



- [54] **METHOD AND APPARATUS FOR A STENT CRIMPING DEVICE**
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- [73] Assignee: **Advanced Cardiovascular Systems, Inc.**, Santa Clara, Calif.
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- [51] **Int. Cl.⁷** **B21D 39/00**
- [52] **U.S. Cl.** **29/516; 29/282; 29/515; 606/1; 606/108**
- [58] **Field of Search** **29/282, 283.5, 29/515, 516, 517, 715; 606/1, 108, 198; 623/1**

- U.S. Patent Application Serial No. 09/072,925 filed May 5, 1998.
- U.S. Patent Application Serial No. 09/169,270 filed Oct. 9, 1998.
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- U.S. Patent Application Serial No. 08/795,335 filed Feb. 4, 1997.
- U.S. Patent Application Serial No. 08/837,771 filed Apr. 22, 1997.
- U.S. Patent Application Serial No. 08/893,936 filed Jul. 15, 1997.
- U.S. Patent Application Serial No. 08/962,632 filed Nov. 3, 1997.
- U.S. Patent Application Serial No. 09/024,910 filed Feb. 17, 1998.
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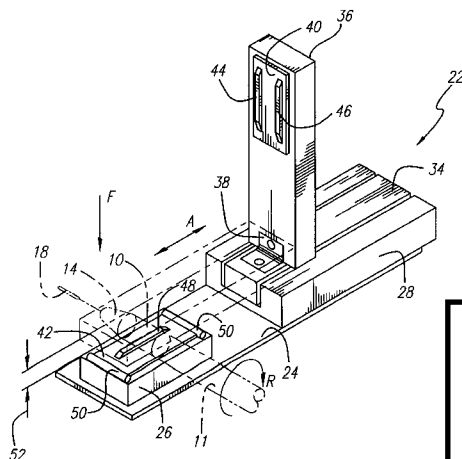
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[57] **ABSTRACT**

A stent crimping tool for firmly and uniformly crimping a stent onto a balloon catheter is constructed from a stationary plate and a sliding platform connected to the stationary plate and slidable linearly relative thereto. A closing plate is hinged to the sliding platform so that it at least partially overlies the stationary plate in a down position, and swings away from the stationary plate to an up position, whereby the stent already having been hand crimped onto the balloon catheter is placed on the stationary plate from a lateral position, and the closing plate is moved to the down position to hold the stent between the closing plate and the stationary plate so that an external force on the closing plate as well as translational motion of the closing plate together crimp the stent onto the balloon catheter. The surfaces engaging the stent may be covered by elastomeric pads having ridges corresponding in location to respective rings or cylindrical elements of the stent.

