

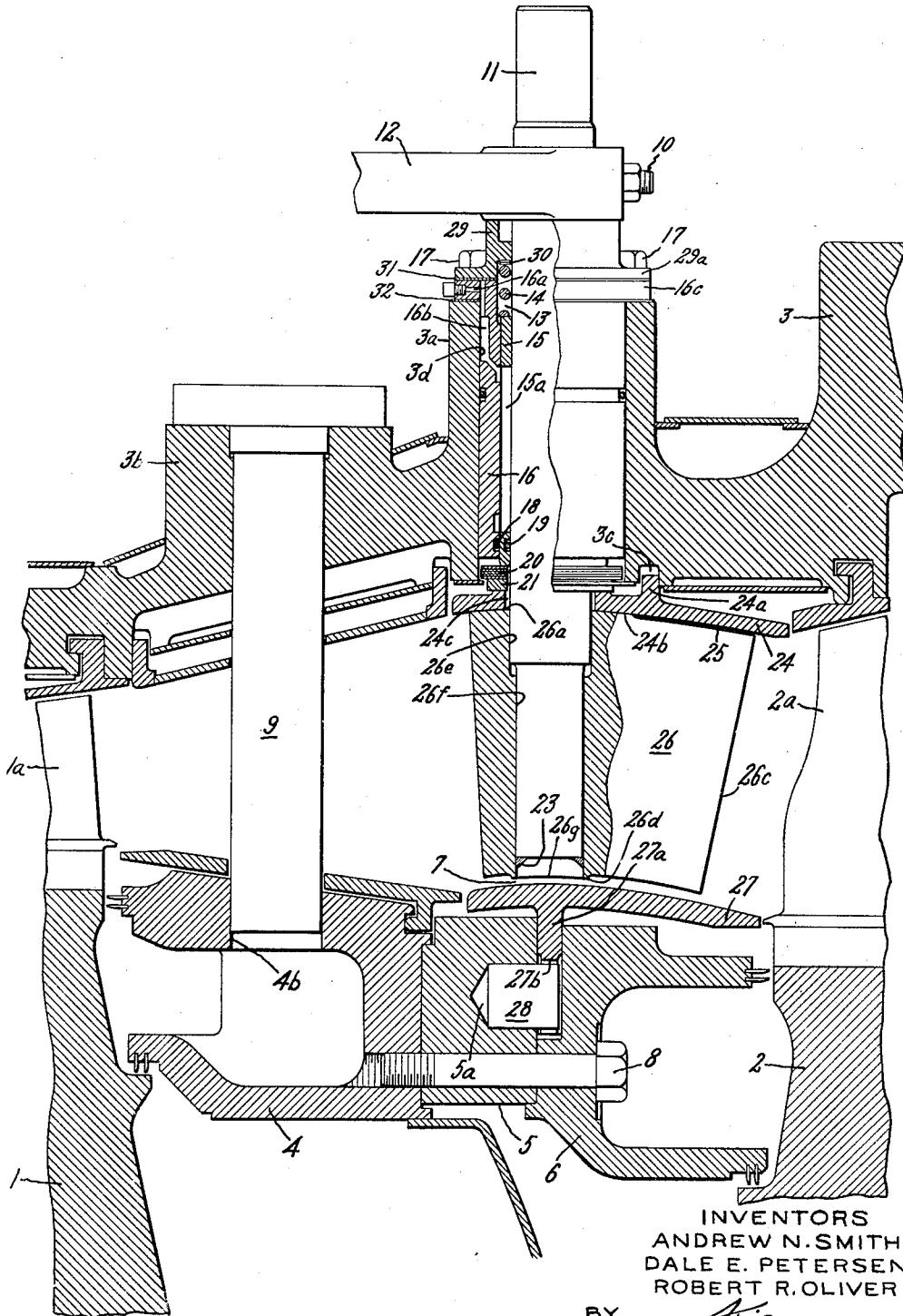
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ADJUSTABLE GAS TURBINE NOZZLE ASSEMBLY

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ADJUSTABLE GAS TURBINE NOZZLE ASSEMBLY

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6 Claims. (Cl. 253—78)

This invention relates to a high temperature gas turbine, particularly to the structure of a variable area nozzle assembly for directing hot motive fluid to the bucket wheel.

