

AN INSTALLATION FOR THE PREPARATION OF RADIUM EMANATION FOR THERAPEUTIC USE.—BY GEORGE HUGH HENDERSON, PH. D., King's College, Halifax, N. S.

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Abstract: A description is given of a method used for the purification and tubing of radium emanation, which gives high purification although simplified considerably by the avoidance of drying agents.

Radium was first used for therapeutic purposes in the form of a salt sealed permanently into small glass tubes. This method is gradually being abandoned in favour of the use of radium emanation, the radium being kept in solution in a safe place, while the gaseous emanation is pumped off regularly, freed from impurities and sealed into glass tubes.

The advantages of the latter method over the former are threefold. The costly radium can be kept in a safe, while the emanation tubes if lost or destroyed, may be replaced at the cost of only a short delay. The emanation method possesses great flexibility as the emanation can be subdivided in any desired way and distributed where needed. Finally the emanation can be concentrated more than a salt of radium, permitting the use of smaller tubes—a very decided advantage.

The preparation of emanation tubes is not very easy. The main difficulty arises in the purification of the emanation, which necessitates a complicated purification process, a costly pumping system, experimental skill and much experience.¹ The emanation as first collected is mixed with large quantities of hydrogen and oxygen from the water of the solution, as well as carbon dioxide from tap grease. The mixed gases collected with one millicurie of emanation amount to at least 200 cubic mm, while modern usage demands a concentration of not less than 25 millicuries in a cubic mm. Thus the impurities must be reduced at least 5000 fold.

¹ Hahn, Ber. Deut. Chem. Ges. 59. p. 284. 1926.

It has usually been stated that at least one gram of radium is necessary to justify the erection of an emanation plant, and accordingly the use of radium in this way has been restricted to a few large centres of population. Recently the Victoria General Hospital, Halifax, N.S., purchased 200 mgs. of radium, and the writer undertook to develop an emanation plant suitable for handling this relatively small quantity. Obviously, the first considerations must be low first cost and simplicity of operation. A description of the method evolved forms the subject of this paper.

METHOD.

Many descriptions of purification methods have been given.² In general the hydrogen and oxygen are united by sparking the mixture and carbon dioxide removed by potassium hydroxide. An excess of hydrogen always remains after sparking, and several methods have been used to remove it. (1) In a purely physical method, the emanation is condensed by liquid air and the hydrogen pumped off. (2) The hydrogen may be removed by hot copper oxide. (3) An excess of pure oxygen may be added before sparking, and the excess later removed by phosphorus.

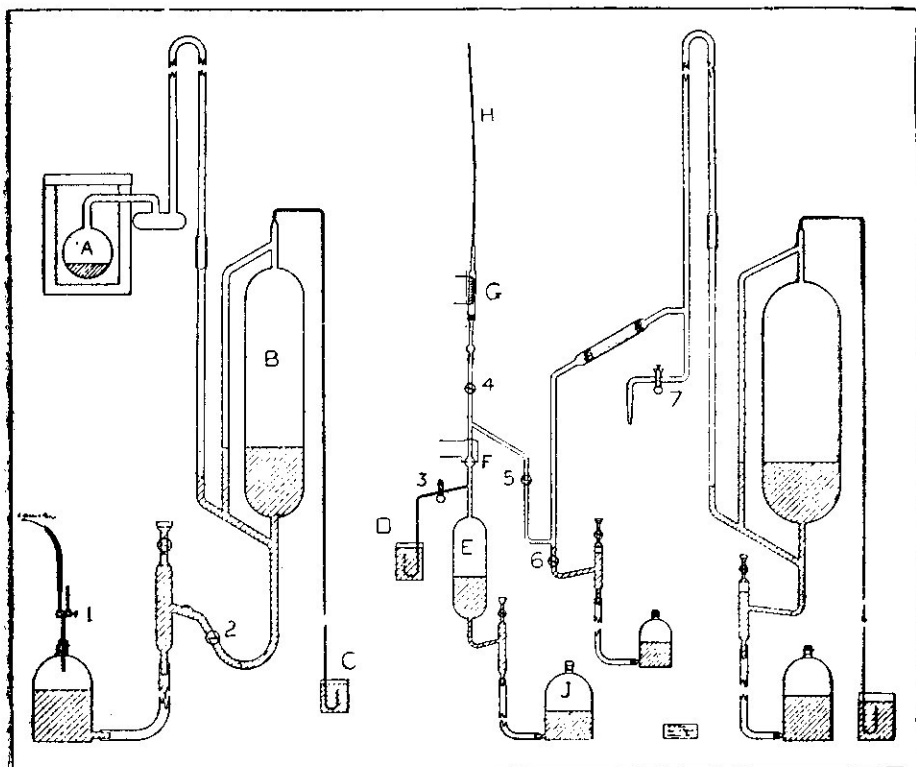
The first method permits of high concentration of the emanation, but requires a regular supply of liquid air, which is generally inconvenient and in many localities impossible. Experience with chemical methods indicated that sufficient purification could be obtained only by the second method, and then only if the copper oxide were raised to a bright red heat. This method seems first to have been described by Duane and later elaborately developed by Failla. The apparatus to be described is simpler than that of Failla. The emanation after purification passes directly into the final capillary tube without further pumping or handling, and the use of phosphorus pentoxide has been avoided.

