some of these experiments, Dr José M. R. Delgado of Yale University, one of the foremost practitioners of ESB research, notes that laboratory animals have been made 'to perform a variety of responses with predictable reliability, as if they were electronic toys under human control'.

Here again we must return to the notion of participant evolution – something that has a nice, democratic ring about it – and concede that only a *few* might be doing the participating. Such was the case in Aldous Huxley's prophetic novel *Brave New World*, in which genetic engineering is used to establish a biochemical hierarchy in which some are decidedly more equal than others. ESB, similarly, could be used to establish an electrohierarchy, with a powerful 'Electroligarchy' governing the masses with the aid of computer-controlled electrodes. A frightening future of this sort is envisioned in Chapter Four, in which, in place of Huxley's biochemical strata, there are electronic castes. At the bottom are the 'Neutrons', individuals with the greatest number of implanted electrodes, robotised for low-grade labour. Above them are the 'Positrons', with fewer electrodes, designed for white-collar work. And above them the 'Electrons', the most creative members of society with fewer still electrodes (but with enough to ensure their loyalty to the ruling zero-electrode Electroligarchy).

But, you are thinking, even though the technology for such a world may be at hand, we will never permit such a thing to happen; without the co-operation of the masses no oligarchy, no matter how powerful, could ever implant electrodes in the brains of every one of its subjects – or even of a majority of its subjects. This is probably true, but why be so confident that the all-important ingredient in the scenario, co-operation, will not be forthcoming? The 'doomsday denigrators', as a columnist in *New Scientist* calls them, too often overlook man's willingness, in fact his eagerness, to 'cash in' on the latest wonders of Science. To many people, Science – with a capital S – is the new god, to be followed, obeyed, idolised as something that can do no evil, that can solve all ills. But the masses submit to the implantation of electrodes, even if the powers-that-be lure them in by promising 'electronic nirvana'? Nonsense!

Four

MECHANISING THE MIND

BRAVE NEW WORLD OF ESB

Animals with implanted electrodes in their brains have been made to perform a variety of responses with predictable reliability as if they were electronic toys under human control.

– Dr José M. R. Delgado
Yale University School of Medicin

The once-human being thus controlled would be the cheapest of machines to create and operate.

– Curtiss R. Schafer
Electrical Engineer

In the field of brain physiology, I think it [ESB] is the most exciting single discovery. . . . I am almost frightened to say what I think might come of this. . . .

– Dr Robert H. Fe
Testifying before the Senate
Appropriations Subcommittee on Hea

Man is possessed of an almost overwhelming desire – some insist that it is actually an *instinct* – to explore, to pit himself against the unknown, to charge headlong into the frontier whatever its nature, whenever and wherever it might present itself. Alas, the opportunities for challenge, confrontation and conquest on the land inevitably must dwindle as rapidly as the wilderness itself, and that has been very rapidly indeed. Man has blazed his destructive trail to every corner of the earth. DDT is now detectable in significant quantities in the 'remote' polar caps; once beautiful lakes and rivers are now open sewers; beer cans and even rusting auto bodies are there at trail's end to greet the most ambitious 'wilderness' backpacker; 'camping out' is now an exercise in togetherness with no greater challenge than finding a place to park the old (TV-equipped) Kamp King.

Where are the new frontiers? The oceans? Possibly – but only for a few, and for only a little while. Some ecologists fear that even these great bodies of water will be almost irretrievably polluted in two or three decades. Thor Heyerdahl, on his papyrus-borne odyssey across the Pacific, expressed horror at the abundant bobbing, floating, reeking evidence of man's 'progress' that persisted even into mid-ocean: cans, bottles, garbage, unidentifiable sludge and, of course, the innumerable and practically immortal oil slicks. More subtly offensive are the tons of pesticides and phosphates that ultimately seep into the oceans from the ground water, not to mention the nerve gas that is deposited there directly by man.

And so, perhaps, space? A good bet, provided we still have enough resources to spend much time there. But even then only a few will ever be able to venture to the other planets (at least in the forseeable future), though many others may benefit vicariously, as outlined in the preceding chapter. Are there no other possibilities? Yes – *one*. And it could prove to be the most significant wilderness of all, a frontier which, if 'conquered', could obviate the 'need' for *all* other frontiers. This is the frontier called 'mind'; some of the pioneering excursions into this (until recently) almost entirely uncharted world are described in this and the subsequent chapter.

