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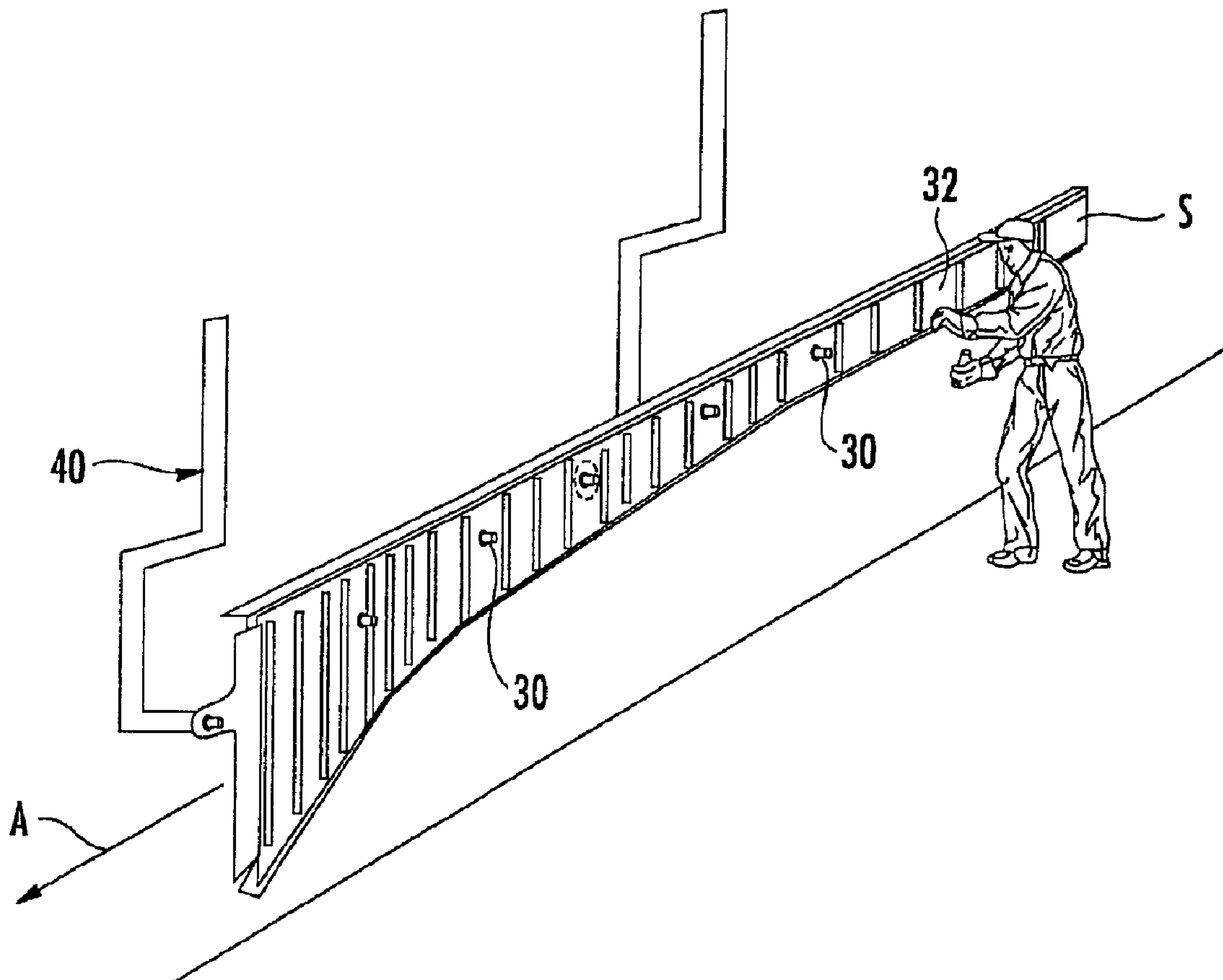
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(54) Titre : SYSTÈME DE FABRICATION DE STRUCTURES AERONAUTIQUES ET D'AUTRES STRUCTURES DE GRANDE DIMENSION

(54) Title: MANUFACTURING SYSTEM FOR AIRCRAFT STRUCTURES AND OTHER LARGE STRUCTURES



(57) Abrégé/Abstract:

A production system for manufacturing a workpiece comprises an index system including a plurality of index devices removably mounted on the workpiece at known longitudinally spaced locations therealong, and a longitudinally extending index member



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(57) **Abrégé(suite)/Abstract(continued):**

releasably engaged with at least two of the index devices such that a position and orientation of the index are fixed relative to the workpiece by the index devices, the index member having position-indicating features distributed therealong. The production system further comprises a machine module mounted for longitudinal movement along the index member and operable to perform an operation, the machine module being operable to detect the position-indicating features on the index member and thereby determine a position of the machine module relative to the workpiece.

MANUFACTURING SYSTEM FOR AIRCRAFT STRUCTURES AND OTHER
LARGE STRUCTURES

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ABSTRACT

10 A production system for manufacturing a workpiece comprises an index
system including a plurality of index devices removably mounted on the workpiece at
known longitudinally spaced locations therealong, and a longitudinally extending
index member releasably engaged with at least two of the index devices such that a
position and orientation of the index are fixed relative to the workpiece by the index
15 devices, the index member having position-indicating features distributed therealong.
The production system further comprises a machine module mounted for longitudinal
movement along the index member and operable to perform an operation, the
machine module being operable to detect the position-indicating features on the index
member and thereby determine a position of the machine module relative to the
workpiece.

