

## COMPACT TUBE SEALER

### TECHNICAL FIELD

**[0001]** This invention relates to a compact tube sealer, and in particular to a compact tube sealer for sealing polymeric tubes.

### BACKGROUND

**[0002]** Tube sealers are often used in blood centres and at blood donation drives to close off blood bags when they are filled, and also to segment blood-filled bag tubing into small sections without any exposure to air that may cause contamination for use as test samples to check that the donated blood is safe for use by recipients. Tube sealers are also increasingly used in the biotech industry where stem cells, cultured media, and other biological fluids are transferred via bags and tubing sections. Similarly, samples are often also required to be taken for testing and quality control measures.

**[0003]** Existing tube sealers typically comprise radio frequency (RF) tube sealers or thermal tube sealers. RF tube sealers use RF to generate heat in tubes made of dielectric plastic materials that have polar molecular structures, such as polyvinyl chloride (PVC), polyvinylidene chloride (PVDC), ethylene-vinyl acetate (EVA), and polyurethane (PU) to create an RF weld. RF energy provided by a RF tube sealer to layers of such material causes the material to heat up and melt and, together with pressure, seals the layers of material together. Thermal tube sealers provide heat and pressure to seal tubes made of plastic materials that do not respond to RF energy, such as thermoplastic elastomers (TPE), polystyrene (PS), polypropylene (PP), and polyethylene (PE). Thermal tube sealers generally work by having heating elements in the sealing surfaces providing heat by direct conduction. Both sides of the sealing surfaces come together and with a controlled clamping force, the walls of the tubing placed between the sealing surfaces come together and fuse with each other to form a seal.

**[0004]** However, existing tube sealers are typically large and bulky desktop models, especially for thermal tube sealers which require high energy input to achieve and maintain the required sealing temperature. Furthermore, as it is often required to separate a single tubing containing a biological fluid therein into multiple tubing sections, existing tube sealers

require significant time and effort to do this. In addition, existing tube sealers also face downtime when their worn-out parts need to be replaced by skilled technicians at a service centre. There is therefore a demand for a tube sealer that addresses these problems.

## SUMMARY

**[0005]** This application discloses a tube sealer that is readily portable and allows users to easily change worn out parts to reduce downtime. In some configurations, the tube sealer may be able to perform simultaneous sealing of multiple tubes.

**[0006]** According to a first aspect, there is provided a compact tube sealer for sealing a polymeric tube, the tube sealer comprising: clamping jaws comprising a fixed jaw and a movable jaw movable between a rest position where the tube may be placed or removed from between the clamping jaws and an activated position where the tube is diametrically compressed between the clamping jaws; an energy generator provided to raise a temperature of the tube to its melting point when the movable jaw is in the activated position, the energy generator comprising one of: a radio frequency (RF) generator to provide RF through the tube via the clamping jaws, and heating elements to heat the clamping jaws and consequently the tube; a lever to actuate movement of the movable jaw from the rest position to the activated position when the lever is depressed; and a resilient member biased against movement of the movable jaw towards the fixed jaw so as to return the movable jaw from the activated position to the rest position when the lever is released.

**[0007]** The compact tube sealer may further comprise: a female port provided on a first side of the tube sealer and a male port provided on a second side of the tube sealer opposite the first side, the female port of one unit of the tube sealer and the male port of another unit of the tube sealer configured to releasably engage each other to allow multiple identical units of the tube sealer to be connected side by side, thereby allowing a single tube to be laid between the clamping jaws of the multiple units of the tube sealer for simultaneous sealing of the single tube at fixed intervals apart.

**[0008]** The compact tube sealer may further comprise: a handgun on which the clamping jaws, the lever, the resilient member and at least part of the energy generator are provided; and a portable control unit to house control circuitry of the energy generator and to which the handgun is connectable via an appropriate detachable cable; wherein the movable jaw has a

pin hook provided below a clamping surface of the movable jaw, wherein the lever comprises a lever pin fixedly provided on the lever to rotatably engage the pin hook, wherein bias action of the resilient member keeps the pin hook in engagement with the lever pin, wherein the lever pin is provided between a pivoting end of the lever and a free end of the lever; wherein the pivoting end of the lever is provided with a slot to pivotably and translatably engage a fixed pivot provided on the handgun, a first end of the slot being nearer the pivoting end and a second end of the slot being nearer the free end; wherein moving the movable jaw towards the fixed jaw against the bias of the resilient member without depressing the lever disengages the pin hook from the lever pin to allow movement of the lever to a disengaged position via translation of the slot relative to the fixed pivot; and wherein when the lever is in the disengaged position, the lever pin is moved away from the pin hook to allow removable of the movable jaw from the handgun.

**[0009]** The compact tube sealer may further comprise a charging dock having a charging case for placing the portable control unit therein for charging and a handgun support for placing the handgun therein.

**[0010]** The female port may be provided on a first side of the charging dock and the male port is provided on a second side of the charging dock opposite the first side, and wherein the clamping jaws are provide on a third side of the charging dock between the first side and the second side when the handgun is placed in the handgun support.

