

An inexpensive automated vitrectomy machine

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Abstract

A low-cost automated vitrectomy machine was developed locally by the Department of Medical Physics and Engineering at Edinburgh University. The machine uses disposable handpieces, and has proved to be user-friendly, reliable, and efficient for anterior segment vitrectomy and, for selected patients, for posterior segment vitrectomy. The construction and mechanics of the machine are described. Similar inexpensive vitrectomy machines could easily be constructed in any ophthalmic department that has access to proper medical engineering facilities.

Key words: Anterior segment, Vitrectomy

Introduction

Since the introduction of simple vitreous cutting instruments 4 decades ago,^{1,2} vitreo-retinal surgery has been revolutionized by the development of vitreous cutter suction infusion technology, which can be used through a small pars plana incision.^{3,4} The past 3 decades have witnessed a rapid evolution of vitrectomy machines through the use of automated linear suction cutter mechanisms that can be controlled by a foot pedal.⁵ Subsequently, such machines became increasingly complex and expensive.

In this paper, an inexpensive, simple automated vitrectomy machine that can be easily set up, using commercially available disposable vitrectomy probes for anterior segment procedures, is described. Although it was not the original intention, it has also proved useful (because of its simplicity and reliability) for posterior segment vitrectomy procedures.

The Instrument

The machine was developed locally by the Department of Medical Physics and Engineering at Edinburgh University. The vitrectomy unit is housed in a small instrument case (**Figure 1**), which resides on the top of a theatre trolley that has been modified to accommodate 2 F size air cylinders (1 active and 1 spare) with pre-set regulators.

The compressed air provides both controlled cutter drive and vacuum generation. The cutter is driven by air from the F size medical air cylinders at a pressure of 3.2 bar as indicated by the supply pressure gauge (P) [**Figure 1**] on the front panel. Subsequently, pressure of the supplied air is pre-set internally by the adjustable air speed controller SC1 (**Figure 2**) at an optimal level of 2.0 bar. The admitted air operates the cutter by a solenoid valve SOL1 (**Figure 2**)

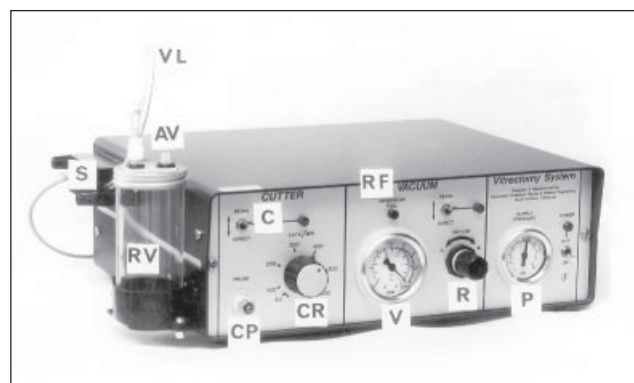


Figure 1. External view of vitrectomy machine (modified theatre trolley is not shown).

Abbreviations: AV = vacuum supply tube; C = cutter switch; CP = cutter tube; CR = cutter rate; P = pressure gauge; R = ARI regulator; RF = reservoir full indicator; RV = reservoir; S = slotted optical switches; V = vacuum gauge; VL = vacuum line.

