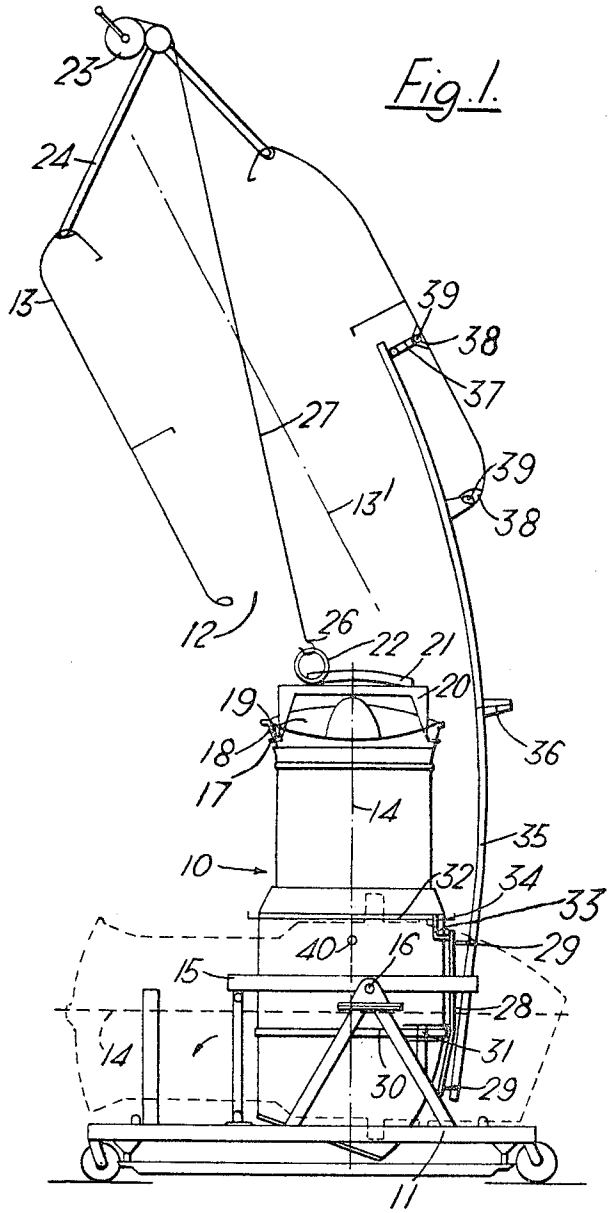

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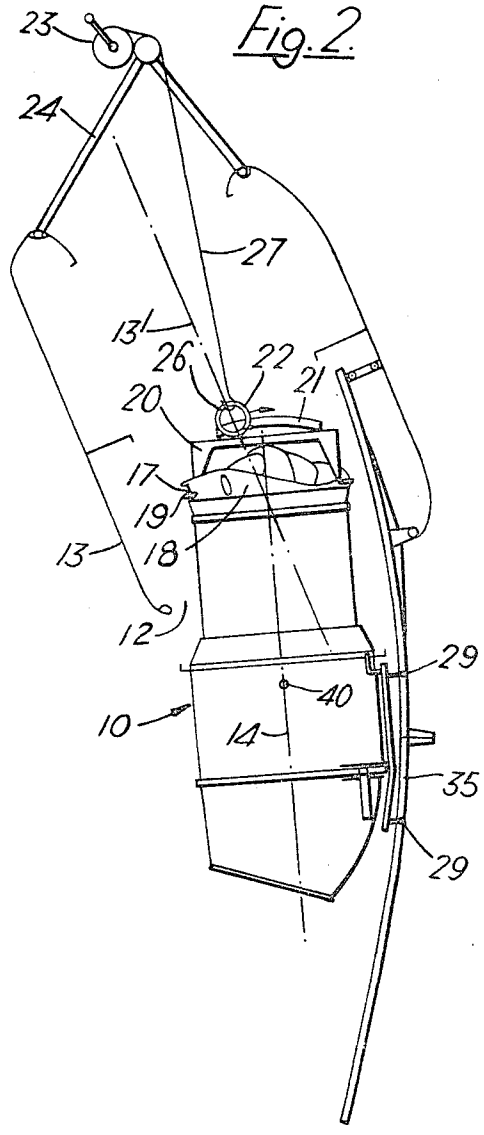
Fig. 2



