New Frontiers of the Mind

By GILBERT BRIGHOUSE

PSYCHOLOGY is a young science, perhaps the youngest. Born about 1860, it has the lusty enthusiasm of youth, and youth's proneness to error; yet in its short life psychology already has had to meet three obstacles to progress. First are the barriers imposed by the enemies of psychology: a small but articulate group who find something indecent or frightening in investigations of mental life. They feel, with Immanuel Kant, that consciousness is so personal that it should not be probed. Perhaps they fear what insight might reveal. Second are the handicaps of the would-be friends of psychology; a larger and much more menacing species which includes those who have read a book on abnormal psychology and then proceed to diagnose the defense and escape mechanisms of their friends and relations: those pseudo-scientists who prey on the gullible with astrology, numerology, palmistry, phrenology, and other schemes. As the term "psychologist" is not legally recognized, any of these "friends" can call themselves psychologists with impunity.

The third obstacle to the development of psychology has been the personalities of the psychologists. There is something about the discipline which attracts peculiar individuals. My readers will recognize that psychology is not unique in this respect; even the hallowed laboratories of physics and chemistry are not completely free from eccentrics. Psychology, however, seems to have more than its share.

Despite its conspicuous lunatic fringe, experimental psychology has established itself as a true scientific discipline with carefully controlled methods and an increasing body of established data. Our insight into the human mind is far richer, our appreciation of its beauty and complexity far keener, and our control over its irregularities far more effective than in 1860.

The confluence of three streams of thought—philosophical, biological, and social—made a new science necessary. The ratiocinations of philosophy had carried knowledge of mental phenomena perhaps as far as uncontrolled methods could go. Physiological experiments on the functions of cells and organs demanded study of the total organism. Increasing interest in economics, political science, and history called for an understanding of the individual at the root of all social phenomena. The confluence showed the need; two books showed methods with which to begin. Darwin's "Origin of Species" (1859) gave a rational approach to the study of mental phenomena; Fechner's "Elements of Psychophysics" (1860) posed a series of problems and described experimental techniques for their solution.

RESEARCH AND APPLICATIONS

The first great psychological experiment grew out of an incident at the Royal Observatory at Greenwich in the eighteenth century. Maskelyne, the astronomer royal, had to discharge from his employ a promising assistant named Kinnebrook, because the latter, though conscientious, was unable to observe the transits of stars with sufficient accuracy. Maskelyne made a brief note of the incident in the transactions of the observatory and Kinnebrook passed into oblivion. In the early 1880's, however, the incident was revived when a young American, James McKeen Cattell, doing graduate work in the new psychological laboratory at Leipzig, demonstrated that abnormally slow reaction times had accounted for Kinnebrook's failure. Cattell conducted a series of investigations into reaction times for different sense organs, differences among children and adults, among men and women, normal and abnormal persons, and the intelligent and the feebleminded.

Out of these experiments, techniques have been developed for studying the effects of fatigue, emotion, alcohol, drugs and other influences. Out of these also has come better selection of streetcar motormen, turret-lathe operators, job-printers, hundred-yard-dash men, and combat pilots. Some day we may choose better automobile drivers with reaction time tests.

In the early 1890's the great William James, of Harvard, gave one of his graduate students, Edward Lee Thorndike, the privilege of keeping chickens in the basement of the James' home, since referred to as the first psychological laboratory in America. From Thorndike's pioneering experiments on the learning curves of chick-

Based on a talk at the 1944 Alumni Seminar.

