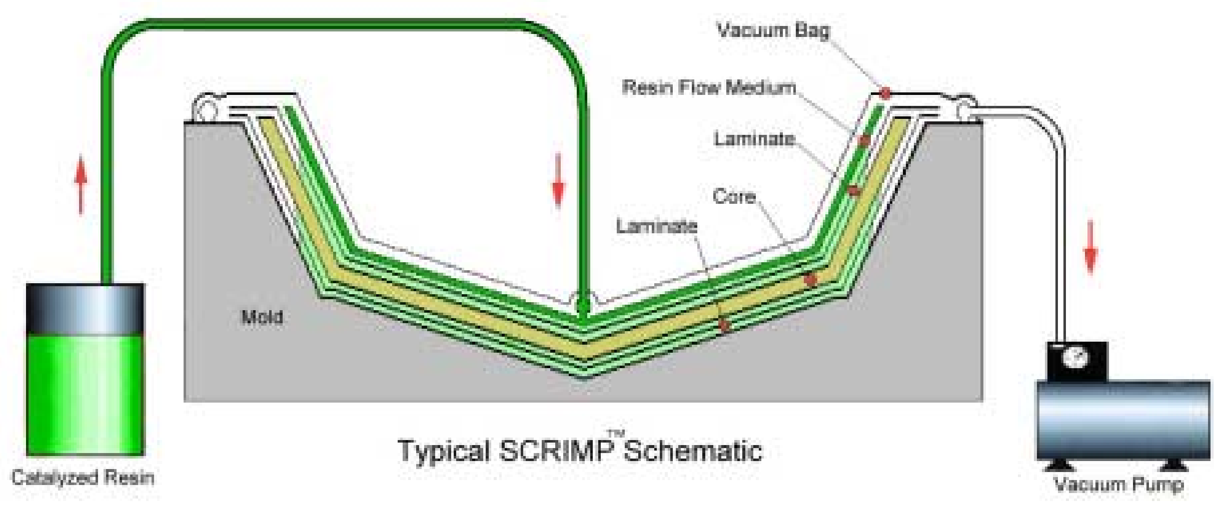
An Overview of the SCRIMP™ Technology

SCRIMP™ (an acronym which stands for **S**eemann **C**omposites **R**esin **I**nfusion **M**olding **P**rocess) is a resin transfer molding process that uses a vacuum to pull liquid resin into a dry lay-up and is used for making very high quality, repeatable composite parts with almost zero VOC emissions. SCRIMP™ technology was invented by Bill Seemann, as a means to meet the demanding requirements of projects for the U.S. Navy. The first of ten U.S. patents owned by TPI Technology, Inc. (TPI) was issued on February 20, 1990 and the latest was issued on December 12, 2000. The SCRIMP™ technology serves a variety of applications and is compatible with all types of fiber reinforcements and resin matrices commonly used today. It is uniquely suited to build large-scale structural composite parts where high strength, durability and light weight are critical.

NOTE: This overview is not intended to provide a comprehensive review of all of the technology, trade secrets, and related patents and intellectual property held by TPI, but it is intended to communicate the key elements of the SCRIMP™ technology. For a detailed understanding of the patented technology, a review of the individual patents is required.

In the basic SCRIMP™ process, fiber reinforcements, core materials and various inserts are laid up in a tool while dry, followed by a vacuum bag that is placed over the lay-up and sealed to the tool. The part is then placed under vacuum and the resin is introduced into the part via a resin inlet port and distributed through the laminate via a flow medium and series of channels, saturating the part.

The vacuum pressure compacts or debulks the dry fibers. For this reason, parts made with the SCRIMP™ process have high fiber volumes, typically about 60-75% fiber by weight (50-65% by volume), depending on the type of fiber, the fiber architecture and the type of resin used. The vacuum removes all of the air from the lay-up before and while resin is introduced. The pressure differential between the atmosphere and the vacuum provides the driving force for infusing the resin into the lay-up.



Typical SCRIMP™ Schematic

The basic premise of the SCRIMP™ technology is the controlled flow of resin through an in-plane distribution system which allows the through the thickness (out of plane) infusion of a dry laminate or dry laminate stack. The first two patents, U.S. 4,902,215 and U.S. 5,052,906, specifically address the use of a flow medium fed by a "pervious conduit" (a resin feed or channel) communicating with the flow medium. This conduit can also consist of channels in the mold. The equivalent of U.S. Patent 5,052,906 has also been filed in Europe.

SCRIMP™ Core Structure Technology

TPI's intellectual property portfolio includes technology directed at the use of core materials with resin flow features. This technology includes U.S. Patents 5,721,034, 5,904,972, 5,958,325 and 6,159,414, with TPI foreign patent filings in Europe, Japan, Norway, Australia, Canada, China, Hong Kong, India, Korea and New Zealand. An aspect of this technology includes the use of grooved core with larger resin feeds and smaller flow channels under the composite reinforcement. Another aspect includes resin flow in not only the X and Y axes, but also in the Z axis (through the thickness of the cores).

SCRIMP™ Reusable Vacuum BagTechnology

TPI's technology also includes four U. S. Patents that have been issued for reusable vacuum bags with resin feeds and a resin distribution network, including 5,316,462, 5,439,635, 5,601,852 and 5,702,663, with TPI foreign patent filings in Europe, Japan, Norway, Australia, Canada, India, Korea and New Zealand. This technology includes the use and fabrication of these vacuum bags which are usually made of, but not limited to, silicone elastomers. With the use of silicone bags with molded-in resin feed channels and flow channels, typical disposables are greatly reduced as is the labor required to install the bag and associated flow materials. These patterned vacuum bags provide for repeatable, engineered resin flow in an easy to use, error-proof manner. To date, silicone bags have produced hundreds of parts with minimal maintenance.

