A. G. POPCKE AND W. R. JOHNSTON.

APPARATUS FOR TREATING OIL WELLS.

APPLICATION FILED FEB. 3, 1917.

1,354,757.

Patented Oct. 5, 1920.

2 SHEETS—SHEET 1.

Fig. 1.

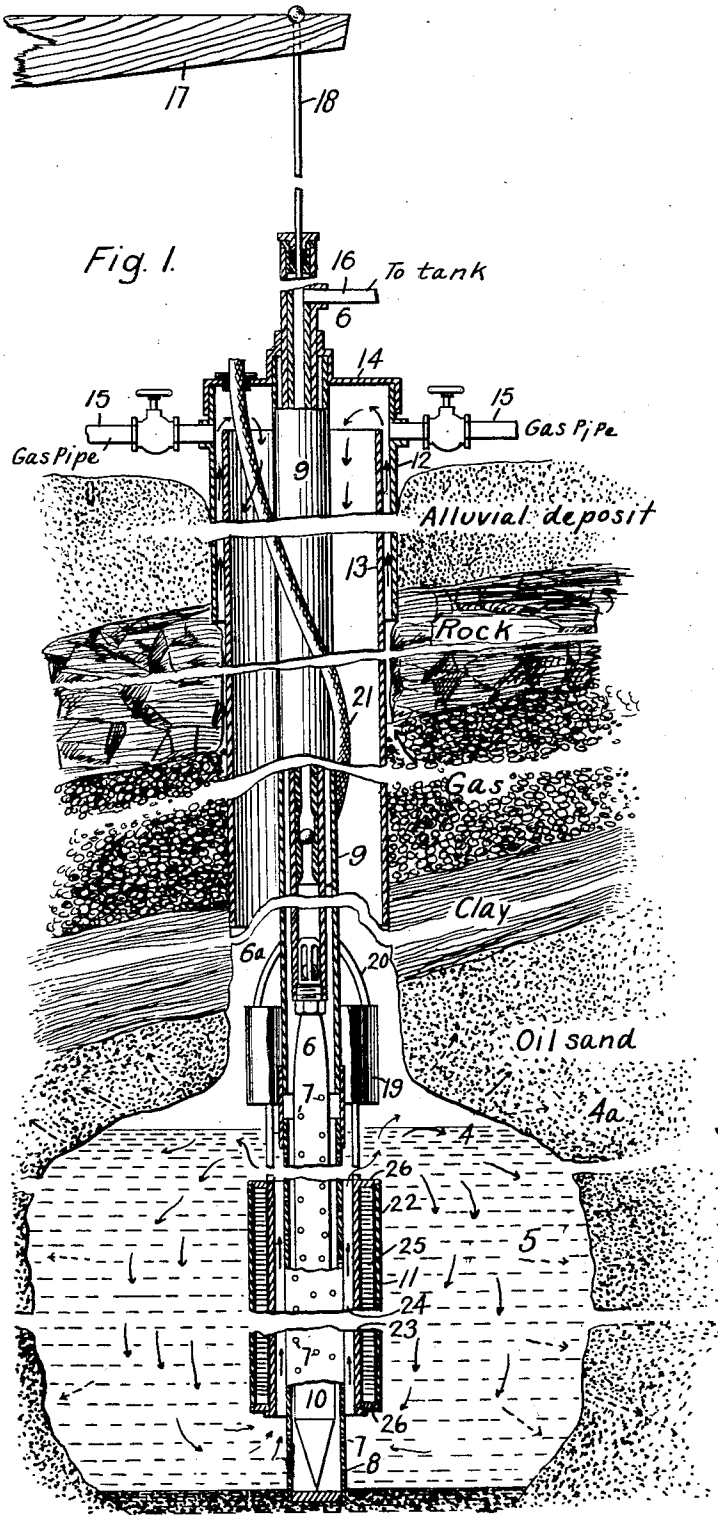
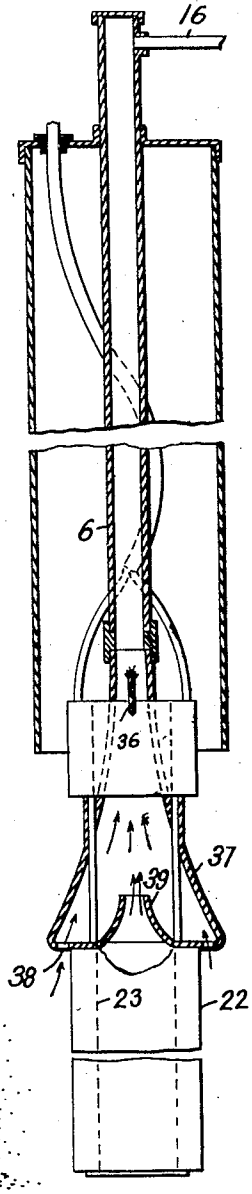


Fig. 2.