**[0011]** The handgun support may be provided above the charging case.

**[0012]** The charging dock may include an external lever arm movable to actuate depression of the lever.

**[0013]** The portable control unit may house an internal battery or battery pack for powering the energy generator.

**[0014]** The compact tube sealer may further comprise a sling pouch provided to carry the portable control unit about.

**[0015]** The energy generator may comprise a RF generator control circuit provided in the portable control unit in connection with a RF transmission circuit board provided in the

handgun, the RF generator control circuit provided to generate RF energy and the RF transmission circuit board provided to transmit the generated RF energy to the clamping jaws, wherein the clamping jaws serve as electrodes through which the generated RF energy is passed through the tube when the tube is diametrically compressed between the clamping jaws.

**[0016]** Alternatively, the energy generator comprises a temperature and timer controller circuit board provided in the portable control unit in connection with a heater driver circuit board provided in the handgun and heating elements and thermal sensors provided in the clamping jaws, wherein the heater driver circuit board is provided to turn on and off the heating elements under the control of the temperature and timer controller circuit board.

**[0017]** In an alternative embodiment, the compact tube sealer may further comprise a casing housing the energy generator and the resilient member, wherein the clamping jaws and the lever extend from the casing.

**[0018]** The female port may be provided on one side of the casing, the male port may be provided on a second side of the casing opposite the first side, and the clamping jaws may be provided on a third side of the casing between the first side and the second side.

**[0019]** Engagement of the female port of a first unit of the tube sealer and the male port of a second unit of the tube sealer may connect and establish electrical communication between both units of the tube sealer to allow simultaneous charging of both units of the tube sealer when only the first unit of the tube sealer is physically connected to a power supply.

**[0020]** Each unit of the tube sealer may be configured to transmit a signal that notifies of a total number of connected multiple units of the tube sealer to a first of the connected multiple units of the tube sealer when electrical communication is established between connected multiple units of the tube sealer that are connected in series, and the first of the multiple units of the tube sealer when physically connected to a power supply may be configured to stop charging of the connected multiple units of the tube sealer when it detects that a predetermined number of connected multiple units of the tube sealer has been exceeded.

**[0021]** The compact tube sealer may further comprise a bushing provided in a fixed position relative to the fixed jaw and an adjustment screw in threaded engagement with the bushing, wherein the adjustment screw is attached to the movable jaw such that rotating the

adjustment screw within the fixed bushing translates the movable jaw relative to the fixed jaw to allow adjustment of spacing between the fixed jaw and the movable jaw.

## BRIEF DESCRIPTION OF DRAWINGS

**[0022]** In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only exemplary embodiments of the present invention, the description being with reference to the accompanying illustrative drawings, in which:

FIG. 1A is a perspective view of a first exemplary embodiment of a first exemplary configuration of a tube sealer.

FIG. 1B is an exploded perspective view of the tube sealer of FIG. 1A.

FIG. 2 is an exploded perspective view of a portable control unit of the tube sealer of FIG. 1A.

FIG. 3A is an exploded perspective view of a handgun of the tube sealer of FIG. 1A.

FIG. 3B is an exploded perspective view of an alternative embodiment of a handgun of the tube sealer of FIG. 1A.

FIG. 4 is a perspective view of a second exemplary embodiment of the first exemplary configuration of the tube sealer.

FIG. 5 is an exploded perspective view of a handgun of the tube sealer of FIG. 4.

FIG. 6 is an exploded perspective view of a portable control unit of the tube sealer of FIG. 4.

FIG. 7 is an exploded assembly view of an exemplary embodiment of an internal clamping mechanism in a handgun of the tube sealer.

FIG. 8 is a perspective view of an exemplary embodiment of a movable jaw.

FIG. 9 is a schematic cross-sectional view of a first exemplary handgun in a rest position.

FIG. 10 is a schematic cross-sectional view of the handgun of FIG. 9 in an activated position.

FIG. 11 is a schematic cross-sectional view of a second exemplary handgun in a rest position.

FIG. 12 is a schematic cross-sectional view of the handgun of FIG. 11 with its movable jaw in a pushed-in position.

FIG. 13 is a schematic cross-sectional view of the handgun of FIG. 11 with its trigger handle in a disengaged position.

FIG. 14 is a schematic cross-sectional view of the handgun of FIG. 11 with its movable jaw removed.

FIG. 15 is a schematic cross-sectional view of an exemplary jaw adjustment feature in a first position.

FIG. 16 is a schematic cross-sectional view of the jaw adjustment feature of FIG. 15 in a second position.

FIG. 17 is a perspective view of the tube sealer of FIG. 1 in a carrying sling pouch.

FIG. 18 is a front perspective of the tube sealer of FIG. 1 in a charging dock.

FIG. 19 is a rear perspective of the tube sealer in the charging dock of FIG. 18.

FIG. 20 is a schematic cross-sectional view of the tube sealer in the charging dock of FIG. 18.

FIG. 21 is a front perspective view of multiple units of the tube sealer in the charging dock of FIG. 18 in a connected configuration.

FIG. 22 is a front perspective view of an exemplary embodiment of a second exemplary configuration of the tube sealer.

FIG. 23 is a rear perspective view of the tube sealer of FIG. 22.

FIG. 24 is a front perspective view of multiple units of the tube sealer of FIG. 22 in a connected configuration.

## DETAILED DESCRIPTION OF THE EMBODIMENTS

**[0023]** Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, “having” and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to.”

**[0024]** Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including” will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

**[0025]** Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by a skilled person to which the subject matter herein belongs.

**[0026]** Exemplary embodiments of a tube sealer 10 will be described below with reference to FIGS. 1A to 24 wherein the same reference numerals are used to refer to the same or similar parts.