METHOD AND APPARATUS FOR INSTALLING JET ENGINES

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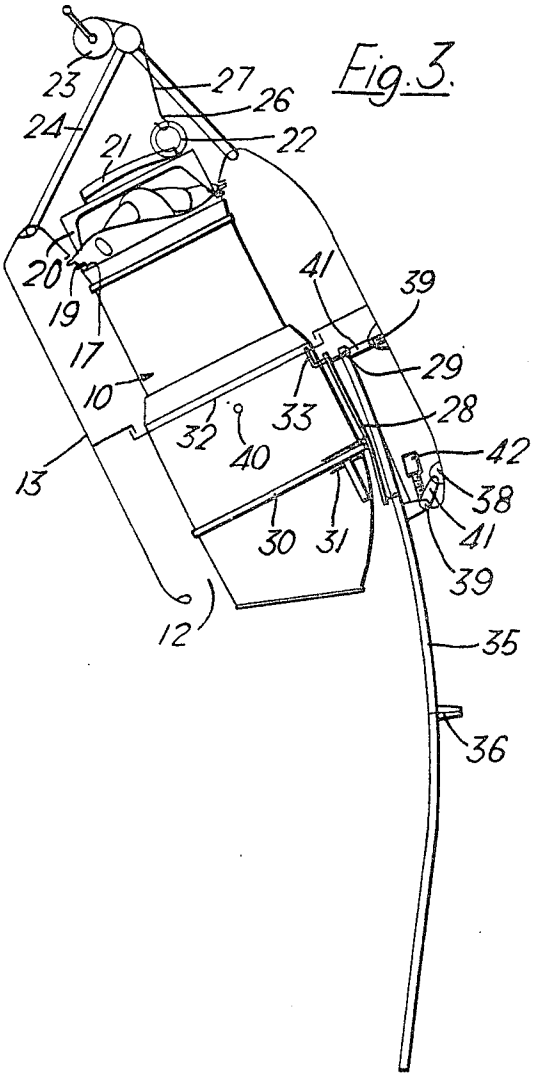

Fig. 3.

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METHOD AND APPARATUS FOR INSTALLING JET ENGINES

Leonard John Rodgers, Derby, England, assignor to Rolls-Royce Limited, Derby, England, a British company

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U.S. Cl. 29—464 13 Claims
Int. Cl. B25j 3/00; B66d 1/30

ABSTRACT OF THE DISCLOSURE

The invention concerns installing an engine in a housing, e.g. a V.T.O.L. jet engine in a pod. A curved guide rail is secured to the housing on which rollers or the like attached to the engine may run and the engine is hoisted into the housing by a hoist arrangement mounted on the housing. When the engine is in position within the housing, it is secured thereto, and the curved rail together with the rollers are detached and completely removed from the housing.

The present invention relates to an engine handling method and apparatus.

According to the present invention, a method of installing an engine in a housing comprises securing curved guide means to the housing to extend downwardly therefrom, engaging at least one guide-engaging element on the engine with said guide means, hoisting the engine into the housing in a position inclined at an angle to the vertical, the engine being guided by said guide means, securing the engine within the housing in said inclined position; and finally removing the guide means from the housing.

The method preferably includes mounting hoisting means on the housing and attaching the hoisting means to a hoist-engaging member secured to the engine, said hoisting means and hoist-engaging member being removed after the engine has been secured within the housing.

The method is particularly applicable where the engine is a gas turbine jet lift engine and the housing has open upper and lower ends, the hoisting means being mounted on the upper end of the housing and the hoist-engaging member being secured to the air intake end of the engine so that the hoisting means hoists the engine through the open lower end of the housing into an installed position in which the intake end of the engine is disposed adjacent the upper, and the exhaust end of the engine adjacent the lower, end of the housing.

The guide means may guide the engine from a position beneath the housing in which the axis of the engine is substantially vertical to an installed position within the housing in which the axis of the engine is inclined to the vertical.

Thus where the housing is inclined to the vertical the guide means may comprise a curved rail extending downwardly from the side of the housing which is spaced further from the ground, the rail being secured to the interior of the housing. The hoisting means are then preferably arranged to hoist from a point above the open upper end of the housing and displaced from the axis of the housing towards the said side of the housing to which the rail is secured.

The invention also comprises engine handling apparatus for carrying out the method set forth above, said apparatus comprising curved guide means adapted to be detachably secured to an engine housing and to extend downwardly therefrom, hoisting means mounted on the housing adapted to engage the engine and at least one guide-engaging element on the engine for engaging said guide means to guide the engine into the housing at an angle inclined to the vertical as it is hoisted by the hoisting means, a hoist-engaging member adapted to be detachably secured to the engine, said hoist-engaging member including a movable connection element, and said hoisting means including including a flexible hoisting element for attachment to said connection element, said connection element having limited freedom of movement in a substantially horizontal plane so that during operation of the apparatus the point of application of the housing force to the engine changes to accommodate changes in orientation of the engine.