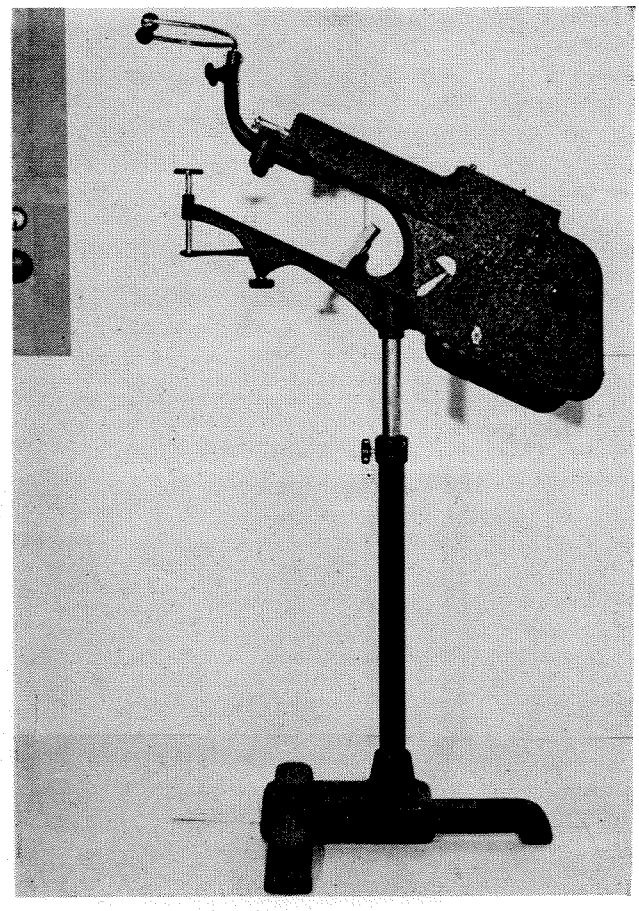


Illustration showing the eye-movement camera. With this equipment accurate photographs of the behavior of the eyes during reading enable the psychologist to determine the exact efficiency of reading and the causes for any bad habits. The subject, who sits at the left of the instrument, reads a standardized test card while light, projected onto his eyes, is reflected back and focused upon a moving 35-millimeter film.

ens, a vast amount of research has given us intimate knowledge of human learning and memory, and practical information on efficiency.

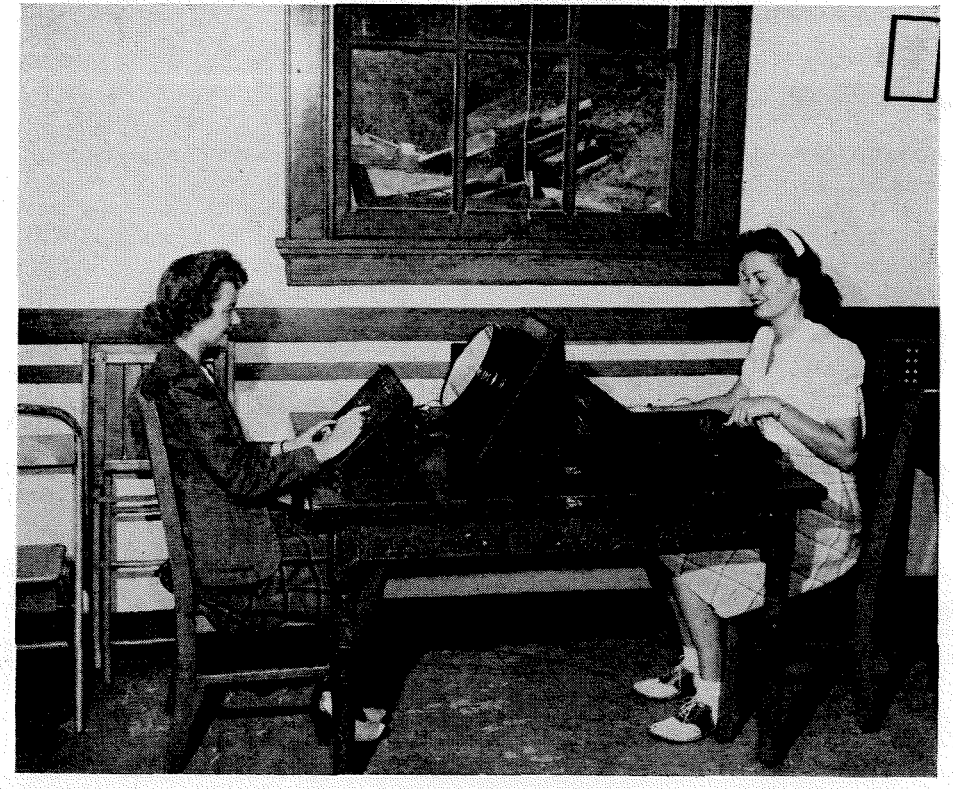
A highly important part of this research has attacked the question: "Do we inherit our emotions or learn them?" Results show that the mechanism for the release of emotion is innate, but we have to learn to perceive emotional stimuli. In other words we are born knowing how to emote, but not why to emote. At birth we respond with a generalized excitement and it is only with the passage of many months that we learn specific emotional patterns. This observation is highly important for our understanding of mental hygiene. For example, if fears are learned, can they be unlearned? Mrs. Mary Cover Jones, of Berkeley, has shown that acquired fears can be eradicated by reversing the process of fear formation. A little boy was conditioned to fear rabbits by having an unpleasant experience (a startling sound) occur whenever rabbits were present. The fear was later removed by having only pleasant experiences (ice-cream or games) when the rabbit was near. The removal process takes much longer than the original fear conditioning and requires expert direction, but in competent hands it is positive and effective.

