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The Horsley-Clarke Stereotaxic Instrument: The First Three Instruments

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Dr. Marshall received her Ph.D. in 1935 from the University of Chicago, where she also met and married Wade H. Marshall, and developed her lifelong interest in the Neurosciences. She was in the Aviation Medicine program at the NIH from 1943-46 and as a research physiologist from 1946-65. From 1965-75, she was a professional associate at the National Research Council with executive responsibility for the Committee on Brain Sciences which spearheaded the drive to found the Society for Neuroscience. She served as Acting Secretary-Treasurer for the Society in 1969-70. From 1975 to the present, she has been associated with the Brain Research Institute Neuroscience History Program in collaboration with Dr. Magoun. Dr. Magoun has in preparation a book on the history of the anatomy of the brain and played an active role in the revival of the Horsely-Clarke Stereotaxic instrument in Ranson's Institute of Neurology at Northwestern University in 1928. Dr Marshall can be reached at 213-825-3191. The following article is copyrighted by L.H. Marshall.

Editor's Note: *The first part of this article appeared in the previous issue of the Carrier. In that article, Drs. Marshall and Magoun gave a detailed account of the initial development of the Horsley-Clarke Stereotaxic Instrument and its in-ital use around the turn of the century. In this part of the history, the instrument is traced through its subsequent use and development to the time at which the Stereotaxic instrument began to receive more widespread use and acceptance. Copies of the previous Carrier may be obtained from Kopf'Instruments or from the Editor.*

Experimental Application of Horsely-Clarke Unit One

Although publication of the results of the experimental use of the Horsely-Clarke apparatus had been twice-promised by its creators, the first purely experimental work was reported by a vis-itingvAmerican, Ernest Sachs (1879-1958). Born into a gifted and cultured New York family, Sachs was educated at his father's private school and Harvard, and graduated from Johns Hopkins Medical School. On the advice of his uncle, neurologist Bernard Sachs, and after a residency at Mount Sinai Hospital, New York, the young surgeon spent the greater part of a two-year period of postdoctoral training with Victor Horsley, who at that time had the only well established neuro-surgical practice in the world. Sometime during those years, 1907 to 1909, Sachs used the instrument in a study suggested by Horsley of .the poorly known optic thalamus, a situation largely remedied after publication of the results in 87 tightly written pages (1909). After thanking Sir Victor for help and encouragement, Sachs stated "I am also much indebted to Dr. R. H. Clarke... for the use of his Stereotaxic instrument. To Miss E. Clarke's [presumably a sister] unflagging interest and careful assistance the results obtained are in a great part due" (p.96). Perhaps the most significant contribution of this early endeavor in a long and productive career may be gleaned from three items in the 11-point summary:

"From the results of excitatory experiments as well as...very localized lesions the inner and outer divisions of the thalamus appear to be...relatively independent organizations.Jackson lecture of 1901.

Cortical localization or mapping of function became a major experimental interest "The thalami-cortical fibers...are arranged dorso-ventrally, so that those for

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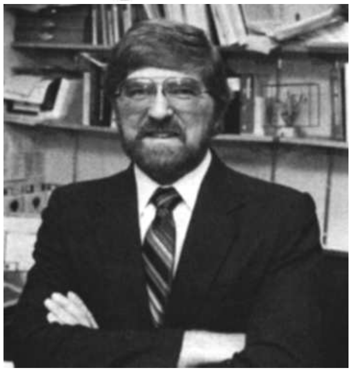

Editor's Column

Spring has arrived in southeast Ohio; a beautiful time here, with the redbud and dogwood trees providing a purple and white covering to the woodlands in a way not seen in such splendor in 10 years.