20 Claims, 2 Drawing Sheets



**Edwards Lifesciences v.
 Boston Scientific
 U.S. Patent No. 6,915,560
 IPR2017-00444 EX. 2051**

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FIG. 1

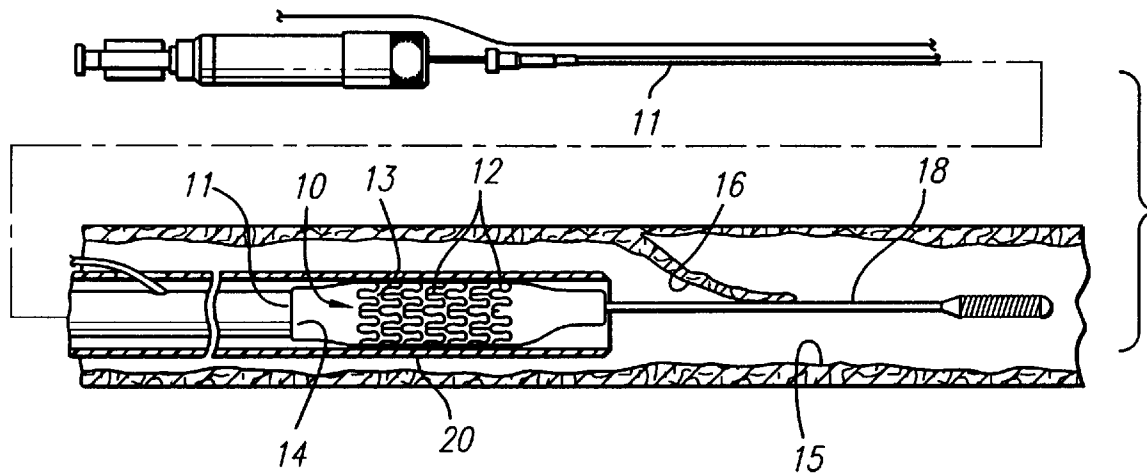
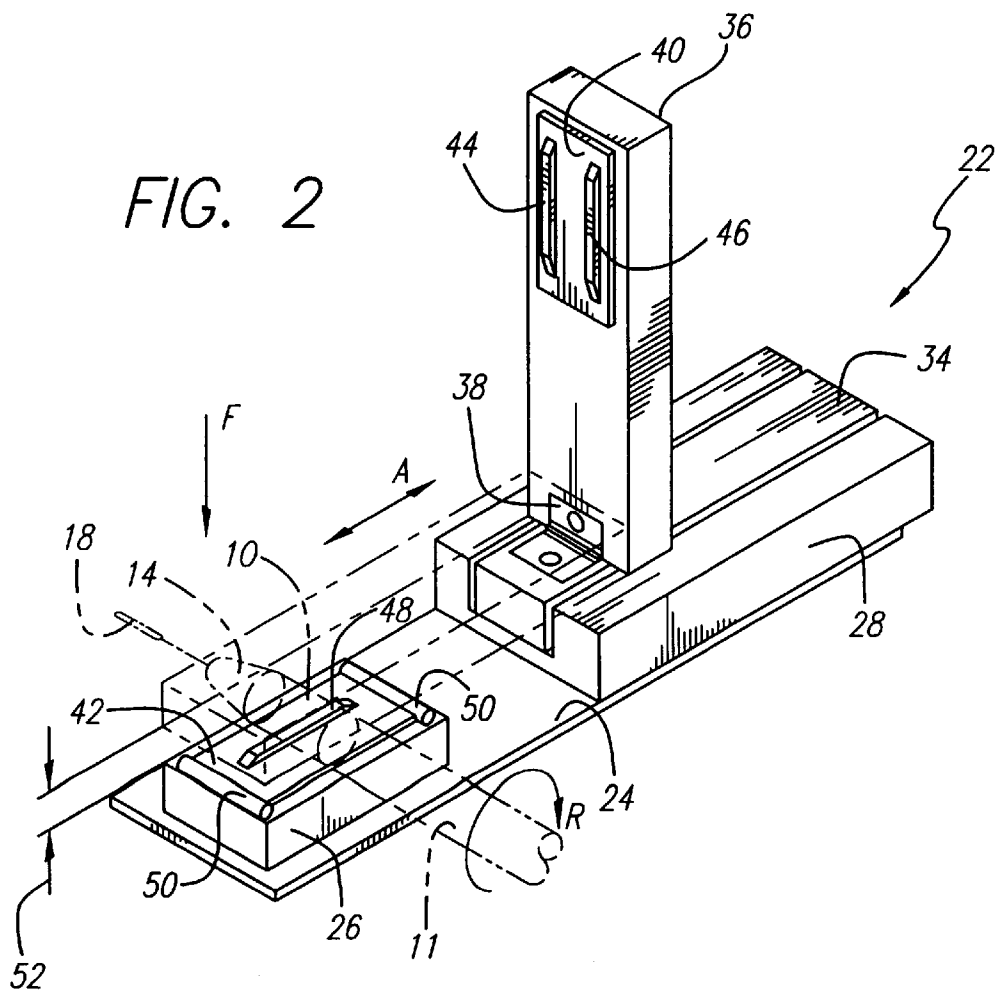