There are many advantages to be had for making the turbine nozzles adjustable. Among these are, better performance at light load conditions, better control in the event of overspeed, and improved operation at varying ambient temperatures.

In this connection, the problem of differential thermal expansion between the various parts of the adjustable nozzle assembly becomes very critical. This is especially true when the differential thermal expansion is not provided for and the various elements tend to bind against each other. In these instances, the adjustability of the nozzle becomes extremely difficult. The problem of differential thermal expansion results from the fact that the turbine starts quickly and requires high temperatures to bring the machine up to speed, with the result that the turbine is subjected to a rapid increase in temperature and attendant expansion of the turbine parts. In contrast to steam turbines, changes in load on gas turbines are frequently accompanied by very substantial changes in temperature of the motive fluid entering the turbine.

The blades on the turbine bucket wheel are, of course, free to expand longitudinally into the clearance space provided in the casing. However, the tendency for the stationary nozzle blades to expand in the radial direction, unless adequately compensated for, tends to cause very high stresses which may result in cracking of parts of the nozzle assembly, or the supporting structure.

Accordingly, the object of the present invention is to provide a variable turbine nozzle assembly of the type described, arranged to permit the substantial differential thermal expansion which must take place between the nozzle blades and the associated annular walls between which the nozzle blades are supported, without imposing excessive stresses on either the blades or supporting members.

Another object is to provide an inner sidewall mounting assembly which permits the use of a solid inner sidewall.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawing which is a longitudinal section of an adjustable gas turbine nozzle assembly incorporating the invention.

Generally stated, the invention is practiced by providing a resiliently supported nozzle blade and outer sidewall that is permitted to move radially in response to forces imposed by the inner sidewall resulting from thermal expansion. Also, the inner casing assembly is designed so that a solid inner sidewall can be used which prevents leakage of motive fluid thereacross.

Referring now more particularly to the drawing, the invention is shown as applied to a turbine having two mechanically independent rotors 1, 2 supported in a common casing 3. The respective bucket wheels are provided

with circumferential rows of radially extending blades 1a, 2a supported in separate bearings (not shown). The detailed structure of the bucket wheels and the method of fastening the blades to the disks are not material to an understanding of the present invention and, therefore, will not be discussed further herein.

The casing arrangement includes an outer casing member indicated generally at 3 and an inner casing assembly. To facilitate manufacture and assembly, the outer casing member 3 is formed of two or more arcuate segments secured together by bolts (not shown), while the inner casing members are solid continuous rings.

The inner casing member 4 is supported from the outer casing 3 by a plurality of radially extending studs 9. Specifically, there are about six of these studs and they extend through boss 3b in outer casing 3 into bore 4b defined by member 4. The studs 9 fit with a press fit in bore 4b.

The inner casing assembly further includes annular inner side wall support members 5, 6. The inner casing members 4, 5, 6 are connected together by a series of bolts 8. The inner and outer sidewalls 27, 24 respectively form the motive fluid flow path. These walls 27, 24 are connected to the inner and outer casing by structure to be hereinafter described in detail.

This invention particularly relates to the adjustable nozzle assembly for the second stage buckets 2a. Each adjustable blade 26 is secured to a rod 11 supported for limited rotational movement in a sleeve 15. The adjustable vanes or blades 26 may be forged, machined from bars, or fabricated from sheet metal. As shown, they are solid, forged, or cast blades. The rod 11 extends through aligned cylindrical openings 24c in the outer wall member, openings 26e, 26f defined by the blade, and is welded, as shown at 23, to the blade 26 at its extreme inner end.