Another application concerns the eradication of bad habits. Professor Knight Dunlap, of the University of California at Los Angeles, finding that practice often fails to make perfect, has developed the intriguing technique called "negative practice," which consists of intentional practice of the wrong kind of behavior in order to control it. The technique obviously cannot be applied to all habits (chronic alcoholism, for example), but Dunlap has been successful with cases of stagefright and some kinds of stuttering, as well as with such minor bad habits as typing *"hte"* for *"the."*

BRAIN FUNCTIONS

In 1861 a French surgeon and anthropologist named Broca was called in for consultation on the case of a soldier who had lost the power of speech. Broca examined the soldier for four days, and on the morning of the fifth, the patient died. Broca made an immediate autopsy, found a lesion or area of damage in the left frontal lobe of the brain, wrote a paper describing the localization of speech in that frontal lobe, and presented the paper and the preserved brain to the French Academy, all by five o'clock that evening. For that one big day, although the soldier remained anonymous, Broca's name goes down in history in the term "Broca's convolution."

That was only one of a number of important developments during the last four decades of the nineteenth century which gave rise in the twentieth century to a host of experiments on brain functions and their relation to mental phenomena. The basic investigations of Professor Lashley, of Chicago and Harvard, are among the most notable. Lashley, who works principally with rats, places the animal on a small pedestal facing a wall. In the wall there are two doors. On one door is painted a triangle, on the other a circle. Behind each door is a shelf with food. The door with the circle is unlatched so that if the animal jumps for that door, it goes down and he can get to the food. The door with the triangle on it is secured. If the rat jumps to it, he bumps his nose and falls into a net below. The order of placing of the two doors is completely random, because rats, having a very keen sense of spatial direction, quickly learn to jump always to one side if the correct door is always on the same side. After some dozens or hundreds of trials, depending upon the I.Q. of the rat, he learns how to jump always to the correct door. Lashley then operates on the rat's brain and removes a small, carefully delimited area, the location and size of which are varied systematically from rat to rat. After recovery from the surgery, the animal is once again tested to see whether or not he has forgotten his previously acquired skill. If he has lost the skill, presumably the destroyed area of the brain was necessary for that skill. By making



AT LEFT:

Reaction time determination. The experimenter, on the left, after a warning signal, presents a light or sound to the subject, who must respond as quickly as possible by pressing down one of the five keys. Through a pair of matched relays, the delicate chronometer, reading in one-thousandths of a second, runs only during the time elapsing between the presentation of the stimulus and the response of the subject. Simple reaction time experiments consist of the re-

An eye movement record. The behavior of both eyes is shown graphically. The duration and placement of each eye fixation and each regression can be measured by study of the film, which also shows eye-coordination and, by means of a standardized test, the degree of comprehension of the material. (a) Above, eye-movement, poor reader—slow, excessive regressions. (b) At right, eye-movement, good reader—poor lateral control.

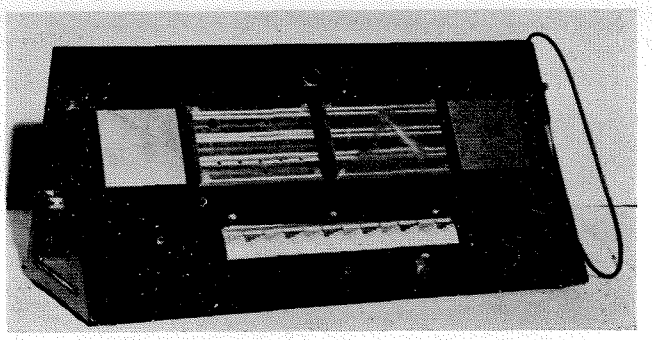
hundreds of such carefully controlled experiments, Lashley discovered just which areas of the brain are essential for various kinds of learning.

