

# Evaluation of an Emergency Drive System for a Disabled Arterial Pump Head

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## Abstract

This study evaluates an Emergency Drive System (E.D.S.) developed by the authors to provide an electrically powered drive system for a disabled arterial pump head.

The methods used in this study were designed to evaluate the E.D.S. under simulated clinical conditions using an American Optical Model 16655 pump with 1/2" tubing in the arterial pump head and a Sarns 5000 pump with 3/8" tubing in the arterial pump head. The E.D.S. was applied to the arterial pump head and was required to produce a six liter per minute flow based on the revolutions per minute of the pump head. The study was deemed successful if the E.D.S. was capable of providing the revolutions per minute for a two hour period.

The E.D.S. was capable of providing the 100 revolutions per minute for American Optical pump and the 230 revolutions per minute for the Sarns 5000 pump, necessary to produce a six liter per minute flow rate.

In conclusion our study shows the E.D.S. is an easy and accurate device for providing temporary power to a disabled arterial pump head.

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## Introduction

Since the early days of cardiopulmonary bypass (CPB) it has been a goal of perfusionists, researchers, and manufacturers to improve the safety of the CPB systems. Major advances have been made in reducing trauma to cellular components of the blood by technical improvements in pumps, oxygenators, cardiotomy reservoirs, tubing, and filters.<sup>1,2</sup> Improvements in perfusion techniques such as hemodilution and hypothermia have been important factors in reducing patient morbidity and mortality.<sup>3,4</sup>

Today, safety features on CPB systems are primarily directed toward prevention of gas embolization. This is accomplished by a number of different devices that warn the perfusionist and/or stop the arterial pump head when the level of blood in the oxygenator drops below a pre-set point.<sup>5</sup> Sophisticated detectors are available that will stop the arterial pump head if a gas bubble of 1 ml. or larger is detected in the arterial line.<sup>6</sup>

The presence and importance of gaseous emboli within the CPB system is well documented and prevention of gas embolization cannot be over emphasized.<sup>7,8</sup> However, another area of consideration within the CPB system that needs equal emphasis is the flow rate of arterialized blood to the patient. It has also been documented that organ and physiologic system failure can result from inadequate perfusion.<sup>2(pp 307-309),9</sup> This study examines a new device, developed by the authors,

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which restores constant, controllable power to a disabled arterial roller pump. Personal experience with a shorted powerbase on a modular pump, and a malfunction of a blood level detection system led to the development of an alternative to hand cranks.

Cappola, et. al. reported slippage of an arterial pump head due to improper drive belt tension on a pump which had just returned from routine maintenance.<sup>10</sup> If this situation had not responded to the increased speed of the pump, the perfusionist might have found himself hand cranking the pump to provide the necessary perfusion flow rate.

Kurusz et. al. reported emptying of an oxygenator secondary to a "runaway pump head."<sup>11</sup> This perfusionist had to rely on a malfunctioning pumphead to provide his patient's perfusion flow rate. During this time period the perfusionist had no way of knowing if the problem would develop again. The only other alternatives would have been to change pumps or hand crank the arterial pump head.

One pump manufacturer<sup>12</sup> offers a battery inverter power pack for the resumption of power to a pump console that has lost power because of an electrical power failure to the surgical suite.<sup>a</sup> In the event of an intra-pump electrical or mechanical failure, the only device the manufacturers offer is either a ratcheted one-way, or speed wrench type, hand crank.<sup>a,b</sup> (Figure 1 and 2). These hand cranks would be used in a situation where external electrical power is not getting to the pump head. Examples of potential intra-pump problems are listed in Table I.

Hand cranking an arterial pump head is not only physically exhausting, but could be physiologically detrimental to the patient if the perfusionist were unable to maintain the perfusion flow rate.

## Methods and Materials

The Emergency Drive System (E.D.S.) is an electrically powered device that adapts to most roller pumps for the purpose of supplying auxiliary power to an arterial pump that is malfunctioning due to an internal electrical or mechanical problem. The E.D.S. adapts to most major types of roller pumps using adaptors that are designed after the pumps' hand cranks. The supporting struts are adjustable to allow

<sup>a</sup> Sarns, Inc., Ann Arbor, MI 48103

<sup>b</sup> Cambridge Instruments, Inc. (Formerly American Optical), Bedford, MA 01730



FIGURE 1. Hand cranking the Sarns 5000 pump head.

