J Neurosurg 59:673–676, 1983

The first human stereotaxic apparatus

The contribution of Aubrey Mussen to the field of stereotaxis

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✓ The first human stereotaxic apparatus was probably built in London, England, around 1918 to the specifications of Aubrey Mussen, a neuroanatomist and neurophysiologist who had worked with Clarke. The recent acquisition by the Montreal Neurological Institute of Mussen's original apparatus prompts this report on the salient points of his career, and summary of his early contributions to stereotaxy.

KEY WORDS · stereotaxy · stereotaxic apparatus · neurosurgical history · medical instrumentation · Aubrey Mussen · Horsley-Clarke apparatus

THE history of stereotaxic instruments began with Dittmar who, in 1873, used a guiding device for his instruments to produce circumscribed lesions of the bulbar vasomotor centers of the rat.[15] In 1889, Zernov,[17] Professor of Anatomy at Moscow University, built his own guiding apparatus, called an "encephalometer." Although Zernov and his colleagues used this apparatus in human surgery, and it was later recognized by Kandel and Schavinsky[6] as an ancestor of modern stereotaxic apparatus, the "encephalometer" was employed mainly in surface topography for localization of the cranial sutures and cerebral sulci.

The modern era of stereotaxy arrived in 1908 when Horsley and Clarke,[4] aiming at deep brain structures of the cat and monkey, used a Cartesian tricoordinate system. Their device proved accurate in animal experiments, even though it was based on cranial bone landmarks. The first model of their stereotaxic apparatus, designed by Clarke, was built in 1906 by James Swift, an instrument maker in London.[3] In 1920, the second model was sold to the Johns Hopkins University, Baltimore; the university subsequently published a detailed description of the apparatus[2] in accordance with the conditions of purchase.

Ernest Sachs, after completing his training with Horsley, brought the first stereotaxic apparatus (the Horsley-Clarke model) to America around 1911.[1,3,13] The stereotaxic method developed by Horsley and Clarke received little attention thereafter,[1,3,7] until it was revived by Ranson and Ingram in 1932.[5] In 1931, Kirschner developed a much simpler stereotaxic device for puncturing the Gasserian ganglion through the foramen ovale in man,[14] but that instrument could not be applied to intracerebral structures. Although Clarke[2] perceived the method's potential use in human surgery in 1920, it was not until a quarter of a century later that Spiegel, *et al.*,[16] actually employed it in surgery on humans.

Aubrey T. Mussen (Fig. 1) was among the pioneers of the stereotaxic method in North America. He designed the first human stereotaxic apparatus, which was built by an instrument maker in London around 1918. His work in neuroanatomy and neurophysiology using Clarke's instrument has remained relatively unnoticed for over 40 years.

Mussen was born in Montreal, Canada, in 1873. He graduated from McGill Medical School, Montreal, in 1900. In 1905 to 1906 and 1908, he worked at the National Hospital, Queen Square in London, and collaborated with Horsley and Clarke. He purchased one of the first Horsley-Clarke stereotaxic instruments for $100, and with this instrument successfully stimulated the XII nucleus in the cat and monkey. After completing his research at McGill University the following year, he published his work in *Brain* in 1909.[11] He then joined Professor Alzheimer at the Psychiatric Klinik in Munich for the next 5 years, and worked on the elab-

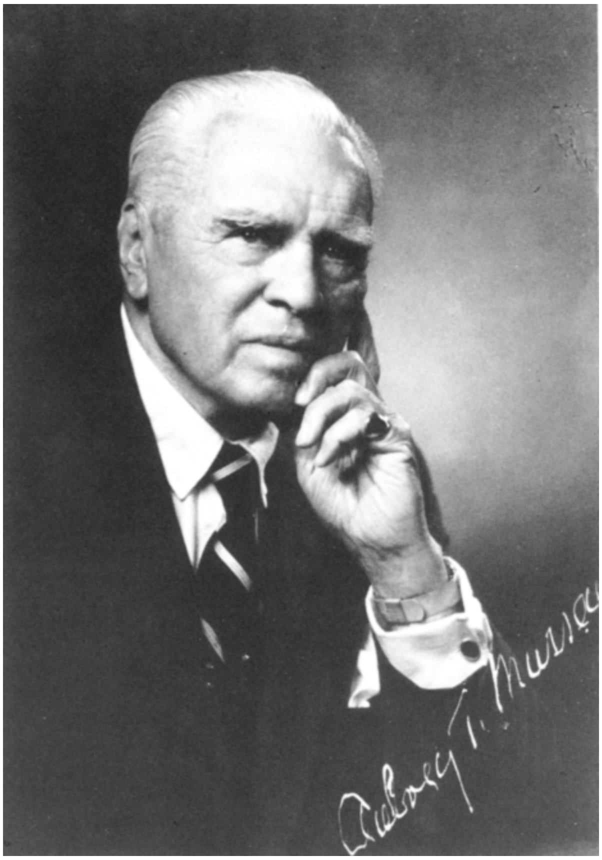

FIG. 1. Aubrey T. Mussen, neuroanatomist and neurophysiologist.