More important still is Lashley's observation that under certain conditions a rat which has lost a given skill, through surgical removal of an essential part of its brain, can later relearn that skill, presumably with some other part of the brain. This has significant implications for cases of human brain injury or tumor. An example is that of a little girl of seven who, up to that age, had been developing quite normally and who had a large vocabulary. At that time she suffered an attack of encephalitis, which, after subsiding, left an area of chronic infection in the left frontal lobe. The surgeon had to remove much of that lobe in order to clear up the infected area. After the operation she lost all her speech except the words "No, No" and "Mama." The older view, that there were rigid, permanently established areas for each psychological function, held that this girl, since she had lost the normal speech area, would now be permanently mute. The newer view, encouraged by the work of Lashley and many others, suggested that this girl might possibly relearn speech with some other part of the brain. Accordingly, after several weeks of complete rest, she was given a 15-minute training program each morning and afternoon by a competent speech specialist, who made sounds for her and encouraged her to repeat them. At the end of some 10 weeks, she had acquired about 20 words and was progressing so rapidly and relishing her education so much that the training was intensified. But one evening she had a violent convulsion. She had two more during the night and by morning she had lost not merely the 20 new words, but also "No, No" and "Mama." The convulsions were the brain's way of protecting itself against an over-strenuous program. She was once again given several weeks of rest and then the training was reinstated, this time for only five minutes a day. Her progress was naturally slower, but the convulsions did not reappear, and gradually she was restored to a complete school course. She is now almost 11, has an intelligence quotient of 140 and hardly ever stops talking. Unfortunately, we do not know what her intelligence quotient was before the illness. It is possible that it was somewhat lower than 140, because there are some

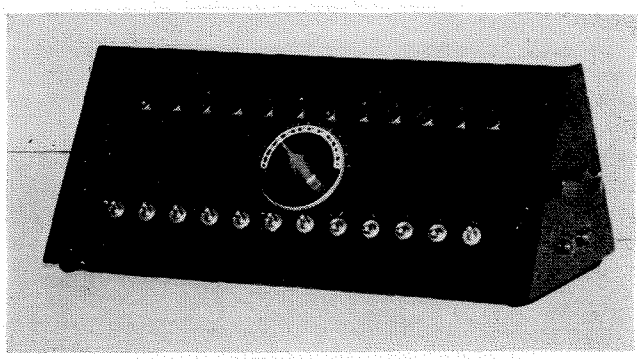
sponse by a predetermined key to a predetermined stimulus. In the more complicated discrimination experiments, the subject has to reply with a certain key for a certain light, and he does not know beforehand which light will come on.

AT RIGHT:

The examiner, on the right, is here presenting one of the tests in the Wechsler-Bellevue Scale, which is one of the best intelligence tests for adults.



With this motor skills apparatus accurate measures of steadiness, dexterity, precision, and reaction time can be made.



The Occidental modification of the Yerkes apparatus allows the psychologist to study the ways in which concepts or hypotheses are formed. Problems of varying degrees of difficulty are set up for the subject on the apparatus. His method of attack shows vividly forms that his mental processes take.

cases where surgery seems to improve intellectual efficiency by removing some of the inhibitions which bedevil so many people. Unfortunately these reeducational procedures as yet are applicable to only a limited number of brain disturbances. The location and size of the injury, the intelligence, personality, and age of the patient all influence the amount of reeducation possible.

INTELLIGENCE MEASUREMENT

Let us go back to the 1880's. Charles Darwin's cousin, Sir Francis Galton, whose career was bound up not merely with psychology, but also with meteorology, statistics, and eugenics, began a series of investigations into the causes of genius. Galton, as part of his program, invented a little test of thinking and imagination. This was apparently the beginning of the intelligence testing movement. About 1900 a better series of tests was begun by a great French scientist, Alfred Binet, who was invited by the French government to discover how feebleminded school children could be distinguished from lazy but bright children.

Out of these beginnings, one at the upper end of the intelligence scale and one at the lower, there has grown up a vast literature on intelligence measurement and a number of reliable techniques for investigation. This movement had its real impetus in 1917, when a committee of psychologists was invited by the Surgeon General of the United States to prepare a group of intelligence tests for the proper placement of Army recruits. The committee's work resulted in the development of two famous measures, Army Alpha and Army Beta. Alpha was given to men who could read, write, and understand English; Beta was for illiterates and foreign born. These tests were given to a total of over two million men, and while by modern standards they were crude, with a considerable probable error, they still did a helpful job in recruit placement. They showed that the most intelligent occupational group in the Army was composed of the engineers. In World War II, the improved descendants of Alpha and Beta are being relied upon very heavily in the classification program of the armed services. Modern intelligence, aptitude, and personality tests are particularly valuable in selecting men for the air corps and the mechanized divisions of the armed forces, and are also used extensively in industry and education.