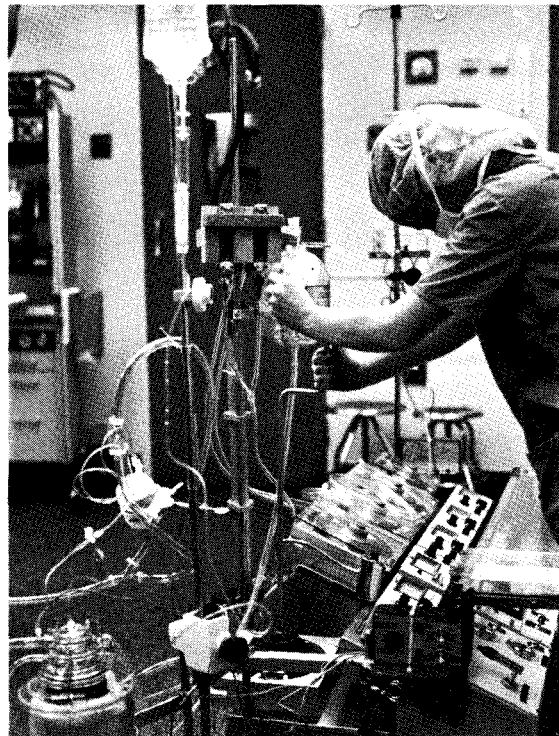


FIGURE 2. Hand cranking The American Optical 16655 pump head

TABLE I  
Potential Problems That Can Alter Pumphead  
Operation

<i>Electrical Problems</i>	<i>Possible Cause</i>
Pump Motor Malfunction:	Improper maintenance, internal water leak, voltage surge compensator malfunction
Speed Control Malfunction:	Fluid or dust inside speed control, voltage surge compensator malfunction.
Main Power Switch:	Constant usage (worn out), broken switch handle due to object being dropped on pump.
Inability to re-set main circuit breaker:	Internal short circuit, voltage surge compensator malfunction.
Broken Power Cord or plug:	Accident in surgery, cord constantly being rolled over.
Power Base malfunction (modular pump): Blood level detector override malfunction	Fluid or irrigation spilled on power base.
<i>Mechanical problem</i>	<i>Possible Cause</i>
Slipping or broken drive belt:	Improper maintenance, worn drive belt due to pump being too occlusive.

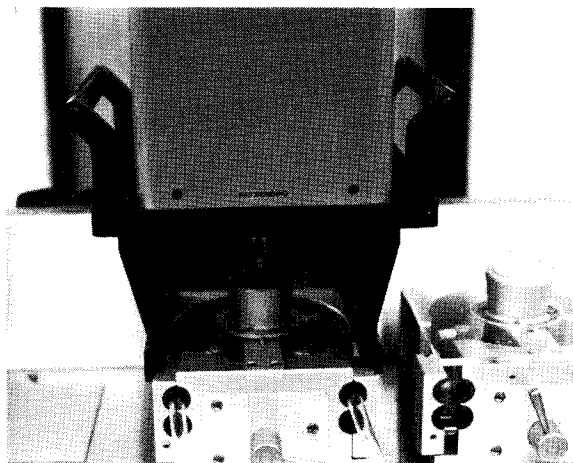


FIGURE 3. The E.D.S. adaptor system for the Sarns pump

positioning of the E.D.S. on pump head casings ranging from 6 inches square to 9 inches square. (Figure 3)

Power to the pump head is supplied by a Bodine  $\frac{1}{8}$  horsepower parallel shaft motor with a 9.4:1 gear reducer.<sup>13</sup> The external dimensions of the E.D.S. are 10"  $\times$  10"  $\times$  20". The casing was constructed of  $\frac{1}{16}$ "

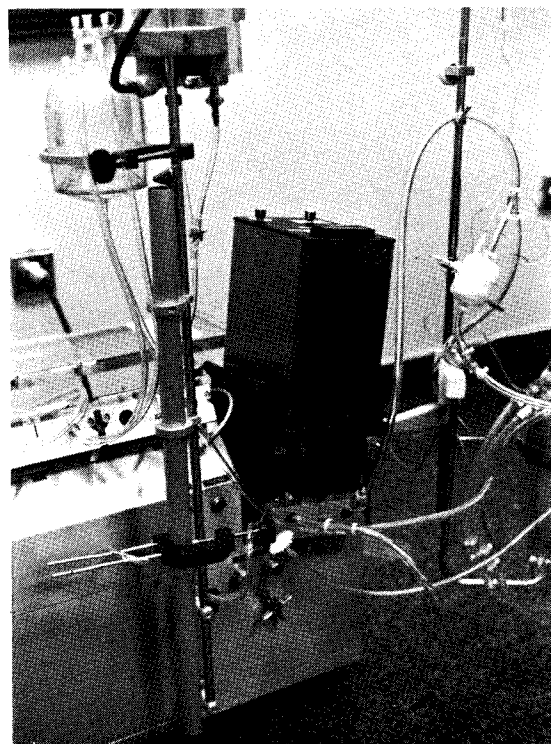


FIGURE 4. The E.D.S. in position on The American Optical pump

stainless steel with the handles, control panel, and supporting struts made from anodized aluminum. Total weight of the E.D.S. prototype is 42 pounds. (Figure 4)

The motor is variable speed and can operate in either a clockwise or counter clockwise rotation. The digital speed indicator is calibrated in revolutions per minute (RPM). (Figure 5). The prototype utilizes 110 volt A.C. power, but can be adapted for use with a D.C. power supply.

