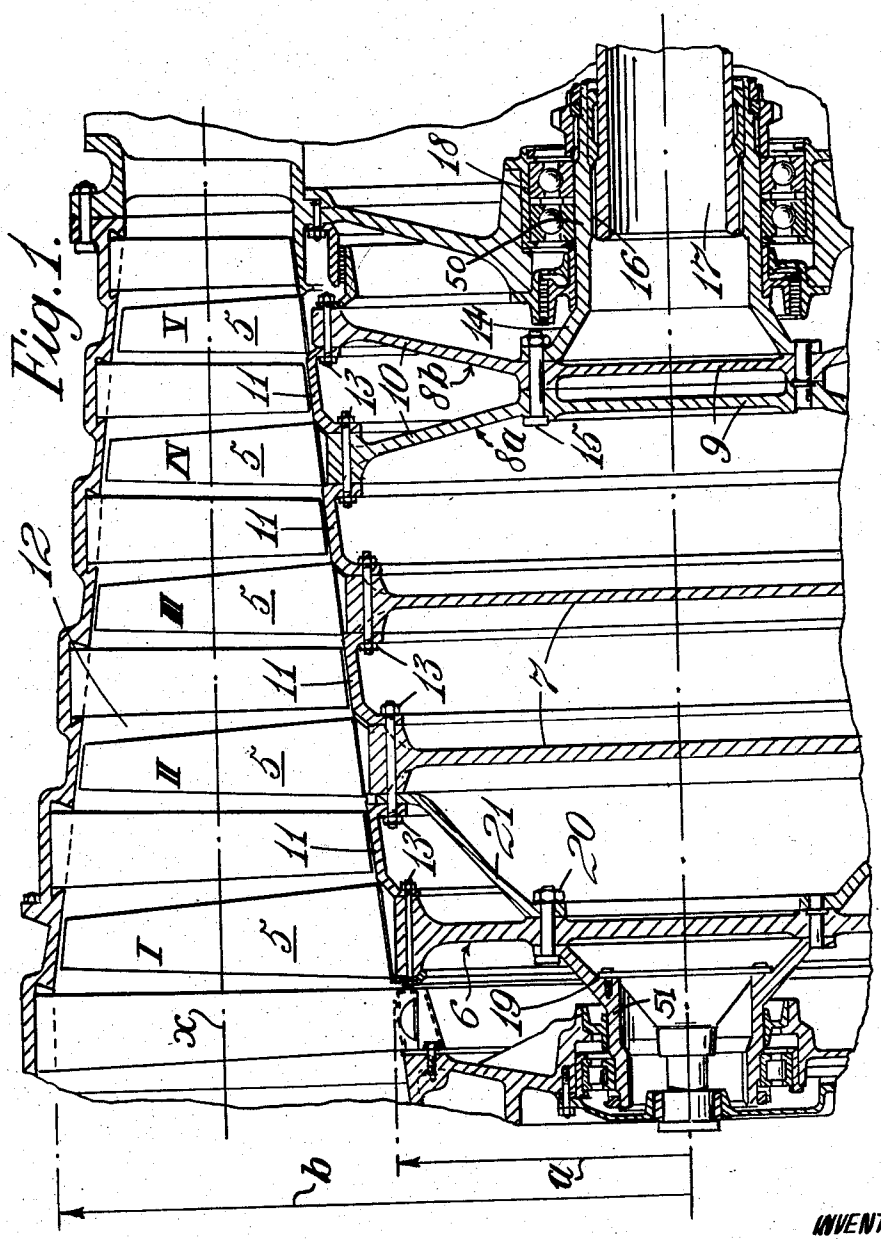
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ROTORS FOR AXIAL FLOW COMPRESSORS OR TURBINES

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Fig. 1.