SOCIAL PSYCHOLOGY

The past 20 years have seen the birth of an experimental social psychology. People say, "There will always be wars because it is human nature to be aggressive and competitive." Can we experiment to determine the truth or the falsity of that assertion? We can and have and know the assertion to be incorrect. Human beings learn to be competitive or cooperative according to the kind of culture in which they are reared. Professor Lewin, at the University of Iowa, has experimented with Boy Scout troops and others boys' and girls' groups. One group was led by an aggressive, self-assertive, domineering personality, who directed activities about as follows: "Boys, we'll take a hike Saturday to Pine Creek. We shall leave at 2:30 and you will bring wieners and buns." Another group was led by a laissez-faire adult who let the boys alone to do as they pleased. A third group was under a leader who guided without directing. If a hike was planned, his group decided where to go, when to leave, and what to take. Of these three, the laissez-faire group became bored and tended to disintegrate. In the autocratic group, friction among boys became increasingly common, cliques formed, and aggressive outbursts against a scapegoat indicated barely suppressed resentment. The democratically led group showed increasing cooperation and, because there was no pressure from above, the boys could afford to feel friendly and generous toward each other. Contrary to the popular belief that competition is essential to success, children in the democratic group worked and played harder and with much more enjoyment than children in the highly competitive autocratic group.

Experimental investigations of this sort are complemented by the observations of our sister disciplines, anthropology and ethnology, whose research shows that the cultural patterns determine the competitive-cooperative patterns. New Mexico's Zuni and New Guinea's Arapesh have high degrees of internal cooperation, because from infancy each individual can best satisfy his motives through cooperation. The Nundugomor of New Guinea and the Kwakiutl of Vancouver Island learn to be highly competitive because only in that way can they survive in their respective cultures.

These studies show us that aggressiveness and altruistic cooperation are the result of training rather than of heredity. Therefore war is not an inevitable product of a depraved human nature; it is instead a cultural product which can be eradicated by educational processes.

CONTRIBUTIONS OF FREUD

In the 1880's a young physician sat day after day in his office in Vienna waiting for the patients who never came to him. A classmate of his, already well established as a fashionable doctor, one day said in pity, "Sigmund, I am going to send you one of my patients. She has

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final assembly on the factory line, may be accomplished without drills, files or other cutting tools, needing only "a wrench and a screwdriver."

Successful airplane production, like all modern machine manufacturing, depends upon the interchangeability of those parts and assemblies which are intended to be identical. This feature of interchangeability is achieved through the use of ingeniously coordinated jigs and fixtures. Designs then, are executed so that the fabrication process may be adapted to the use of such tooling.

Individual parts are manufactured rapidly and with precision by being designed for production on such machines as the punch press and turret lathe. These machines make possible the aircraft industry's closest approach to true mass production. Such methods of joining as spotwelding and metal stitching are also worthy of mention in this connection.

A large portion of aircraft design work is purely mechanical in aspect; it is the same kind of work that is done in designing a vacuum cleaner, a farm tractor and a Diesel-electric locomotive. Naturally, close attention is given to weight saving; in other respects, airplane design is simply product design.

It is therefore not difficult to perceive the importance of such "design for production" in our industry today. It makes possible the high rate of delivery that will provide the planes necessary to win the war. After victory, the same consideration will be an outstanding factor in controlling costs of commercial aircraft, and of the private planes which many of us will own or operate.

In conclusion, it is not intended to disregard the importance of the great number of inventions and developments that have advanced aviation—using the term aviation as distinguished from airplane design. Most of these applications, although not falling into the categories discussed, are of an engineering nature. Some of them have revolutionized certain phases of flying, and thereby have influenced design. De-icing mechanisms, for instance, have made operation possible in weather that otherwise would be prohibitory. Cabin pressurizing and improved oxygen apparatus have made flying practical at the high altitudes attainable with our supercharged engines. Auxiliary airfoils and high-lift devices such as wing slots and flaps permit operation from small landing areas. Blind-flying instruments and the automatic pilot so extend the range of permissible flying conditions that designs must be modified accordingly.