The sleeve 15 is disposed within a bushing 16 which is secured between a cap 29 and a boss 3a defined by the outer casing member 3. The cap 29 and bushing 16 have square flanges 29a, 16b respectively through which extend threaded fastenings 17 to secure them to the boss 3a. The bushing 16 is disposed in the bore 3d defined by boss 3a. The bushing 16 defines passages 16a, 16b through which grease is admitted to one or more longitudinal slots 15a cut through sleeve 15. This grease provides a lubricant between the sleeve 15 and the rod 11 and bushing 16 so that the rod can be easily rotated. The flow of lubricant radially inward to the main flow path is prevented by packing rings 18, 19. The lubricant is prevented from leaking between the bushing 16 and cap 29, and boss 3a by gaskets 31, 32 respectively.

The means for adjustably positioning the rods 11 includes an axially projecting handle 12 having one end connected to the outer end of rod 11. The handle is connected to the rod 11 by a shear pin 10.

Defined between the cap 29, bushing 16, rod 11, and sleeve 15 is a spring chamber 13. Disposed in chamber 13 is a compression spring 14 biasing the sleeve in an inward direction. Shims 30 are located between the cap 29 and spring 14 for adjusting the force of the spring. Located between the inner end of sleeve 15 and the outer sidewall 24 is a series of shims 20 and a washer 21 for spacing the wall 24 from the end of sleeve 15. Thus it can be seen that the spring 13 provides for resilient mounting for the nozzle assembly including sleeve 15, shims 20, washer 21, outer sidewall 24, and partition 26 so that it is free to move radially outward. The inward movement of the blade assembly is limited by the contact of the lever member 12 with the upper end of cap 29.

A major problem confronted in variable nozzles of this type is that of preventing excessive leakage between the inner and outer walls with which the nozzle blades cooperate without at the same time risking seizure be-

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tween the blades and the cooperating walls due to differential thermal expansion. This problem is solved in the present instance in the following manner.

The outer wall member with which the blades cooperate is an annular ring made of a plurality of segmental members, one of which is indicated at 24. The specific details of a segmental wall of this type is disclosed in the prior patent of B. O. Buckland and G. B. Warren, No. 2,651,496, issued to the assignee of the present invention. The inner surface 24b is not a cylindrical surface about the axis of the powerplant, but is spherical, with a center located at the axis of the rotor. The cooperating end of blade 26 has a spherical portion 26a adapted to engage the spherical surface 24b, but the rearward or trailing edge portion 26c of blade 26 is relieved somewhat to provide a clearance shown at 25. This is to reduce the friction area between segment and blade and thus reduce the turning effort required from the positioning motor means (not shown), and to permit completely free differential thermal expansion between the comparatively thinner trailing edge of the blade relative to the wall 24. This avoids the possibility of imposing excessive compressive stresses on the thin trailing edges of the blades when motive fluid is first admitted to the turbine, as might otherwise occur since the thin trailing edges will naturally heat up faster than the comparatively heavier section through which the rod 11 passes. These features are disclosed in the aforementioned Patent No. 2,651,496.

To prevent axial shifting of the outer sidewall 24, as well as to reduce leakage of motive fluid around the outer surface thereof, each segment is provided with a radially projecting circumferentially extending tongue 24a, which is received in an annular groove 3c in the outer casing.

The inner boundary of the motive fluid flow path is formed by the solid inner sidewall 27. Using a continuous annular inner sidewall prevents the leakage which normally occurs through the joint between segments of a segmental wall. The inner sidewall is separated from the inner surface of blade 26 by the clearance 7. The inner sidewall defines a circumferentially extending web portion 27a which is disposed between the annular casing members 5, 6. The web 27a further defines an opening 27b through which a dowel pin 28 is disposed to prevent the inner sidewall 27 from rotating. The dowel pin 28 is pressed into hole 5a drilled in member 5. The fit between the web 27a and the members 5, 6 is sufficiently free to permit the annular wall 27 to expand radially in response to increased temperature. At normal operating temperature, the solid inner sidewall, which has a diameter of about 30 inches, grows approximately .04 inch in diameter to contact the blades.