A key element of this robust process technology is the ability to design resin infusion schemes that will completely saturate the dry fibers in a timely, controlled and cost effective manner. The nature of the infusion scheme depends on many different variables, all of which must be carefully considered, such as temperature, resin viscosity, fiber architecture and shape complexity. SCRIMP™ is a proven robust process that is capable of producing large-scale structural composite parts with high reinforcement to resin ratio in a cost effective manner. It has been successfully demonstrated in building a wide range of structures including:

- Ocean going yachts up to 60' in length
- Automated people mover systems
- Heavy duty transit buses
- 24 meter long earthquake-proof gymnasium roofing panels
- Light weight truck components
- Naval vessels and component parts thereof
- Insulated and refrigerated freight rail cars … and many more…

The schematics that follow show some of the principals that are part of the SCRIMP™ technology.

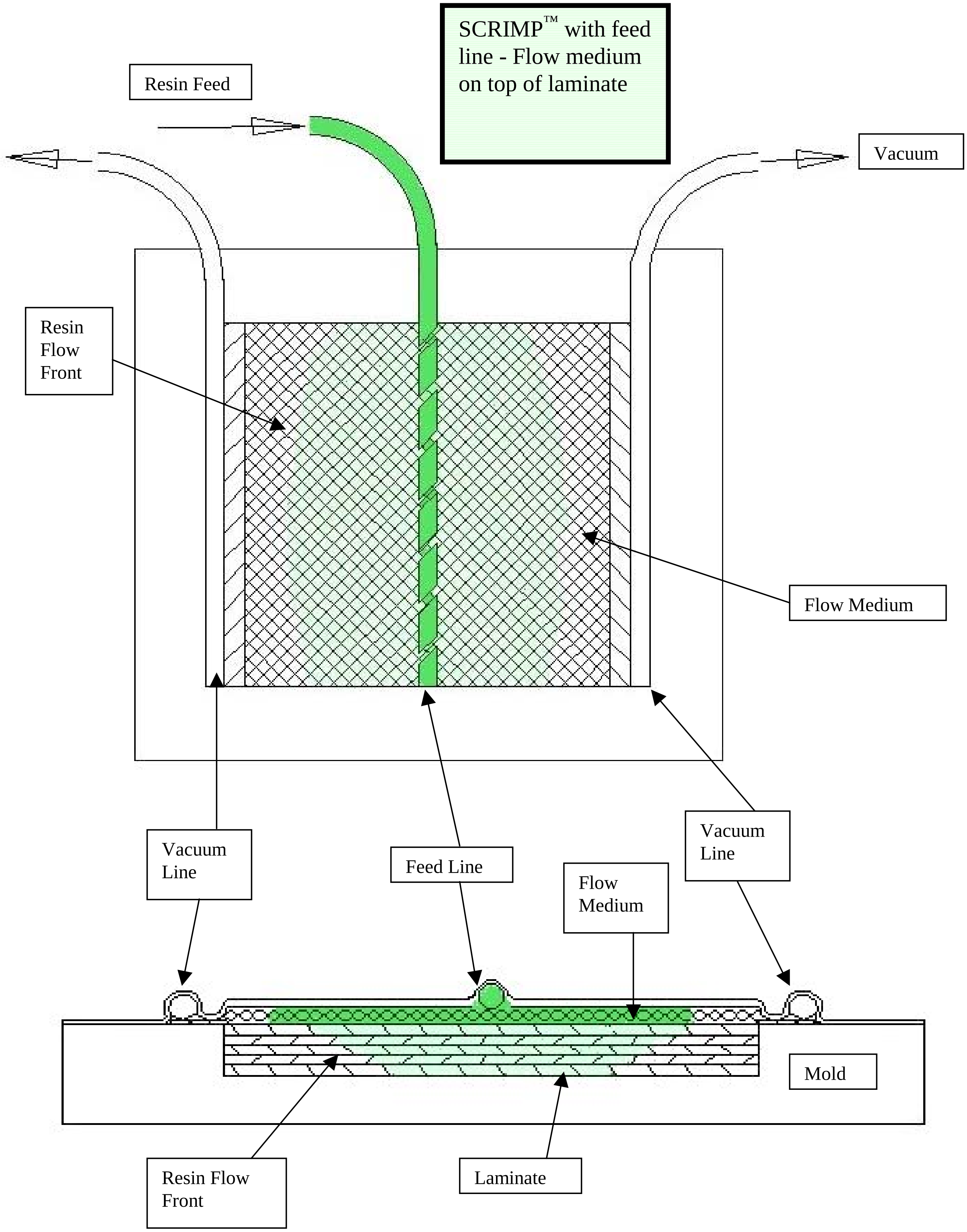

SCRIMP™ with feed line - Flow medium on top of laminate
Resin Feed
Vacuum
Resin Flow Front
Flow Medium
Vacuum Line
Feed Line
Vacuum Line
Flow Medium
Mold
Resin Flow Front
Laminate

FIGURE 1.