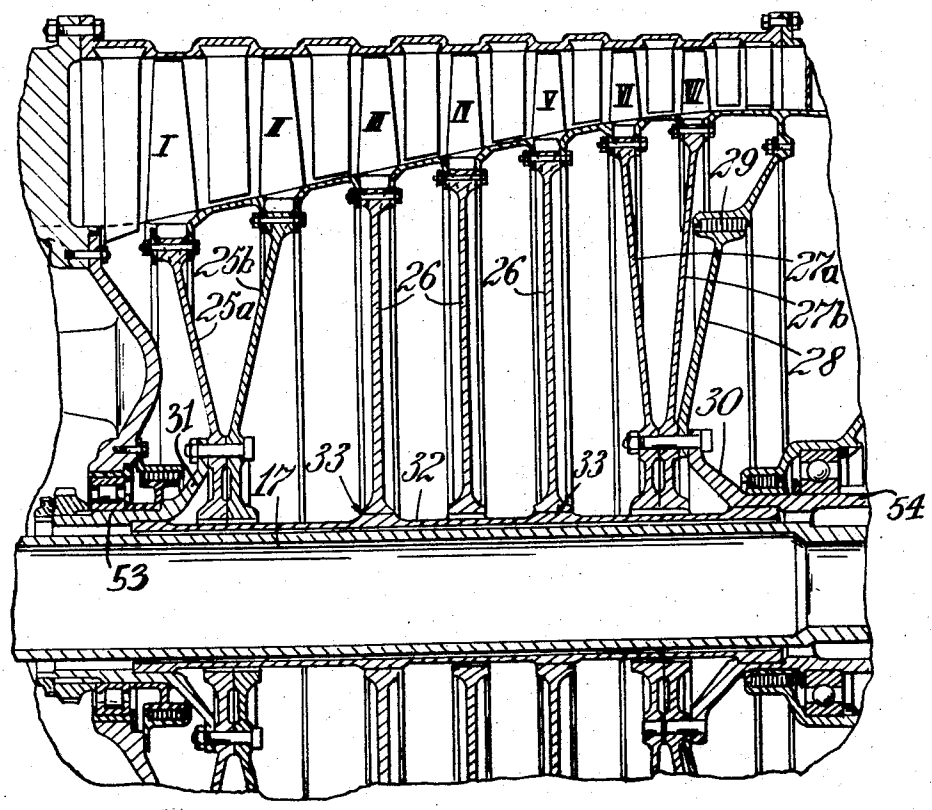
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ROTORS FOR AXIAL FLOW COMPRESSORS OR TURBINES

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Fig 2.



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ROTORS FOR AXIAL FLOW COMPRESSORS OR TURBINES

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Fig. 3.

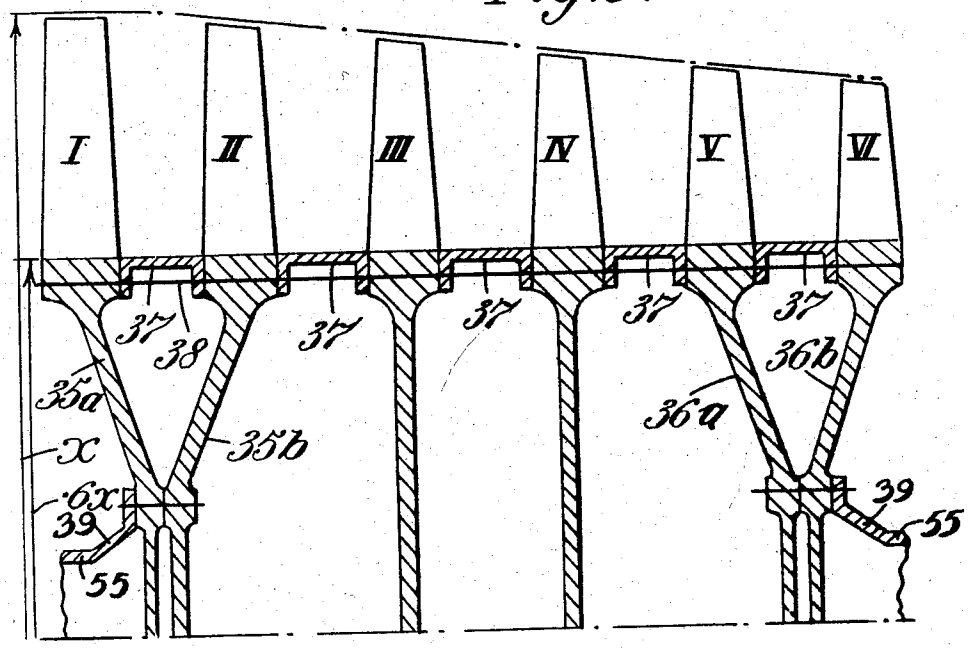
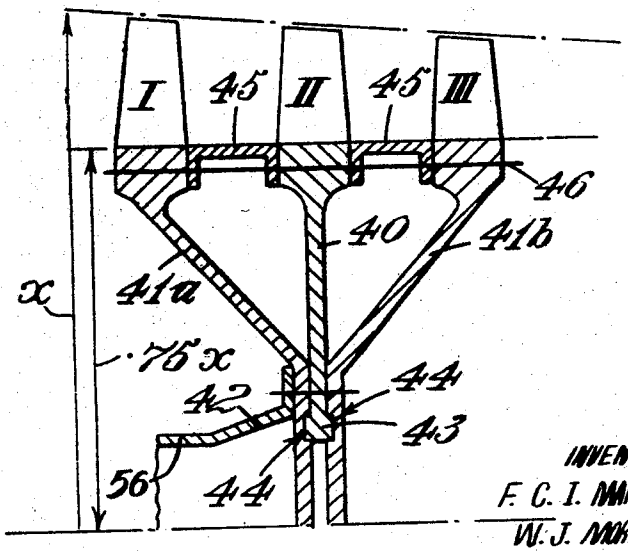