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2 SHEETS—SHEET 2.

Fig. 4.

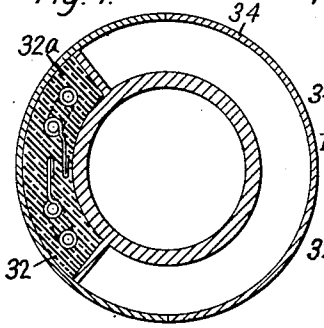


Fig. 3.

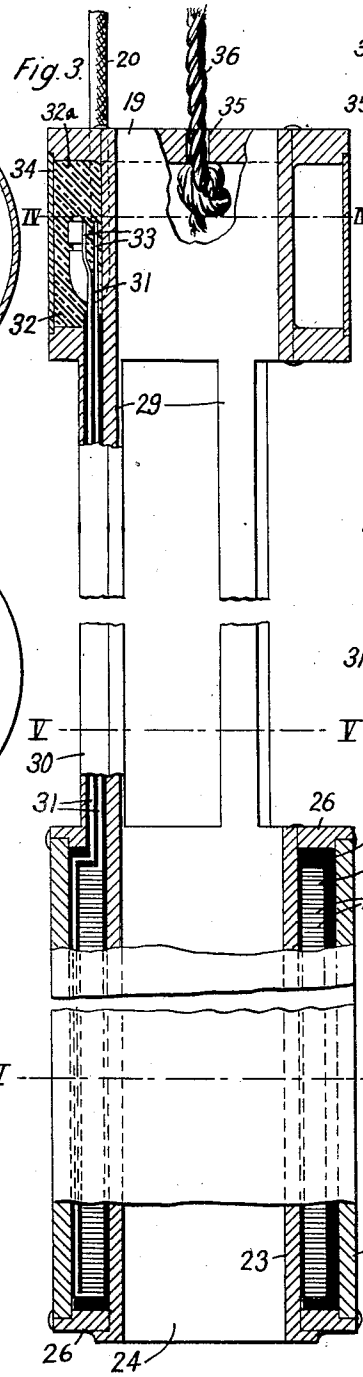


Fig. 6.

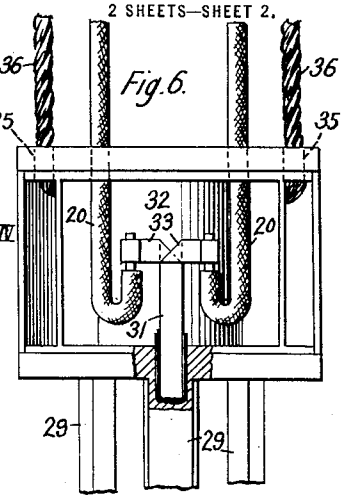


Fig. 5.

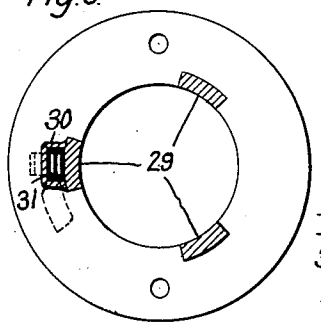


Fig. 7.

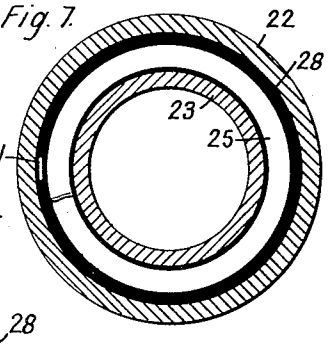
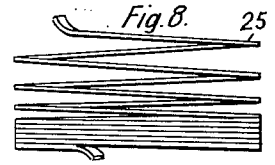


Fig. 8.



