No. 798,106. PATENTED AUG. 29, 1905.

C. V. KERR.

STEAM TURBINE NOZZLE.

APPLICATION FILED NOV. 5, 1904.

2 SHEETS—SHEET 1.

Fig. 1.

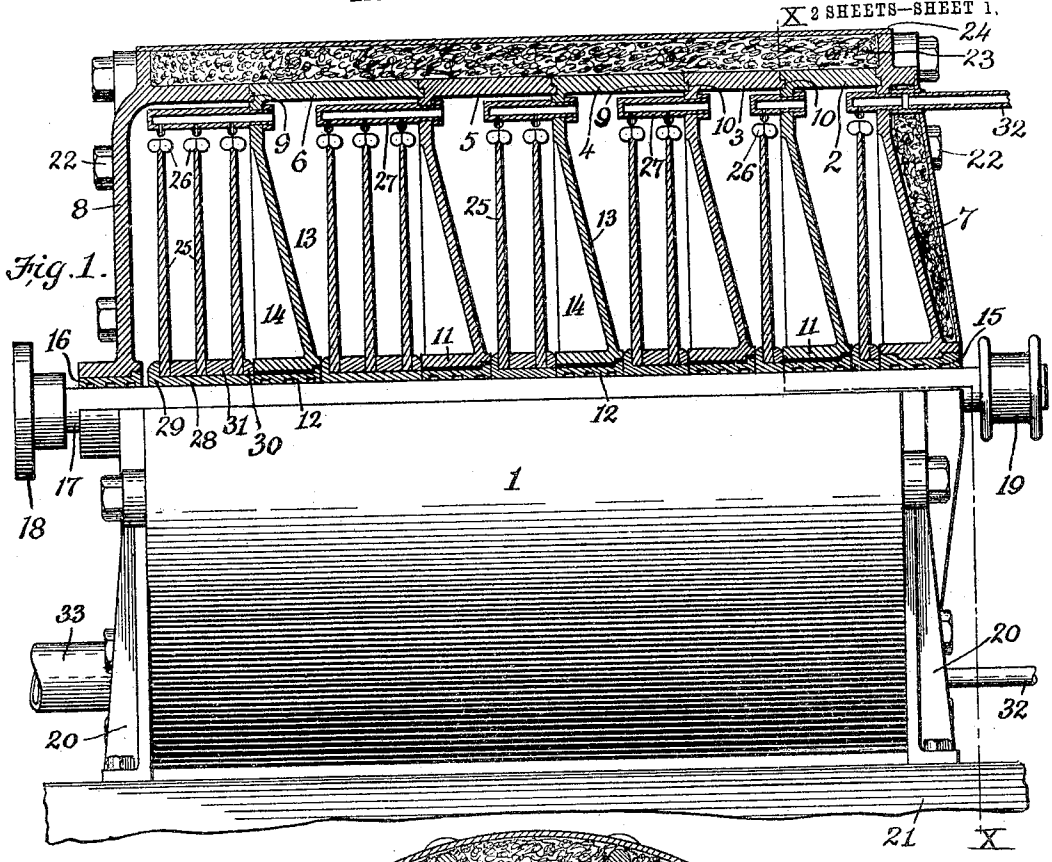
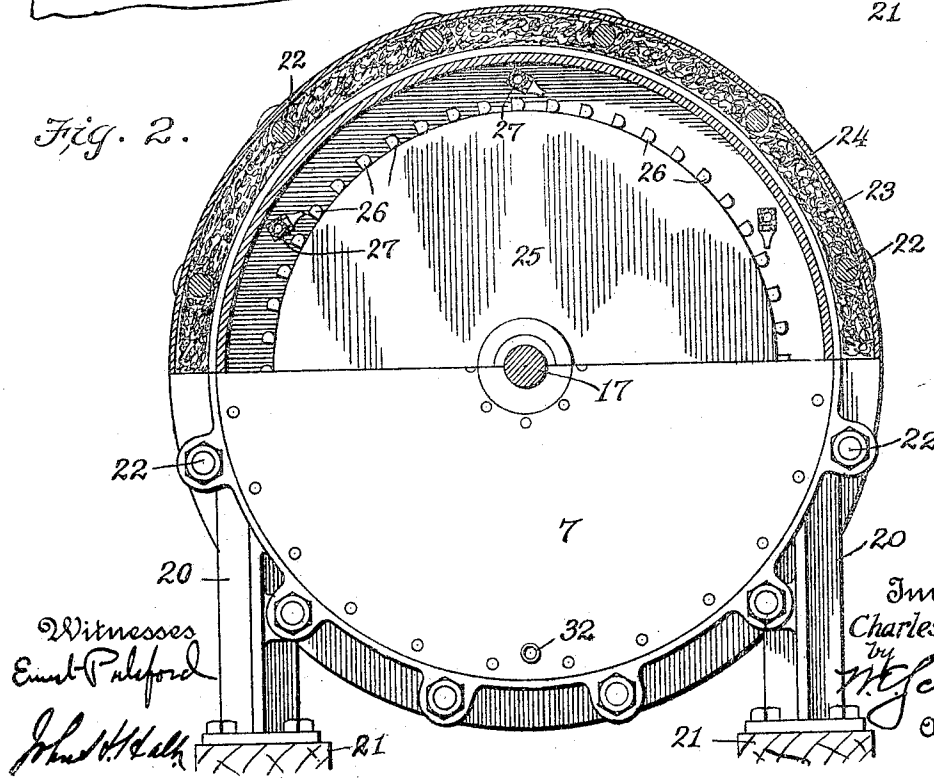