**[0027]** In general, in all configurations of the tube sealer 10, clamping jaws 20 are provided to diametrically compress a tube to be sealed (i.e. compress the tube across its diameter) while temperature of the tube at the site of diametral compression is raised to its melting point by an energy generator 30 provided in the tube sealer 10, thereby forming a seal across the tube. The clamping jaws 20 comprise a fixed (or stationary) jaw 21 and a movable (or moving) jaw 22, as can be seen in greater detail in FIGS. 7-16 and 20. The movable jaw 22 is movable between an open or rest position and an activated position. At the open or rest position, as shown in FIGS. 1, 4, 9 and 11, the clamping jaws 20 are spaced apart at a distance that allows the tube to be easily placed between the fixed jaw 21 and the movable jaw 22. The clamping jaws 20 are preferably made of hardened metal to minimize wear and tear from repeated usage. The clamping jaws 20 are further preferably designed to optimize the sealing properties of the jaws 20 while preventing denaturing of the material of the tube during the sealing process.

**[0028]** When the tube sealer 10 is activated while the tube is placed between both jaws 21, 22 of the clamping jaws 20, the movable jaw 22 is moved from its rest position towards the fixed jaw 21, thereby diametrically compressing the tube, while the energy generator 30 raises the temperature of the tube to its melting point. In use, the tube sealer 10 is held in the activated position as shown in FIG. 10 for a predetermined period of time to ensure complete sealing of the tube between the clamping jaws 20. In all embodiments, the tube sealer 10 is mechanically activated by hand. Activation of the tube sealer 10 may be effected by manually moving a lever 40, for example in an upward direction as indicated by arrow Y1 in FIG. 9, wherein the lever 40 movably engages the movable jaw 22 such that movement of the lever 40 moves the movable jaw 22 towards the fixed jaw 21, for example in a horizontal direction as indicated by arrow X1 in FIG. 9. The movable jaw 22 is also in mechanical engagement with a resilient member 50 (such as a compression spring, for example) that is biased against movement of the movable jaw 22 towards the fixed jaw 21. In this way, when the lever 40 is released, the movable jaw 22 is automatically returned to its rest position by the resilient member 50 acting against the movable jaw 22, thereby unclamping the sealed tube and allowing it to be removed from the tube sealer 10. The lever 40 and the clamping jaws 20 are

part of an internal clamping mechanism 60 of the tube sealer 10 that will be described in greater detail below.

**[0029]** Preferably, one (21 or 22) of the clamping jaws 20 is provided with a scoring feature 23 in the form of a raised ridge 23 integrally provided on a clamping surface 24 of the jaw (21 or 22). Together with the clamping surface 24, the raised ridge 23 comes into contact with the tube when the tube sealer 10 is activated. FIG. 8 shows a detail of an exemplary embodiment of a movable jaw 22 having a raised ridge 23 formed on its clamping surface 24. The scoring feature 23 is oriented in a direction perpendicular to a longitudinal axis of the tube to be sealed such that after sealing, a thin homogenous layer (the sealed region) with a thinner region known as a scoring line in the middle of the sealed region will be formed at the clamping or sealed region due to the presence of the raised ridge 23. This sealed region is subsequently frozen back to solid state after the circuit of the energy generator 30 has run its course. The scoring lines enables the sealed tube sections to be easily separated as needed, by allowing the sealed tube to be broken by hand along the score line. In this way, after sealing the tube at multiple locations spaced at intervals along the length of the tube to obtain multiple sealed sections of the tube, subsequent breaking of the sealed regions of the tube at all the multiple score lines results in the formation of multiple small sections of tubes sealed at both ends. Such sealed sections of the tube each containing the fluid in the tube can be easily transported to serve as test samples in myriad tests that may be desired to be performed on the fluid.

**[0030]** In a first exemplary configuration of the tube sealer 10, as shown in at least FIGS. 1A to 20, the tube sealer 10 comprises a handgun 11 and a portable control unit 12 to which the handgun 11 may be connected via an appropriate detachable cable 13. In this configuration, the clamping jaws 20 and at least part of the energy generator 30 are provided in the handgun 11. The portable control unit 12 is provided to control the energy generator 30. The tube sealer 10 may further comprise a power cord 14 for connecting the portable control unit 12 to a power source such as a wall socket (not shown).

**[0031]** In a first exemplary embodiment of the first configuration of the tube sealer 10, the tube sealer 10 comprises a RF-type tube sealer 10 for sealing tubes made of dielectric plastic materials such as polyvinyl chloride (PVC), polyvinylidene chloride (PVDC), ethylene-vinyl acetate (EVA), and polyurethane (PU), as shown in at least FIGS. 1A to 3 and

17 to 21. In this embodiment, as shown in FIG. 2, the energy generator 30 comprises a RF generator control circuit 31 in connection with a RF transmission circuit board 31-1 and the clamping jaws 20. The RF generator control circuit 31 is provided in a compact enclosure 19 of the portable control unit 12 while the RF transmission circuit board 31-1 and the clamping jaws 20 are provided in the handgun 11. The RF generator control circuit 31 generates RF energy. The RF transmission circuit board 31-2 serves as a transmitter that sends the generated RF energy to the clamping jaws 20. The clamping jaws 20 serve as electrodes through which the generated RF energy is passed through the tube when the tube is diametrically compressed between the clamping jaws 20. The clamping jaws 20 may comprise solid metal pieces.