WITNESSES:

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BY

Geo. W. Hansen.

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UNITED STATES PATENT OFFICE.

ARTHUR G. POPCKE, OF SWISSVALE, PENNSYLVANIA, AND WILLIAM R. JOHNSTON, OF PARSONS, NEW MEXICO, ASSIGNORS, BY DIRECT AND MESNE ASSIGNMENTS, OF ONE-FOURTH TO FRANK C. REED, OF WILKINSBURG, PENNSYLVANIA, AND ONE-FOURTH TO ISAAC DE KAISER, OF WILKINSBURG, PENNSYLVANIA.

APPARATUS FOR TREATING OIL-WELLS.

1,354,757. Specification of Letters Patent. Patented Oct. 5, 1920.

Application filed February 3, 1917. Serial No. 146,362.

To all whom it may concern:

Be it known that we, ARTHUR G. POPCKE, a citizen of the United States, and a resident of Swissvale, in the county of Allegheny and State of Pennsylvania, and WILLIAM R. JOHNSTON, a citizen of the United States, and a resident of Parsons, in the county of Lincoln and State of New Mexico, have invented a new and useful Improvement in Apparatus for Treating Oil-Wells, of which the following is a specification.

Our invention relates to apparatus for treating oil wells, gas wells and the like for the purpose of increasing their yield and facilitating in removing the mineral bearing substances therefrom. In one of its aspects, our invention relates to electrical heating devices and specially to those of the induction type which may be utilized in connection with oil wells and the like, for the purposes mentioned above.

More particularly, our invention refers to heaters of the above indicated character that are adapted to promote the circulation of the bodies of fluid in which they may be immersed, and that are efficient in operation and economical to construct. One of the uses for which the heater of our present invention is especially adapted is for heating the contents of wells containing subterranean bodies of fluids, such as crude oil, gas, sulfur, water and the like, which may be pumped or removed from the well simultaneously with the heating operation. Again, the heating of a body of fluid contained in a well may be desired for the purpose of generating a pressure in the well either for assisting in the removal of the submerged fluid from the well, for forcing the heated fluid contained in the well back into the adjacent strata and to permeate the oil bearing sands with heat in order to enhance the yield of the mineral or oil substances. For the accomplishment of the aforesaid objects and for other objects that may be hereinafter mentioned or pointed out with particularity in the appended claims, the induction heater of our invention is especially adapted.

In order to more fully understand the scope and the nature of our invention, reference may be had to the following description and the accompanying drawings in which Figure 1 is a diagrammatic representation of an oil well of a usual character in which a heater employed in accordance with our invention is submerged, the heater and a portion of the pump being shown in section; Fig. 2 is a view, partially in elevation and partially in section, of a modified form of the structure shown in Fig. 1, the heater, in this instance, being associated with the central pipe or tubing of an oil well in such a manner as to form a portion of an injector device; Fig. 3 is a detailed view, partially in elevation and partially in section, of the induction heater of Fig. 1; Fig. 4 is a sectional view taken along the line IV—IV of Fig. 3; Fig. 5 is a sectional view taken along the line V—V of Fig. 3; Fig. 6 is a front view, partially in section, of the upper structure or terminal block of the heater of Fig. 3; Fig. 7 is a sectional view taken along the line VII—VII of Fig. 3, and Fig. 8 is a view of a portion of the current-carrying or magnetic flux-generating coil embodied in the heater of Fig. 3.

Referring to Fig. 1, a subterranean chamber 4 formed in a stratum 4^a of oil bearing sand is filled with a body 5 of crude oil which it is desired to remove by means of an oil pump 6. For the purpose of illustration, we may assume that the oil well 4 has become clogged by accumulations of paraffin, sulfur, asphalt or other heavy hydro-carbons which seriously interfere with the production of oil from the well by clogging up the interstices in the oil bearing stratum and perforations 7 in the lower end 8 of a tubing 9 and in an anchor 10 of the pumping device 6. Of course, the body of oil 5 may be quite viscous as is characteristic of those oils having asphaltic bases. In this instance, difficulty is likewise experienced in removing the oil from the well by means of the pump 6. To facilitate in removing the oil 5 from the well, a heater 11, which is employed in accordance with our invention and is to be hereinafter described in detail, surrounds the lower end or perforate pipe 8 of the tubing 9 and also the perforated anchor 10. The heat emanating from the device 11 affects the oil 5 in such a manner as to permit it to be readily pumped from the well. This heat may also be utilized to enhance the flow of oil into the well 4 from the oil bearing sands 4^a.