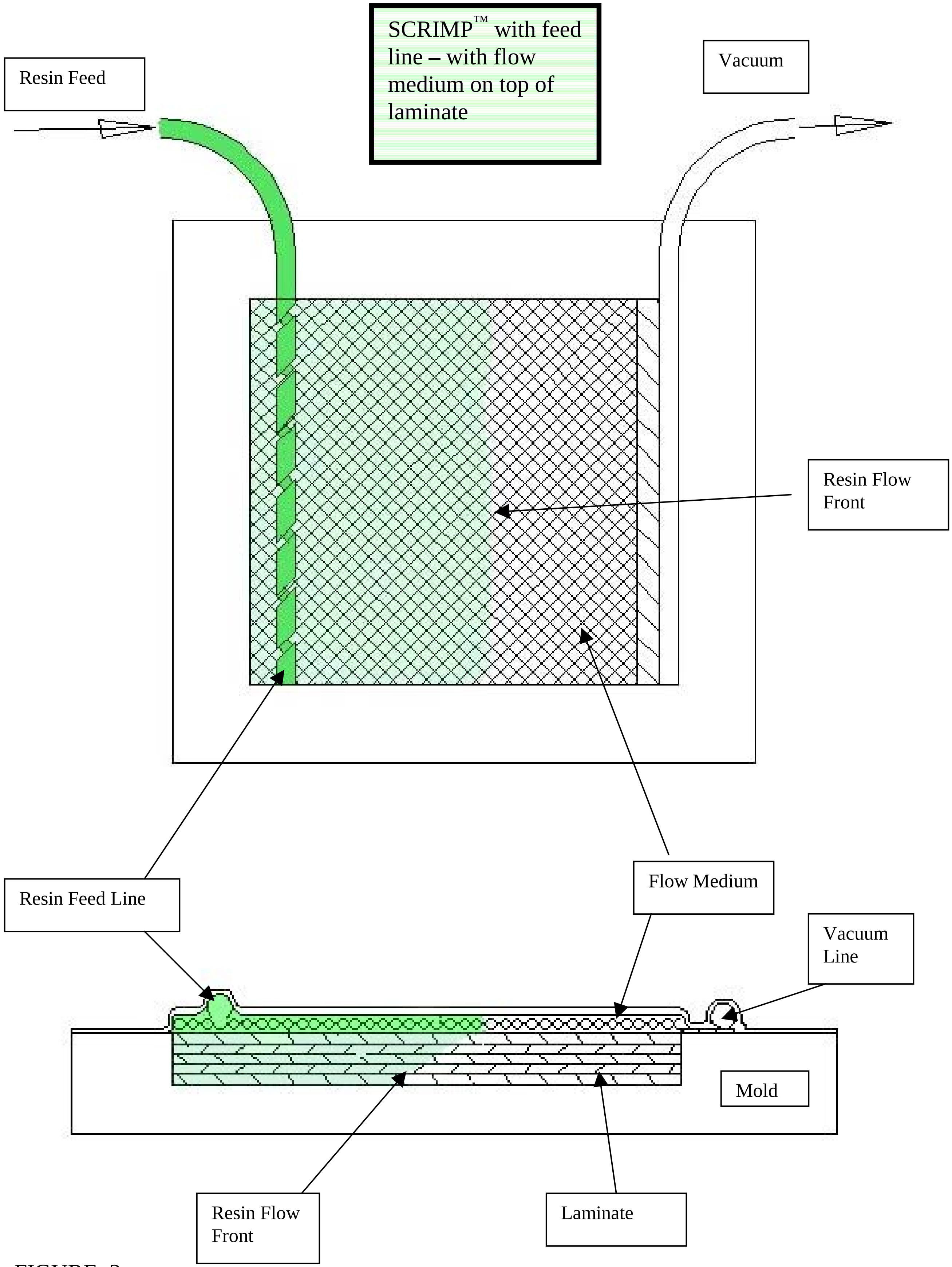

SCRIMP™ with feed line – with flow medium on top of laminate
Resin Feed
Vacuum
Resin Flow Front
Resin Feed Line
Flow Medium
Vacuum Line
Mold
Resin Flow Front
Laminate

FIGURE 2.

