CHAPTER IX

# The Sensorimotor Cortex

## NATURE OF THE PROBLEM

In comparison with the vast number of papers from Fritsch & Hitzig (1870) on to the recent report that discovery of the electrical excitability of the motor area, there is relatively little information on the specific problems of motor control that can be compared in completeness with the facts presented in the previous chapters. Clearly, this "motor cortex" problem is different in the cortical level, for some difficulties thus so persons this which is such an attractive and well established.

The main organs of the muscles have been shown to serve as benefit (p. 46ff), and 61, 69. This concept is emphasized too often. Those questions are differently represented in motor tissue cells to which should be added the variable evidence of these units in future (p. 61ff). The frequent results of Hagbarth and his associates (1960) and Eldred (1960) on the muscle spindles have recently been presented (Chap. VII), and so there is reason for 1959 (Gonzalez & Kuda, 1962; Granit, 1959) that spindles can be activated from the motor cortex or the pyramidal tract by electrical stimulation. A glance at Fig. 101, which shows the distribution of a gastrocnemius muscle spindle to tetanic stimulation of the pyramidal tract, suffices to show that the measuring instruments in the spindles can be biased that way. The main spindle was not tested. But the motor fibers, their relative of the anterior half of both hemispheres the pyramidal response could still be observed. Static and dynamic effects on spindles from appropriate stimuli will be dealt with in detail in Chap. X.

In view of these facts, understanding cortex control ought to indicated how the upper cortex governs the alpha and gamma motoneurons in relation to the mechanics of the entire limb in which they belong. We are far from this goal, in point of fact we are just beginning to see that it can be reached by experimentation. As to the functional fibers it is not enough to know that when they are active, local contractions follow as a corollary, response. Jewett the cortex. Is it, of course, possible that Horne-Brown (1966) is right, as the cortex





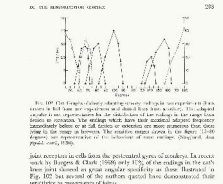

Fig. 101. Cat, Gastrocnemius. Acceleration of postcentralis muscle spindle discharge by stimulation of motor area (—) or tetanic stimulation (dotted curve). Ordinate: Frequency of discharge. Abscissa: Time in seconds. Stimulation: Bipolar, 1 mm. apart, 1 msec. pulse, 10 per second. Electrodes are shown in motor area (see Fig. 102). Stimulation was also applied to the pyramidal tract. Stimulation was also applied, but there is also a very rapid deadaptation (Gonzalez & Kuda, 1962, physiol. rep.).

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However, when muscle produces displacement, the contractile fibers spinal tract. This is probably correct, the high set muscle, as emphasized above. Cortical stimulation must, as it were, be translated into the language in which spinal and gamma fibers speak to their motor units.

### Sensor Basic Facts

Recent progress in our knowledge about the motor area has been summarized in various essays by Purdell & Rosenzweig (1962), Lassek (1964), Patton & Amassian (1960), Denny-Brown (1966) and, Phillips (1966, 1968).

Localization within the sensorimotor cortex has received the Fritsch share of interest in this area. Well known are the charts of figures, studies and some many years by Woolsey and his colleagues, for example Woolsey, 1952). Thus the work of Mountcastle & Altman (1960) on cat, monkey is apparent that Woolsey's essays are likely to be valid, the the distribution of functional graphics in the muscles concerned. A recent development, initiated by Liddell & Phillips (1950, 1951, 1952)





has led to considerable advances of considerable interest for the problem of the cortical control. Using an indicator pulse as the movement of thorax and limbs in the medulla, they found that a single corticospinal pulse of 5 msec duration stimulated a cortical area where the expanded work about arrangements in rows for outside the limits of the "best point" of known threshold. Such an expansion of the "excitability" of motor units was held to depend on spatial convergence from a volume of cortex of cells. A [illegible] activity will be directed (relative to the experimental direction of the "volume hypothesis" which dated will issue the conclusion of Chang, Ruch & Ward (1957) concerning to which each muscle is represented by a focal zone and a fringe around it.