**[0032]** An internal battery or battery pack 32 is also provided in the enclosure 19 to power the energy generator 30, thereby allowing the portable control unit 12 to be readily taken about by a user and used anywhere without a local power source. The portable control unit 12 may also be provided with a power button (with or without indicator lights) 34, and a power supply input port 35 for charging the battery pack 32. The portable control unit 12 further includes a power connector port 33 for connection with the handgun 11 via a detachable RF cable 13, as shown in FIG. 1B.

**[0033]** Alternative embodiments of the handgun 11 of the RF-type tube sealer 10 are shown in FIGS. 3A and 3B. The handgun 11 comprises the clamping jaws 20, the lever 40 configured as a trigger handle 40 and the resilient member 50 that together form part of the internal clamping mechanism 60 of the handgun 11, as well as the RF transmission circuit board 31-1 (shown only in FIG. 3B). In exemplary embodiments, the resilient member 50 may be housed in a handgun enclosure 15 (shown only in FIG. 3A) while the clamping jaws 20 may be partially housed in a separate jaw enclosure 16 of the handgun 11. Preferably, the RF handgun 11 is ergonomically designed for operation by females, to allow easy activation by smaller hands, as the majority of users of the RF type tube sealer 10 are expected to be women such as female nurses and other female staff.

**[0034]** In a second exemplary embodiment of the first configuration of the tube sealer 10 as shown (at least in part) in at least FIGS. 4 to 16, the tube sealer 10 comprises a thermal-type tube sealer 10 for sealing tubes made of plastic materials that do not respond to RF energy, such as thermoplastic elastomers (TPE), polystyrene (PS), polypropylene (PP), and polyethylene (PE). In this embodiment, the energy generator 30 comprises a temperature and

timer controller circuit board 36 in electrical connection with a heater driver circuit board 36-1 and heating elements and thermal sensors (not shown). The temperature and timer controller circuit board 36 is provided in the compact enclosure 19 of the portable control unit 12 (as shown in FIG. 6), while the heater driver circuit board 36-1 is provided in the handgun 11 as shown in FIG. 7. The heating elements and thermal sensors are provided within the clamping jaws 20 in the handgun 11. The heater driver circuit board 36-1 functions as a heater driver that turns on and off the heating elements under the control of the temperature and timer controller circuit board 36.

**[0035]** The portable control unit 12 of the thermal-type tube sealer 10 has a compact enclosure 19 that allows it to minimize space taken up on a workspace and enables easier moving about of the tube sealer 10 when needed. A battery pack 32 may optionally be provided in the enclosure 19 to power the energy generator 30, thereby allowing the portable control unit 12 to be readily taken about by a user and used anywhere without a local power source. The portable control unit 12 may also be provided with a power button (with or without indicator lights) 34, temperature and timer adjustment knobs 37, a display panel 38 to indicate the selected temperature, and a buzzer 39 configured to sound when a selected time duration has elapsed. The temperature and timer adjustment knobs 37 and the display panel 38 contribute to ease of use by allowing for fine adjustments of the settings of the thermal-type tube sealer 10 when used on different types of tubes. The buzzer 39 serves as a safety measure and also alerts users when the sealing process is complete, thereby minimizing accidental overuse that may cause damage to the tubes and fluid samples within.

**[0036]** A power cord 14 is provided to connect the portable control unit 12 to a power supply such as an electrical wall socket. The portable control unit 12 further includes a power connector port 33 for connection with the thermal handgun 11 via a detachable power cable 13, as shown in FIG. 4.

**[0037]** The handgun 11 of the thermal-type tube sealer 10 comprises the clamping jaws 20, the lever 40 configured as a trigger handle 40 and the resilient member 50 that together form part of the internal clamping mechanism 60 of the handgun 11. In an exemplary embodiment, the resilient member 50 may be housed in a handgun enclosure 15 while the clamping jaws 20 may be partially housed in a separate jaw enclosure 16 of the handgun 11.

**[0038]** For all embodiments of the tube sealer 10 comprising a handgun 11, as shown in FIGS. 7 to 14, the internal clamping mechanism 60 provided in the handgun 11 comprises the clamping jaws 20 and the lever 40 configured as a trigger handle 40, and may include a mechanism base 61 on which the fixed jaw 21 may be provided, as well as the jaw enclosure 16, as shown in FIG. 7. The resilient member 50 may also be considered part of the internal clamping mechanism 60, as can be seen in FIGS. 9 to 14, and may be housed within the mechanism base 61 beneath and behind the fixed jaw 21.

**[0039]** In an exemplary embodiment of the tube sealer 10, the internal clamping mechanism 60 may further include a dowel rod 62 provided in the handgun 11, the dowel rod 62 being fixedly connected to the movable jaw 22, as shown in FIGS. 9 and 10. The dowel rod 62 is provided to engage the resilient member 50 that may be in the form of a spring 50 (e.g. via a faceplate 63 of the dowel rod 62) to compress the resilient member 50 when the movable jaw 22 is moved towards the fixed jaw 21 during activation of the tube sealer 10. A limit switch 64 may be provided in the handgun 11 such that a free end 65 of the dowel rod 62 activates the limit switch 64 only when the tube to be sealed is properly clamped between the clamping jaws 20.

**[0040]** In alternative embodiments of the first configuration of the tube sealer 10, a dowel rod may not be provided. Instead, as depicted in FIGS. 11 to 14, the movable jaw 22 may be in direct contact with the resilient member 50 such that movement of the movable jaw 22 towards the fixed jaw 21 compresses the resilient member 50 and also activates the limit switch 64.