In the oil well, we have shown a drive-

pipe 12 which extends through an alluvial deposit to a rock formation. A second casing 13 having a relatively smaller diameter than the drive-pipe 12, must of necessity be furnished, the same penetrating the rock stratum and a gas bearing stratum and extending into a clay stratum, as shown. Continuing the drilling operation, the oil sand 4^a is reached in which the oil well 4 is blasted or formed in any other suitable manner. The body of crude oil 5 accumulates in the chamber 4 and the pump 6 is employed to remove it therefrom. The tubing 9 is centrally placed to project through the drive pipe 12 and the casing 13 and to extend to the well 4 where it terminates in the perforated pipe 8. The pump 6 is contained in the tubing 9 and comprises the perforated anchor 10 having a tubular form and constituting the lower end of the pump stock 6^a.

It will be noted that the gas bearing stratum is penetrated by the casing 13 which is surrounded by the drive pipe 12. As a result, gas emitting from the gas-bearing stratum is excluded from communicating directly with the oil well 4 since the clay stratum seals the oil well against the gas-bearing stratum. By applying a casing head 14 to the drive pipe 12, this gas may be introduced into two gas pipes 15 for withdrawing it from the well or confined within the casing 13 and consequently the oil well 4. The tubing 9 and the pump 6 project through the casing head 14 and the pump stock communicates with an oil pipe 16 which conveys the oil to a tank (not shown). The pump 6 is operated by means of a walking beam 17 and a rod 18.

As mentioned above, the body of oil 5 has such a heavy composition that the pump 6, when unassisted, can remove only small quantities of oil from the well. In order to render the oil more liquid so that the pump 6 may remove it from the well, the heater 11 is placed exteriorly of the perforate pipe 8 and immersed in the body of oil 5, as shown in Fig. 1. The heater is supported by cables (not shown) one of their ends being attached to a terminal block 19 of the heater 11 and suspended in any suitable manner from the top of the well. Electrical conductors 20 which are contained in a cable 21 provide means for conducting electrical current to the heater 11.

The heater 11 comprises an outer tubular member 22 and an inner tubular member 23, the dimensions of said tubular members being so selected that an annular space 24 is formed between the perforate pipe 8 of the well casing 9 and the inner tubular member 23 of the heater. In placing the heater in its operating position, it should be disposed substantially concentric with the perforate pipe 8 in order that the open space 24 may entirely surround the lower end of the well casing 9, to permit unimpeded circulation of the body of oil 5.

The tubular members 22 and 23 of the heater 11 are formed of magnetizable current conducting material such as wrought iron pipe, and are concentrically placed with respect to each other in order that a current conducting coil 25 may be interposed between, and inclosed by, them, as shown in Fig. 7. The conductors 20 are connected to terminals of the current-conducting coil 25, as will be hereinafter explained. The casing surrounding the coil 25 and formed of the tubular members 22 and 23 and annular members 26 is autogenously sealed to preclude any moisture from entering within the heater and coming in contact with the insulation on the coil 25. Alternating current of any commercial frequency is supplied to the coil 25, and the alternating flux thus generated is greatly augmented by reason of the permeability of the magnetizable casing surrounding the coil. The alternating magnetic fluxes set up in the tubular members 22 and 23 and the annular members 26 generate short-circuited currents in the casing which comprises the heat-generating element of the heater. In other words, the coil 25 acts as the primary or inducing winding of a transformer, and the casing inclosing the coil acts as a short-circuited secondary winding which constitutes the heating element.

