A DUAL FOCUS FIBER OPTIC ANEMOMETER FOR MEASUREMENTS IN WET STEAM

by

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According to the method developed by Schodl, a L2F has been designed using fiber optic both for transmission and reception of the light. After some feasibility tests on laboratory prototypes a 25 mm diameter probe head has been built for pratical performance evaluation.
The final system for measurements of large droplets velocities inside steam turbines is in costruction, and it will be provided with LED light sources instead of a laser one.

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1. In the course of a research programme concerning the experimental evaluation of the performance of highpower steam turbines, attention has been given to the problem of knowledge of liquid phase motion.
   In particular, this work deals with the motion of large drops leaving the blade trailing edges. The main parameters affecting the erosion of the following blade row are velocity and direction, ,and on these attention has been focused for the development of a suitable probe.

2. The measuring system for this purpose should have the following characteristics:

   - measuring head consistent with Ansaldo's probe inserting system.
   - minimum disturbance of the flow in the measuring point.
   - velocity range up to 300 m/s.
   - on-line data reduction.

   Both LDV and L2F techniques have been considered and subjected, during the early development of the programme, to experimental performance evaluatiȯn.
   After a series of laboratory tests, both in air and in wet steam flows, the LDV has been discarded for two main reasons:

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1) The access ports to the turbine are comparatively too small in size (25 mm diameter) and are located too far from the measuring point (3÷4 m) to have a sufficient f-number.
Alternatively, a long-arm LDV could be designed, but the mechanical stiffness necessary for optical alignement cannot be easily guaranteed.

The use of a coherent fiber optic has also been considered but not applied, because the optical system could not be reduced to the required size; in fact a lower limit exists to the parallel beams distance, if the number of fringes has to be high enough (20÷25) to have good measurement accuracy and easy signal treatment.

2) If the volumetric concentration of droplets is high, as it is to expect in wet steam turbine stages, a coherence loss takes place and the system can no longer operate satisfactorily.
The L2F technique is not affected by this second drawback, and the first one may be easily overcome due to its characteristics. In fact, the L2F technique can, in principle, operate also with a non-coherent light source, loosing, of course, the capability of measuring small particles travelling at high velocity.

If the use of non-coherent light is accepted, the combined use of fiber optics makes the alignement problems more easy to solve.

3) Starting from some experiences on the L2F system as proposed by Schodl, firstly an L2F system has been developed using laser light and lenses for the illumination and fiber optics for the back-scatter light collection.
This system is easy to arrange, because fiber optics in the diameter range of 100-200 μm substitute the doublepinhole otherwise required, with only a small loss due to the front reflection.

Moreover, flexible fiber-optics cables allow for a fixed mounting of photodetectors.
Experimental evaluation of feasibility has been done with a laboratory prototype on a wire rotating at known velocity, in order to make a performance evaluation.
In these tests the electronic chain consisted of a computer-driven counter, with a time interval resolution of 10 nsec, by which a statistical analysis of photodiodes signals has been done. The main components of this system were:

- laser: Spectra Physics Ar-laser mod. SP164-06
- fiber optics: FORT type PZ (200 μm core)
- photodiodes: HP mod. 5082-4207
- counter: HP - 5328 A
- computer: HP - 9835 A

A statistical error was found to be less then the instability of the small driving engine.
This system is now undergoing other tests, with velocity measurements in fuel sprays with a cross-correlator (HP-3721A) on line. Some problems have arisen due to the mutual influence of the low duty cycle of the signal, the frequency responce of the pin photodiodes, and the limited frequency band of the correlator.
Hopefully, these problems will be overcome in the next future just improving the experimental set-up.

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4. As far as measurements inside a turbine are concerned, fig. 1 shows a sketch of the small size probe head, presently in construction. Major characteristics of this head are as follows:

- outer diameter: 25 mm
- front lens diameter: 22.4 mm
- front lens focal length: 40÷60 mm
- transmitting and receiving lenses diameter: 8.3 mm
- transmitting and receiving lenses focal length: 22mm
- illuminating fiber optics: FORT LG, 50 μm core,N.A.=0.2
- receiving fiber optics: FORT HP, 100 μm core, N.A.=0.29

Each of the four fiber optics (two for the illumination, two for the collection) is composed by a fiber piece, terminated at one end by a ferrule with the end surface polished, and at the other end by a fiber optic connector, to allow easy mounting and replacing of components. Connectors are supported inside the probe stem by a mounting ramp, that carries also the weight of the upper, 7 meter long, fiber optic cable.