oration of a cytoarchitectural atlas of the brain stem and thalamus of the monkey. Although the *Atlas* was completed in 1914, because of the war it was not published until several years later.[10] Mussen returned to England and was appointed neuropathologist to London's Medical Research Committee.[9] Later he served as major-in-charge of the neurological wards at Ste. Anne's Hospital in Montreal, where he remained until demobilization. In 1920, he became an associate in neurological research at Johns Hopkins Hospital under Professor Adolph Meyer. Meyer persuaded the University to buy the second model of Clarke's stereotaxic instrument for $2,500, and to publish Clarke's book on the technique and apparatus.[2] Mussen continued his research on the cerebellum and red nucleus of the cat and monkey with this improved apparatus. He wrote many original publications, remarkable for their criticism and clarity of detail. He also served as a research associate with the Carnegie Institute in Washington from 1930 until his retirement in 1933. A collection of his significant papers was published in book form in 1967.[8] Mussen died 8 years later, in 1975.

It was after his return from Germany that Mussen designed his human stereotaxic apparatus, which, as mentioned earlier, was built in London around 1918. In 1971, Mussen wrote to his son, an engineer, who was inquiring about his father's apparatus:[12]

"It must be the first instrument made for the human brain because at that time no one was interested in it. My idea at that time was to make a complete instrument of the human brain and then make an atlas of the human brain like in the

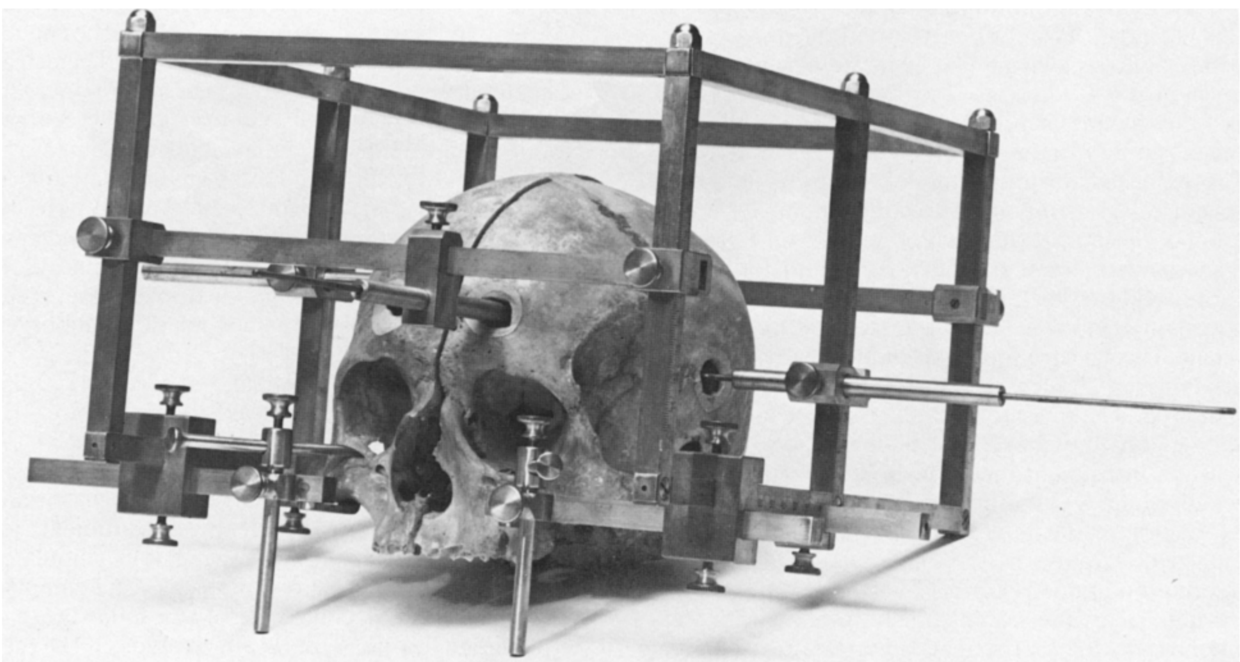

FIG. 2. The first human stereotaxic apparatus, designed by Mussen and built about 1918.

cat. Then you could locate any structure in the human brain by looking at the atlas and it was my thought that if there was a tumor in the brain that could not be located, you could send an electrode in and get the reaction of a normal brain and the difference if you came to the tumor. And then by making a number of degenerations with the galvanic current you might be able to destroy the tumor. And all this could be done through a 5 mm trephine in the skull and puncturing the dura without exposing the brain at all."