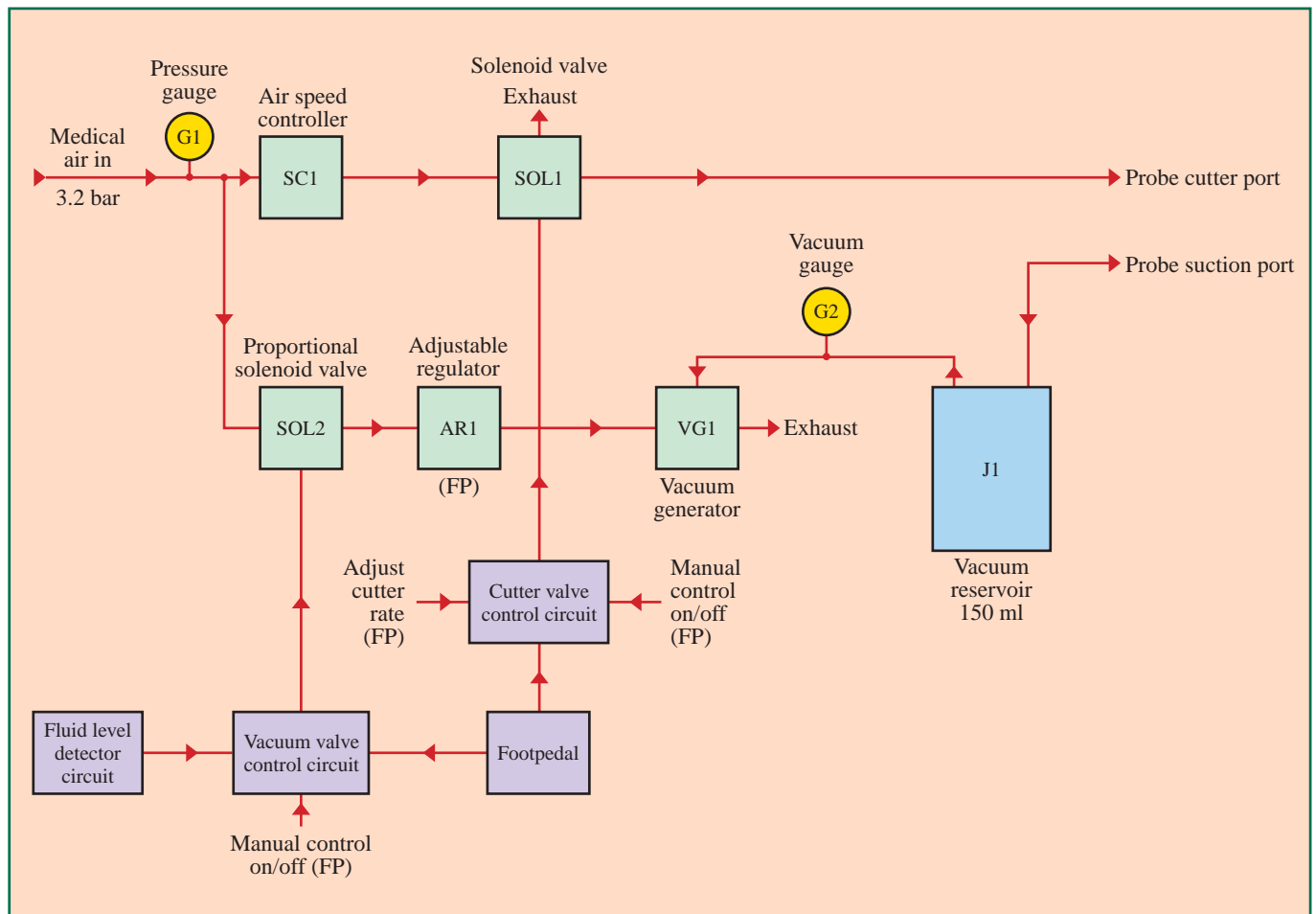


Figure 2. Schematic plan of construction of vitrectomy machine.
Abbreviation: FP = front panel control.

which is controlled by the cutter valve control. The fixed cutter rate (CR) can be pre-set within the range 60 to 600 cuts/minute, and can be activated by either a lateral movement (L) of the foot-pedal (**Figure 3**), or by using the cutter direct switch (C) [**Figure 1**] on the front panel. A green indicator on the front panel will flash with each pulse of air delivered to the cutter.

The suction mechanism is obtained through a vacuum generated by the airflow through the solenoid valve SOL2 (**Figure 2**), which is controlled by the vacuum valve control circuit. This allows for a linear control of the vacuum using direct downward pressure (D) on the foot-pedal (**Figure 3**). The maximum level of vacuum can be pre-set within a range of 0 to 450 mm Hg using the regulator ARI (R) [**Figure 2**]. During operation, a vacuum gauge (V) on the front panel (**Figure 1**) will indicate the actual vacuum demanded in relation to the amount of depression of the foot-pedal. Should electronic control of the valve fail, suction may still be operated manually from the front panel to provide a vacuum that can be adjusted to the required level using the regulator ARI control knob (R).