² Hess, *Phil Mag*, 47, p. 713 1. 24. q. v. for further reference. Alton, *A Clinical Index of Radium Therapy*. The Radium Institute, London 1925. *Viol*, *Radium XIV*. Oct. 1919.

The radium bromide is contained in the flask A (See Fig.) dissolved in water to which a little hydrochloric acid has been added. The emanation is pumped from the solution by the Toepler pump B, and collected in a small tube over mercury in the trough C.

The purification apparatus EFGH has been previously evacuated thoroughly through the pumping system shown on the right of the line FH., after which taps 4 and 5 are closed.

The emanation is then transferred in the small tube referred to above, to the trough D, and allowed to enter E. A spark is passed in the mixture between the platinum electrodes F,



uniting the hydrogen and oxygen explosively. Tap 3 is opened and the gas pushed up into G for final purification by means of the mercury cistern below. G is provided with a spiral of oxidized copper, which may be heated electrically, and with some potassium hydroxide fused to the glass just below the coil. After 10 minutes exposure to the wire at a bright red, the purification is complete. The heating current is cut off and the emanation compressed into the capillary tube H, which is sealed off with a small gas flame and subdivided as desired.

The essential feature of this method is that the purification takes place progressively along the line EFG and that the emanation is pushed directly into the capillary F without further pumping. This is possible since there is no phosphorus pentoxide in the purification line as a drying agent. Removal of water vapour has been found unnecessary, the vapour apparently condensing on the walls as the emanation is compressed.

DETAILS.

Some details may be of interest. The flask A is surrounded by a Pyrex beaker and an outer porcelain dish in case of breakage. The whole is enclosed in a lead safe with walls one and one half inches thick. Lead screens about an inch thick also cover the traps between A and B. In case of accident the mercury is prevented from rushing into A by (1) a glass float valve, (2) by making the tube connecting B to A rise to more than barometric height above the top of B. (3) by an emergency trap near A.

The pump B is semi-automatic in action. Its mercury cistern may be connected by the three-way tap, either to the atmosphere or to a vacuum pump (Hyvac oil pump). Thus the mercury in B may be moved up and down without moving the cistern. The cistern is connected to the pump B by rubber tubing and must be raised to push the larger quantities of gas over the top of B into C. Tap 2 is closed except when pumping off. It is placed in such a position that it can readily be cleaned without admitting air into B.

All the purification apparatus has been erected on heavy galvanized wire netting. This has been found a very simple and satisfactory mounting which provides easy access for glass blowing and does not warp.

The coil G of No. 30 copper wire is heated a bright red by a current of 10 amperes at 8 volts. It is coated with oxide by exposing it to the air for about one minute at a dull red. With care, such a coil may be made to last for a number of purifications. G is connected to tap 4 by a ground glass joint, facilitating change of capillary H.

The purification apparatus is roughly evacuated through tap 7 and a phosphorus pentoxide tube, by the same vacuum pump which actuates the pump B. After 7 is closed, three or four strokes of the Toepler pump shown on the right completes the evacuation. Connection between this pump and the purification line EFGH is cut off by opening tap 6, raising the attached mercury cistern until mercury flows into E, then closing 5 and 6.

The apparatus could be further simplified by connecting the emanation pump directly to the purification line, joining the top of B to tap 3. This has not been done in the present instance, partly because separation ensures greater protection to the operator. The pumping system on the right of the diagram might be replaced by a single mercury vapour pump, if as is usually the case, there is no need for saving the pumped off gas.

PERFORMANCE.

The capillary tube H is used in two sizes producing two kinds of emanation tubes usually called "tubes" and "seeds". The emanation is sealed off at a pressure about two-thirds of atmospheric.

"Seeds" are about .7 mm. external and .25mm. internal diameter and 4 mm. long. They can easily be made to contain 5 millicuries, though a strength of 2 mc. is preferable.

“Tubes” are about 1.1 mm. and .5 mm. internal and external diameters respectively and 15 mm. long. Usually 25 millicuries is sufficient, though they may be made to contain 75mc.

The apparatus has been found to produce emanation tubes averaging in strength about 94% of the theoretical yield. The installation has been in operation for over six months and has proved simple and reliable in operation.

In conclusion I wish to thank Dr. D. McIntosh for generous help and Mr. W. G. Moran, B. Sc. for the drawing.