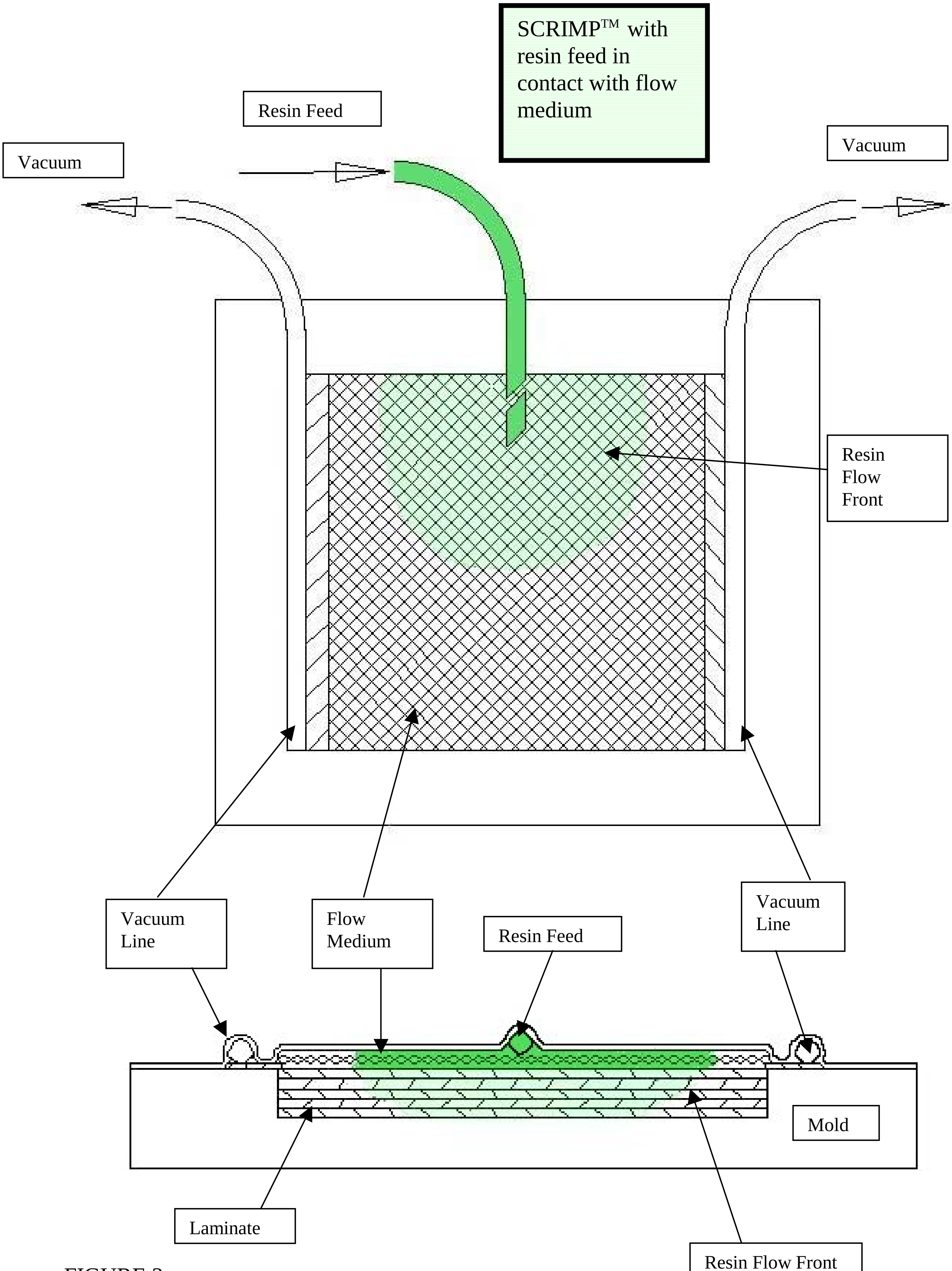

SCRIMP™ with resin feed in contact with flow medium
Resin Feed
Vacuum
Vacuum
Resin Flow Front
Vacuum Line
Flow Medium