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MANUFACTURING SYSTEM FOR AIRCRAFT STRUCTURES AND OTHER LARGE STRUCTURES

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FIELD OF THE INVENTION

The present invention relates to a production system for manufacturing large structures such as aircraft spars, planks, wing sections, fuselage sections, and the like, and other large structures. The invention relates more particularly to a production system of non-fixed-base type employing either a continuous-flow or pulse-flow process and using machine modules that are brought into engagement with the workpiece as the workpiece travels along its process flow path and that index to the workpiece with the aid of index devices mounted on the workpiece.

BACKGROUND OF THE INVENTION

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Large structures such as those mentioned above are traditionally manufactured using large fixed-based machines such as robotic drilling machines and riveting machines. Some of the well-known drawbacks of using such machines include the high initial capital investment to acquire and install the equipment and the large and expensive foundations that they require, the significant amount of time and resources required for training workers how to operate the complex machines and for maintaining and supporting the machines, and the loss of productive use of the machines during certification, qualification, and maintenance of the machines. Additionally, large fixed-based machines do not lend themselves to Continuous Flow Manufacturing (CFM), which is considered by most leading manufacturing experts to be the most efficient manufacturing method. Furthermore, manufacturing of large structures such as airplane structures has conventionally required model-specific tooling such as floor assembly jigs (FAJs) and Gemcor header systems. Such model-specific tooling represents a substantial fraction (e.g., about one-third) of the total cost of developing a new airplane.

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Because of disadvantages such as those mentioned above, alternative manufacturing methods that avoid one or more of these disadvantages are desirable. Preferably, the methods should be capable of supporting a CFM process, and should facilitate off-line maintenance and qualification of a machine while another replacement machine continues

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10 production, and hence a system employing non-fixed-base machines in need.
Although these goals are desirable, they have been difficult to achieve for various
reasons, not the least of which is the difficulty of accurately positioning non-fixed-
base machines relative to the workpiece. Systems such as laser positioners can be
used for positioning machines relative to the workpiece, but such systems are highly
15 complex and usually require set-ups that are specific to the particular workpiece being
manufactured, and are often limited by line-of-sight considerations.

SUMMARY OF THE INVENTION

The present invention addresses the above needs and achieves other
20 advantages by providing a production system employing non-fixed-base machines
that interface with a workpiece via an index system that can travel along with the
workpiece in a CFM or pulse-flow manufacturing process, the index system
accurately locating the machine relative to the workpiece by physically indexing to
index devices removable mounted on the workpiece.

25 In accordance with one aspect of the invention, there is provided a production
system for processing a workpiece. The system includes a material handling system
operable to hold the workpiece and transport the workpiece along a process flow path.

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10 The system also includes an index system fixed relative to the workpiece in a known
position and orientation with respect thereto. The system further includes an index
support system connected with the index system and supporting one or more items
used in processing the workpiece, the material handling system moving the workpiece
15 along the process flow path and causing the index support system with the index
system to be passively transported along with the workpiece.

The index support system may include a zero-balance device.

The index support system may include a wheeled cart.

The index support system may include a spring suspension.

The index support system may include a sliding base that slides along a floor.

20 The production system may further include a machine supported on the base
and connected with the index system, the index system including an index member
operable to clamp onto a pair of index devices affixed to the workpiece such that the
base with the machine thereon is pulled with the workpiece along the process flow
path, and the machine being operable to perform one or more work operations on the
25 workpiece as the base and machine move along with the workpiece.

The base may be operable to slide back and forth between a starting location
and an ending location, and the index member is operable to disengage from the index

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10 devices when the base reaches the ending location to allow the base to be moved back to the starting location.

The production system may further include a machine supported on the base and connected with the index system, the machine being operable to clamp onto the index system such that the sliding base with the machine thereon is pulled with the
15 workpiece along the process flow path, and the machine being operable to perform one or more work operations on the workpiece as the base and machine move along with the workpiece.

The index system may include a longitudinally extending index member having a machine-readable position-encoded strip extending therealong, and further
20 comprising a machine engaging the index member, the machine being operable to determine a position of the machine relative to the workpiece by reading the position-encoded strip.

In accordance with another aspect of the invention, there is provided an index device for mounting on a workpiece to be used as a reference feature in
25 manufacturing operations. The device includes a housing structured and arranged to attach to the workpiece and engage a hole formed in the workpiece so as to locate the

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10 index device relative to the workpiece. The device further includes, and a machine-readable sensor mounted in the housing, the sensor storing an identifier, whereby the identifier can be correlated with the location of the index device on the workpiece.

The housing may have a generally pin-shaped configuration.

15 The housing may have a first portion and a second portion that are positioned on opposite sides of the workpiece and are connected together by a shaft passing through the hole in the workpiece.

Each of the first and second portions may define at least one datum surface providing a position reference.

20 The sensor may be located in one of the first and second portions, and the other of the portions has a second sensor therein.

The housing may define at least X and Y datum surfaces providing X and Y position references.

The housing may further define a Z datum surface providing a Z position reference.

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BRIEF DESCRIPTION OF THE DRAWINGS

10 The above and other objects, features, and advantages of the invention will
become more apparent from the following description of certain preferred
embodiments thereof, when taken in conjunction with the accompanying drawings in
which:

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Examples of such positioning systems include but are not limited to laser positioners. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed
5 herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