Fig. 2.




Witnesses
Ernest Pickford
John A. Kalb

Inventor
Charles V. Kerr,
by
W. G. Thornburn
Attorney

ANDREW B. GRAHAM CO., PHOTO-LITHOGRAPHERS, WASHINGTON, D. C.

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2 SHEETS—SHEET 2

Fig. 3.

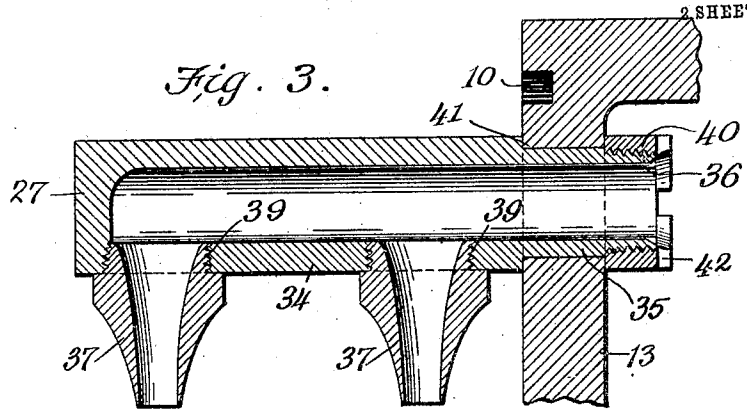



Fig. 4.

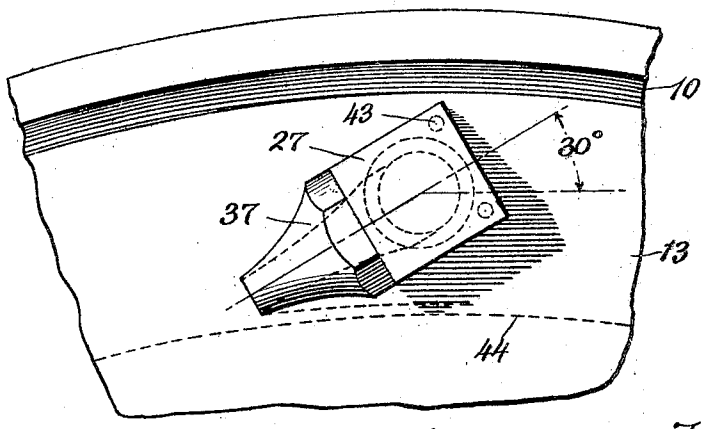



Fig. 5.

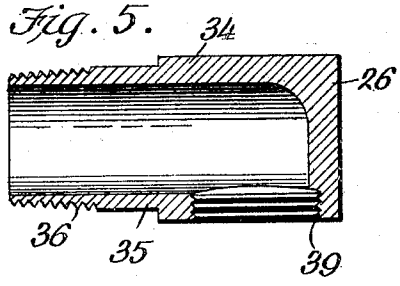



Fig. 6.