Resin Feed
Vacuum Line
Mold
Laminate
Resin Flow Front

FIGURE 3.

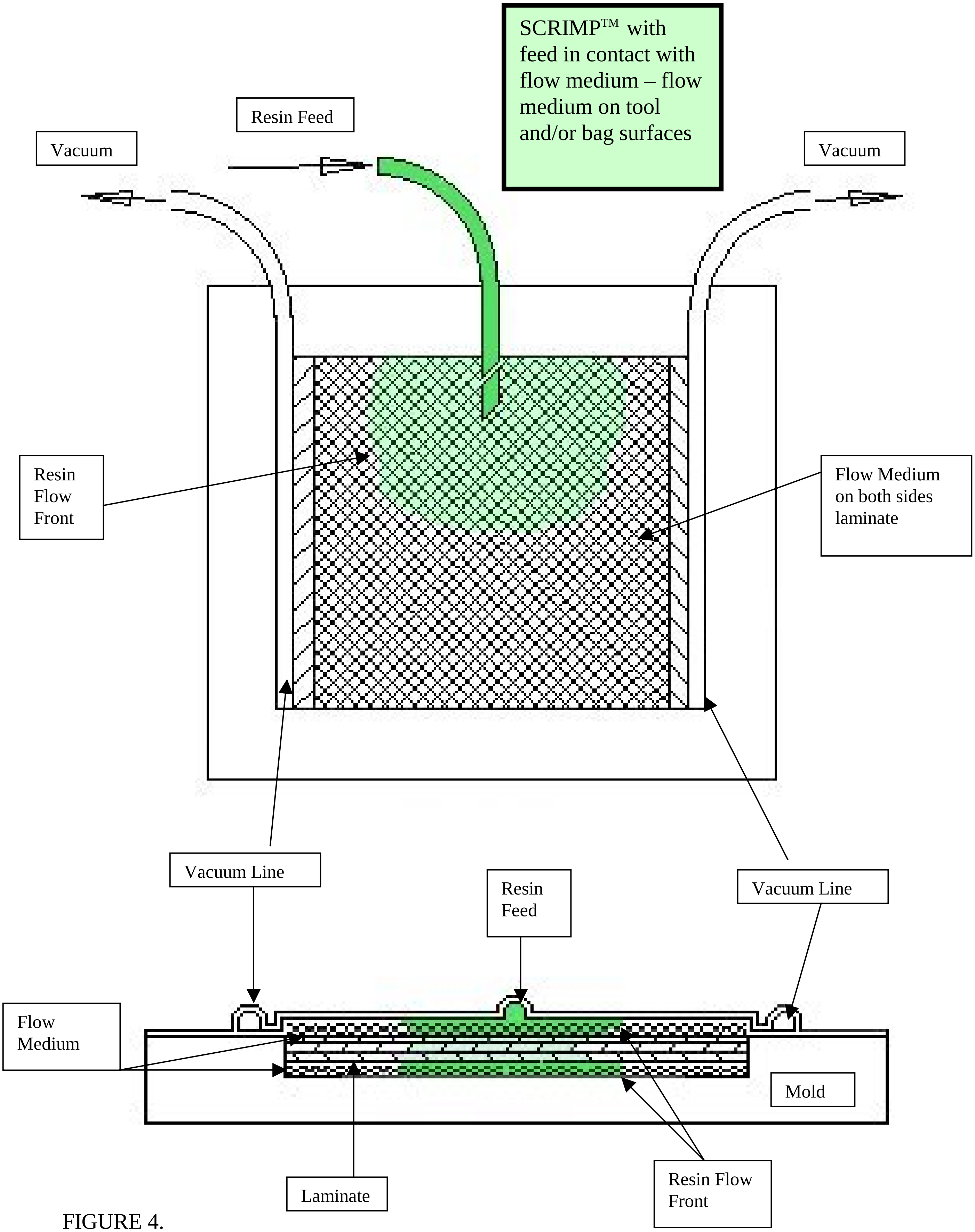
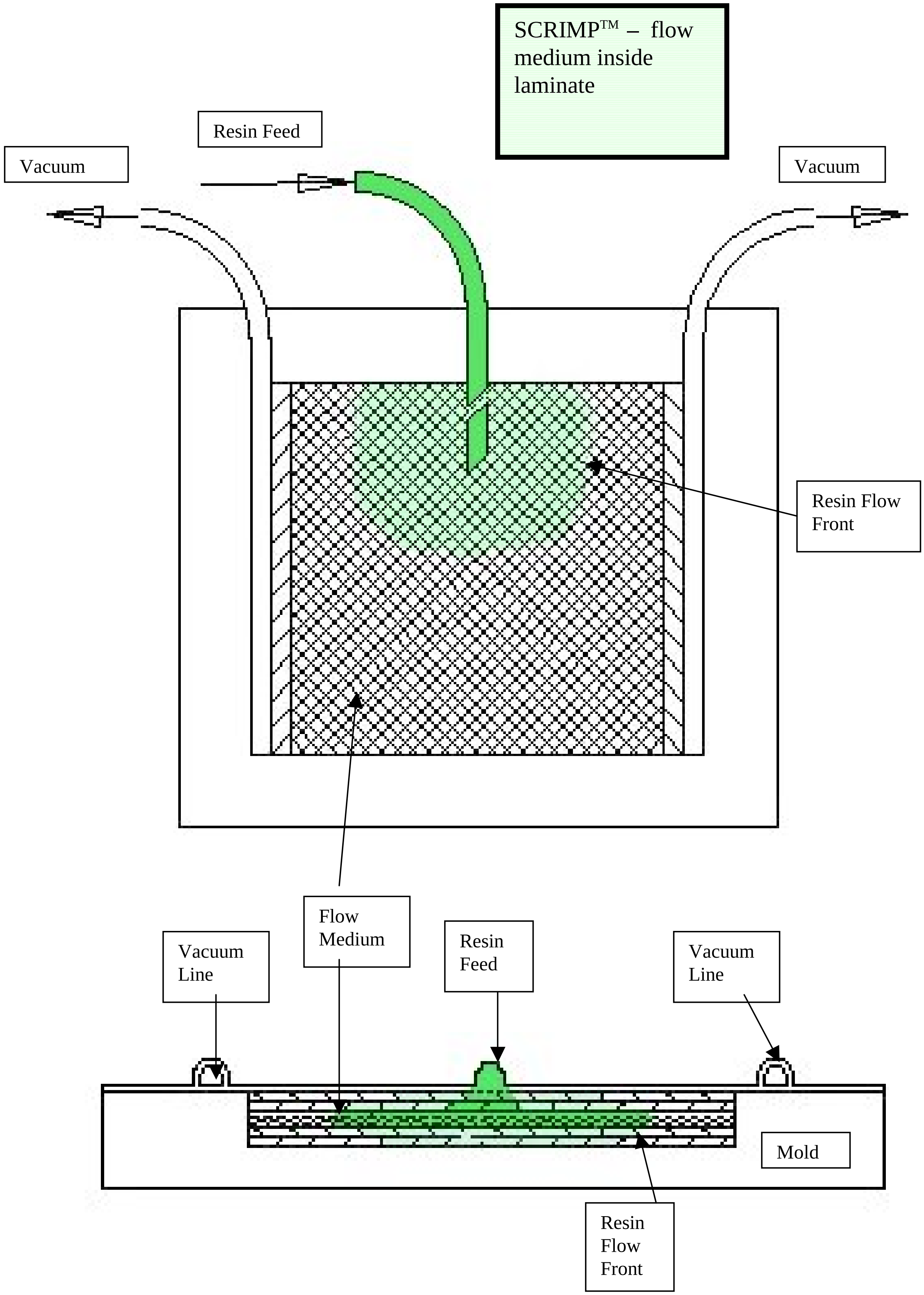

