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5. TSI'S LDV BLOOD FLOWMETER

JOHN A. BORGOS

Since its incorporation in 1961, TSI's primary business has been identifying requirements for the measurements of details of fluid flow, and then developing solutions to meet these needs. The company's earliest products were a series of thermal anemometers used for measuring the flow of hot gases. This product line soon expanded into a broad line of hot wire and hot film probes and electronics for fluid flow measurement in research, medical, and industrial applications.

In 1973 TSI introduced its first laser-Doppler velocimeter. This was a major breakthrough at the time, because it allowed for the measurement of the details of fluid motion in a way that was completely noninvasive. Today these LDV products are primarily used in fluid mechanics research, industrial research and product development, and biomedical research and engineering. For example, the development of heart valve prostheses has benefited greatly by the ability of LDV instrumentation to characterize the details of flow in experimental models.

As TSI continued to develop a high level of expertise in the design of optical systems and signal processing, the company began to identify other areas in which laser-Doppler techniques could be applied advantageously for the measurement of fluid flow. One of these areas was the measurement of microvascular blood flow. It was apparent that the ability to quantify levels of capillary perfusion would greatly aid in the diagnosis and evaluation of a wide variety of diseases and injuries, and would greatly improve patient

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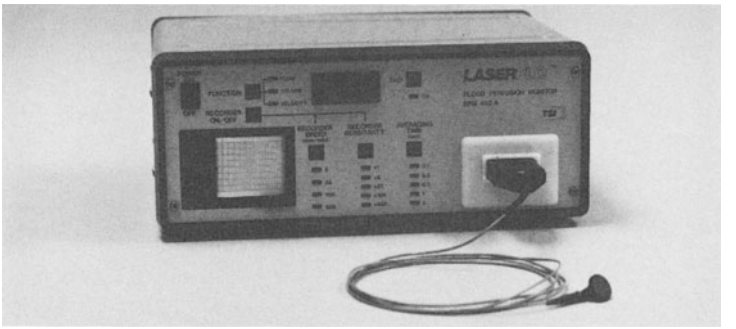


Figure 5–1. The Laserflo Blood Perfusion Monitor.

management in critical situations where therapeutic intervention is required to restore the circulation.

TSI was not the first to introduce a laser-Doppler blood perfusion monitor. Other researchers had developed and tested prototype instruments [1–5], and various early reports seemed to confirm the fundamental capabilities and advantages of the technique [6–11]. Early commercial versions also appeared (see chapters 3 and 4). However, in order for a laser-Doppler instrument to be a truly useful clinical tool, it seemed that three particular requirements had to be met:

1. The results must be quantifiable. In other words, the instrument must be able to measure in absolute flow units, and not arbitrary or simply qualitative values.
2. The instrument must be capable of measurements of microvascular blood volume, velocity, and flow. The volume and velocity parameters have particular relevance in evaluation of microangiopathy, for example.
3. The instrument must be easy to use for clinical personnel.

With these three criteria in mind, TSI began the development of an advanced version of a laser-Doppler instrument, and in 1985 introduced the Laserflo® Blood Perfusion Monitor (figure 5–1). This chapter summarizes considerations that went into this instrument's design. Our objective is to give the reader a greater understanding of its capabilities and limitations and to make him or her more proficient in its use.

THEORETICAL ASPECTS AND ASSUMPTIONS

The theory of laser-Doppler measurements of tissue perfusion is discussed fully in chapter 2. However, a brief summary of several theoretical concepts is included here to facilitate a better understanding of the operation of the instrument. First of all, let us examine the source and nature of the Doppler

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