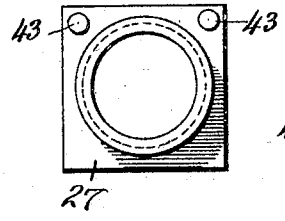



Fig. 7.

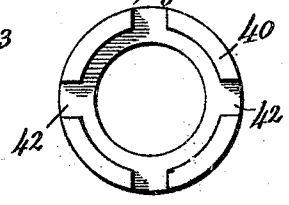



Fig. 8.

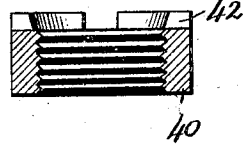



Fig. 11.

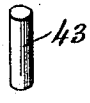



Fig. 9.

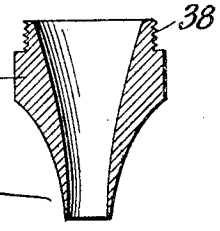
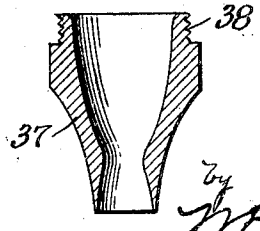



Fig. 10.




Witnesses

Ernest Fulford

John A. Kalb

Inventor

Charles V. Kerr,

by W. E. Schoenborn

Attorney

# UNITED STATES PATENT OFFICE.

CHARLES V. KERR, OF WELLSVILLE, NEW YORK, ASSIGNOR TO KERR TURBINE COMPANY, OF WELLSVILLE, NEW YORK, A CORPORATION OF NEW YORK.

## STEAM-TURBINE NOZZLE.

No. 798,106. Specification of Letters Patent. Patented Aug. 29, 1905.

Application filed November 5, 1904. Serial No. 231,490.

*To all whom it may concern:*

Be it known that I, CHARLES V. KERR, a citizen of the United States, residing at Wellsville, in the county of Allegany and State of New York, have invented certain new and useful Improvements in Steam-Turbine Nozzles, of which the following is a specification.

My invention relates to nozzles particularly adapted for compound steam-turbines, known more especially as the "multicellular type" and shown, for example, in my former patent, No. 756,241, dated April 5, 1904, of which the present invention is an improvement.

The objects of this invention are, first, to construct a nozzle with removable tips of such form and structural features so that the nozzles may be readily manufactured from stock sizes and shapes of soft steel rods or tubes; second, to construct a nozzle in which the number or kind of nozzle-tips can be rapidly varied without much labor or time; third, to construct a nozzle which can be easily detached from the cylinder-casting or quickly replaced in its proper relation with respect to the rotary bucket-wheel; fourth, to construct a nozzle which will have all the above characteristics above stated and yet be inexpensive to manufacture, highly efficient in its operation, and most durable; fifth, other evident advantages and features of the specific construction and arrangement of the parts, which will hereinafter appear from the detailed description of the nozzle and manner of applying the same.

My invention consists of structural features and relative arrangements of elements, which will be hereinafter more fully and clearly described, and pointed out in the appended claims.

Referring to the two sheets of drawings, in which similar reference characters indicate the same parts in the several figures, Figure 1 is a side view of my form of turbine, showing the upper half in section and the relation of the improved nozzles with respect to the division-walls and bucket-wheels. Fig. 2 is an end view of the turbine, partly in transverse section, on line *x x* of Fig. 1. Fig. 3 is an enlarged longitudinal section of the form of nozzle having two tips and showing the manner of attaching the same to one of the division-walls which separate the several expansion-chambers. Fig. 4 is an end view of an enlarged and fragmentary section as shown in Fig. 3, illustrating the relation and angle of the nozzle-tips with respect to the circle described by the outer periphery of the bucket-wheel. Fig. 5 is a longitudinal section of the form of nozzle having a single tip with the removable tip detached. Fig. 6 is an end view of a nozzle, showing the relation of the dowel-pins or openings. Fig. 7 is a plan view of the securing-nuts which engage the threaded ends of the nozzles passing through the division-walls. Fig. 8 is a transverse section of a securing-nut shown in Fig. 7. Fig. 9 shows a sectional view of the removable nozzle-tip. Fig. 10 is a sectional view of a modified form of nozzle-tip. Fig. 11 is a view of one of the dowel-pins detached from a nozzle or division wall.