Preferably the or each guide-engaging element is adapted to be detachably secured to the engine.

The invention will be described, by way of example only, with reference to the accompanying drawings, in which FIGURES 1, 2 and 3 show stages in the installation of a gas turbine jet lift engine in an aircraft pod, FIGURE 3 incorporating a modification of the apparatus shown in FIGURES 1 and 2.

Referring first to FIGURE 1, there is shown a gas turbine jet lift engine **10** which has been transported by means of a trolley **11** to a position beneath an open lower end **12** of a pod **13** in which the engine is to be installed. The engine **10** was initially disposed on trolley **11** with its axis **14** horizontal (broken lines) and has been swung in a cradle **15** about a pivot **16** provided on the trolley **11** to the position illustrated in FIGURE 1 in which the axis **14** is vertical. The engine **10** is formed with a number of blind sockets **17** around the internal surface of its intake duct **18** and spigots **19** provided on a sling **20** are received in the sockets **17** to attach the sling **20** to the intake end of the engine **10**. A suitable sling **20** is described in U.S. Patent No. 3,352,592 issued to Rodgers. The sling **20** has an arcuate rail **21** on its upper side on which a ring **22** is slidably retained. A hand-operated hoist **23** is adapted to be mounted by means of a tripod **24** on the upper (intake) surface of the pod **13**, enabling a hoisting force to be applied to the ring **22** and thence to the engine **10** through a hook **26** provided at one end of a cable **27** or other flexible hoisting element which forms part of hoist **23**.

In this example the axis **13'** of the pod **13** is inclined to the vertical, and it is necessary to guide the engine **10** as it is hoisted into the pod **13** so that the axis **14** of the engine **10** coincides with the axis **13'** of the pod when the engine is finally installed in the latter.

On the side of the engine **10** which will be spaced furthest from the ground when it is installed in pod **13** there is secured a detachable support **28** carrying a set of rollers **29**. The support **28** is secured to a flange **30** of the engine **10** by a toggle-clamp **31** (shown diagrammatically) and to a flange **32** of the engine **10** by a peg **33** received in an aperture **34** in flange **32**.

A guide rail **35**, which may comprise either a single section or a number of sections bolted together in end-to-end relationship as at **36**, is secured to the side of the pod **13** which is spaced furthest from the ground. The rail **35** is secured to the pod **13** by links **37** which are attached

to lugs **38** provided on the internal surface of the pod **13** by removable pegs **39** received in apertures in lugs **38**. The guide rail **35** extends downwardly from the pod **13**, and the rollers **29** are adapted to engage the rail **35** and thus stabilise the engine **10** horizontally while it is being hoisted into the pod **13**.

When the hoist **23** is operated, the engine **10** is hoisted into the pod **13** through the open lower end **12** thereof, passing successively through the stages shown in FIGURES 2 and 3.

Since, in this example, the tilt of axis **14** changes as the engine is raised towards the pod **13**, the line of action of the lifting force applied to the engine **10** by the hoist **23** varies accordingly, so that said line of action at all times passes through the centre of gravity **40** of the engine **10**. To enable the cable **27** to take up a position along this line while progressively accommodating the changing attitude of the engine **10** as the latter is hoisted, the rail **21** is arcuate in shape, the centre of the arcuate rail **21** being a point (not indicated) on the axis **14** which is at or above the centre of gravity **40**, the ring **22** sliding on the rail **21** to permit the line of action of the hoisting cable **27** to vary appropriately. Preferably, the ring **22** and rail **21** are formed of low friction material at least on their inter-engaging surfaces or the ring **22** may be replaced by suitable rollers (not shown) and the rail **21** adapted for these rollers to roll thereon.

When the engine **10** has reached the installed position shown in FIGURE 3, it is secured in the pod **13** by trunnions (not shown) or other suitable means. The tripod **24** and hoist **23** are then removed, the hook **26** being detached from ring **22**. The spigots **19** are released from the sockets **17** so that the sling **20** can be detached from the engine **10**. The pegs **39** are also removed, thus freeing the guide rail **35**, and the toggle-clamp **31** and peg **33** released from the respective engine flanges **30**, **32** to free the rollers **29** and their support **28**, leaving the engine **10** supported in the pod **13** by said trunnions or other suitable means.

To remove the engine **10** from the pod **13**, the reverse procedure to the above is followed, in the sequence of FIGURES 3, 2 and 1. It is to be noted that no specialized tools are necessary in using the equipment according to the invention, nor have the engine **10** or pod **13** any additional fixtures which might increase the weight thereof.