Unfortunately, we must report here the passing of one of the giants of the Neuroscience community. Dr. Horace W. Magoun passed away on March 6, 1991 in Santa Monica. He was 84 years old. His career spanned the early days of our discipline and he had a part in not only some of the most exciting discoveries of the times, but also helped shape the environment for those of us who followed in the exciting field of brain function and structure. He and Giuseppe Moruzzi became famous for discovering that the reticular formation had vast influence on cortical arousal and activity, which led to his postulation of the vital roles of the reticular activating system in sleep-waking control. He was instrumental in the early use of the Horsely-Clarke stereotaxic instruments, and had coauthored the monograph of which this Carrier article is the second part, detailing the developmental history of the machine. He was a member of the first Central Council of IBRO and of the NRC Committee on Brain Sciences, from which the Society for Neurosciences emerged. He was an avid historian, with interests in this area dating from his high school days. He was instrumental in compiling a series of 42 posters on the history of the human brain shown at the 1985 Society for Neuroscience Convention in Dallas. He founded the Brain Research Institute at UCLA, as a home for the distinguished group of investigators which he nurtured. Surely, one of the truly great minds and figures of the field of brain research has passed from us. We dedicate this issue of the Carrier to his memory. I also thank Louise Marshall, Ph.D. for providing so many details of Dr. Magoun's life.

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the representation of the face are ventral to those for the limbs.

" The general direction of the large majority of axones...is outwards and dorsalwards" (p.181).

The second study carried out with the original unit was that of S.A. Kinnier Wilson (1878-1937), American-English neurologist at the National Hospital, London, published in 1914. Wilson's experiments on 25 monkeys were "carried out in the laboratory of experimental neurology at University College, under the aegis of Sir Victor Horsley, who performed my operations for me...[I used] stimulation and electrolytic meth-ods...[and] the stereotaxic instrument of Clarke and Horsley...." (p. 439). In his discussion Wilson paid tribute to Sherrington's "...illuminating conception of a 'final common path1 [which] is not further applied by Sherrington in a detailed manner, but by implication may be applied to the problem before us" (ibid., p.484). To summarize his own experimental work with the "Clarke-Horsley machine," Wilson offered a diagram of a specific example of Sherrington's classic concept.

As Carpenter and Whittier (1952) later pointed out, Wilson had serious reservations about destruction of brain tissue. Four points were emphasized by Wilson: 1the remaining tissue may be responsible for many phenomena credited to the lesion; 2-the lesion size does not necessarily parallel the severity of the symptoms; 3the locus of the lesion is not always the locus of the function; and 4lesions in dissimilar structures may produce the same symptoms. Those reservations influenced the young neurologists to launch a comparative study of the stereotaxic technique, as we shall see.

The third investigator known to have used the first unit of Clarke's instrument was a urologist whose sudden death in 1956 almost resulted in its permanent loss. [There have been attempts to reverse the names of the originators (see, e.g., O'Leary and Goldman, p. 197) and Horsley always referred to it as "Clarke's instrument."] The natural history of this near disaster was pieced together by Magoun and Fisher (1980). At the centenary (1957) of Horsley's birth, programs were held at meetings in London, Brussels, and Detroit, at which the British participants were gently chided for not knowing the fate of the original model.

Stimulated by the comments, inquiries were made which turned up a letter written by Clarke

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in 1925 to the instrument maker which furnished some clues. Clarke wrote: "I have given my first instrument which you made...to Mr. F.J.F. Barrington...of the surgical unit, University College Hospital Medical School. [He] has done an excellent piece of work with it which he published in...the Quarterly Journal of Physiology..." (quoted in Shurr and Merrington, 1978, p.35). Barrington's paper reported his experiments on the effect of brain lesions on micturition in cats and we quote from it: "I am indebted to Dr. R.H. Clarke, not only for the loan of his own instrument, but also for the very large amount of valuable advice and help in the earlier experiments. The instrument used was of the older pattern, in which the needle can only be inserted horizontally or vertically...." (Barrington, 1925, p.6). The instrument was later loaned to workers in Oxford and returned. As noted, Barrington died in 1956, and among the contents of his laboratory room, "in true British fashion, was a biscuit tin..."(Ma-goun and Fisher, 1980, p. 33). It contained a number of pieces first thought to be the original apparatus but later shown to be "[o]nly the cere-bellar electrode holder, the spinal apparatus, the grid, and some original electrodes..." (ibid., p.33). After continuing inquiries, a technician in the Royal Veterinary College where Barrington had once worked produced a mahogany box that contained the original model, and it was returned to University College Hospital Medical School in 1970, sixty-five years after its invention. Peter H. Schurr, British neurosurgeon who provided valuable information about the by-then historic apparatus, wrote that "[t]he instrument is illustrated in Palmer's catalogue (W150) [about 1910] quoting the reference in Brain, and offering it at a price of/60!" (letter Schurr to H.W.M., 20 July 1976).