In the drawings the same reference characters indicate the same parts throughout the several figures.

Referring to Figs. 1 and 2, 1 represents the cylinder of a turbine to which my improved nozzle is especially adapted, and, as indicated in the present showing, consists of five separable sections 2, 3, 4, 5, and 6, and inlet or head section 7, and an exhaust end section 8. Sections 2, 4, and 6 are the same in width and have the same number of bucket-wheels as the sections 3, 5, and 8, respectively. Each of the annular rims of the separable sections 2 to 6 has a tongue 9 on one and a corresponding groove 10 on the opposite side, whereby they may be easily fitted to each other or any number of the sections may be added or interposed between the inlet and exhaust sections 7 and 8. The inlet-section 7 is provided with a groove and the outlet-section 8 with a tongue corresponding to their adjacent sections 2 and 6, respectively. The separable sections 2 to 6 are provided at their centers with hubs 11, which surround and form fluid-tight joints with circular bearing blocks or bushings 12. 13 is a thin wall or web connecting the periphery of each hub 11 of the separable sections to the other or opposite side of the annular rim, which is provided with a groove 10, thereby forming in each section a dish-shaped center, which on one side slants toward the center and on the other side toward the rim. By this construction of separable sections it will be seen there is formed a series of

chambers in the cylinder-casing whose separating walls or webs 13 13 are inclined toward the exhaust end section 8. 14 14 are radial ribs cast integral with the walls or webs 13 13 for the purpose of making a light as well as a strong form of construction. Passing through suitable bearings 15 and 16, respectively, in the inlet and outlet sections 7 and 8 and through the steam-tight bearings 12 12 of each of the separable sections 2 to 6 is a rotary shaft 17, from which at one end power may be taken by means of a coupling 18 or other expedient. 19 at the other end of the shaft is a pulley, from which a belt or other means may be connected to a governor for the purpose of regulating the motive fluid to the turbine. 20 20 are standards cast integrally or attached to the end sections 7 and 8 for the purpose of supporting and securing firmly the turbine to the usual foundation or bed 21. 22 22 are bolts passing through suitably-spaced lugs and openings in the inlet and exhaust end sections 7 and 8, and which when screwed up securely hold the separable sections 2 to 6 and end sections together. 23 is the ordinary lagging outside of the cylinder for the purpose of preventing radiation and which is provided with the usual sheet-metal covering 24. Secured to the rotary shaft 17 and interposed between each of the end sections and the central hubs of the separable sections 2 to 6 are one or more bucket-wheels 25, which may be of any desired type or well-known form of construction. 26 26 are the buckets attached to the periphery of the wheels 25 for receiving the impact of the motive fluid injected from the nozzles 27 27, which will be presently described. The wheels 25 may be secured to the shaft 17 in a suitable manner, and while I have herein shown (see section 8 of Fig. 1) a split collar 28 engaging suitable keys or means on the shaft to prevent rotation any other expedient may be employed to accomplish the same result. 29 is a shoulder at one end of the collar 28, and 30 is a circular nut at the other end for fastening the collar to the shaft. 31 is an annular washer, which is interposed between the bucket-wheels when more than one is used in an expansion-chamber. 32 32 are the pipes leading the motive fluid to the nozzles in the first section 2 or stage of expansion, and 33 a pipe connected to the exhaust-section 8 for leading the exhaust to the atmosphere or a condenser. The general construction of the separable sections, means for securing them together, the arrangements of variable number of bucket-wheels in said separable sections, and expedients for securing them to the rotary shaft, as hereinabove described, are substantially the same as already described and claimed in my application filed October 10, 1904, Serial No. 227,804.