**[0041]** Activation of the limit switch 64 may be configured to turn on the energy generator 30 to melt the tube between the clamping jaws 20 in order to form the seal. Turning on the energy generator 30 results in either the RF signal (for the RF-type tube sealer 10) or the thermal energy (for the thermal-type tube sealer 10) from the energy generator 30 to pass through both jaws 21, 22 of the clamping jaws 20, causing the compressed tube material to reach at least glass transition temperature for tube sealing to occur under the clamping force provided by the clamping jaws 20.

**[0042]** As can be seen in FIG. 9, in a “before” or rest state of the tube sealer 10 where the internal clamping mechanism 60 is in an open configuration, the movable jaw 22 and fixed jaw 21 are at a distance or spaced apart from each other to allow placement of an

uncompressed tube therebetween, the spring 50 is uncompressed, and the limit switch 64 is not activated. When the trigger handle 40 or trigger handle 40 is depressed as shown in FIG. 10, the movable jaw 22 is moved towards the fixed jaw 21 so that the tube sealer 10 is in the activated position. In the activated position, the resilient member 50 is compressed and the limit switch 64 is activated to turn on the energy generator 30.

**[0043]** In an exemplary embodiment, the movable jaw 22 may be L-shaped with a first arm L1 and a second arm L2, wherein the clamping surface 24 of the movable jaw 22 is provided on an inner part of the first arm L1. In order for the trigger handle 40 or trigger handle 40 to movably engage the movable jaw 22 as mentioned above, a pin hook 25 may be provided at an end of the second arm L2 (FIGS. 8 to 14), while a moving jaw pin 45 (also referred to as lever pin 45) is fixedly provided on the trigger handle 40 to rotatably engage the pin hook 25 of the movable jaw 22. Regardless of the shape of the movable jaw 22, the pin hook 25 is preferably always provided below the clamping surface 24 of the movable jaw 22.

**[0044]** During normal use, bias action of the resilient member 50 against the end of the second arm L2 keeps the pin hook 25 in engagement with the lever pin 45. When the pin hook 25 is in engagement with the lever pin 45, depression of the trigger handle 40 in the Y1 direction (as shown in FIG. 9) results in translation of the lever pin 45 with a component in the X1 direction (as shown in FIG. 9), thereby drawing or pulling the movable jaw 22 towards the fixed jaw 21 in the X1 direction to allow a tube to be clamped by the clamping jaws 20. To achieve this, a pivoting end 41 of the trigger handle 40 may pivotably engage a fixed pivot 62 (as shown in FIGS. 11 to 14) while a free end 42 of the trigger handle 40 is left free to be moved by hand. The fixed pivot 62 may be provided in the mechanism base 61 (hidden from view in FIGS. 11 to 14). Appreciably, the lever pin 45 should be provided on the trigger handle 40 between the pivoting end 41 and the free end 42 of the trigger handle 40 in order that depression of the trigger handle 40 in the direction Y1 translates the movable jaw 22 towards the fixed jaw 21 in the direction X1. FIG. 10 shows the activated or after state of the clamping mechanism 60 where the trigger handle 40 is depressed and the movable jaw 22 is in the activated position to clamp a tube for sealing between the clamping jaws 20.

**[0045]** As the movable jaw 22 will wear out with use, particularly for the RF-type tube sealer 10 that can expect heavy usage such as during blood donation drives, the movable jaw

22 is preferably configured to be easily replaced by a user without requiring the services of a skilled technician. This will reduce downtime that occurs if the tube sealer 10 has to be sent to a workshop for jaw replacement. To facilitate easy jaw replacement, in an exemplary embodiment, a push and drop system may be provided wherein the pivoting end 41 of the trigger handle 40 is provided with a slot 43 that pivotably and also translatably engages the fixed pivot 62, as shown in FIGS. 11 to 14. The slot 43 has a first end 44 located nearer the pivoting end 41 of the trigger handle 40 and a second end 46 located nearer the free end 42 of the trigger handle 40.

**[0046]** The heat sealer 10 is configured such that during normal usage of the heat sealer 10, whether in the activated position or rest position, as shown in FIG. 11, the fixed pivot 62 rotatably engages the slot 43 at a predetermined distance away from the first end 44 of the slot. At the same time, the pin hook 25 of the movable jaw 22 is kept in engagement with the lever pin 45 of the trigger handle 40 by the resilient member 50 continually applying a force to the movable jaw 22 (whether directly or via the dowel rod 62).

**[0047]** To remove the movable jaw 22, in a first step as shown in FIG. 12, the movable jaw 22 is moved towards the fixed jaw 21 to a pushed configuration (or pushed-in position) against the bias of the resilient member 50 without moving the trigger handle 40. This may be effected by applying a force F1 to the movable jaw 22 towards the fixed jaw 21 as shown in FIG. 12. This causes the pin hook 25 of the movable jaw 22 to disengage from the lever pin 45 of the trigger handle 40 while compressing the resilient member 50.

**[0048]** As shown in FIG. 13, the trigger handle 40 is moved to a dropped configuration (or disengaged position) where the first end 44 of the slot 43 engages the fixed pivot 62 as a result of translation of the slot 43 relative to the fixed pivot 62, while the movable jaw 22 is held in the pushed-in position and the resilient member 50 is still compressed. The trigger handle 40 may be moved to the disengaged position by simply dropping or allowing it to fall from its original position under the action of gravity as indicated by arrow G.