SCRIMP™ with feed in contact with flow medium – flow medium on tool and/or bag surfaces
Resin Feed
Vacuum
Vacuum
Resin Flow Front
Flow Medium on both sides laminate
Vacuum Line
Resin Feed
Vacuum Line
Flow Medium
Mold
Laminate
Resin Flow Front

FIGURE 4.



SCRIMP™ – flow medium inside laminate
Resin Feed
Vacuum
Vacuum
Resin Flow Front
Flow Medium
Vacuum Line
Resin Feed
Vacuum Line
Mold
Resin Flow Front

FIGURE 5.

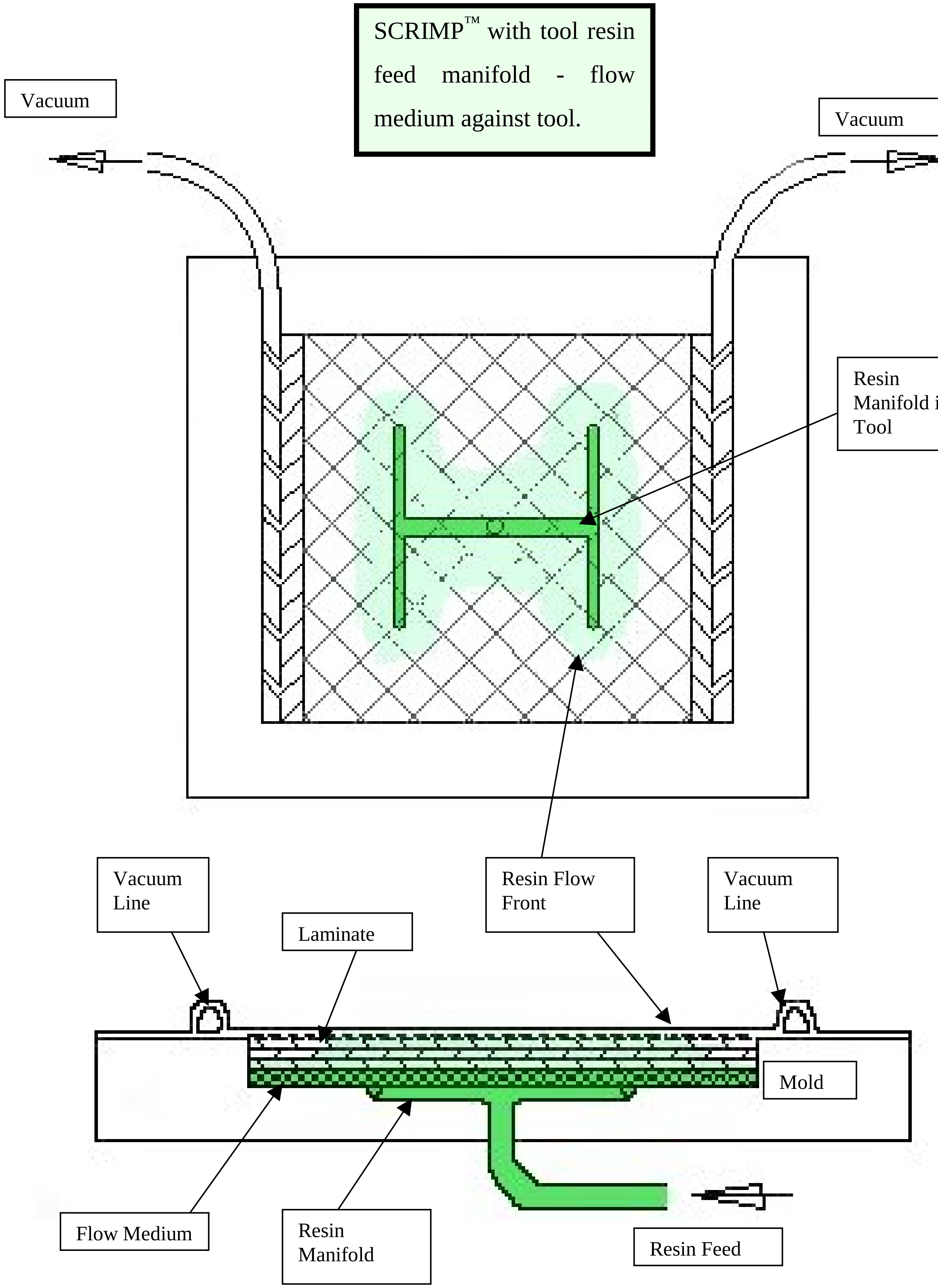
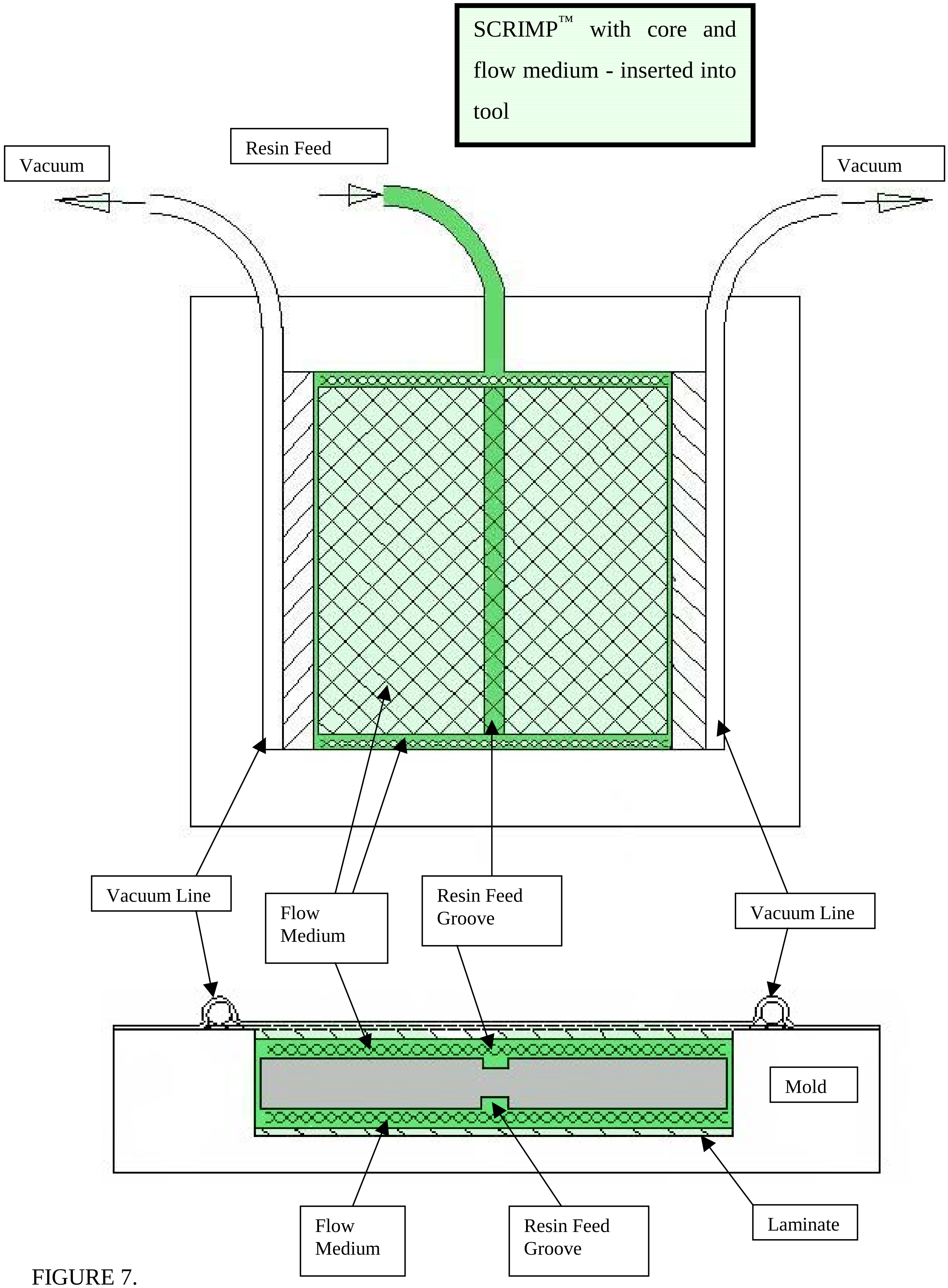

SCRIMP™ with tool resin feed manifold - flow medium against tool.
Vacuum
Vacuum
Resin Manifold in Tool
Vacuum Line
Resin Flow Front
Vacuum Line
Laminate
Mold
Flow Medium
Resin Manifold
Resin Feed

FIGURE 6.



SCRIMP™ with core and flow medium - inserted into tool
Vacuum
Resin Feed
Vacuum
Vacuum Line
Flow Medium
Resin Feed Groove
Vacuum Line
Mold
Flow Medium
Resin Feed Groove
Laminate

FIGURE 7.