FIG. 2



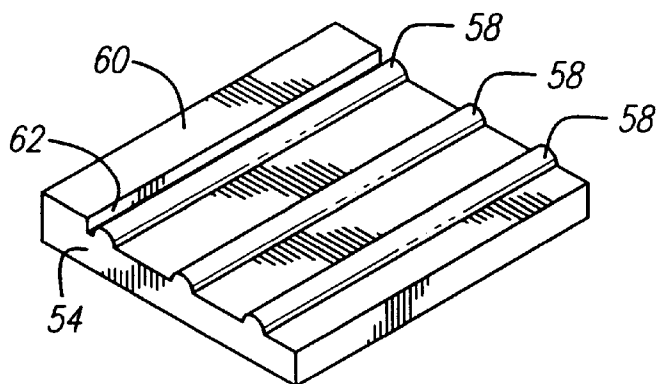


FIG. 3A

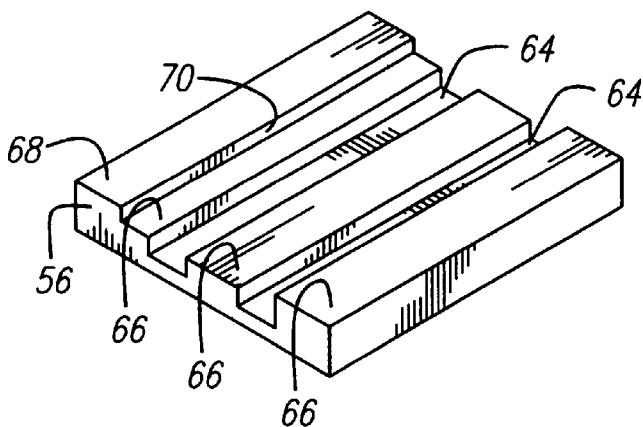


FIG. 3B

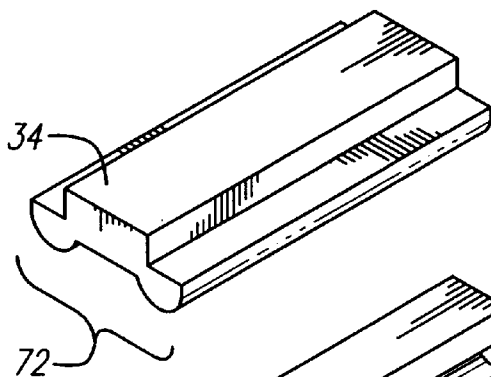


FIG. 4

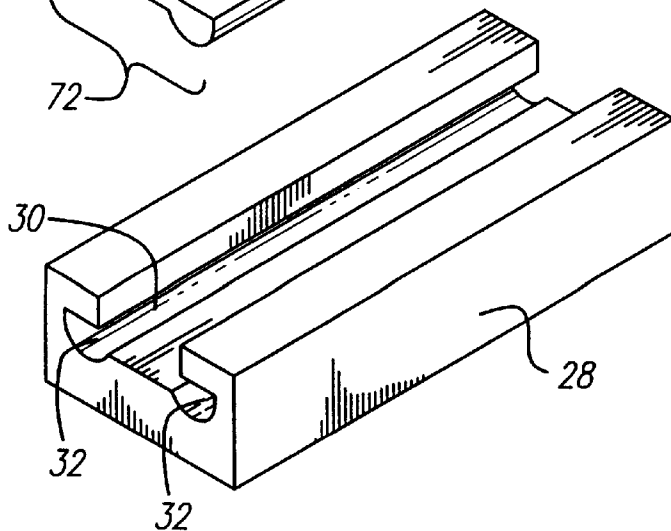


FIG. 5

METHOD AND APPARATUS FOR A STENT CRIMPING DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for loading a tubular graft, such as a stent, onto the distal end of a catheter assembly of the kind used, for example, in percutaneous transluminal coronary angioplasty (PTCA) or percutaneous transluminal angioplasty (PTA) procedures.

In typical PTCA procedures, a guiding catheter is percutaneously introduced into the cardiovascular system of a patient through the brachial or femoral arteries and advanced through the vasculature until the distal end of the guiding catheter is in the ostium. A guide wire and a dilatation catheter having a balloon on the distal end are introduced through the guiding catheter with the guide wire sliding within the dilatation catheter. The guide wire is first advanced out of the guiding catheter into the patient's coronary vasculature and the dilatation catheter is advanced over the previously advanced guide wire until the dilatation balloon is properly positioned across the arterial lesion. Once in position across the lesion, a flexible and expandable balloon is inflated to a predetermined size with a radiopaque liquid at relatively high pressures to radially compress the atherosclerotic plaque of the lesion against the inside of the artery wall and thereby dilate the lumen of the artery. The balloon is then deflated to a small profile so that the dilatation catheter can be withdrawn from the patient's vasculature and the blood flow resumed through the dilated artery. As should be appreciated by those skilled in the art, while the above-described procedure is typical, it is not the only method used in angioplasty.