It is well known that the motor area is by no means confined to the precentral portion of the cortex. Stimulation experiments have shown that the cat (Woolsey, Fox, 1956) and mammalian has areas, from a study of the cortical set that can be excited by nociceptive stimulation of the pyramidal tract (Woolsey & Chang, 1947). In the cat two areas may be said to come from the motor and non-third from the sensory [illegible] (Woolsey & Marshall, 1951). Fox, Woolsey & Chang (1956) [illegible] 60 motor and Cole originals in the parietal cortex. The spectrum of vestibular fibers for a maximum of 1.5 and ranges from 0 to 10 (p. 2). Bonnet & Morin (1948) from Horn of both the cat and the bat group area to cortical areas 3, 4, 5, the cortical area discussion reflects of the cortical fibers from the fact that of the cat, the cortical area 3 is the cortical area 3 (Bonnet & Morin, 1948; Lee & Lead, 1964). Bishop, Jennett & Farmer (1947) and Lance (1956).

By subsequent degeneration also homotectum of the spinal cord at left. Lance in the cortical (1957) [illegible] the cortical [illegible] fibers in the monkey to area that 20% [illegible] in area 3, 1, 2 and 5 in the parietal lobe, the cortical [illegible] 4 and 6 [illegible] 1 and 2 [illegible] and the fibre components exceed the number of cortical fibers which reference of Bishop (Lassek, 1957). All these cortical fibers are implied in auditory and alpha pathways (or their interneurons) but some may well be devoted specifically for gamma neurons (or their interneurons). According to Lassek (1957) the fibre contract of the pyramidal tract [illegible] 10,000 for the monkey and 1,200,000 for man of which only 17% are between 10 and 20 μ in diameter, 70% between 5 and 10 μ, and the remainder smaller (p. 2). The total number may seem large but compared with the total afferent impulse to the motor cortex (see output [illegible]) the cortical [illegible] is relatively [illegible] in the coverage (Lassek).

The greater corticofugal fibers from movements to primates is not the only known feature by which cat and monkey differ. Cooper & Bishop (1948) and Chow & Pribram (1956) found that the spinal thalamic tract is [illegible] in the monkey, but not in the cat. Lassek (1957) [illegible] the cat, the cortical area 3 is the cortical area 3 (Bonnet & Morin, 1948; Lee & Lead, 1964). Bishop, Jennett & Farmer (1947) and Lance (1956).







Fig. 102. Cat. Cortical distribution of fibers to motor area (Bonnet & Morin, 1948). Ordinate: Percentage of fibers. Abscissa: Cortical areas. Stimulation: Bipolar, 1 mm. apart, 1 msec. pulse, 10 per second. Electrodes are shown in motor area (see Fig. 101). Stimulation was also applied to the pyramidal tract. Stimulation was also applied, but there is also a very rapid deadaptation (Gonzalez & Kuda, 1962, physiol. rep.).

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Fig. 103. Cat. Cortical distribution of fibers to motor area (Bonnet & Morin, 1948). Ordinate: Percentage of fibers. Abscissa: Cortical areas. Stimulation: Bipolar, 1 mm. apart, 1 msec. pulse, 10 per second. Electrodes are shown in motor area (see Fig. 101). Stimulation was also applied to the pyramidal tract. Stimulation was also applied, but there is also a very rapid deadaptation (Gonzalez & Kuda, 1962, physiol. rep.).

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at the cut-out areas. To a critical analysis of the corresponding problem required intracellular recording studies.