It will be noted that the tubular member 23 is closely adjacent to, but spaced from, the perforate pipe 8 of the well casing 9. The heat generated in the tubular member 23 by reason of the currents induced therein promotes the circulation of the body of oil 5 as indicated by the arrows. Portions of the body of oil 5 successively coming in contact with the heated tubular member 23 soon render the body of oil 5 more liquid, thus permitting it to be readily pumped by the pump 6. At the same time, the perforate pipe 8 is maintained at a high temperature by reason of its proximity to the tubular member 23, and also by eddy currents induced therein from the stray magnetic fields originating in the heater 11. Therefore, the perforate pipe 8 is protected against being clogged by the heavy asphaltic bases or paraffin contained in the body of oil 5. It will be noted from the foregoing that the heater 11 effectively heats the whole body of oil 5, protects the perforate pipe 8 and likewise the perforated anchor 10 of the pump 6 against accumulations of paraffin or other heavy hydro-carbons, and permits a continuous flow of oil from the pump simultaneous with the heating of the oil.

When a casing-head 14 seals the well, as

shown in Fig. 1, the volume of gas liberated from the gas-bearing stratum is collected within the casing 13 and the well 4. The heater 11, by reason of the large quantities of heat generated therein, raises the temperature of the gas and also the temperatures of other vapors and gases collected in the well 4. As a consequence, a high vapor pressure is developed within the well 4 which forces these heated gases outwardly from the well in all directions through the oil bearing sand. The congealed heavy hydro-carbons and other asphaltic minerals retarding the flow of oil from the oil-bearing stratum into the oil well 4 are heated and thereby removed from the interstices and openings in the oil sand, thus greatly enhancing the flow of oil into the oil well. By permeating the oil bearing stratum with these heated gases that are projected from the oil well 4, the clogging of the well is substantially eliminated and the hydro-carbons are permitted to flow to the well from which they may be pumped. This operation serving to remove the heavy hydro-carbons from the oil bearing stratum may be performed as the pump 6 is operated. It will be apparent that the congealing hydro-carbons may, in this manner, be removed from the oil bearing stratum without applying pressure and heated gases from an external and separate source, as has heretofore been customary.

Fig. 3 is a view showing the detailed construction of a heater that may be employed in connection with our invention. The current-conducting coil 25 is composed of a flat helically wound ribbon, the adjacent turns of which are separated from one another by means of split mica washers 27. The coil is thoroughly insulated from the iron casing composed of the tubular members 23 and 24 and the annular members 26 by means of a mica lining 28. The upper portion of the inner tube 23, as shown in Figs. 5 and 6, is slotted intermediate its ends to provide upwardly-extending arms 29 upon which the terminal block 19 is supported. One of the arms 29 has a casing 30 welded to it in which is contained two strap conductors 31 that constitute the ends or terminals of the coil winding 25. The strap conductors 31 extend into a compartment 32 formed in the terminal block 19 and shown in detail in Figs. 3, 4 and 6. The ends of the conductors 31 are bent at right angles and terminate into clips 33 which are electrically connected to the ends of the leading-in conductors 20. The conductors 20 extend into the terminal block 19 and are bent upwardly in a U-shape to engage the clips 33. The conductors 31 are spaced from each other in any suitable manner, and the whole is embedded in an insulating compound or cement 32^a that completely fills the chamber 32. A covering 34 is then welded to the sides of the terminal block 19 in order to autogenously seal the chamber 32. The upper interior rim of the terminal block 19 is provided with two holes 35 through which supporting cables 36 are threaded, these cables being employed to suspend the heater from the top of the well.

It will be noted, by referring to Figs. 7 and 8, that the current-conducting coil 25 is a flat metallic ribbon wound on edge, thereby using the minimum lineal space for a given permissible conductor width and for a predetermined current flow. Since the exterior diameter of the tubular member 22 is fixed by reason of the standard dimensions of the casing 13 and the interior diameter of the tubular member 23 is fixed by reason of the standard dimensions of the perforate pipe 8 of the tubing 9 and the necessary annular space 24, required for adequate circulation of the body of oil 5, the coil 25 is formed of a strap conductor wound on edge in order to give the coil maximum current-carrying capacity, with fixed resistance losses, for minimum space to be occupied by the coil. In this manner, the maximum number of ampere-turns per unit length of the heater is obtained with the utilization of the minimum amount of insulating material. This permits of a very rigid construction which is a most important feature in heaters adapted to this class of service.