The foot pedal (**Figure 3**) is purpose-built and linear control of the vacuum level is achieved by progressively depressing the pedal towards the floor. Moving the pedal slightly to the

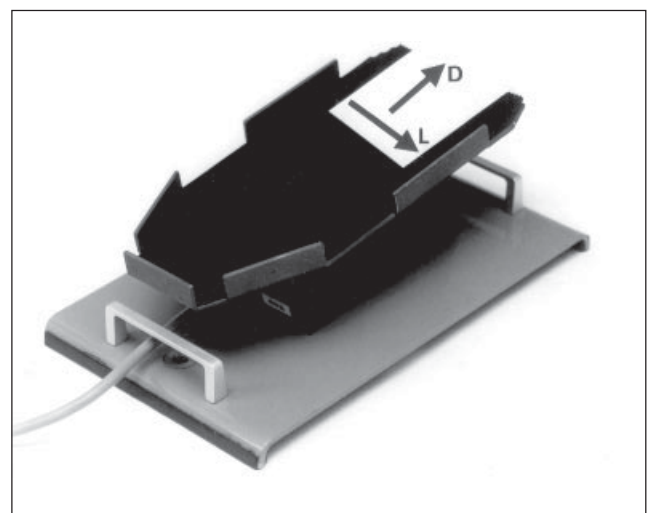


Figure 3. External view of foot-pedal.
Abbreviations: D = downward; L = lateral.

right switches on the cutter and operation of the cutter is independent of the level of vacuum selected.

Fluid is drawn from the eye into a clear plastic disposable reservoir (RV) [**Figure 1**] with a capacity of 150 ml. The reservoir is a standard 150 ml 'Sterilin' clear plastic disposable specimen container. The screw-on metal lid is

modified to accept 2 female Luer bulkhead connectors which are mechanically locked to the lid to prevent them from turning when connected to their respective tubes, and whose threaded fixings are sealed against vacuum loss with silicone rubber sealing compound.

The cutter (CP) and vacuum supply (AV) tubes are connected to the reservoir by the 2 Luer connectors mounted on the lid. The lid's integral seal ensures a suitable vacuum connection between the lid and the reservoir. The lid may be used repeatedly, although the container may be disposed of after every use or cleaned and re-used as preferred.

To avoid damage to the vacuum generator that may result from fluid back-flow in case of reservoir overfilling, the clear plastic vacuum line (VL) passes through 2 slotted optical switches (S) [Figure 1], which detect the presence of any fluid back-flow. A rapid collapse of the vacuum in the system is then immediately initiated preventing fluid ingress to the vacuum generator. This will be accompanied by flashing of the red 'reservoir full' (RF) indicator on the front panel.

The unit is powered from the normal 230 volt mains supply using an internal linear power supply. Power for the solenoid valves is supplied from a 24 volt DC unregulated line, while the remaining circuitry is supplied by a 12 volt DC stabilized line.

Comment

The immediate availability of an easily set up automated vitrectomy machine remains crucial for the management of the complications of anterior segment procedures. However, commercially available automated vitrectomy machines can be time-consuming to set up, and can be expensive for small ophthalmic units.

Two identical machines with the above description were developed locally at a cost of approximately GB£1400 each. They have been used regularly at the Royal Infirmary of Edinburgh for more than 2 years with no breakdowns of any kind. Although initially designed for automated vitrectomy during extra-capsular cataract extraction, their speed of set-up, ease of use, and reliability have encouraged some surgeons to prefer their use when dealing with vitreous loss during phacoemulsification and for some types of vitreo-retinal surgery.

Conclusion

The authors suggest that construction and maintenance of similar low-cost, yet reliable, vitrectomy machines can be achieved locally by any eye unit that has access to a department of medical physics and engineering with the appropriate level of expertise, using materials readily available from easily accessible sources.

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