## Refrigerating Apparatus for Medical Use

Cryotherapy and cryosurgery have proved to be one of the most important and promising fields of research and development in recent years. Various means are already known for obtaining extremely low temperatures at the tip of instruments that can be manipulated to reach organic tissues. The degree of cold applied may also be varied in relation to the use being made of individual techniques. It has been shown experimentally that, apart from special cases, the most frequently employed temperature is between $-70\,°C$ and $-130\,°C$.

The equipment here described is capable of reaching a temperature of $-89.7\,°C$ under normal ambiental conditions and of maintaining such a temperature for long periods at an extremely low running cost. It is very convenient and practical, as well as being extremely easy to set up and disassemble after use.

The unit is known as the MINICRIO R 89 and is composed of 3 main parts (see Figure 1, a): a) refrigerant source; b) tubing for the refrigeration fluid; c) hand-grip, with various sounds designed for different forms of management.

The refrigerant source consists of a commercially available, inexpensive $N_2O$ bottle; this is sold in portable containers weighing from 2–5 kg. It is housed in an aluminium cradle (2), the front of which has a pressure gauge (3) and an attachment (4) for the flexible tube leading to the hand-grip. Under normal working conditions, the working pressure in the tubing and hand-grip is from 40 to 70 atm.

To ensure that only the liquid phase of the $N_2O$ is used, the bottle must be tilted at 25° so that any unwanted residues such as oil or metal fragments are held at the lowest point of the bottle. This will usually contain a very small percentage of water, whether in liquid or vapour form. If this were allowed to reach the operative equipment, it would freeze and block the flow

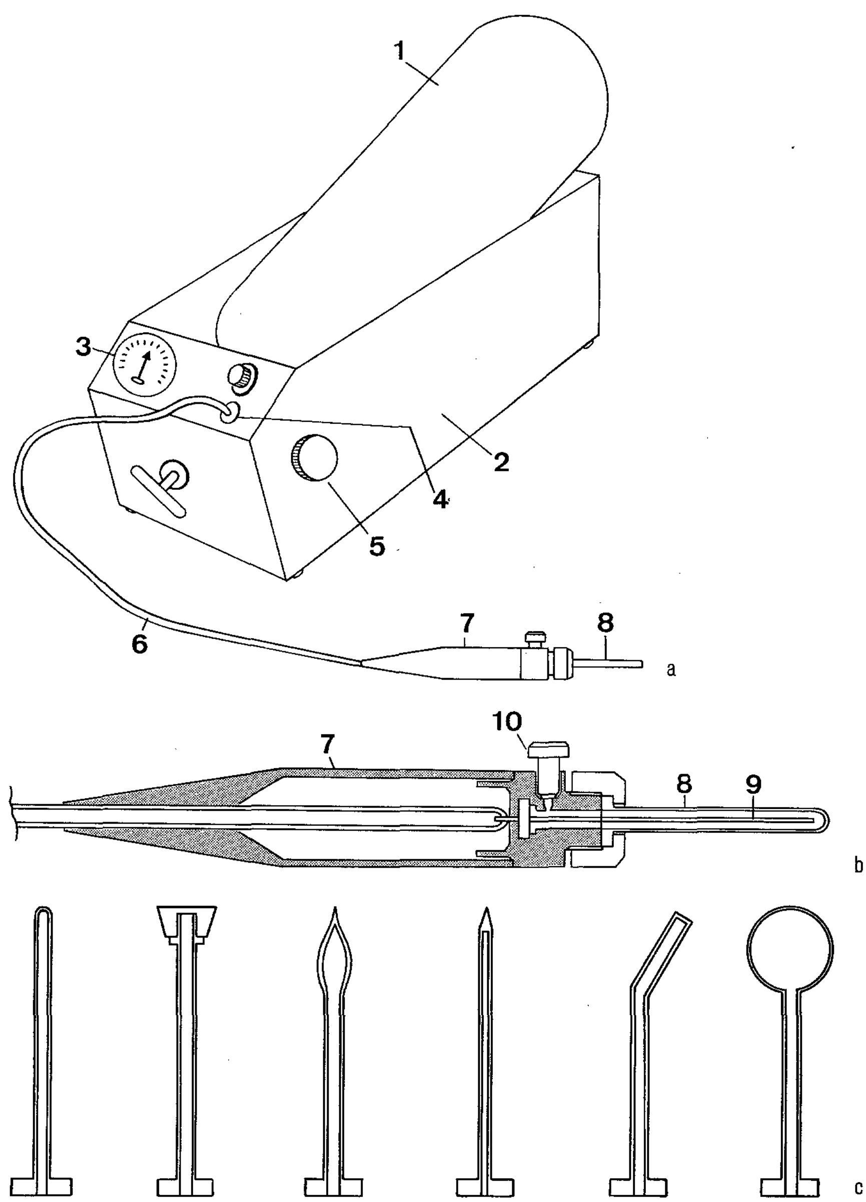


Fig. 1. a) The Unit Minicrio R.89 – General Assembly (see text for description). Reduced about 5 times. b) The operating hand-grip (1:2 size). c) Different sound which may be fitted to the hand-grip.

of $N_2O$. To prevent this a dehydrating filter is inserted immediately downstream from the bottle.

The flexible tube (6) is made of a plastic material (e.g. Teflon, Ertalon or tecalan) unaffected by the chemical agents normally present in $N_2O$ or other refrigerant gases. It is very strong but nevertheless allows a very wide range of movement while using the hand-grip. It is about $1^1/_2$ m long.