Fig. 4.



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2,869,820

ROTORS FOR AXIAL FLOW COMPRESSORS OR TURBINES

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Application April 12, 1952, Serial No. 281,958

Claims priority, application Great Britain April 18, 1951

10 Claims. (Cl. 253—69)

This invention relates to rotors for rotary power conversion machines such as axial flow compressors or turbines which rotors are of the kind comprising at least three blade-carrying discs joined at or near their rims to form a drum structure.

A principal object of the invention is to provide such a structure which while being light in weight and readily assembled and dismantled shall be stiff against lateral deflections so as to provide a high critical whirling speed.

Another object of the invention is to provide such a structure in which, while maintaining a minimum overall length of the rotor and its supporting bearings, the end blade-carrying discs are substantially relieved of bending stresses associated with lateral deflection.

According to the invention, in a rotor of the kind described, an end blade-carrying disc has a frusto-conical disc attached at each side at a common intermediate radius one being convergent and carrying at its end of minimum diameter a stub shaft, and the other being divergent and forming part of another of the blade-carrying discs or being attached to another such disc at or near its rim.

The invention also includes a rotor of the kind described in which the disc carrying the lowest pressure blading is flat and has a frusto-conical disc attached at each side at a common intermediate radius, one being convergent and carrying at its end of minimum diameter a stub shaft, and the other being divergent and attached at its end of maximum diameter to the next adjacent blade-carrying disc at or near its rim.

In another arrangement according to the invention an end blade-carrying disc has a central flat portion and an outer frusto-conical portion diverging axially and radially away from the transverse central plane of the rotor, a convergent frusto-conical disc carrying at its end of minimum diameter a stub shaft, being attached at its end of maximum diameter at the margin of the central flat portion on one side and on the other side the next or next but one blade-carrying disc being of oppositely dished plano-conical form and attached directly or with an interposed disc at the margin of said central flat portion.

All the blade-carrying discs may be secured together at or near their rims with interposed spacing members by bolts extending from end to end of the drum structure assembly, or by bolts which are individual to the blade-carrying discs.

Figure 1 illustrates an axial flow compressor having five stages (I–V) and intended for use as the low pressure compressor of a jet propulsion compound gas turbine,

Figure 2 illustrates an axial flow compressor having seven stages (I–VII) intended to follow the compressor illustrated in Figure 1 as a high pressure compressor,

Figure 3 illustrates an axial flow low pressure compressor having six stages (I–VI), the compressor being of the constant root diameter type, and

Figure 4 illustrates an axial flow high pressure compressor having eight stages (I–VIII), the compressor being of the constant root diameter type.

