Title
A CONTINUOUS CARBON FIBER MONITOR

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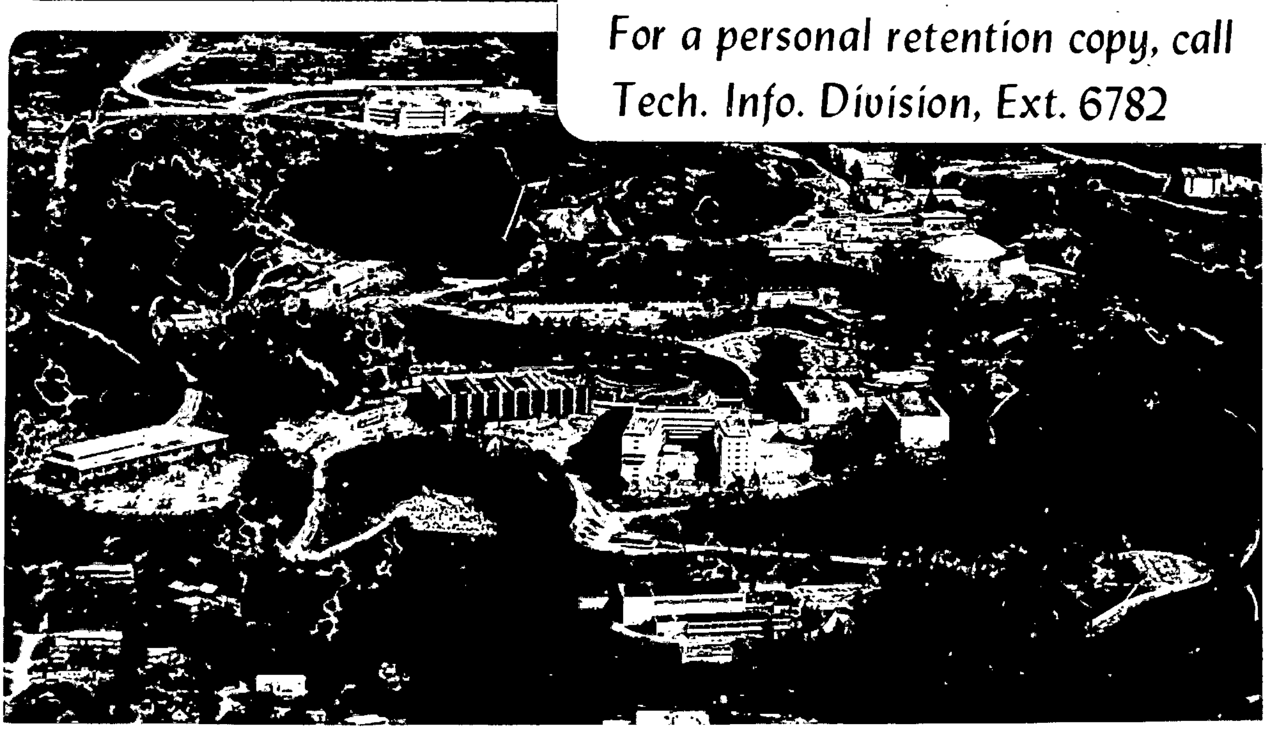

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DISCLAIMER

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Introduction

Over the past decade, there has been an upward trend of substituting high performance composite materials for a significant amount of steel, aluminum and titanium alloys used in the aerospace, sporting goods and transportation industries. Due to their many excellent performance characteristics, carbon (including graphite) fiber-filled composites are likely to face accelerated commercial and military applications. A potential problem related to the extensive use of carbon fiber composites is the release of individual fibers into the atmosphere as the result of fiery accidents or improper waste disposal. Since carbon fibers are good electrical conductors, they may lead to adverse performance or even destruction of electronic and electrical equipment (NASA 1978). Our objective is to devise a continuous detector which is specific for carbon fibers and to determine their ambient concentration and length distribution.