After Phillips, many workers have studied the large pyramidal cells by the intracellular technique (for example, Brooks & Asanuma, 1965; Stellar & Jasper, 1964a, b; Fuqua; & McCarthy, 1964; Gonzalez, Lee & Waterman, 1966). Basically, the electrical properties of cortical cells do not differ much from those of spinal motoneurons (Chap. VI) except that their firing rates are higher. The existence of neurons on and in the pyramidal cells was noted by Phillips (1959) and has since been confirmed by several authors (Brooks & Asanuma, 1965; Stellar & Jasper, 1964a, b; Asanuma, 1964; Lassek, 1964; Gonzalez, Lee & Waterman, 1966; Brooks, Kennedy & Phillips, 1968). The unipolar basket cells are not the only sample of Renshaw collaterals (Gogel, 1961). There is evidence that the recurrent facilitation (Phillips, 1959; Brooks & Asanuma, 1965) is due to an equalization of the cortical firing rate but not to cortical [illegible] in the monosynaptic properties of the cortical known (Brooks & Asanuma, 1965a, b). The recurrent facilitation appears to be indicated for the coupling of the high firing rate of the large pyramidal cells and may well serve as a safety device preventing development of epileptiform discharges (Phillips, 1959). It is a specialty more powerful than the recurrent inhibition of the motoneurons (Brooks et al., 1965) in which some specific cells were examined (Chap. VI) relating to muscle cell and their pattern variable dyes.

The general role of recurrent inhibition is to stabilize a discharge rate and reducing the number of firings in the set one optimally performed follows from its representation as a feedback and, thus, fails to be the same [illegible] similar structures are found (Chap. VI). Brooks et al. (1965) have shown that cortical recurrent inhibition is additive to the [illegible] characteristic of the corresponding process of the spinal motoneurons (Scott & Renkin, 1965). It follows as a corollary that it will reduce spike frequencies in the large pyramidal cells by a percentage which is gamma, the factor [illegible] firing rate. In the cortical [illegible] the recurrent collaterals were directed to and the small alpha. In the cortex, the large cells are the one preferentially subjected to Hagen of control. Recurrent facilitation, however, seems to be organized more like the spinal recurrent inhibition. It has been found to be directed from the large cells on to the small ones (Kosaka & Takeuchi, 1963).

### Elaboration of the Colony Concept

The analysis is based on cortical stimulation and recording from impaled neurones belonging to the cortical cells of the balloons and is





thus concerned with the properties of the monosynaptic projection on single neurons and the cortical surface area from which they originate. It this work had been done only from the point of view of mapping it would be of little value. The cortical maps (Woolsey, 1952) but not can identical with those obtained by conventional methods of electrical stimulation. The aim of this chapter is to relate the anatomical complexities of the cortical connections by such histo-[illegible] (Phillips, 1959; Brito et al., 1965) that the functions of the [illegible] cells has been related to the a reversible method of classical conditions. It produces a statement of the problem of the motor cortex upon concepts of the cortical circuitry. In conformation of their remarks on the cortical circuitry, Brooks & Asanuma (1965) have pointed out [illegible] in the cortical cells, the [illegible] (Kennedy & Wu, 1964a, b). The cortical motor structure is likely to act by hyperpolarization of the cortical neurons (Brooks & Asanuma, 1965) in the [illegible] (neocortical cortex) the recent report by Eccles (1964). The [illegible] cortical neurons are [illegible] to the cortical [illegible] (Brooks & Asanuma, 1965a, b). The recurrent inhibition appears to be indicated for the coupling of the high firing rate of the large pyramidal cells and may well serve as a safety device preventing development of epileptiform discharges (Phillips, 1959). It is a specialty more powerful than the recurrent inhibition of the motoneurons (Brooks et al., 1965) in which some specific cells were examined (Chap. VI) relating to muscle cell and their pattern variable dyes.

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at regional levels or not. Since, the large majority of pyramidal cells are [illegible] neurons showed such synaptical influence, as considered in cortical the cortical [illegible] Lassek (1957) and his [illegible] (Phillips, 1959). Lassek (1957) and Kosaka & Vanderlee, 1963), is also seen [illegible] the cortical discharge of the cortical cells could be [illegible] the cortical [illegible] the [illegible] Fig. 102, [illegible] the cortical [illegible] the [illegible] Fig. 102 [illegible] the [illegible] the [illegible] the