Referring now to Figs. 3 to 11, in which is shown on an enlarged scale the construction of my improved nozzle especially adapted for a turbine, as just described. The nozzle 27 consists of a hollow or tubular body portion 34, which may be readily formed and cut from soft steel found in the stock sizes of square and hexagon shape in cross-section. The said body portion is closed at one end and at the other end is provided with a reduced section 35 and a threaded end 36, preferably tapered, as shown. Distributed along the hollow body portion 34 and communicating with the interior thereof are one or more removable nozzle-tips 37 37, which are conveniently secured thereto by screw-threads 38, which engage correspondingly-threaded openings 39 39. The form of nozzle-tips as indicated in Figs. 9 and 10 may be readily machined from existing form of soft steel, and when it is desired to expand the motive fluid less than fifty-eight per cent. the form shown in Fig. 9 is employed, and when a greater expansion than fifty-eight per cent. is desired that illustrated in Fig. 10 is used. Fig. 5 shows a nozzle in which only one tip is provided for and used in the early stages of expansion, as indicated in sections 2 and 3 of Fig. 1, and while I have shown in Fig. 3 a nozzle having only two tips any number can be provided, from three, as used in sections 6 and 8, to four or more, if the nature of the case deems it necessary. The nozzle-tips and body portions may be constructed of brass or bronze or other material; but I have found soft steel much cheaper and easily worked and may be case-hardened, if desired, to give longer life in service with superheated steam of high pressure or in gas-turbines where high temperatures of the burned gases are utilized. The nozzles 27 are secured to the division-walls 13 of the different separable sections 2 to 6 by means of nuts 40, which engage the reduced threaded ends 36 after having been passed through the properly spaced and distributed openings 41 near the outer edge of wall 13 of each of the separable sections. These nuts 40 are likewise easily constructed from steel pipe-couplings or from solid round stock, and their heads may be fashioned, as shown in Figs. 7 and 8, with slots or openings 42 42, which may be engaged by any suitable tool of screw-driver shape, thereby enabling one to quickly and firmly attach and closely secure the nozzle to the division-wall 13, as indicated in Fig. 3. Each of the ends of the nozzles 27, adjacent to the walls 13, is provided with two or more dowel-pins 43, (see Figs. 6 and 11,) which engage corresponding holes in the wall 13, or, if so desired, the dowel-pins can be attached to the wall and the openings made in the nozzles. The function of the dowel-pins and openings is not only for the purpose of preventing the nozzles from turning should the securing-nuts 40 become loose, but at the same time enable the nozzles when removed for inspection or

repairs to be quickly and properly replaced, so that the axial line of a nozzle will always make with the tangent to the circle of the path described by the outer edge of the buckets and indicated by the dotted line 44 (see Fig. 4) a constant angle, which in the present case is shown as thirty degrees.

The number of the separable sections or stages of expansion interposed between inlet and exhaust sections may be varied in any manner, and in order to work against a higher initial pressure another high-pressure section or stage 2 may be added, or when running non-condensing and exhausting with five or ten pounds pressure for steam-heating one of the low-pressure sections or stages 5 or 6 may be removed.

It will be seen that the use of a nozzle with a plurality of tips readily permits the use of more than one bucket-wheel at any section or stage of expansion, and hence by this arrangement one can easily increase the number of bucket-wheels and the sizes of the buckets and nozzles toward the last stages or sections, thereby insuring the working of the motive fluid at its best efficiency and maximum capacity with a minimum weight of turbine.

The number of nozzles 27 disposed about the periphery of the bucket-wheels in each separable section may be varied to suit the circumstances at which the initial pressure of the motive fluid is obtained or manner of expanding the same. The number of the nozzles in each section varies from the inlet to the exhaust, and one nozzle in each section or stage is located at the lowest point to facilitate the passage of water of condensation when starting up, and I find no drip-cocks are necessary with this arrangement.

The operation of the invention is as follows: Referring to Figs. 1 and 2, the motive fluid enters by means of the pipes 32 to the nozzles of the first section or stage of the cylinder and impinges against the buckets of the first wheel and then passes in succession through the different sets of nozzles in each section to their respective wheels and is finally exhausted by means of the pipe 33. The degree of expansion can be regulated by the number of separate sections which is interposed between the inlet and exhaust sections, and the jet velocity of the motive fluid or impact of the same on the several buckets is controlled by the number and size of nozzles which are disposed about the periphery of the wheels in each section, thereby insuring as far as possible the same jet velocity and a uniform development of power in each section or distribution of torque along the shaft.