There are scores of other developments, all of them important; none of them perfected; any of them worthy of considerable effort toward improvement. And as new devices come into use, entire new fields frequently are opened for research.

For young engineers, these fields are tough and competitive, and will be increasingly so, but this condition should not be considered a limitation. The industry will continue to need men who appreciate as being unusual the opportunity for interesting engineering work in connection with aircraft and aviation development.

New Frontiers of the Mind

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nothing organically wrong with her, just a lot of hysterical symptoms, and I haven't time to bother with her." Sigmund Freud had time, and let the patient tell him her troubles day after day until, to their mutual surprise, she was cured of "neurosis." Freud then wrote an article describing the method of "mental catharsis." Beyond one or two caustic remarks by older and wiser physicians, however, few noticed the article and the world slumbered on, unaware that it was harboring in that drab Viennese office an *enfant terrible* who, in the words of Thomas Mann, was to exert an impact on the twentieth century comparable to that of Darwin on the nineteenth and of Galileo on the seventeenth. Much of modern literature, drama, and painting can be understood only in Freudian terms. James Joyce, Eugene O'Neill, Salvador Dali, to name only three, are saturated in psychoanalysis.

Freud is one of those people who are now pointed out with pride; now viewed with alarm. It is difficult to be neutral and objective about him. His admirers point out the wealth of helpful concepts which he developed—rationalization, sublimation, projection, repression—and a long glossary of others. His critics assert that many of his interpretations were wrong and much of his thinking fuzzy, that his generalizations were so sweeping that they can neither be proved nor disproved, that his methods were far from scientific, and that his emphases were logically untenable. As one wit has put it: "The sex drive is so very important that it is impossible to over-emphasize it—but Freud has succeeded in doing so."

Freud's preoccupation with the sex and death wishes blinded him to the other motives of men, but his critics have to admit that for all his errors Freud's influence was great enough to produce a radical change in the contours of the psychological frontier. He was the hair shirt which goaded us to activity; he was the red flannel underwear which made us scratch in new places. Freud forced us to consider genetic development, especially of the first three years of life; to recognize the existence of unconscious motives and their rationalization; and to attack the problems of frustration. He was frequently wrong, but his wrongness produced much rightness.

NERVOUS BREAKDOWN

Recent studies of "experimental neurosis" probably would never have been performed had it not been for the work of the great Russian, Pavlov, on conditioning. In the early years of this century, one of Pavlov's assistants reported that a laboratory dog had suffered a "nervous breakdown" when presented with a problem which he could not solve. Like many other important observations, this finding lay dormant for years. But in the 1930's in several laboratories, particularly that under the direction of Professor Maier of Michigan, a series of experiments was started to find out why that dog broke down. Maier uses Lashley's basic method—a rat on a pedestal learning to jump to one of two doors. When the rat has learned to go always to the door with the circle on it, Maier bends out the sides of the triangle so that it becomes more and more circular. Finally the rat can no longer discriminate between the two figures; when that happens he is frustrated between his hunger and his desire to avoid a fall into the net. Under stress, individual rat personalities emerge. Some—the Horatio Algers—keep on trying, getting approximately half of their trials correct by chance. Some appear to try—they jump, twist in the air, kick a glancing blow against the door, and land in the net; they get no food but they avoid the punishment. The shy rats refuse to jump. Some develop a "nervous breakdown." A few jump to the floor and rush blindly around the room; some jump hysterically up and down in one spot; some shiver and shake; others lie completely supine, so that they may be pushed or pulled into any position as though they were wax. We get exactly the same symptoms in a mental illness found in humans, catatonic schizophrenia, which is an attempt

to solve a problem by completely passive resistance, by utter resignation.

These experiments of Maier and others extend our frontiers for two reasons: They substantiate the theory that some nervous breakdowns, at least, result from psychological frustration rather than from purely physical illness. Moreover, they throw some light on the practical problems of heredity and environment by determining whether the children of neurotic rat parents are more easily disturbed than are the children of "Horatio Alger" parents. To control the environment, it is, of course, necessary to have both neurotic and normal young rats raised by neutral foster parents.