The inner end portion of blade 26 defines an annular boss 26d, having a spherical surface 26g surrounding the recess 26f, which is contacted by the inner sidewall member 27. In the cold condition, prior to starting the turbine, a clearance space 7 exists between the annular lip 26d of the blade 26 and the adjacent surface of the sidewall 27. The size of this space is determined by the amount the sidewall member 27 expands in response to the initial increase in temperature of the parts. Over the operating range there is appreciable variation in this temperature and the size of the clearance is chosen to correspond to the maximum thermal expansion of ring 27 that is expected to take place. More specifically, this clearance space is so selected that at normal operating temperature the ring 27 contacts all the lips 26d. Any further expansion of ring 27 will then cause the springs 14 to be equally compressed.

It may be noted that the inner sidewall member 27 will ordinarily be made of a temperature resisting alloy, such as a suitable austenitic steel, while casing members 4, 5 and 6 are of a lower temperature alloy, such as a fer-

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ritic steel. Since the austenitic alloy has a much higher coefficient of thermal expansion, the above described differential expansion effect is enhanced and will occur even when the parts 5, 6, 27 are brought to the same temperature in normal operation.

The spring 14 insures that all parts of the variable vane arrangement will be held firmly in desired position when the machine is cool, yet permits the blade 26 to expand radially relative to shaft 11, and also permits blade 26 to move outward if ring 27 expands enough to contact the lip portion 26d when the machine comes up to normal operating temperature. With this arrangement, the nozzle parts are free to adjust themselves with respect to the movable blade 26, and to expand and contract according to temperature changes.

In assembly, the bushing 16 is disposed in place in the outer casing 3. The sleeve 15 is then inserted in the bushing 16. The shims 20 and washer 21 are then located in place and the outer segmental sidewall 24 is placed in position with the flange portion 24a disposed in recess 3c of the upper casing member 3. The rod and blade assembly is then inserted into the sleeve 15. The spring 14 is then disposed against the upper portion of the sleeve 15. The cap 29 is then located in place and secured to the flange 16c of bushing 16b and boss 3a of the upper casing member 3 by bolts 17. If adjustment of the spring force is required, suitable shims 30 are then inserted. The handle 12 is then secured to the rod 11 by the shear pin 19 and abuts against the upper portion of cap 29. The contact between the handle 12 and the upper portion of cap 29 determines the spacing 7 between the boss 26d and the inner sidewall member 27.

The lower casing assembly 4 is secured to the upper casing by means of the studs 9. The inner wall support member 5 is then located in place and the inner wall member 27 is disposed adjacent thereto. The dowel pin 28 is then disposed through opening 27b and into recess 5a of support member 5 to prevent the inner sidewall member from rotating. The support member 6 is then located in place and the bolt 8 extended therethrough to connect together all the members of the inner casing assembly. The solid inner sidewall 27 is thus firmly located and radially spaced from the blade 26 by the clearance space 7.

The operation of the nozzle assembly can be seen from the following:

Hot motive fluid is supplied to the nozzle assembly causing the inner sidewall member 27 to expand into contact with the lip 26d. As noted above, at normal operating temperature the inner sidewall expands into contact with all the annular lips 26d, so that the ring 27 is maintained concentric with the ring of vanes 26. The movement of the upper sidewall members is in turn transferred through the washer 21, shims 20 to the sleeve 15 and spring 13. Upon further increase in temperature, the further expansion of the inner sidewall 27 will tend to bias the nozzle blade, outer wall 24, and sleeve 15 radially outwardly against the spring 13. Thus, the differential thermal expansion existing due to the increased temperature will be permitted by the retraction of the blade against the resilient support means including the outer sidewall 24, sleeve 15 and spring 14. Deformation and high thermal stresses will accordingly be prevented.