Exploratory progress in this realm has been such to date that Dr Carl R. Rogers, professor of psychology at the University of Wisconsin, has been moved to state that 'we have in the making . . . a science of enormous potential importance, an instrumentality whose social power will make atomic energy seem feeble by comparison'. Dr B. F. Skinner takes a similar view: 'Science,' he says, 'is steadily increasing our power to influence, change, mould – in a word, *control* – human behaviour.' So does Dr Robert S. Morison of the Rockefeller Foundation: 'Knowledge of human behaviour,' he observes, 'is becoming organised and accumulative. . . . It is becoming scientific. . . . It is not too early to prepare ourselves for the day when there will be a behavioural science which will make possible the control of human behaviour with a high degree of precision.'

That day, in fact, appears to be dawning. What man will make of it remains to be seen. This frontier, more than any other, has a potential for exploitation by the self-serving and the shortsighted. If wisely managed, however, it can provide the greatest return of all, something that is often yearned for but seldom attained: peace of mind, possibly even mind leached of its destructive urges.

Electronic Stimulation of the Brain

Though the 'battle for men's minds' is being waged on several fronts, attention here is focused on the approach that promises the most dramatic results: electronic stimulation of the brain. ESB, as it is called, provides a means of 'mapping' the mind, of locating within the brain the specific sites at which various categories of emotion, feeling, action and thought originate. More than this, ESB provides a means of exerting some *control* over those feelings and actions. It can even help reactivate parts of the brain that have ceased functioning because of disease or trauma, induce immense pleasure, override 'intractable' pain and, for a finite period, enable one to relive one's past, even the most remote, 'unremembered' past.

Recent rapid development in ESB technique follows upon what was rather a slow start. Direct electrical stimulation of the brain, in fact, dates back nearly two centuries to the experiments of Volta, Galvani, du Bois-Reymond and others, who discovered that the brain is more susceptible to electronics than to obscure chemical forces ('animal spirits', they were called) that were in vogue up to that time. During the Franco-Prussian War of 1870, battlefield brain surgeons used crude electronic probes that would curl the hair of today's neurologists in an attempt to locate damaged brain tissue. They would simply stick wires into the brain, apply the electrical voltage and wait for some response, a twitch here, a kick there, an erection, excessive salivation, etc.; if *no* response was forthcoming, the surgeon would assume brain damage in the area under stimulation. Then he would

generally take scalpel in hand and excise the affected tissue – usually to rather horrible effect.

This medical 'technology' lay mercifully dormant for decades after the war – until Dr Walter R. Hess, a brilliant Swiss neuro-physiologist, devised the modern technique of electrode implantation in 1932, demonstrating in the process that nearly all of man's functions and emotions can be influenced by electrical stimulation of specific cerebral areas. 'For the first time,' observes Dr José M. R. Delgado, one of the foremost practitioners of ESB research, 'it was revealed that psychological manifestations like rage do not depend exclusively on sensory inputs and physiological stimuli, but can be induced by electrical currents applied directly to the brain. Although these findings did not produce a significant impact on philosophical thinking, in retrospect they may be considered as important as the nineteenth-century demonstration that the contraction of a frog muscle did not depend on circulating spirits and could be controlled by physical instrumentation.'

Epoch-making as Hess' work was, it wasn't until nearly twenty years later that he received the Nobel Prize for his discoveries. And it is only now that ESB is coming into its own as a routine procedure in animal studies and, on a much smaller scale as yet, as a clinical tool for treatment of human disorders. As a research tool alone, it is invaluable, for it makes possible, *for the first time*, physiological exploration of the *conscious* mind.

Presenting the annual James Arthur lecture on 'The Evolution of the Human Brain' in 1965, Dr Delgado, a professor of physiology of the Yale University School of Medicine, cautioned that ESB is not a panacea for all of man's woes, 'but I do believe', he declared, 'that an understanding of the biological bases of social and antisocial behaviour and of mental activities, which for the first time in history can now be explored in the conscious brain, may be of decisive importance in the search for intelligent solutions to some of our present anxieties, frustrations and conflicts. Also, it is essential to introduce a balance into the future development of the human brain, and I think that we now have the means to investigate and to influence our own intellect.'

Wiring the Brain

To understand fully the impact ESB may have in the very near future, it is important first to understand something of the actual technique of implanting electrodes in the brain. Thousands of laboratory animals, including cats, rats, dogs, dolphins, bulls and even crickets, have been wired, some with more than one hundred electrodes. Dozens of humans, most of them suffering from serious diseases or mental disorders, have been similarly wired – some with scores of electrodes and for periods in excess of a year. To date, electrodes have been left intact in lab animals for more than five years without any visible ill effects.