Mussen's human stereotaxic apparatus is illustrated in Fig. 2. Inspired by Clarke's animal device, he designed a rectangular brass frame with rectilinear coordinates for an orthogonal approach to the sagittal or coronal plane. The lower surface of the frame represents the basal zero plane of the cranium, Reid's orbitomeatal line. The cranium is adjusted to this basal horizontal plane by two graduated auricular bars and two adjustable anterior rods that anchor the lower borders of the orbits on the Reid's plane and support a pair of maxillary brackets. The coronal zero plane is represented by the interaural line and the sagittal plane is adjusted to the midline of the skull. The frame includes horizontal and vertical posts graduated in millimeters with movable side bars carrying electrode holders which are adjustable by screw clamps. The electrode can thus penetrate the brain orthogonally, reaching any deep brain structure by a Cartesian tricoordinate system.

The lesion could be made either by a galvanic current applied to the electrode or by a mechanical device, called a "spherotome," designed by Mussen and used by Clarke.[2] This "spherotome" was made with a watch spring, and is surprisingly similar to the leukotome used more recently in human stereotaxy. Mussen had stressed its usefulness in controlling the shape and extent of a lesion. In animal experiments, brain structures could also be stimulated through the electrode by a faradic battery connected to an induction coil, the strength of the current being modified by the height of the secondary coil (Fig. 3).

It is indeed surprising that Mussen's pioneer work in stereotaxy has remained relatively unnoticed for so many years. The recent gift to the Montreal Neurological Institute of Mussen's original human stereotaxic apparatus has prompted us to report the salient points of his career. Mussen, like Clarke,[2] foresaw the immense potential of the stereotaxic technique for surgery in the human 30 years before this method was first applied to man.[16] His ingenious device unfortunately received little attention, probably because he could never convince a neurosurgeon to use it. Similarly, for a long while his innovative work in neuroanatomy and neurophysiology was also overlooked. We hope this article will contribute to a wider awareness of Aubrey Mussen's important role in the history of the neurosciences.

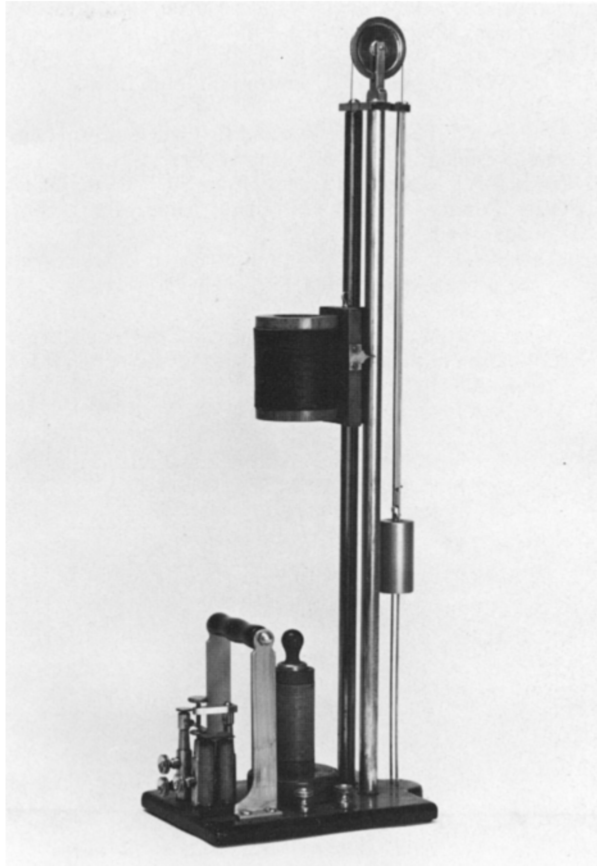

FIG. 3. Apparatus designed for electrode stimulation of brain structures in animal experiments.

Acknowledgments

The authors wish to thank Dr. Victoria Lees for editorial suggestions, Dr. Francis McNaughton, who provided information on Dr. Mussen's work, and Ms. Iris Shestowsky for her secretarial expertise.

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Manuscript received February 16, 1983.

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