In FIGURE 3, a modified arrangement for securing the guide rail **35** to the lugs **38** of pod **13** is shown diagrammatically. The rail **35** is supported by pivoted links **41** which are connected by removable pegs **39** to the lugs **38**. A screw jack **42** or like device is attached to one or both of the links **41** to enable a limited adjustment of the position of the engine **10** within pod **13** to be made to compensate for misalignment of the trunnions or other means on the pod **13** with respect to the engine **10** when the latter is installed in the pod **13**.

In a modification (not shown) of the embodiments illustrated, the rail **21** of hoist **23** may be replaced by two intersecting rails and the ring **22** by sliding or rolling elements which co-operate with one of the rails. The sliding or rolling elements would be arranged in use to co-operate with whichever of the rails is selected to coincide as nearly as possible with the line of greatest slope of the axis **14** of the engine **10** when the latter is installed in the pod **13**.

I claim:

1. A method of installing an engine in a housing, said method comprising the steps of: securing curved guide means to the housing to extend downwardly therefrom; engaging at least one guide-engaging element on the engine with said curved guide means; hoisting the engine into the housing in a position inclined at an angle to the vertical, the engine being guided by said guide means; securing the engine within the housing in said inclined position; and removing the guide means from the housing.

2. A method as claimed in claim **1** in which the said at least one guide-engaging element is detachably secured to the engine and removed therefrom after the engine has been installed in the housing.

3. A method as claimed in claim **1** including mounting hoisting means on the housing and attaching the hoisting means to a hoist-engaging member secured to the engine, said hoisting means and hoist-engaging member being removed after the engine has been secured within the housing.

4. A method as claimed in claim **3** in which the engine is a gas turbine jet lift engine having air intake and exhaust ends and the housing has open upper and lower ends, the hoisting means being mounted on the upper end of the housing and the hoist-engaging member being secured to the air intake end of the engine so that the hoisting means hoists the engine through the open lower end of the housing into an installed position in which the intake end of the engine is disposed adjacent the upper, and the exhaust end of the engine adjacent the lower, end of the housing.

5. A method as claimed in claim **4** in which the guide means guides the engine from a position beneath the housing in which the axis of the engine is substantially vertical to an installed position within the housing in which the engine is in said inclined position with its axis inclined to the vertical.

6. A method as claimed in claim **5** in which the guide means comprise a rail extending downwardly from the side of the housing which is spaced further from the ground, the rail being secured to the interior of the housing.

7. A method as claimed in claim **6** in which the hoisting means are arranged to hoist from a point above the open upper end of the housing and displaced from the axis of the housing towards the said side of the housing to which the rail is secured.

8. Engine handling apparatus for installing an engine in a housing, said apparatus comprising curved guide means adapted to be detachably secured to the engine housing and to extend downwardly therefrom, hoisting means mounted on the housing adapted to engage the engine, at least one guide-engaging element on the engine for engaging said guide means to guide the engine into the housing, at an angle inclined to the vertical as it is hoisted by the hoisting means, a hoist-engaging member adapted to be detachably secured to the engine, said hoist-engaging member including a movable connection element, and said hoisting means including a flexible hoisting element for attachment to said connection element, said connection element having limited freedom of movement in a substantially horizontal plane so that during operation of the apparatus the point of application of the hoisting force to the engine changes to accommodate changes in orientation of the engine.

9. Apparatus as claimed in claim **8** wherein said at least one guide-engaging element comprises a rolling element which is adapted to engage with and ride on the guide means.

10. Apparatus as claimed in claim **8** wherein the said guide means comprise a rail formed in at least two sections joined detachably together in end-to-end relation.

11. Apparatus as claimed in claim **8** wherein said movable connection element comprises a ring engageable by said flexible element, and said hoist-engaging member is provided with an arcuate rail on which the ring is movable, the centre of said arcuate rail lying on the axis of the engine at or above the centre of gravity thereof.

12. Apparatus as claimed in claim **8** in which the hoist-engaging member is provided with a plurality of spigots which may be engaged in corresponding sockets provided in the intake wall of the engine.

13. Apparatus as claimed in claim **8** in which removable links are provided for securing the guide means to the interior of the housing, and means for adjusting at least one of said links is also provided, whereby the posi-

tion of the engine may be adjusted when the latter is in its installed position.

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CHARLIE T. MOON, *Primary Examiner.*

U.S. Cl. X.R.

29—200, 469; 214—1; 254—150, 167