The compressor illustrated in Figure 1 is of the type having blades 5 of constant mean radius x and a ratio of hub diameter to tip diameter at the first row of moving blades (a/b) of about 0.45. The blades 5 are mounted around the rims of five discs 6, 7, 8*a*, 8*b* all of which are solid, i. e. have no central holes. The first three discs 6, 7 are flat, that is to say they are symmetrical on each side of a flat central transverse plane, while the last two discs 8*a* and 8*b* at the high pressure end are dished toward one another and comprise central flat portions 9 in abutting relation and outer frusto-conical parts or portions 10 diverging from one another. Discs 6 and 8*b* constitute the end blade-carrying discs. At their rims the discs are spaced from one another by members 11 defining the inner conical surface of the annular air passage 12 and are connected to the said spacing members by rows of bolts 13 individual to each disc so as to form a frusto-conical drum structure. At the high pressure end of the drum structure a short convergent frusto-conical disc 14 is bolted to the central flat portion of the end disc by bolts 15 which also pass through the flat portion 9 of the discs so that these three parts are firmly connected together around the margin of the flat portions. The disc 14 is formed integrally, at its end of minimum diameter, with a stub shaft 50 which is splined internally, at 16, for the reception of a driving shaft 17 and which is supported by a bearing and air sealing assembly 18 which, by reason of the dished shape of disc 8*b*, is partly housed within the blade-carrying length of the rotor, thereby reducing the length of the compressor.

At the low pressure end of the rotor a similar short frusto-conical disc 19 carrying a stub shaft 51 at its end of minimum diameter is bolted to the flat first stage disc 6 by a ring of bolts 20 arranged about midway between its centre and rim. Disc 6 is advantageously made flat since this is the best form for taking the centrifugal loads from the blading, which are highest for this stage, but it has the disadvantage with the arrangement as so far described that forces associated with lateral deflection of the rotor tend to bend the disc, against which form of distortion it is relatively weak. To overcome this objection without increasing the maximum diameter and taper of the conical disc 19, and therefore its projection, a frusto-conical disc or stiffening member 21 is attached to disc 6 by the bolts 20 and extends within the drum structure divergently to the rim of the second stage disc 7, where its end of maximum diameter is sandwiched between the rim and its spacing member 11.

Considering the rotor construction in axial section, the frusto-conical disc 19, frusto-conical stiffening member 21, spacing members 11 between the discs 7, 8*a* of stages II, III and IV, disc 8*a* of stage IV and frusto-conical disc 14 form a strength drum of generally "peg top" form from which the discs 6 and 8*b* project and are stabilised by the first and last spacing members 11.

Referring to Figure 2, in this case the blade-carrying discs 25*a*, 25*b*, 26 and 27*a*, 27*b* are all provided with central holes for the passage of the shaft 17 driving the low pressure compressor.

The high pressure compressor has a constant tip diameter, so that the rotor drum has a conical outer surface as in the construction of Figure 1, in this case however the hub-tip ratio is very much smaller, being about 0.69, and this has permitted the first and second stage discs 25*a*, 25*b* to be dished towards one another to form a construction as described for the high pressure end of the construction of Figure 1, a frusto-conical disc 31 carrying a stub shaft 53 being bolted to the discs 25*a*, 25*b*. The high pressure end is also constructed in a similar manner but has an additional frusto-conical disc 28 carrying at its end of maximum diameter part of a labyrinth seal 29. The additional disc 28 has its end of minimum

diameter sandwiched between the disc 27*b* and the frusto-conical disc 30 which carries a stub shaft 54. The two stub shafts 53, 54 also retain between them a tubular member 32 passing through the central holes of the discs. The discs 26 of stages III and V bear on the outside of this tubular member, as at 33, for steadying purposes, the remaining discs being provided with clearance holes.

Referring to Figure 3, in the compressor rotor illustrated the first row of moving blades has a hub tip ratio of about 0.6, the first and second and the fifth and sixth blade-carrying discs 35*a*, 35*b*, 36*a*, 36*b* respectively (i. e. at the ends of the rotor) are dished towards one another and provided with frusto-conical discs 39 carrying stub shafts 5 as described above for the high pressure end in the construction of Figure 1. At their rims all the blade-carrying discs are bolted together with interposed spacing members 37 defining the inner cylindrical surface of the air passage between the blades by a ring of bolts 38 extending from end to end of the rotor. To ensure correct re-assembly after dismantling, each of the bolted joints is preferably provided with a locating peg or dowel (not shown) and similar provision may be made in the other constructions described.