Various changes may be made in the general construction of the separable sections comprising the cylinder, bucket-wheels, and means for providing a fluid-tight joint between the several sections and the rotary shaft, and while I have shown my preferred form I do not care to limit myself to these specific arrangements, as they could be modified in many ways without departing from the spirit of my invention and will accomplish the same results.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A nozzle for motive-fluid turbines of the class described, comprising a hollow or tubular section having one of its ends closed and the other end open and a plurality of hollow nozzle-tips distributed along the hollow or tubular section and communicating with the interior thereof.

2. A nozzle for motive-fluid turbines of the class described, comprising a hollow or tubular section having one of its ends closed and the other end open and a plurality of removable hollow nozzle-tips distributed along the hollow or tubular section and communicating with the interior thereof.

3. A nozzle for motive-fluid turbines of the class described, comprising a hollow or tubular section having one of its ends closed and the other end open, means for attaching and securing the nozzle at the open end of the tubular section, a plurality of hollow nozzle-tips distributed along the hollow or tubular section and communicating with the interior thereof.

4. A nozzle for motive-fluid turbines of the class described, comprising a hollow or tubular section having one of its ends closed and the other end open, means on said tubular section for properly securing in a predetermined relation the nozzle with respect to the rotary element of a turbine, a plurality of hollow nozzle-tips distributed along the hollow or tubular section and communicating with the interior thereof.

5. A nozzle for motive-fluid turbines of the class described, comprising a hollow or tubular section having one of its ends closed and the other end open, means on said tubular section consisting of dowel-pins for properly securing in a predetermined relation the nozzle with respect to the rotary element of a turbine, a plurality of hollow nozzle-tips distributed along the hollow or tubular section and communicating with the interior thereof.

6. A nozzle for motive-fluid turbines of the class described, comprising a hollow or tubular section having one of its ends closed and the other end open, means on said tubular section consisting of dowel-pins for properly securing in a predetermined relation the nozzle with respect to the rotary element of a turbine, a plurality of hollow removable nozzle-tips distributed along the hollow or tubular section and communicating with the interior thereof.

7. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the sev-

eral stages of expansion of the motive fluid, a rotary shaft passing centrally through each of said sections, a rotary element consisting of one or more bucket-wheels within each of the separable sections and fixed to the shaft, a row of buckets on the periphery of each of the bucket-wheels, a set of nozzles extending into each of the separable sections and forming a direct communication between any section and the next succeeding section, each of said nozzles provided with as many nozzle-tips as there are bucket-wheels in their respective sections.

8. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a rotary shaft passing centrally through each of said sections, a rotary element consisting of one or more bucket-wheels within each of the separable sections and fixed to the shaft, a row of buckets on the periphery of each of the bucket-wheels, a set of nozzles extending into each of the separable sections and forming a communication between any section and the next succeeding section, the nozzles in the successive sections progressively increasing in number from the high-pressure stage to the low-pressure stage of expansion and each of said nozzles provided with as many nozzle-tips as there are bucket-wheels in their respective sections.

9. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a rotary shaft passing centrally through each of said sections, a rotary element consisting of one or more bucket-wheels within each of the separable sections and fixed to the shaft, a row of buckets on the periphery of each of the bucket-wheels, a set of nozzles extending into each of the separable sections and forming a communication between any section and the next succeeding section, the nozzles in the successive sections progressively increasing in number from the high-pressure stage to the low-pressure stage of expansion and each of said nozzles provided with as many removable nozzle-tips as there are bucket-wheels in their respective sections.

10. A multicellular compound turbine comprising a cylinder composed of a series of separable and independent sections for the several stages of expansion of the motive fluid, a division-wall separating one section from another, a rotary shaft passing centrally through each of said sections, a rotary element consisting of one or more bucket-wheels fixed to the shaft within each of the separable sections and between the division-walls, a row of buckets on the periphery of each of the bucket-wheels, a set of nozzles extending into each of the separable sections and forming a communication between any section and the next succeeding section, as many nozzle-tips on each of the nozzles as there are bucket-wheels in their respective sections, and means on each of said nozzles for engaging a division-wall and properly alining the axes of the nozzle-tips with respect to the path described by the buckets on the rotary element.

In testimony whereof I affix my signature in presence of two witnesses.

CHARLES V. KERR.

Witnesses:
V. R. BRUCE,
ALFRED G. MCCLURE.