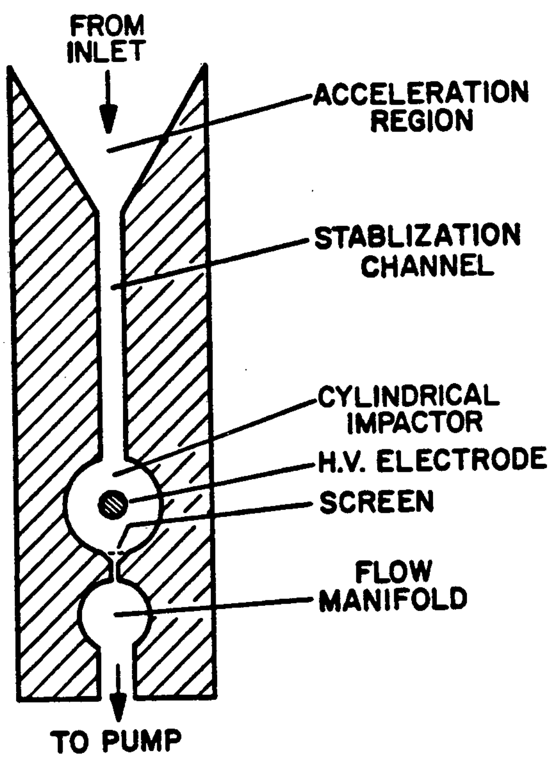
Method

When a conducting fiber of diameter D_F and length L comes into contact with a conducting sphere of diameter D_S and potential V, the net charge Q acquired by the fiber is calculated by Bucher (1976) to be:

$$Q = \frac{3\pi\varepsilon V L^2 [1-(1/\alpha)\ln(1+\alpha)]}{D_S(3/2+\alpha)^2 \ln(4L/D_F-1)]} \quad (1)$$

where α is the ratio $2L/D_S$, and ε is the dielectric permittivity of free space.

However a simple ball detector so constructed (Shelton, 1979) has several severe limitations. First of all, since the attractive electrical force on the fiber is in competition with the inertial and drag forces, only fibers in the immediate vicinity of the sphere are to be detected. Moreover, this detection efficiency is a strong function of fiber length and flow rate. Secondly, the precision of the measurement is compromised by the uncontrolled fiber orientation with respect to the electric field. Finally, the susceptibility of the detector system to electrical noises limits its short fiber detection capabilities.



Cross section of C.F. Detector.

To overcome these difficulties, we have designed a detector with a cylindrical geometry whose sectional view is shown in Fig. 1. A total flow of 5 m^3/hr is distributed along a cavity which is 10cm long and 2.54cm in diameter. A 6.35mm diameter high voltage rod (maintained at +1500V) is used as part of a cylindrical impactor and is connected directly to a low noise charge preamplifier. A vertical drift section is provided to stablize the fiber orientation with respect to the stream lines after the acceleration region at the inlet. Special linear amplifiers are designed to process signals which may span six orders of magnitude.

Results and Discussion

The carbon fiber detector has been calibrated by using a laser-based carbon fiber generator which can produce fibers with an accuracy of 5μm (Loo, 1981). The results of these calibrations are tabulated below.

Fiber Length (μm)	Charge (Coulomb)	Efficiency (%)	Precision (μm)
143	$1.34(.23)\times10^{-15}$	78	8.2
237	$5.17(.62)\times10^{-15}$	89	9.5
486	$3.46(.12)\times10^{-14}$	100	5.6
1009	$2.09(.05)\times10^{-13}$	100	8.0
2016	$1.25(.03)\times10^{-12}$	100	16.3

Results for fibers 4mm and longer are much less precise (~20%) and we are still in the process of improving the design. Detector geometry, flow rate and high voltage are to be optimized with the goal of measuring conducting fibers in the 0.1 to 10mm range with high efficiency, accuracy and precision.

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