THE FUTURE OF PSYCHOLOGY

All of these studies present certain foci of emphasis which give us clues to the future development of the science of psychology. They show us the psychosomatic principle—that mind and body are a unity, that there are no mental phenomena divorced from physiological or chemical influences, and conversely that there are no body changes which are uninfluenced by mental phenomena. They give us more understanding of what the psychologist calls readjustive behavior. They show us that, whereas we bring into the world an innate pattern of reflexes and of hungers, it is possible to modify these inherited mechanisms to an enormous degree. That means that it is possible to produce either the civilized man or the criminal, the sane or the insane, the selfish or the altruistic, by varying the kinds of conditions under which the child is reared. We know now enough to prevent a considerable percentage of all the insanity and of the crime which bedevils the world, if the public is willing to apply to these problems the techniques which modern science has developed. It is not over-optomistic to state that we also know enough to prevent future wars as we learn to feed properly the fundamental hungers of individual men. Psychologists are emerging from the ivory tower of the early years of experimentation and are taking an increasing interest in problems of social control and progress. The research which they are carrying on will yield better ways of living.

The Marker Principle

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performs the following tasks in a time interval of about one-half second.

1. The marker locates the test terminals of the called line, using a "number-group-connector" circuit to accomplish this mission.
2. The called line is then tested to see if it is idle or busy, and if found to be busy, the marker orders the trunk circuit equipment to return a busy signal to the calling subscriber. This test also indicates what type of ringing current should be applied in order to signal the proper party on the line.
3. From the test terminals the marker then determines the location of the called line on the line-link frame.
4. The marker then selects a clear channel for a talking circuit from incoming trunk to the called subscriber's line, in the same manner that the originating marker set up a channel from the calling subscriber to the outgoing trunk.
5. Under control of the marker, the relay equipment in the incoming trunk circuit applies the proper type of ringing current to the called line and sends an audible ringing signal back to the calling party.
6. If the called number is that of a P.B.X. (private branch exchange) or a subscriber having more than one line, the marker will recognize this arrangement and test all of the lines associated with this subscriber's listed telephone number, testing as many as 20 simultaneously, and will select an idle one. A point of special interest here is that whereas all previous telephone switching systems required that all the lines to one subscriber be numbered consecutively to permit this "trunk hunting" feature, the crossbar system with its marker operation permits scattering the trunks of a P.B.X. group, or they may even be assigned in certain instances to a special group of numbers outside the regular 10,000 series. This scattering of trunks which have high incoming calling rates is of particular interest to the traffic engineer since it permits better balancing of the load carried through the various channels of the equipment.
7. If the number which has been called is an unassigned line, or one which has been disconnected, the marker recognizes this condition, and routes the call to a special intercepting operator.

TROUBLE INDICATOR CIRCUIT

With a system as intricate and complicated as the crossbar system, the location of the source of trouble would be a very involved process, and would cause equipment which should be working at a high call fill to be held out of service a considerable length of time unless some automatic trouble-indicating feature were included. When a marker encounters circuit trouble, it routes the call over an alternate channel and calls in a trouble indicator circuit which locates the trouble and sounds an alarm, thus permitting the repairman to get the faulty equipment back in service in a minimum length of time.

NEW TYPE RELAY

One item of equipment which has not been mentioned thus far but which contributes in a large measure to marker operation, is a new type of relay which is called the "multi-contact relay." This relay employs two magnets and two armatures, each of which operates half of the contacts. With both halves functioning together, the relay will close 60 contacts simultaneously; however, the halves may be operated separately with a maximum of 30 contacts each. Each contact is double, the end of each moving contact spring being forked with a contact on each tine of the fork. With a single contact the number of failures per thousand operations is very small, but with two contacts in parallel, the probability of failure is negligible. With this type of relay, the large number of circuits in the marker can be extended to the associated equipment almost instantaneously, permitting a high call handling capacity for each marker.

CONCLUSION

Present indications are that the marker principle is here to stay, and new applications of this type of circuit continually are being discovered. That this is not just a laboratory model, but is a commercially-proved system is evidenced by the initial installation which has been functioning in New York for several years, and other installations scattered across the United States, including two or three in the East Bay district of San Francisco. To date none has been introduced in southern California, the step-by-step system being used exclusively in this area thus far. As far as the telephone user is concerned, he places a call through a crossbar system in exactly the same way that he does through a step-by-step system, but to the telephone engineer the introduction of the marker principle represents an entirely new approach to the problem of telephone switching.

Flash of Genius Doctrine

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Patent Office then the Patent Office must institute a new type of prosecution in which each inventor-applicant is required to show his personal prior art. The ramifications of such a requirement in cases of research organizations of any size constitute a tremendous burden. A