Thus it will be apparent that the invention provides a novel variable turbine nozzle construction which is permitted to expand and contract in accordance with temperature changes, while employing a spring biasing arrangement for the blade and outer side wall to prevent setting up large thermal stresses. It further provides for the use of a solid inner sidewall which eliminates the leakage that takes place when a segmental sidewall is used.

While only one embodiment of the invention has been

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described specifically, it will be apparent to those skilled in the art that many alterations and substitutions of mechanical equivalents may be made. For instance, the inner sidewall can be prevented from rotating and maintained concentric by a series of circumferentially disposed pins. Also, the sleeve 15 could be located between the rod and the casing with the bushing 16 eliminated. In addition, the inner sidewall member can be made in two halves.

It is, of course, intended to cover by the appended claims all such modifications as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent in the United States is:

1. In a variable nozzle assembly for an axial flow turbo-machine, the combination of a first annular outer casing member, an annular inner casing assembly spaced radially from the outer casing, radially spaced inner and outer sidewall members disposed between said casings and defining an annular flow path, a plurality of circumferentially spaced rotatably adjustable control rods supported in the outer casing with their axes substantially radial and their inner ends projecting into the fluid flow path and each carrying an airfoil-shaped blade at its innermost end for directing the flow of fluid, stop means for preventing inward radial movement of the control rods beyond a predetermined point, the outer wall of the flow path comprising a plurality of circumferentially extending arcuate segments loosely supported between the blades and the outer casing member, the inner sidewall member being a continuous ring having a radially extending projection on its inner surface, said control rods projecting through openings in the outer segmental sidewall, means located between the outer housing and outer side wall for resiliently biasing the outer sidewall into contact with the outer ends of the blades whereby each blade and its associated rod is free to move radially outward, and means on the inner casing defining a radially extending recess for receiving said inner sidewall radial projection to axially locate the inner sidewall with respect to the inner casing while permitting differential radial expansion therebetween, said inner side wall being located adjacent to and radially spaced from the inner ends of said blades, whereby the inner side wall is free to expand radially into contact with the inner ends of the blades to prevent the leakage of motive fluid between the blades and inner side wall.

2. A nozzle assembly in accordance with claim 1 in which the inner casing assembly comprises first and second annular casing members with means detachably securing them together, an annular recess defined between said annular casing members, the inner sidewall having an inwardly extending web portion loosely disposed in said annular recess, and key means preventing the inner sidewall from rotating relative to the inner casing assembly.

3. In a variable nozzle assembly for an axial flow turbo-machine, the combination of a first annular outer casing member, an annular inner casing assembly spaced radially from the outer casing and defining an annular radial recess facing the outer casing, radially spaced inner and outer sidewall members disposed between the casings and defining an annular flow path, first means cooperating with the outer and inner casings for supporting the inner casing assembly relative to the outer casing, a plurality of circumferentially spaced rotatably adjustable control rods supported in cylindrical bores defined by the outer casing with their axes substantially radial and their inner ends projecting into the fluid flow path and each carrying an airfoil-shaped blade at its innermost end for directing the flow of fluid, stop means of the control rods beyond a predetermined point, the radially outer wall of the flow path comprising a plurality of circumferentially extending arcuate segments loosely supported between the blades and the outer casing member,

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the inner sidewall member being a continuous ring, said control rods projecting through cylindrical bores in the outer sidewall segment, slidable guide means surrounding each rod radially outward of and adapted to contact the outer sidewall, an abutment cap secured to the outer casing adjacent each control rod, resilient means disposed between said abutment cap and guide means to bias the outer sidewall into contact with the outer ends of the blades, and means for supporting the inner sidewall ring member from the inner casing assembly comprising a radially extending web disposed on the inner surface of said inner sidewall ring and loosely fitting in said inner casing annular recess whereby the inner sidewall is free to expand radially outwardly against the inner ends of the resiliently mounted blades in response to thermal expansion.