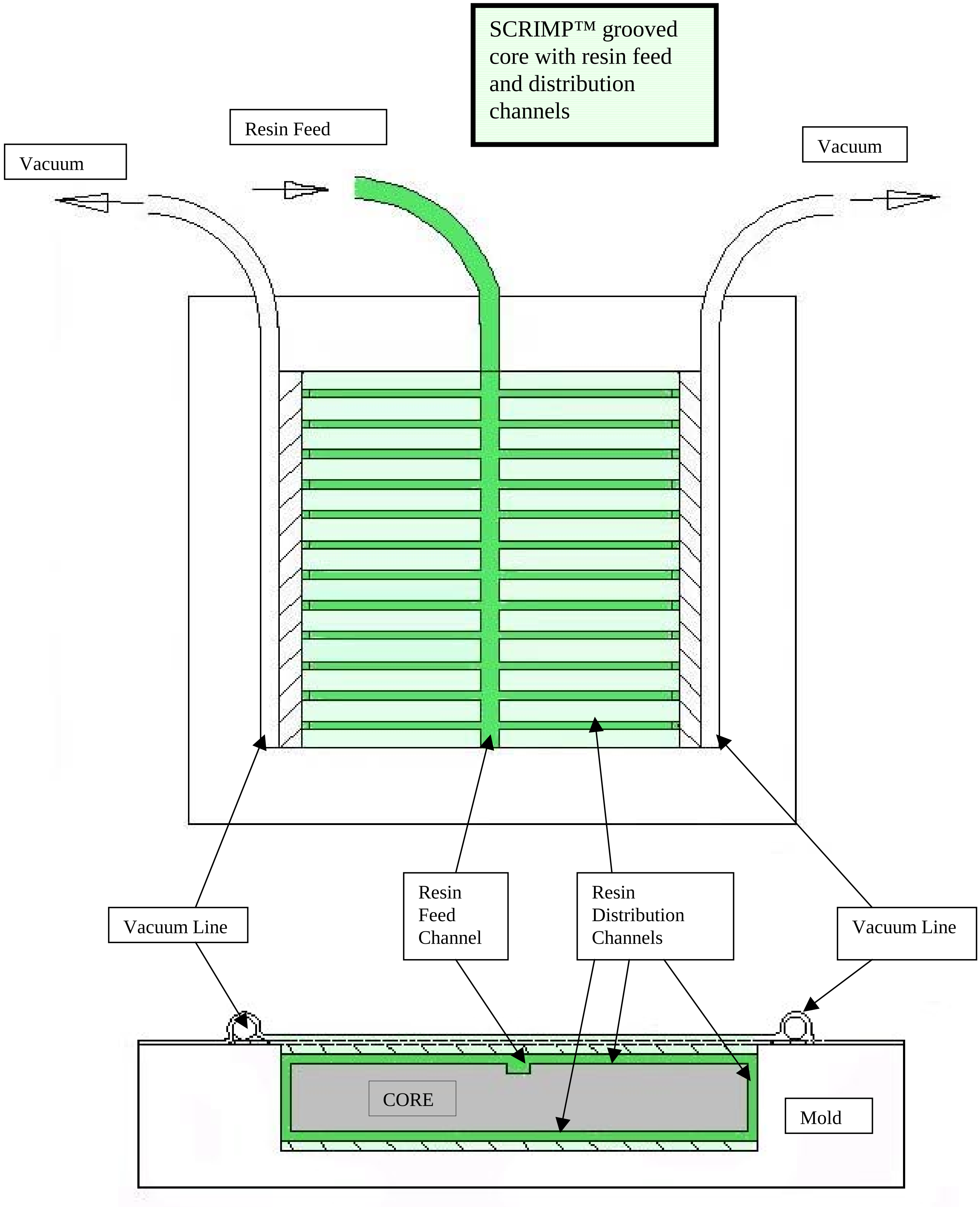
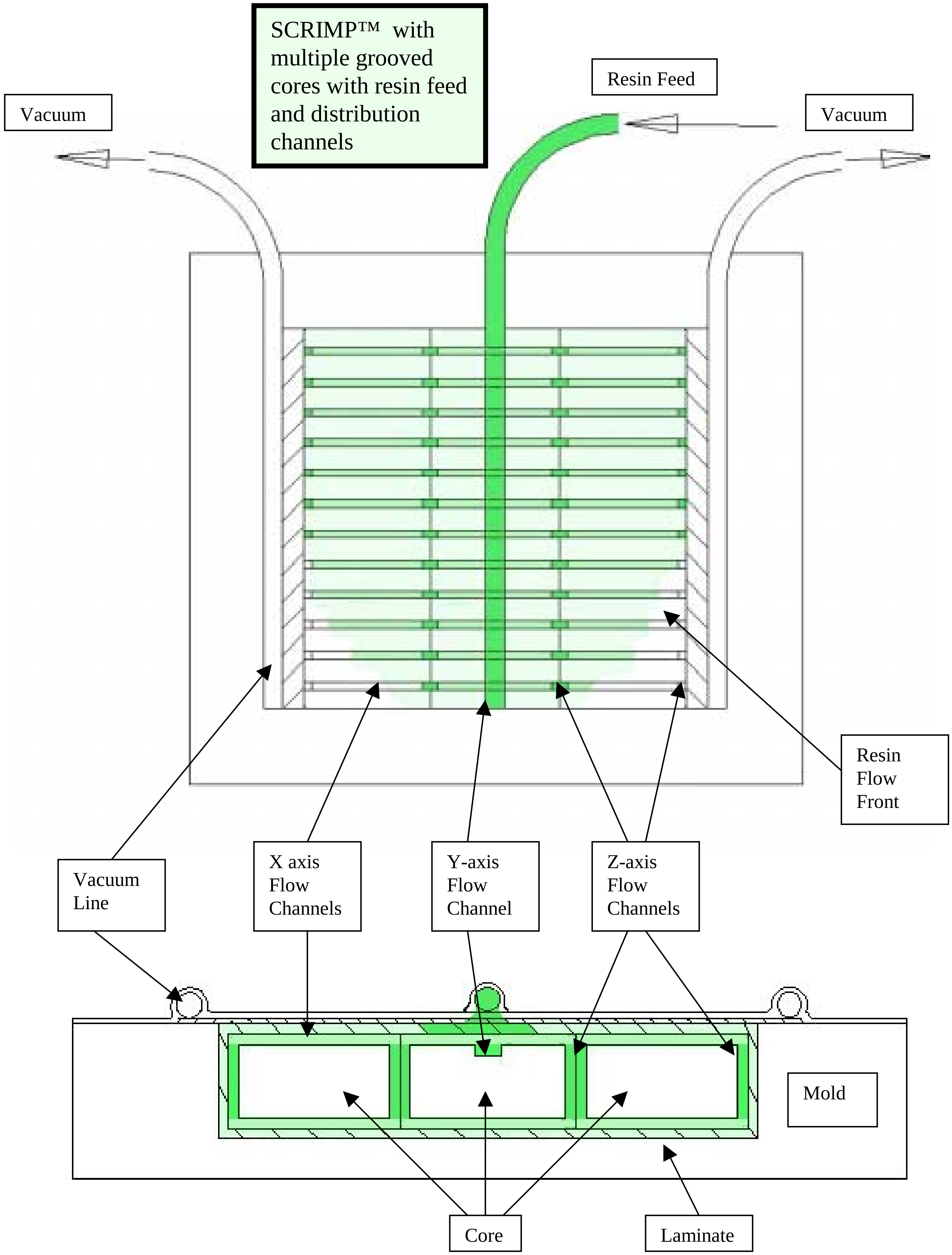
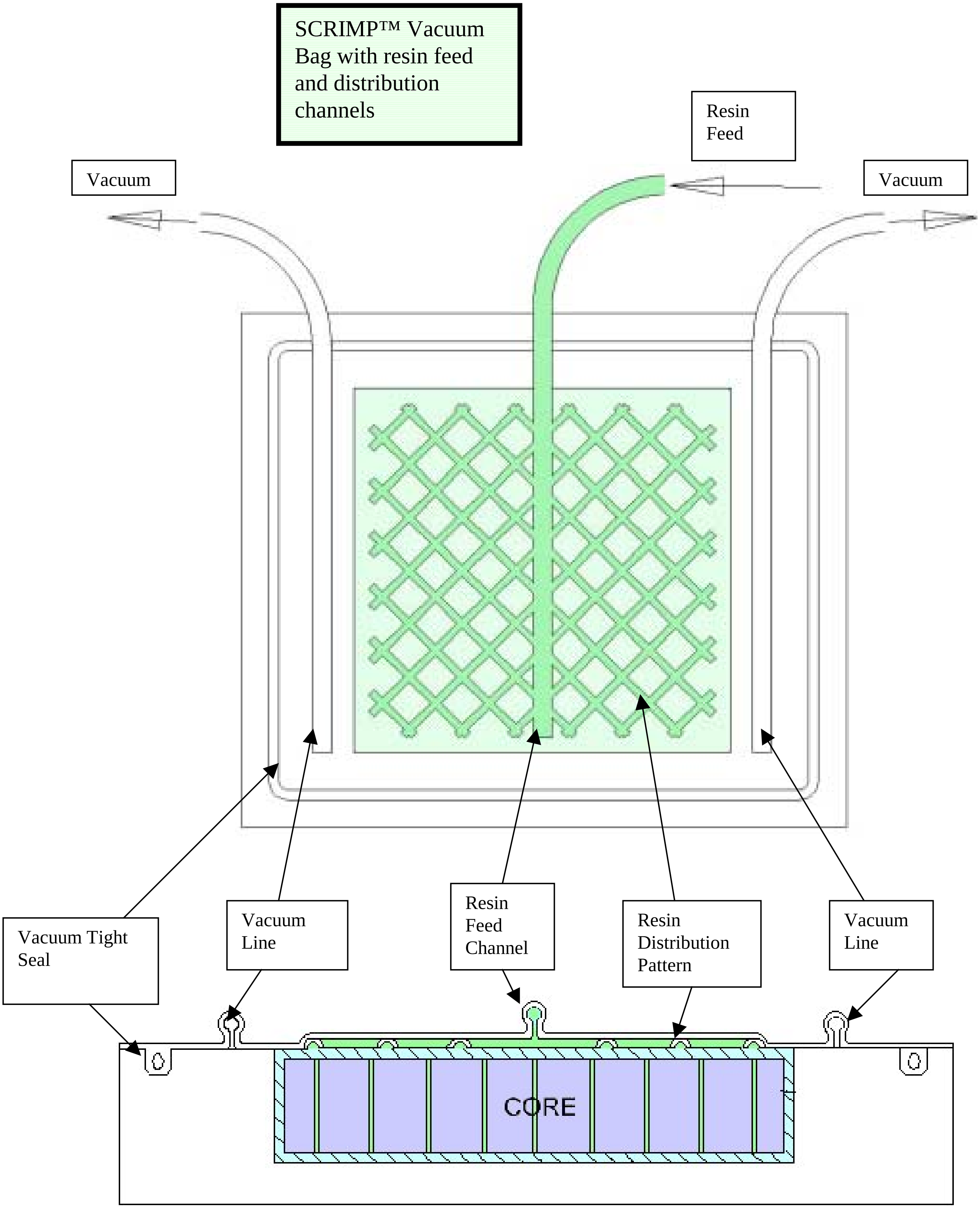

SCRIMP™ grooved core with resin feed and distribution channels
Resin Feed
Vacuum
Vacuum
Vacuum Line
Resin Feed Channel
Resin Distribution Channels
Vacuum Line
CORE
Mold

FIGURE 8.



SCRIMP™ with multiple grooved cores with resin feed and distribution channels
Resin Feed
Vacuum
Vacuum
Resin Flow Front
Vacuum Line
X axis Flow Channels
Y-axis Flow Channel
Z-axis Flow Channels
Mold
Core
Laminate

FIGURE 9.



SCRIMP™ Vacuum Bag with resin feed and distribution channels
Resin Feed
Vacuum
Vacuum
Vacuum Tight Seal
Vacuum Line
Resin Feed Channel
Resin Distribution Pattern
Vacuum Line
CORE

FIGURE 10.