The distance between the two illuminating as well as the two receiving fiber is fixed at 1 mm; the larger diameter of the receiving fibers allow for the tolerance in manufactoring the ferrule emplacement.
With a 44 mm front lens, beams of 100 μm diameter in the measuring point are produced, 2 mm apart, and this gives a measuring range of 200 m/s with a 10% error with 10 MHz electronics. A jump to 50 MHz, and more, electronics will be possibly justified by the first results.
In order to have a device that could allow for an easy mounting on the field, the illumination system has been modified such as to use light emitters (FORT mod. PTE-19D30), with the light reception always done by means of pin photodiodes (FORT mod. PTR-19D50).

The electronic system will consist of a computer-driven counter if the volumetric concentration of drops, as compared to the photodetectors rise time, is low enough to assure single drop detection, otherwise, if the optic signal will appear as a continuous behind the photodetectors, a correlator will be used.

The first tests of the complete system are foreseen by November 1981 when a complete test campaign will be carried out on a 320 MW turbine, with combined measurements of wetness, aerodynamic characteristics, and droplets motion.

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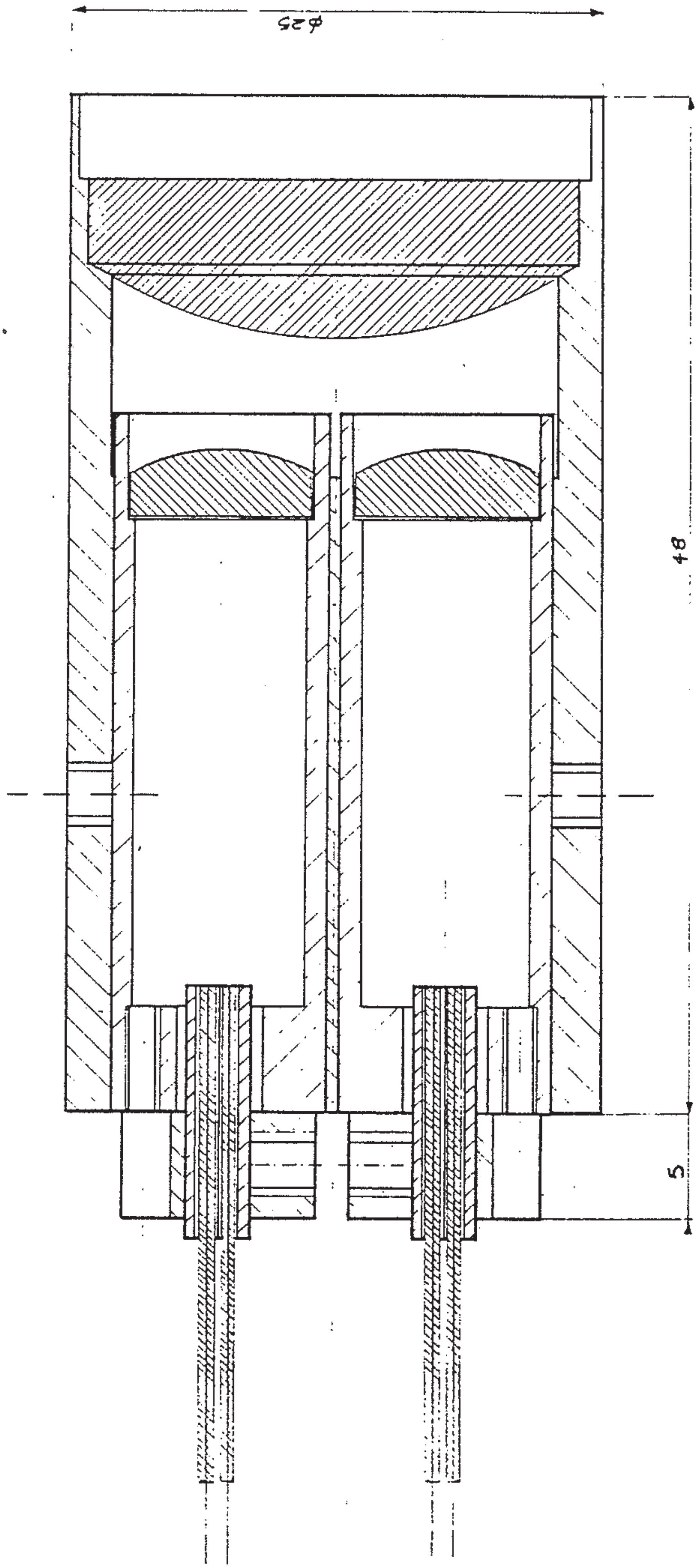

FIG. 1

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