In the construction shown in Figure 4 the compressor rotor has a hub-tip ratio at the first row of moving blades of about 0.75 and is constructed as described with reference to Figure 3 except that at the low pressure end, instead of the first and second discs being dished towards one another, the second disc 40 is flat and clamped at an intermediate radius between the first and third discs 41*a*, 41*b*, which are dished towards the disc 40, a frusto-conical disc 42 carrying a stub shaft 56 at its end of minimum diameter being also attached at the same clamping radius. The other discs in this construction all have central holes for the passage of a shaft for driving an adjacent low pressure compressor, the discs being suitably increased in thickness around the holes to provide the necessary reinforcement as described with reference to Figure 2. All the discs except the second extend inwardly to a tube held between the stub shafts, the second projecting only a short distance inwardly of the clamping radius and being provided around the central hole with a thickened rim 43 spigotting into recesses 44 in the disc 41*a*, 41*b* so that these latter provide an anchorage for the inner rim. At their outer rims the discs are held together with interposed spacing members 45 by bolts (at 46) extending from end to end of the rotor as in the third construction.

The several constructions described with reference to the accompanying drawings are given by way of example only.

The invention is also applicable to rotor constructions in which the blades are held between adjacent discs instead of being mounted around the disc rims. In such constructions the blades take the place of the spacing members previously referred to, while the rims of the discs form the inner surface of the annular air passage between the blade rows.

Although the invention has been particularly described as applied to compressors it will be clear that the same principles can apply in the case of multi-stage axial flow turbines.

We claim:

1. In a lightweight rotor for an axial flow rotary power conversion machine said rotor comprising at least two end blade-carrying discs, an intermediate blade-carrying disc, and means joining said discs together and connected thereto adjacent their rims to form a rigid drum structure: a first frusto-conical disc bolted at an intermediate radius to the side of one of said end blade-carrying discs forming an end face of said drum structure, said frusto-conical disc being of a lesser maximum diameter than said end blade-carrying disc and being carried by said end blade-carrying disc so as to be concentric therewith and convergent away therefrom, a stub shaft for said rotor on said first frusto-conical disc at its end of minimum diameter; a blade carrying disc having at least a frusto-conical part bolted to said one end blade-carrying disc at said intermediate radius on the side thereof remote from said first frusto-conical disc so as to be concentric with said one end blade-carrying disc, said frusto-conical part being divergent away from said one end blade carrying disc; and bolts attaching said frusto-conical part at its end of maximum diameter to the outer periphery of an adjacent part of said drum structure.

2. A rotor as claimed in claim 1 wherein said one of said end blade-carrying discs has a central flat portion and an outer frusto-conical portion diverging axially and radially away from the transverse central plane of the rotor, and said first frusto-conical disc is bolted to said one end blade-carrying disc at the margin of said central flat portion, and said blade-carrying disc having the frusto-conical part is next adjacent to said one end blade-carrying disc and said frusto-conical part is bolted to said one of said end blade-carrying discs at the margin of said central flat portion.

3. A rotor as claimed in claim 1 wherein said means to join said blade-carrying discs together adjacent their rims comprises a plurality of bolts and interposed spacing members, between each adjacent pair of discs.

4. In a lightweight rotor for an axial flow rotary power conversion machine said rotor comprising at least two end blade-carrying discs, an intermediate blade carrying disc, and means joining said discs together and connected thereto adjacent their rims to form a rigid drum structure: a first frusto-conical disc bolted at an intermediate radius to the side of one of said end blade-carrying discs forming an end face of said drum structure, which end blade-carrying disc is flat, said frusto-conical disc being of a lesser maximum diameter than said one end blade-carrying disc and being carried by said one end blade-carrying disc so as to be concentric therewith and convergent away therefrom, a stub shaft for said rotor on said first frusto-conical disc; and a second frusto-conical disc bolted to said one end blade carrying disc at said intermediate radius on the side thereof remote from said first frusto-conical disc so as to be concentric with said one end blade-carrying disc, said second frusto-conical disc being divergent away from said one end blade-carrying disc and being bolted to said intermediate blade-carrying disc.