The procedure for implanting electrodes in humans (basically the same as for animals) goes like this: air or radiopaque material is injected into the intracerebral spaces inside the skull so that the various parts of the brain can be visualised by means of X-rays. A metallic skullcap – called a stereotaxic machine – is attached to the head with three or four little spikes that penetrate the scalp. Then X-rays are taken from various angles. ESB experiments during recent years have provided increasingly detailed maps of the brain, thus making it possible to pinpoint the exact areas they wish to stimulate. They make geometrical calculations, using the X-rays and the reference-point grids on the stereotaxic apparatus, to get three-dimensional co-ordinates for positioning of electrodes.

When the desired target is fixed, the subject is further anaesthetised and small burr holes are drilled into his skull at the appropriate points. Micromanipulators on the stereotaxic machine are used to guide the hair-like stainless steel electrodes through the holes, sinking them to the desired depth in the brain. Some of these electrodes are only a millionth of an inch in diameter – *small enough to be placed inside an individual nerve cell*. Even the larger electrodes, however, leave brain function unimpaired and are entirely painless because the brain itself has no sense of 'feel'. Once the electrodes are in place, their exposed ends are attached to small terminal sockets that are cemented to the scalp. Electrical current, measured in millionths in most cases and lasting only fractions of a second, is passed through the sockets and discharged at the tips of the electrodes, providing the desired stimulation of the brain.

Originally, the electrical wires feeding into the sockets were connected to bulky consoles that were immobile for all practical purposes. This had obvious disadvantages since it didn't permit spontaneous movement and, of course, restricted the subject to a small area. Deranged individuals and rambunctious lab animals, moreover, often tried to rip the electrodes out of their skulls with less than felicitous results. To circumvent these serious problems and achieve a more natural man-machine symbiosis, technicians developed stimulators packaged in collars, small backpacks and little boxes that fit securely on the crown of the head. These contain batteries, transistors and timing devices to regulate and control the stimulation. They also serve as receivers, tuned to pick-up radio signals from remote operators who can regulate the tempo and intensity of stimulation in whatever way they desire at any given moment.

Researchers at the Yerkes Primate Centre in Atlanta have developed a head unit that is even equipped with a solar cell so that free-swinging monkeys need never come in for a recharge. Emphasis is very much on miniaturisation, and Yale's Dr Delgado and his colleagues have developed portable instruments tiny enough to fit inside the head bandages of their human patients. Some of them conceal their electronic head-gear under wigs and hats. Very soon researchers hope to have terminal devices that can be wholly implanted under the scalp. But whatever the gear, the result is much the same. When current is discharged into the brain the patient reacts. He may be induced, for example, to hold his arm out rigidly in front of him. He may be induced to sleep or to work happily. In many cases the patient forgets that he is being artificially stimulated. At any rate he never feels that he is doing something against his own will. Stimulated to make a specific motor action, he 'feels' that he himself created the stimulation.

Government by Electroligarchy

The incredible power that one can exert over an individual's actions and emotions with ESB has given rise to some alarm. What works for lower animals in this realm can also be made to work for man. Most scientists assume, of course, that this technology will remain in (their) benign hands, ushering in a new era of 'electronic nirvana'. But if the technology should fall into decidedly unscrupulous hands (and this must certainly be considered a possibility), then a strange and fearful world could result.

An electrical engineer named Curtiss R. Schafer alluded to this very possibility in a paper he presented before the National Electronics Conference in Chicago some years ago. Half in jest, he proposed that computer-controlled electrodes be implanted in the brains of babies a few months after birth, robotising them for life. 'The once human being thus controlled would be the cheapest of machines to create and operate,' he pointed out. 'The cost of building even a simple robot, like the Westinghouse mechanical man, is probably ten times that of bearing and raising a child to the age of sixteen.' Other scientists have admitted the possibility that governments could try to control citizen behaviour by techniques of ESB.

The vision of a society controlled by such a government is not pleasant to contemplate – yet it is certainly as 'realistic' as that envisioned by Aldous Huxley in his famous novel *Brave New World*, in which the masses were *bio-chemically* stratified via the sort of genetic engineering that is already becoming possible in laboratories around the world. An electronically contrived Brave New World, however, might actually be easier to achieve. The stratification here, of course, would be somewhat different, as the following scenario will demonstrate:

To begin with, let us imagine a conspiracy participated in by a small group of powerful men who seek to 'optimise' society. Noting the fantastic potential of ESB, they envision themselves at the top of an electronically sustained socio-structure that might be called the Electro-hierarchy. The conspirators, let us say, are leading figures in the military-