4. In a nozzle assembly in accordance with claim 3 in which the inner casing assembly comprises first and second annular inner casing members with means detachably securing them together and defining an annular radially directed recess between said inner casing members adapted to receive the inner sidewall, and means preventing circumferential movement of said inner sidewall relative to said inner casing assembly.

5. In a variable nozzle assembly for an axial flow turbo-machine, the combination of a first arcuate outer casing member, an annular inner casing assembly spaced radially from the outer casing and defining an annular radial recess facing the outer casing, radially spaced inner and outer sidewalls disposed between the casings and defining an annular flow path, first means cooperating with the inner and outer casings for supporting the inner casing assembly relative to the outer casing, a plurality of circumferentially spaced control rods supported in cylindrical bores defined by the outer casing with their axes substantially radial and their inner ends projecting into the fluid flow path and each carrying an airfoil-shaped blade secured to its innermost end for directing the flow of fluid, stop means for preventing the inward radial movement of the control rods beyond a predetermined point, means for rotatably adjusting each blade, the radially outer wall of the flow path comprising a plurality of circumferentially extending arcuate segments loosely supported between the blades and the outer casing member, the inner sidewall being a solid continuous ring disposed adjacent to and radially spaced from the inner ends of said blades, said control rods projecting through openings in the outer sidewall segments, slidable guide means surrounding each rod and adapted to contact the outer sidewall, an abutment cap secured to the outer casing adjacent each rod, resilient means disposed between said abutment cap and guide means whereby the blade and outer sidewall is resiliently supported for outward movement relative to the outer casing, said stop means contacting said abutment cap to form a clearance between the inner end of the blade and the inner sidewall, and means loosely supporting the inner sidewall relative to the inner casing assembly comprising a continuous radial web disposed on said inner sidewall and fitting in said annular casing recess whereby it is free to expand radially into contact with the inner ends of the blades.

6. In a variable nozzle assembly for an axial flow turbo-machine, the combination of a first arcuate outer casing member, an annular inner casing assembly spaced radially from the outer casing, first means cooperating with the inner and outer casings for supporting the inner casing assembly relative to the outer casing, a plurality of circumferentially spaced control rods extending through cylindrical bores defined by the outer casing member with their axes substantially radial, each control rod carrying an airfoil-shaped blade at its inner end for directing the flow of fluid, means secured to each rod outside the casing for rotatably adjusting each blade, stop means for preventing the radial inward movement of

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said control rod beyond a predetermined point, outer sidewall means comprising a plurality of adjacent circumferentially extending spherical segments defining openings for the control rods and disposed radially outward of the blades to be loosely supported thereon, an inner sidewall comprising a continuous ring located radially inward of the blades and the outer surface of which is a portion of a sphere, said inner and outer sidewalls being concentrically disposed between the inner and outer casings and defining an annular flow path, 5
slidable guide means surrounding each of said control rods in said cylindrical bores and located radially outward of said outer sidewall segments to rotatably and slidably mount the control rods in the outer casing, a cap secured to the casing radially outward of and spaced 15
from said slidable guide means to define a spring chamber surrounding the control rod, a compression spring disposed in said spring chamber biasing said guide means toward one of said outer sidewall segments, the inner and outer ends of the blades defining portions of spherical surfaces adapted to conform to the respective spheri-

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cal surfaces on the inner and outer sidewalls, the inner casing assembly comprising first and second annular inner casing members detachably secured together and defining between them an annular radially extending recess, said inner sidewall ring having an inwardly extending radial web portion loosely disposed in said annular recess, the web and first annular casing member defining aligned radially extending openings, a pin extending axially through the aligned openings to allow radial thermal expansion of the inner sidewall with respect to the inner casing but to prevent circumferential movement.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,919,890

January 5, 1960

Andrew N. Smith et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 71, after "means" insert -- for preventing the radial inward movement --;

Signed and sealed this 14th day of June 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents