THE EFFECT OF CORONA CURRENT ON THE COOLING OF A HOT WIRE*

BY SAMUEL R. PARSONS

ABSTRACT

This article describes an experimental study of the cooling of a hot wire in air, when the air is disturbed by a corona discharge to the wire. With a copper wire, No. 30 B. & S. gauge, *in still air*, no effect was found with corona current less than 3 microamperes per cm of wire; but beginning with about that value, the cooling power of the wire increases, at first rapidly, and then more slowly, possibly passing through a poorly defined maximum. A corona current as great as 12 microamperes per cm is sufficient to give nearly the maximum effect. With small currents of air past the wire, a gradual increase of corona current, starting with zero, often shows first a heating effect, followed by a cooling effect. The slow currents of air seem to be appreciably retarded by the cross-flow of the ions carrying the corona current. The number of ions required for appreciable cooling is estimated to be considerably less than one ion per million molecules of the gas.

A SMALL wire gently heated in still air dissipates heat rather slowly, because of the fact that the air close to it forms an effective heat-insulating blanket; and any agency that disturbs this insulating blanket may be expected to increase the loss of heat from the wire. It has seemed probable that if the electrical potential of a wire is raised until a corona discharge is obtained, the motion of the ions in the corona current should cause an appreciable cooling effect. This has been found to be true, and the cooling power of a wire has been doubled, with rather small corona current. The following paragraphs describe an experimental study of this cooling effect.

Perhaps it should be stated that since the experiments are subject to the irregularities of cooling with very feeble convection currents, and also to the irregularities of the corona discharge, too much significance must not be attached to the absolute magnitudes of quantities shown. The results of the experiments should be regarded as representative of similar, but not identical, values that might be obtained under very slightly different conditions.

APPARATUS

A piece of No. 30 bare copper wire, 17.2 cm long, was stretched along the axis of a brass tube of the same length, and 4.3 cm inside diameter. This wire, which will be called the "corona wire", was supported at both ends by current and potential leads of No. 22 enameled copper wire. The ends of the brass tube, supported by insulating rings of Bakelite panel-

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HEAT TRANSFER IN THE ANNULAR SPACE BETWEEN TWO COAXIAL CYLINDERS*

By S. R. Parsons

Abstract

Two brass tubes are mounted with a common axis, one inside of the other, and are warmed by driving hot air, in turbulent flow, through the annular space between them. The rates of transfer of heat to the two tubes are compared by means of a coefficient representing heat transmitted per unit time per unit area of metal surface per unit difference of temperature between metal and air. Lees has shown that in streamline flow there would be a difference in the surface friction per unit area for the two tubes, and if that were true in turbulent flow, there would be a corresponding difference in the coefficients of heat transfer. The experimental results show that if there is such a difference in turbulent flow, it is not of the magnitude to be expected from Lees' equations, and fail to show with certainty that any difference exists.

WHEN air is passed through the annular space between two coaxial cylinders, such as that formed by one metal tube inside of another, the stream acts simultaneously on two surfaces, of which one is convex, and the other concave. Lees[1] has shown that when a fluid passes in streamline flow through such an annular space, the surface friction per unit area is less on the outer tube than on the inner one, and he raises the question whether there is a similar difference in turbulent flow. If there is, there should be a corresponding difference in the rates of transfer of heat between the stream and the two surfaces, which might be interpreted as representing a difference in the character of the flow close to the walls,—that is, a difference in the extent to which the stream may be regarded as scouring the surfaces. The purpose of the work described in this paper was to show whether or not heat is transmitted more readily to one of the two surfaces than the other.

Apparatus and Experimental Procedure

Two pairs of brass tubes were used, the first 91.3 cm in length, and the second, 170.0 cm. The inner and outer diameters of the annular spaces were 0.949 and 1.706, and 0.950 and 2.307 cm, respectively. Each tube was about 1 mm in thickness. Air from a compressor connected to a large tank was forced through a brass tube 1.7 cm in diameter, in which its speed was estimated by means of a Pitot tube; then through a

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[1] C. H. Lees, Proc. Roy. Soc. 92, p. 144 (1915).

THE CURRENT-VOLTAGE RELATION IN THE CORONA

By C. S. Fazel and S. R. Parsons

Abstract

Current-voltage relation for the corona discharge between a cylinder and a coaxial wire.—*An equation* is derived on the basis of a small region (of radius a) of intense ionization around the wire, outside of which the current is carried only by ions of one sign, whose space density ρ is constant. At the boundary between the two regions the field is assumed to be the minimum field required to start the corona, and the field beyond is taken to be the sum of the electrostatic field and that due to the space charge. Putting in the experimental result that a is a linear function of the applied voltage V, the equation for the current i is put in the form $i=cV(V-V_0)/(V_1-V)$, when c is a constant proportional to the mobility. *Measurements* with a brass tube 17.8 cm long and 4.75 cm inside diameter, through which a slow stream of dried or moist air was passed, show good agreement with the above equation as far as variation with V is concerned, for voltages from 4.7 kv to 8.8 kv, for temperatures from 290°K to 417°K and for moisture content up to 44 percent. The theory is evidently imperfect, however, as the absolute values of the mobilities come out from 2 to 4 times the values obtained in small fields although the variation with absolute temperature is correct.

THE relation between current and voltage in the corona discharge between a hollow cylinder and a wire placed at its axis has been studied by Almy,[1] who gave an empirical equation, and by Schaffers[2] and Townsend,[3] who have derived theoretical equations. Both Schaffers and Townsend make use of the fact that ionization takes place principally within a small region surrounding the wire, and obtain relations involving the mobilities of the ions. Schaffers' equation, however, yields mobilities as high as one hundred times as great as those obtained by direct measurement, and Townsend's equation is not in a convenient form, because it expresses the current as an implicit function of the voltage. These difficulties may be removed, as will be shown below, by a treatment of the problem somewhat similar to that of Schaffers, but taking account of the fact that the region of intense ionization expands as the voltage is increased.

From the fact that the ionization takes place almost wholly within a certain short distance of the wire, it follows that beyond this distance,

[1] Almy, J. C., Am. Jour. of Sci. (4), **12**, 175, 1901
[2] Schaffers, V., Phys. Zeits. **15**, 405, 1914
[3] Townsend, J. S., Phil. Mag. (6), **28**, 83, 1914