This trio, then, of experimental studies that utilized the stereotaxic instrument, by Sachs, Wilson, and Barrington, constitutes the extent of its use in England. Only by chance, years later and many miles away, did the machine fulfill the promise of its pivotal role in modern neurosci-ence.

Clarke's Contribution

There is little doubt that the concept and the design belonged to Clarke, as his colleague always maintained, but Clarke's share of the overall accomplishment was limited. Geoffrey Jefferson wrote in his centenary lecture (1957, p. 908) that Horsley's curiosity about the roof nuclei of the cerebellum and his grasp of the physiological neccessity for such an instrument provided the motive for its development: "What a lovely bit of mechanism [Clarke] designed - he never would have done of course had it not been for Horsley" (letter Jefferson to H.W.M., 14 February 1957).

The team of Horsley and Clarke fell apart with the publication of the instrument's description. No precipitating event is recorded, but the disintegration of their friendly collaboration seems inevitable in view of their opposite personalities and the divergence in their careers. In an interesting letter to Clarke's biographer, Sir Francis Walshe, British neurologist, wrote: "I think...that Horsley's radical politics had more to do with their falling-out than Horsley's ambition..."

"But you can see that a rather bucolic Tory, a chaser of the fox and a man who liked his toddy, would act cross with Horsley as his temperance hobby became more prominent..."(letter to Richard A. Davis, 13 April 1965, by kind permission).

Jefferson, too, believed that as Horsley approached his fiftieth year, it was not surprising that experimental and clinical activities that had brought him many honors should become less appealing. Late in his career, Horsley became a crusader for social causes, as already mentioned. Clarke, in contrast, persevered in working with and improving his instrument without Horsley to guide its experimental use.

The collaboration of these two men, each with his own sphere of expertise, may be regarded as an exemplar of the symbiotic relationship possible when engineering and science impinge. (We are indebted to L. Roderick Zweizig for the information that in the 1950s this example was introduced into lectures to students of engineering at UCLA.) Although Clarke may not have had formal training in engineering, there was a breadth to medical education in the late nineteenth century that may have encompassed some acquaintance with mechanical principles. A related point of view was expressed by Clarke's biographer, Richard Davis, who wrote euphorically "The intangible spark of originality which can create...the magnificent instrument designed by man's hand is evanescent and elusive but was given to Robert Henry Clarke. It may have occurred to the investigator, interested in nervous system physiology..., that the geometric form, configuration, and beauty of [the] instrument suggest a fundamental unity between the cultures of art and science" (1964, p. 1340).

Subsequent Models

Four years after its first description, Clarke with another collaborator, the British ophthalmo-logical surgeon and illustrator,

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E. Erskine Hen-derson, published an accumulation of improvements in apparatus and methodology and plates of cat sagittal cranium and brain sections that constituted the first stereotaxic atlas (Clarke and Henderson, 1912). Working now in the Laboratory of Pathological Chemistry at University College (Horsley's laboratory was in physiological chemistry), the authors announced that these sagittal sections of cat brain were the first of a "complete series of sections in three planes of the brains of the cat and monkey, which we hope eventually to complete" (p. 391). That hope was delayed by World War I, which brought about the closure of the laboratory, loss of the instrument maker, and the necessity of finding another publisher. During the interim, Clarke devised and tested "the second [rectilinear machine] which I have designed" (Clarke, 1920, p.vi). Clarke not only modified the original design according to experience with its use, but also supplemented the rectilinear movement by "an arrangement which provides for an inclination of the needle at various angles" (p.v).

A tantalizingly short obituary of Clarke stated: "[He] had one of the best all-round intellects that I have ever come across. He did an enormous amount of original work for which he did not get adequate credit...." (Turner, 1926, p. 229). A biography in depth of Robert Henry Clarke seems long overdue, to balance the acclaim of Horsley's life and contributions.