In angioplasty procedures of the kind referenced above, restenosis of the artery may develop over time, which may require another angioplasty procedure, a surgical bypass operation, or some other method of repairing or strengthening the area. To reduce the likelihood of the development of restenosis and to strengthen the area, a physician can implant an intravascular prosthesis for maintaining vascular patency, commonly known as a stent, inside the artery at the lesion. The stent is crimped tightly onto the balloon portion of the catheter and transported in its delivery diameter through the patient's vasculature. At the deployment site, the stent is expanded to a larger diameter, often by inflating the balloon portion of the catheter. The stent also may be of the self-expanding type.

Since the catheter and stent travel through the patient's vasculature, and probably through the coronary arteries, the stent must have a small delivery diameter and must be firmly attached to the catheter until the physician is ready to implant it. Thus, the stent must be loaded onto the catheter so that it does not interfere with delivery, and it must not come off the catheter until it is implanted.

In procedures where the stent is placed over the balloon portion of the catheter, it is necessary to crimp the stent onto the balloon portion to reduce its diameter and to prevent it from sliding off the catheter when the catheter is advanced through the patient's vasculature. Non-uniform crimping can result in sharp edges being formed along the now uneven surface of the crimped stent. Furthermore, non-uniform stent crimping may not achieve the desired minimal profile for the stent and catheter assembly. Where the stent is not reliably crimped onto the catheter, the stent may slide off the catheter and into the patient's vasculature prematurely as a loose foreign body, possibly causing blood clots in the vasculature, including thrombosis. Therefore, it is important

to ensure the proper crimping of a stent onto a catheter in a uniform and reliable manner.

This crimping is often done by hand, which can be unsatisfactory due to the uneven application of force resulting in non-uniform crimps. In addition, it is difficult to visually judge when a uniform and reliable crimp has been applied.

Some self-expanding stents are difficult to load by hand onto a delivery device such as a catheter. Furthermore, the more the stent is handled the higher the likelihood of human error, which is antithetical to a properly crimped stent. Accordingly, there is a need in the art for a device for reliably crimping a stent onto a catheter.

There have been attempts at devising a tool for crimping a stent onto a balloon delivery catheter. An example of such a tool comprises a series of plates having substantially flat and parallel surfaces that move in a rectilinear fashion with respect to each other. A stent carrying catheter is disposed between these surfaces, which surfaces crimp the stent onto the outside of the catheter by their relative motion and applied pressure. The plates have multiple degrees of freedom and may have force-indicating transducers to measure and indicate the force applied to the catheter during crimping of the stent.

Another stent loading tool design is comprised of a tubular member housing a bladder. The tubular member and bladder are constructed to hold a stent that is to be crimped onto a balloon catheter assembly. Upon placement of the stent over the balloon portion of the catheter, a valve in the loading tool is activated to inflate the bladder. The bladder compresses the stent radially inward to a reduced diameter onto the balloon portion of the catheter to achieve a snug fit. In this way, the stent is crimped onto the distal end of a balloon catheter with a minimum of human handling. The foregoing stent crimping tools are disclosed in, for example, U.S. Pat. Nos. 5,437,083 and 5,546,646 to Williams et al.

Yet another stent crimping tool is known in the art as the BARD XT, which is actually a stent loader. It is constructed from a rigid, tubular body with a ball at one end connected to a plurality of long, thin strips passing through the tubular body. An uncrimped stent is placed over the plurality of long, thin strips, which hold the stent in an expanded state. The balloon portion of a catheter is inserted into the cylindrical space formed by the plurality of strips. When the user pulls the ball while holding the tubular body against the stent, the strips are slid from beneath the stent and the stent is transferred onto the balloon portion.

Still another conventional stent crimping tool is manufactured by JOHNSON & JOHNSON and appears similar to a hinged nutcracker. Specifically, the tool is comprised of two hand operated levers hinged at one end and gripped in the palm of the hand at the opposite end. A cylindrical opening holding a crimping tube is provided through the mid-portion of the tool to receive therein a stent loaded onto a balloon catheter. The crimping operation is performed by the user squeezing the handle thereby pressing the crimping tube which in turn pinches the stent onto the balloon catheter.

While the prior art devices are suitable for crimping stents onto balloon catheters, some suffer from problems such as non-uniform crimping forces, resulting in non-uniform crimps. Consequently, there is a need for improved stent crimping tools for use by physicians in a cath lab who desire to consistently crimp stents onto balloon catheters.

SUMMARY OF THE INVENTION

Both PTCA and PTA procedures have become commonplace in treating stenoses or lesions in blood vessels and

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