**[0049]** With the trigger handle 40 in the disengaged position as shown in FIG. 14, the lever pin 45 is now sufficiently moved away from the pin hook 25 to allow the movable jaw 22 to be able to slide out and be removed from the handgun 11 in a direction indicated by arrow X2 that is opposite to that of the force F1 shown in FIG. 12, as there is no longer any mechanism holding the movable jaw 22 in place. Notably, the predetermined distance (as

mentioned above between the first end 44 of the slot 43 and where the fixed pivot 62 rotatably engages the slot 43 during normal use) should allow the lever pin 45 to be moved sufficiently away from the pin hook 25 to allow removal of the movable jaw 22. Removing the movable jaw 22 results in released configuration and uncompresses the resilient member 50.

**[0050]** Replacing with a new movable jaw 22 can be achieved by reversing the above-described process, by sliding in a new movable jaw 22 while the trigger handle 40 is in the disengaged position and compressing the resilient member 50 until the movable jaw 22 is in the pushed-in position, lifting or pushing up on the trigger handle 40 while the movable jaw 22 remains in the pushed-in position until the lever pin 45 of the trigger handle 40 is aligned with the pin hook 25 of the movable jaw 22, followed by releasing the movable jaw 22 from the pushed-in position so that the resilient member 50 again applies a force to the movable jaw 22 such that the pin hook 25 once again engages the lever pin 45.

**[0051]** In alternative embodiments, the pin hook 25 and lever 45 may be configured such that the disengaged position of the lever 40 is achieved by moving the lever 40 upwards while the movable jaw 22 is held in the pushed-in position and the resilient member 50 is still compressed, until the second end 46 of the slot 43 engages the fixed pivot 62 as a result of translation of the slot 43 relative to the fixed pivot 62.

**[0052]** It is envisaged that the thermal-type tube sealer 10 may be used in various settings (such as a laboratory, for example) to seal tubes of differing diameters and material types, unlike the RF sealable tubes that tend to be used for sealing tubes of the same material and size. Accordingly, the handgun 11 of the thermal-type tube sealer 10 may be provided with a jaw adjustment feature to adjust the position of the movable jaw 22 relative to the fixed jaw 21, as shown in FIGS. 15 and 16. This aids in fine tuning the jaw width to accommodate different tube diameters that the tube sealer 10 will be used on. In an exemplary embodiment, the jaw adjustment feature may comprise an adjustment screw 66 in threaded engagement with a bushing 67. The adjustment screw is attached to the movable jaw 22 such that the movable jaw 22 is translated relative to the fixed jaw 21 by turning the adjustment screw to determine the spacing between the movable jaw 22 and the fixed jaw 21. The bushing 67 is in a fixed position relative to the fixed jaw 21. Translation of the adjustment screw 66 (and together with it the movable jaw 22) is effected by rotating the adjustment screw 66 within the fixed bushing 67. In this way, rotation of the screw 66 in a first direction causes the

movable jaw 22 to be moved further away from the fixed jaw 21 to accommodate larger tube diameters. Conversely, rotation of the screw 66 in a second direction causes the movable jaw to be moved closer to the fixed jaw 21 to accommodate smaller tube diameters. To facilitate rotation of the adjustment screw 66, an adjustment dial 68 may be provided at a head of the screw 66 for easy turning of the screw 66 by hand.

**[0053]** For users constantly on the move, the tube sealer 10 may include a sling pouch 70 provided for carrying the portable control unit 12 about, and preferably also the handgun 11 about, as shown in FIG. 17. The sling pouch 70 allows the portable control unit 12 of the tube sealer 10 to be slung on a shoulder of the user so that both hands of the user are free to hold and seal a tube using the handgun 11. This allows for a more hands-free experience when using the device, such as where users need to be on the move to seal multiple tubes, e.g. during a blood donation drive at a public location.

**[0054]** For the first exemplary configuration of the tube sealer 10 comprising a handgun 11 and a portable control unit 12, the tube sealer 10 may include linkable charging dock 80 having a charging case 81 in which the portable control unit 12 may be placed and a handgun support 82 in which the handgun 11 may be placed with the clamping jaws 20 facing up, to form a charging or docked configuration of the tube sealer 10. In an exemplary of the charging dock 80 as shown in FIGS. 18 to 20, the handgun support 82 is provided above the charging case 81 to result in a generally cuboid envelope being formed when the tube sealer 10 is in the docked configuration. This provides users with the option of a desktop setup, whereby power can be constantly supplied to the tube sealer 10 via an input power port 83 (shown only in FIG. 19) provided on the exterior of the charging dock 80 and linked to a charging point 84 (shown only in FIG. 20) provided in the interior of the charging dock 80, that electrically connects to and charges the portable control unit 12 when the tube sealer 10 is in the docked configuration. This setup allows users to simply put the tube into the exposed jaws of the handgun 11 that is now supported by the handgun support 82 of the charging dock 80 and simultaneously activate a hand-activated mechanism 85 provided at a side of the charging dock 80 in order to depress the trigger handle 40 of the handgun 11 in the charging dock 80. The hand-activated mechanism 85 includes an external lever arm 88 that is movable to actuate depression the trigger handle 40 of the handgun 11.