The Instrument of Ernest Sachs

While training with Horsley in London, Ernest Sachs had utilized the original unit, as already noted, and was so impressed by its potential usefulness in his work that he purchased from Palmer and Company a second unit, described in his autobiography as "...an exact copy of the original that had been invented by Clarke [Author's note: Doubt has been expressed that the first and second units are replicas; a close comparison of unit two with the design published in 1908 revealed differences found by Dr. Eugene Stern, Professor Emeritus of Neurosurgery, University of California Los Angeles- personal communication]...It is to be regretted that all this work that was initiated by Clarke is never attributed to him and that his name is almost unkown. I...know the many years and large sums of money he spent in developing and perfecting his apparatus" (Sachs, 1958, p.50-51). Sachs took his instrument with him in 1911 when he was appointed in surgery at the reorganized Washington University Medical School, St. Louis, and soon found himself acting professor of surgery during World War I. "When the authorities, feeling a sense of obligation for my work during the war, asked what I would like to do, I was ready with my answer: to have my own Department of Neurological Surgery, which I had been brought to St. Louis to develop, and which I had actually developed" (ibid., p. 64). Thus was Victor Horsley's legacy spread directly to the American Midwest by one of the prime promoters of the concept of separation of the speciality of neurosurgery from general surgery. In addition, Sachs had the vision, as did Robert Clarke, to grasp the possibilities of the stereotaxic approach to surgical precision in the brain.

Robert Clarke was as persevering in his friendships as he was in improving his machine and completing the sections of cat and monkey brains needed as references for the stereotaxic placement of the needles. In 1919, after war-time disruptions and again while convalescing, he wrote to Sachs in St. Louis: "I should much like to see you again and have a talk....[If this note reaches you,] there will be a variety of things I wish to write about" (letter R.H. Clarke, 8 September 1919 to Ernest Sachs. The letter was generously given to H.W.M. by Dr. Sachs in 1956.) Five years later, Sachs reported, "We received a letter from...Dr. R.H. Clarke...requesting that I reinves-tigate the cerebellar nuclei, using his instrument, as he and Horsley had never completed the work. Last fall...an opportunity presented itself of taking up this work and...I feel we have gone far enough to justify making a first report here" (Sachs and Fincher, 1926, p. 350). In that short, preliminary report, the authors concluded that the only movements of the eyes produced by stimulation of the globus and fastigial nuclei are conjugate deviation associated with turning of the head; that nuclear and cortical cerebellar fibers project to the region of the red nucleus; and that Horsley and Clarke's previous (1908) conclusion "that all cortical cerebellar fibers only go to the nuclei, is not correct" (ibid., p. 356).

This preliminary report by Sachs and Fincher was the fifth paper delivered at the Symposium on the Cerebellum held in London the summer of 1926 at the combined meeting of the Section of Neurology of the Royal Society of Medicine and the American Neurological Association. That paper was preceded by the account of A.T. Mus-sen's investigations made at Johns Hopkins University "with the aid of the stereotaxic instrument and a bipolar needle" (Mussen, 1927, p. 313). No further reference was made to the

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apparatus, but we know that again Clarke was directly involved. When he and Henderson were seeking a new publisher for the remainder of their series of cat and monkey brain sections, and the Hopkins's Phipps Institute was anxious to possess a stereotaxic machine, Clarke sold his "third, much embellished instrument made by Velacott for Palmer...with the proviso that...[the] description of it would be published in a special volume of the Johns Hopkins Medical Reports" (Magoun and Fisher, 1980, p. 37 footnote).

The consensus of the papers delivered at the symposium in 1926 on the cerebellum at which the Sachs and Fincher results were presented was that "Perhaps there is no subject in neurology today about which there is more controversy than the function of the cerebellum" (Weisenburg, 1927, p.357). Although the confused nomenclature of symptoms of cerebellar lesions received partial blame, the 20-year hiatus in the application of a proven experimental methodology must also be taken into account. The chance observation of the Horsley-Clarke instrument "in action" was the key to opening the door to its successful widespread application. The Fincher experiments on the cerebellum were observed by one if not both of a pair of neuroscientists who had moved to Washington University from Chicago, Professor S. Walter Ranson (1880-1942) and his graduate student, Joseph Clarence Hinsey, III (1901-1981).

The trail of the instruments touched directly by Clarke's hand ends with these three early units. To recapitulate, the first unit was loaned in succession to Sachs, Wilson, and to Barrington, then it reposed on a shelf until discovered through an organized search. The second unit was used by Sachs in St. Louis and never lost as we shall see. The third was used by Mussen at Hopkins and has unfortunately suffered the fate of the "disappeared."

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