Testing of the E.D.S. was done under simulated clinical conditions utilizing two models of heart-lung pumps. An American Optical heart-lung console,<sup>b</sup> model # 16655 and a Sarns,<sup>a</sup> model 5000 heart-lung console. The extracorporeal circuitry was similar to that used during clinical open-heart cases. This consisted of a Bentley<sup>c</sup> Spiroflo BOS-10 oxygenator, Pall model EC 3840<sup>d</sup> arterial line filter with Tygon S-50-HL<sup>e</sup> tubing used in the arterial-venous loop. With the

<sup>a</sup> Bentley Laboratories, Inc. Irvine, CA 92714

<sup>b</sup> Pall Bio Medical Products Corporation, Glen Cove, N.Y. 11542

<sup>c</sup> Norton Health Care Products, Akron, OH 44309

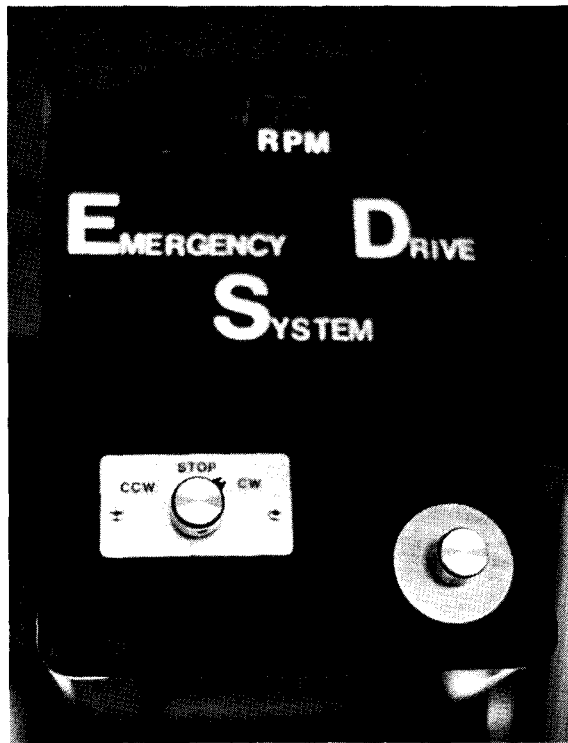


FIGURE 5. E.D.S. control panel

American Optical pump,  $\frac{1}{2}'' \times \frac{3}{32}''$  tubing was used in the arterial pump head, while  $\frac{3}{8}'' \times \frac{3}{32}''$  tubing was used in the arterial pump head of the Sarns 5000. The circuit was primed with 2000 ml of non-sterile water.

Pump head occlusions were checked by holding the separated arterial line 30 inches above the pump and allowing the fluid level to drop at a rate of about 1 cm per minute.<sup>2(p 295)</sup> Calibration of the pumphead was checked by measuring the output of the pumps in a graduated container at 25 revolutions per minute over a period of one minute. These values permitted calculation of the RPM's necessary to produce a six liter per minute flow rate from each pump.

The arterial line was reconnected to the venous line. The E.D.S. was then used to produce this 6 liter per minute flow rate based on the revolutions per minute for a period of two hours.

Prior to the tests, the E.D.S. was equipped with the pump head adaptors and the supporting struts were adjusted for the different sized heads. This would be done by the perfusionist when the E.D.S. was delivered to his or her institution.

## Results

The American Optical pump required 100 revolutions per minute to produce a six liter per minute flow rate. The E.D.S. was applied after the pump's main power was turned off and the pump head had come to a complete stop. The E.D.S. resumed the 100 revolutions per minute and kept it at that point for the two-hour test period. The Sarns 5000 required 230 revolutions per minute for the six liter per minute flow rate. Again, the E.D.S. supplied the necessary 230 revolutions per minute.

During the four hours of testing, the E.D.S. showed no signs of overheating or power loss.

## Conclusion

The E.D.S. is a simple device needed in the field where inadequate perfusion can result in the death of a patient. If the E.D.S. were commercially available, perfusionists would have an alternative to using malfunctioning equipment or hand cranks in an emergency situation.

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