**[0055]** Optionally, as shown in FIG. 21, the charging dock 80 may be configured to allow multiple units of the tube sealer 10 (each in the docked configuration) to be linked or connected side by side in a modular, multilink way such that a single tube may be laid between the clamping jaws 20 of multiple linked units of the tube sealer 10 simultaneously. In this way, multiple sealing of a single tube at fixed intervals apart can be performed simultaneously to obtain multiple sealed small sections of the tube. Furthermore, each sealed segment of the tube (i.e. between adjacent sealed regions of the tube) is of consistent size with the others because the multiple units of the tube sealer 10 are at equal intervals apart between adjacent tube sealers 10.

**[0056]** To facilitate linking of adjacent units of charging docks 80, in a preferred embodiment, each charging dock may be provided with at least one female port 86 on a first side of the charging dock 80 and at least one corresponding male port 87 on a second side of the charging dock 80 opposite the first side, the female and male ports 86, 87 being configured to releasably engage each other respectively. When the handgun 11 is placed in the handgun support 82, the clamping jaws 20 are provided on a third side of the charging dock 80 between the first side and the second side of the charging dock 80. Preferably, engagement of the female and male ports 86, 87 establishes electrical communication between the multiple units of charging docks 80, so as to allow the multiple units of tube sealers 10 in corresponding units of charging docks 80 that are connected in series to be simultaneously charged using only a single power supply. For example, this may be achieved by connecting multiple units of charging docks 80 with each other in series (by engaging their respective female and male ports 86, 87), and physically connecting only a first of the connected multiple units of charging docks 80 (referred to as the master dock) to a power supply such as a wall electrical socket.

**[0057]** Further preferably, each charging dock 80 is configured to detect if another charging dock 80 has been electrically connected with it via their respective female and male ports 86, 87, and to transmit a signal that notifies of the total number of connected multiple units of charging docks 80 to the master dock. The master dock is configured to stop charging of the multiple tube sealers 10 in the multiple connected units of charging docks 80 when it detects that a predetermined number of connected charging docks 80 has been exceeded. This is a safety mechanism to prevent electrical overloading when too many charging docks 80

have been connected together. Preferably, every charging dock 80 is configured to be able to serve as a master dock.

**[0058]** In a second exemplary configuration of the tube sealer 10, as shown in at least FIGS. 22 and 23, the tube sealer 10 may comprise a casing 90 housing the energy generator 30 and the resilient member 50. The clamping jaws 20 and the lever 40 extend from the casing. The clamping jaws 20 are preferably oriented facing upwards. The tube sealer 10 may be powered via an input power port 93 provided on the exterior of the casing 90. This configuration compresses or combines the functionality of the handgun 11, the portable control unit 12 and the charging dock 80 (as shown in the docked configuration in FIG. 18) into a single unit, but has a smaller footprint by comparison with the configuration shown in FIG. 18 due to its more compact design.

**[0059]** Optionally, as shown in FIG. 24, the second exemplary configuration of the tube sealer 10 may be configured to allow multiple units of the tube sealer 10 to be linked or connected side by side to allow a single tube to be laid between the clamping jaws 20 of multiple units of the tube sealer 10 simultaneously. In this way, simultaneous sealing of a single tube at fixed intervals apart may be achieved. The side-by-side connection may be effected by providing at least one female port 96 on a first side of the casing 90 and at least one corresponding male port 97 on a second side of the casing 90 opposite the first side while the clamping jaws 20 are provided on a third side of the casing 90 between the first side and the second side, the female and male ports 96, 97 being configured to releasably engage each other respectively. Further preferably, engagement of the female and male ports 96, 97 enables electrical communication between the multiple units of the tube sealers 10, so as to allow the multiple units of tube sealers 10 to be simultaneously charged using a single power supply. For example, this may be achieved by connecting multiple units of tube sealers 10 with each other in series by engaging their respective female and male ports 96, 97, and physically connecting only a first of the connected multiple units of tube sealers 10 (referred to as the master tube sealer) to a power supply such as a wall electrical socket. Further preferably, each tube sealer 10 is configured to detect if another tube sealer 10 has been electrically connected with it via their respective female and male ports 96, 97, and to transmit a signal that notifies of the total number of connected multiple units of tube sealer 10 to the master dock. The master dock is configured to stop charging of the multiple units of tube sealers 10 when it detects that a predetermined number of connected tube sealer 10 has been

exceeded. This is a safety mechanism to prevent electrical overloading when too many tube sealer 10 have been connected together. Preferably, every tube sealer 10 is configured to be able to serve as a master tube sealer.

**[0060]** Notably, the embodiments of the first exemplary configuration of the tube sealer 10 (comprising a handgun 11 and a portable control unit 12) as shown in FIGS. 17 to 21 (that may include the sling pouch 70 or one or more units of the charging dock 80), as well as the embodiments of the second exemplary configuration of the tube sealer 10 as shown in FIGS. 22 to 24, are particularly suited for the RF-type tube sealer 10 that is usually used where multiple sealed sections of a tube need to be formed.

**[0061]** While there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations in details of design, construction and/or operation may be made without departing from the present invention.