The iron casing inclosing the current-conducting element 25 is autogenously welded in order to exclude all moisture from the coil 25. When the heater is first subjected to the flow of alternating current, the inner tube 23, by reason of its smaller volume and therefore its higher degree of magnetization, is heated to a much higher degree than the outer tube 22, and this unequal distribution of heat will continue until heat is emitted from the heater 11 as rapidly as it is generated. With this form of construction, the heating element constitutes the exterior casing and is directly in contact with the fluid body that it is desired to heat. The current-conducting coil 25 does not constitute the heating element and contributes a small amount only of the total heat generated in the heater 11. Under certain conditions, it may be advisable to design the short-circuited secondary of the heater so that the magnetizable inner casing 23 will become magnetically saturated. In this instance, large stray magnetic fields may be developed which are employed in generating eddy or heat-producing currents in the perforate pipe 8 that the heater 11 surrounds, as hereinbefore mentioned.

In Fig. 2, a modified form of a heater is shown which embodies an upper casing that is designed to utilize the principle of the injector for facilitating in removing the body of liquid in which the heater may be immersed. The outer casing 22 is equipped

with a conically-shaped casing 37, the lower portion of which projects laterally from the casing 22 and is provided with a series of spaced perforations 38, and the upper portion of which is merged into the pump stock 6. The inner tubular member 23 of the heater is equipped with a frusto-conically shaped nozzle 39 which is contained within the casing 37. The liquids contained within the tubular member 23 are heated to a very high degree, and the high vapor pressure thus generated ejects rapidly moving vapors from the nozzle 39. As these vapors or fluids expand on withdrawing from the nozzle 39, the liquid immediately surrounding the tubular member 22 and in which the heater is immersed is drawn upwardly through the perforations 38 and forced into the pump stock 6 where it is conducted by means of the pipe 16 to a containing tank. This injector may be used in conjunction with any pump to assist the pump in removing liquids from a well or subterranean cavity.

While we have shown and described several embodiments of our invention, it will be understood that many modifications may be made therein without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. The combination with a tubular current conducting member adapted to be immersed in a body of liquid, of an electrical induction heater surrounding the tubular member but spaced therefrom to provide a passageway for the circulation therethrough of the body of liquid, said heater being supermagnetically saturated in order that induced currents resulting from stray magnetic fields from said heater may be generated in said tubular member.

2. The combination with a tubular current-conducting member having a perforate portion which is adapted to be immersed in a body of liquid, of an electrical induction heater surrounding the perforate portion but spaced therefrom to provide a passageway for the circulation therethrough of the body of liquid, said heater being magnetized to such a degree that stray magnetic fields therefrom will induce currents in said perforated portion in order to preclude it from becoming congealed by said liquid.

3. In an oil-well, the combination with a perforated, electrically-conducting member subject to clogging by well deposits, of means for setting up an alternating magnetic flux therein, whereby eddy currents are produced therein and said deposits fused.

4. In an oil well, the combination with a perforated pump casing formed of electrically conducting material and subject to clogging by well deposits, of means for producing current flow in the material of said casing for the heating thereof and the fusion of said deposits.

5. In an oil well, the combination with a perforated electrical conducting member made of magnetizable material, said member being subject to clogging by well deposits, of an induction-type electrical heater embracing said perforated member but spaced therefrom to provide an annular passage-way between the inner wall of said heater and the outer wall of said perforated member, and means for generating heat in both the induction heater and the perforated member, whereby the well deposits tending to clog said perforated member may be fused.

6. In an oil well, the combination with a perforated pump casing formed of electrical conducting and magnetizable material, said pump casing being subject to clogging by well deposits, of a magnetizable and electrical conducting tubular casing surrounding said perforated pump casing, but spaced therefrom to provide an annular passageway, and means whereby the said tubular casing, as well as said perforated pump casing, may be heated as the result of generating eddy currents in both of said members.

7. In an oil well, the combination with a perforated pump casing formed of magnetizable and electrically conducting material and subject to clogging by well deposits, of an induction-type electrical heater embracing said perforated pump casing but spaced therefrom to form an annular passage-way, the exterior casing of said heater serving as the sole heating element thereof, and means for generating heat in said exterior casing, as well as in said perforated pump casing, by means of generating eddy currents therein.

In testimony whereof I have hereunto subscribed my name this twenty-sixth day of January, 1917.

ARTHUR G. POPCKE.

In testimony whereof I have hereunto subscribed my name this eighteenth day of January, 1917.

W. R. JOHNSTON.