5. In a lightweight rotor for an axial flow rotary power conversion machine said rotor comprising at least two end blade-carrying discs, an intermediate blade-carrying disc, and means joining said discs together and connected thereto adjacent their rims to form a rigid drum structure: a first frusto-conical disc bolted at an intermediate radius to the side of one of said end blade-carrying discs forming an end face of said drum structure, said frusto-conical disc being of a lesser maximum diameter than said one end blade-carrying disc and being carried by said one end blade-carrying disc so as to be concentric therewith and convergent away therefrom, a stub shaft for said rotor on said first frusto-conical disc; and a second frusto-conical disc bolted to said one end blade-carrying disc at said intermediate radius on the side thereof remote from said first frusto-conical disc so as to be concentric with said one end blade-carrying disc, said second frusto-conical disc being divergent away from said one end blade-carrying disc and being bolted at its end of maximum diameter to said intermediate blade-carrying disc.

6. A rotor as claimed in claim 1, wherein said one of said end blade carrying discs is an unperforated disc, and said blade carrying disc having at least a frusto-conical part is an unperforated disc, the frusto-conical part forming an outer peripheral portion of the disc.

7. A rotor as claimed in claim 2, wherein the cone angle of the outer frusto-conical portion of said one end

blade carrying disc is substantially equal to the cone angle of said frusto-conical part.

8. A rotor as claimed in claim 2, wherein said central flat portion of said one of said end blade carrying discs is unperforated, and said next adjacent blade carrying disc has a central unperforated flat portion.

9. A rotor as claimed in claim 2, further comprising spacing means between said frusto-conical part and said one of said end blade carrying discs, the frusto-conical part being bolted to said one of said end blade carrying discs through said spacing means.

10. In a lightweight rotor for an axial flow rotary power conversion machine, said rotor comprising a plurality of blade carrying discs including at least two end blade carrying discs and means joining said discs together and connected thereto adjacent their rims to form a rigid drum structure; a first frusto-conical disc bolted at an intermediate radius to the side of the end blade carrying disc at the low pressure end of the rotor which forms an end face of said drum structure, said first frusto-conical disc being of a lesser maximum diameter than said low pressure end blade carrying disc, and being carried by said low pressure end blade-carrying disc so as to be concentric therewith and convergent away therefrom; a first stub shaft for said rotor on said first frusto-conical disc at its end of minimum diameter; a second frusto-conical disc bolted to said low pressure end blade carrying disc at said intermediate radius on the side thereof remote from said first frusto-conical disc so as to be concentric with said low pressure end blade carrying disc, said second frusto-conical disc being divergent away from said low pressure end blade carrying disc and being bolted at its end of maximum diameter to said drum structure at

the outer periphery of the drum structure; a third frusto-conical disc bolted at an intermediate radius to the side of the end blade carrying disc at the high pressure end of the rotor which forms the other end face of said drum structure, said third frusto-conical disc being of lesser maximum diameter than said high pressure end blade-carrying disc and being carried by said high pressure end blade-carrying disc so as to be concentric therewith and convergent away therefrom; a second stub shaft for said rotor on said third frusto-conical disc at its end of minimum diameter; a blade carrying disc having at least a frusto-conical part bolted to said high pressure end blade carrying disc at said intermediate radius of the high pressure end blade carrying disc on the side thereof remote from said third frusto-conical disc so as to be concentric with said high pressure end blade carrying disc, said frusto-conical part being divergent away from said high pressure end blade carrying disc; and bolts attaching said frusto-conical part at its end of maximum diameter to the outer periphery of said drum structure.

References Cited in the file of this patent

UNITED STATES PATENTS

770,207	Wilkinson	Sept. 13, 1904
1,030,153	Barbezat	June 18, 1912
2,213,940	Jendrassik	Sept. 3, 1940
2,445,661	Constant et al.	July 20, 1948
2,579,745	Lombard	Dec. 25, 1951
2,662,685	Blanc	Dec. 15, 1953

FOREIGN PATENTS

223,615	Switzerland	Dec. 16, 1942
543,985	Great Britain	Mar. 23, 1942