The operating hand-grip (Figure 1, b) consists of 2 distinct parts: the holder (7) and the refrigerating sound (8). The holder contains the most delicate parts of the whole apparatus; the capillary tube (9) and the control valve (10). The capillary tube is in stainless steel. It is about 8–10 cm long and its external and internal diameters are 0.6 and 0.3 mm respectively. The cross-section of the through diameter can be reduced by the insertion of a 0.05–0.25 mm spindle. This restricts the flow of $N_2O$ and hence varies the degree of cold delivered by the apparatus. The control valve (10) is fitted on the exhaust outlet and connects the front and the capillary tube with the outside air. When this valve is opened, the pressure downstream from the capillary tube is lowered. The liquid $N_2O$ is allowed to evaporate and this refrigerates the immediately surrounding area.

The refrigerating sound (8) is in stainless steel and may be of various shapes (Figure 1, c). It is fitted into the body of the holder and is so arranged that the end of the capillary tube at which $N_2O$ evaporation takes place is set very near (1–2 mm) to its terminal part. This means that it becomes rapidly frozen and will be brought to the evaporation temperature (i.e. $-89.7$ °C) in a matter of seconds. The sound is not usually insulated along its length. When the set is used for long periods, therefore, the temperature of the hand-grip will fall considerably. The holder, however, is covered with a low-bulk layer of insulating Teflon to prevent the danger of cold 'burns' to the operator's hand. The control valve must be suitably regulated to prevent frosting of the handle. Since the sound is not insulated, it can only be used on open tissue; 'Closed-field' work requires the employment of special sounds. These have an extremely short (10–30 mm) freezing tip and a long insulating section. They are designed to cause extensive lesions without damage to the tissue through which they pass. The addition of the insulating material is naturally accompanied by an increase in diameter from 2–3 mm to a maximum of 6.5 mm.

It will be clear from above description that the apparatus is extremely easy to use and handle, as well as highly economical on account of the minute amount of $N_2O$ used during each treatment. About 100 freezing treatments, lasting 2.5 min each, can be obtained from a 2.5 kg bottle. When the apparatus is used for long periods, or where considerable quantities of liquid are withdrawn, there will be a notable drop in pressure in the bottle. The initial number of atmospheres can be regained by switching on the thermostatic heater resistance fitted under the bottle in the support cradle. In this way, the set can be used untill the bottle is completely empty.

*Subsequent development.* The reliable performance of the set may be enhanced, particulary when it is constantly required for use in protracted treatments in which commercially available, and hence sufficiently purified, gas will be employed, by the insertion of a system for the liquifaction of the $N_2O$ after its withdrawal from the bottle in the form of gas. This system is described in Figure 2. The bottle (1) is mounted vertically so that impurities will fall to the bottom. Any water contained in the $N_2O$ saturated vapour will be trapped by the dehydrating filter (2). The pressure is checked by means of the gauge (3). Condensation of the saturated vapour takes place in a coil tightly wound around the evaporator (4) of a refrigeration group (5). The saturated vapour is not merely condensed in the coil; it is also supercooled so that the ensuing fluid can run along a tube of some length without losing its liquid state. A system of valves mounted at the gas discharge point is used to regulate the temperature at the tip of the sound. The higher the pressure in the discharge pipe, the nearer to zero the $N_2O$ evaporation temperature will be at the tip of the sound and vice versa; if, on the other hand, a vacuum pump is used to obtain a state of depression in the discharge pipe, the evaporation temperature will drop below $-89.7$ °C.

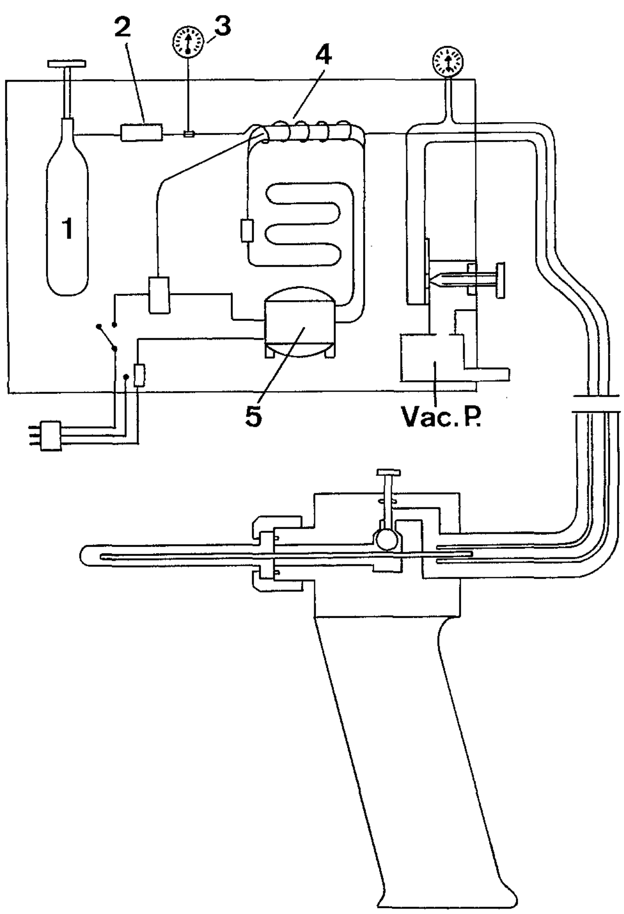


Fig. 2. Diagram of a freezing unit with a system for the liquifaction of the $N_2O$ (see text for description).

*Riassunto.* Si descrive un arnese refrigerante ad uso medico che raggiunge all'estremità della sonda operatoria la temperatura di $-89.7$ °C alle normali condizioni ambiente. Viene qui sfruttata la caduta di temperatura ottenuta dalla evaporazione localizzata e controllata del $N_2O$. È anche descritto un apparato derivato, utilizzante un sistema di liquefazione del $N_2O$, che successivamente viene fatto evaporare alla estremità della sonda operatoria.

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