## CLAIMS

1. A compact tube sealer for sealing a polymeric tube, the tube sealer comprising:  
clamping jaws comprising a fixed jaw and a movable jaw movable between a rest position where the tube may be placed or removed from between the clamping jaws and an activated position where the tube is diametrically compressed between the clamping jaws;  
a energy generator provided to raise a temperature of the tube to its melting point when the movable jaw is in the activated position, the energy generator comprising one of:  
a radio frequency (RF) generator to provide RF through the tube via the clamping jaws, and heating elements to heat the clamping jaws and consequently the tube;  
a lever to actuate movement of the movable jaw from the rest position to the activated position when the lever is depressed; and  
a resilient member biased against movement of the movable jaw towards the fixed jaw so as to return the movable jaw from the activated position to the rest position when the lever is released.
2. The compact tube sealer of claim 1, further comprising a female port provided on a first side of the tube sealer and a male port provided on a second side of the tube sealer opposite the first side, the female port of one unit of the tube sealer and the male port of another unit of the tube sealer configured to releasably engage each other to allow multiple identical units of the tube sealer to be connected side by side, thereby allowing a single tube to be laid between the clamping jaws of the multiple units of the tube sealer for simultaneous sealing of the single tube at fixed intervals apart.
3. The compact tube sealer of claim 1 or claim 2, further comprising:  
a handgun on which the clamping jaws, the lever, the resilient member and at least part of the energy generator are provided; and  
a portable control unit to house control circuitry of the energy generator and to which the handgun is connectable via an appropriate detachable cable;  
wherein the movable jaw has a pin hook provided below a clamping surface of the movable jaw, wherein the lever comprises a lever pin fixedly provided on the lever to rotatably engage the pin hook, wherein bias action of the resilient member keeps the pin hook

- in engagement with the lever pin, wherein the lever pin is provided between a pivoting end of the lever and a free end of the lever;
- wherein the pivoting end of the lever is provided with a slot to pivotably and translatably engage a fixed pivot provided on the handgun, a first end of the slot being nearer the pivoting end and a second end of the slot being nearer the free end;
- wherein moving the movable jaw towards the fixed jaw against the bias of the resilient member without depressing the lever disengages the pin hook from the lever pin to allow movement of the lever to a disengaged position via translation of the slot relative to the fixed pivot; and wherein when the lever is in the disengaged position, the lever pin is moved away from the pin hook to allow removable of the movable jaw from the handgun.
4. The compact tube sealer of claim 3 when dependent on claim 2, further comprising a charging dock having a charging case for placing the portable control unit therein for charging and a handgun support for placing the handgun therein.
  5. The compact tube sealer of claim 4, wherein the female port is provided on a first side of the charging dock and the male port is provided on a second side of the charging dock opposite the first side, and wherein the clamping jaws are provide on a third side of the charging dock between the first side and the second side when the handgun is placed in the handgun support.
  6. The compact tube sealer of claim 4 or claim 5, wherein the handgun support is provided above the charging case.
  7. The compact tube sealer of any one of claims 4 to 6, wherein the charging dock includes an external lever arm movable to actuate depression of the lever.
  8. The compact tube sealer of any one of claims 3 to 7, wherein the portable control unit houses an internal battery or battery pack for powering the energy generator.
  9. The compact tube sealer of any one of claims 3 to 8, further comprising a sling pouch provided to carry the portable control unit about.

10. The compact tube sealer of any one of claims 3 to 9, wherein the energy generator comprises a RF generator control circuit provided in the portable control unit in connection with a RF transmission circuit board provided in the handgun, the RF generator control circuit provided to generate RF energy and the RF transmission circuit board provided to transmit the generated RF energy to the clamping jaws, wherein the clamping jaws serve as electrodes through which the generated RF energy is passed through the tube when the tube is diametrically compressed between the clamping jaws.
11. The compact tube sealer of any one of claims 3 to 9, wherein the energy generator comprises a temperature and timer controller circuit board provided in the portable control unit in connection with a heater driver circuit board provided in the handgun and heating elements and thermal sensors provided in the clamping jaws, wherein the heater driver circuit board is provided to turn on and off the heating elements under the control of the temperature and timer controller circuit board.
12. The compact tube sealer of claim 1 or claim 2, further comprising a casing housing the energy generator and the resilient member, wherein the clamping jaws and the lever extend from the casing.
13. The compact tube sealer of claim 12 when dependent on claim 2, wherein the female port is provided on one side of the casing, the male port is provided on a second side of the casing opposite the first side, and the clamping jaws are provided on a third side of the casing between the first side and the second side.
14. The compact tube sealer of claim 2 and any one of claims 3 to 13 when dependent on claim 2, wherein engagement of the female port of a first unit of the tube sealer and the male port of a second unit of the tube sealer connects and establishes electrical communication between both units of the tube sealer to allow simultaneous charging of both units of the tube sealer when only the first unit of the tube sealer is physically connected to a power supply.

15. The compact tube sealer of claim 14, wherein each unit of the tube sealer is configured to transmit a signal that notifies of a total number of connected multiple units of the tube sealer to a first of the connected multiple units of the tube sealer when electrical communication is established between connected multiple units of the tube sealer that are connected in series, and wherein the first of the multiple units of the tube sealer when physically connected to a power supply is configured to stop charging of the connected multiple units of the tube sealer when it detects that a predetermined number of connected multiple units of the tube sealer has been exceeded.
16. The compact tube sealer of any one of the preceding claims, further comprising a bushing provided in a fixed position relative to the fixed jaw and an adjustment screw in threaded engagement with the bushing, wherein the adjustment screw is attached to the movable jaw such that rotating the adjustment screw within the fixed bushing translates the movable jaw relative to the fixed jaw to allow adjustment of spacing between the fixed jaw and the movable jaw.