COMPUTERS
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CYBERNETICS • ROBOTS • AUTOMATIC CONTROL

Vol. 4
No. 10

The Brain and Learned Behavior

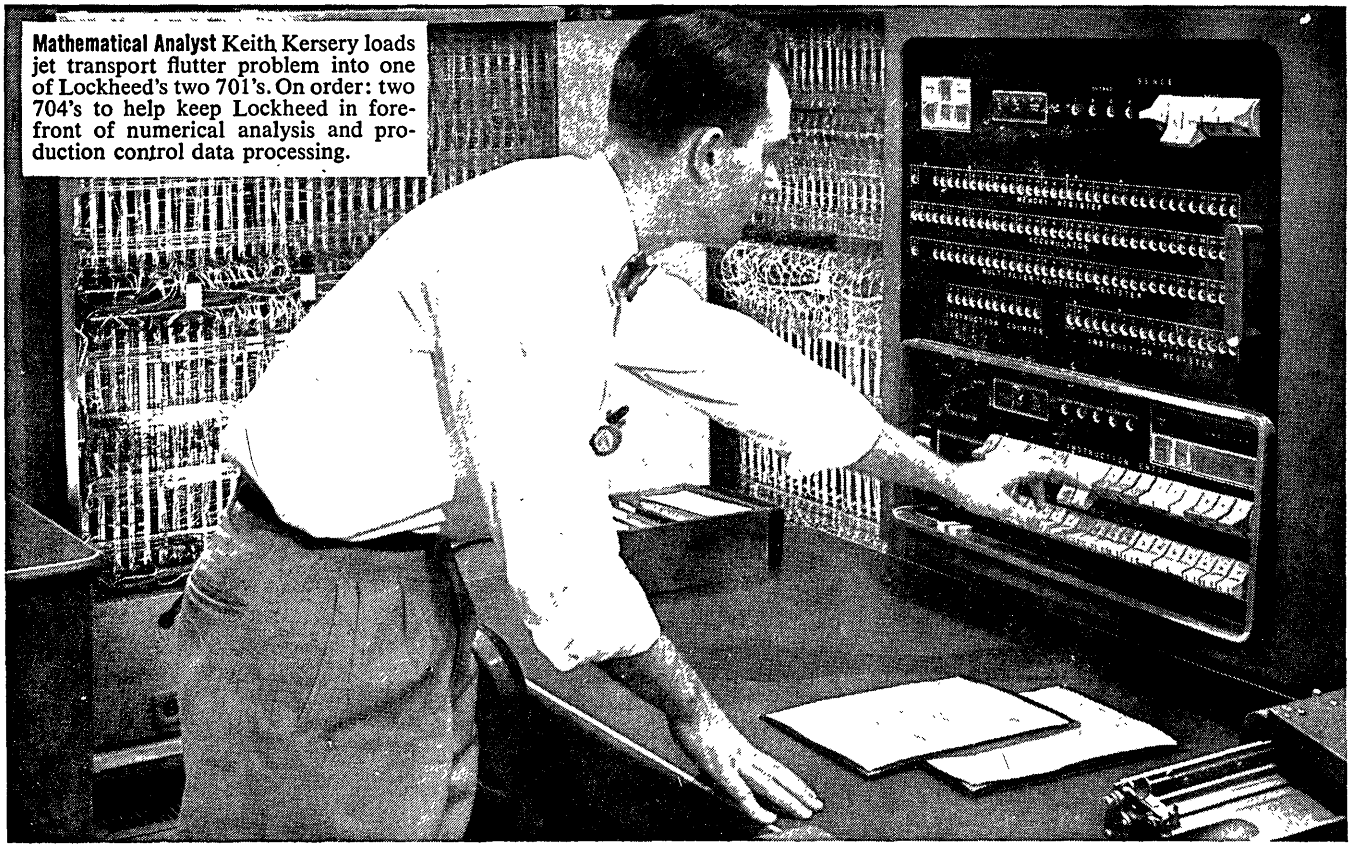
... Dr. Harry F. Harlow

Automatic Programming: The A 2 Compiler System — Part 2

Who Are Manning the New Computers?

... John M. Breen

Oct.
1955



Mathematical Analyst Keith Kersery loads jet transport flutter problem into one of Lockheed's two 701's. On order: two 704's to help keep Lockheed in forefront of numerical analysis and production control data processing.

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THE EDITOR'S NOTES

ANIMAL AND MACHINE BRAINS

Everyone who has come into contact with automatic computers has also come into contact with the argument about whether or not machines "think", whether or not machines "have intelligence". Many investigators of human and animal brains have also wondered whether and to what extent different human and animal brains "think".

Now if we as computer engineers are ever to make useful computers that require little explicit instruction from human beings, but instead have a faculty for rapid and effective learning built into them, then we shall need to be interested in similar intelligent behavior of various animals and human beings, and the objective tests for measuring that intelligence.

But the investigators of animals cannot use words to question animals, nor do they have an instrument that will directly measure "intelligence". So they have devised a number of objective tests of behavior in problem situations. From these tests, the investigators draw conclusions about the extent to which the individuals they measure "act intelligently": how they learn, how much they can learn, how quickly they can learn.

Do these tests have bearing on machines? Certainly, many of these tests require only a moderate amount of adaptation (translation) to fit them to be given to machines — mostly because machines so far are blind and cannot see and recognize. Furthermore, the patterns of these tests suggest types of learning capacities to be built into machines. Finally, we, as computer people rather than psychologists, have the very great advantage that we do not have to guess at the structure of the entity which is carrying out the intelligent or learning behavior: we know the structure — hardware.

Along this path of inquiry, we publish in this issue of "Computers and Automation" an article by Dr. Harry F. Harlow, "The Brain and Learned Behavior". It is full of illuminating suggestions for persons interested in "intelligent behavior" by computers, animals, or human beings.

VARIATION IN INTELLIGENCE

D. A. Laird and E. C. Laird in their book "Sizing Up People" (McGraw Hill, 1951) say that, although the variation in height of men is from 1 to 1.28, (based on 998 out of 1000 persons,

(continued on page 23)

PAPERS AND ARTICLES ON COMPUTERS

At the meeting of the Association for Computing Machinery, September 14-16, 1955, in Philadelphia, "of approximately 175 papers submitted, 129 were chosen for presentation." They were presented in three parallel sessions; the top limit that a single person could actually listen to was about 50. Of these 129 papers presented, probably about two dozen may be published in the Journal of the Association for Computing Machinery, during the next twelve months, at the rate of about 6 per quarter. There remains a considerable number of unpublished papers.

We are eager to publish many papers and articles on computers, although we have no desire to divert to us any papers that will actually be published in the Journal of the Association. We can ordinarily publish papers within a month or two; we can provide authors with reprints if they desire them; and we believe that a technical paper can often be understood better when published, and thus able to be read and studied, than when only presented orally in an auditorium to an audience of over 200 people.

We shall be glad to consider for publication in "Computers and Automation" any papers not accepted by the Association for presentation, and any papers accepted for presentation at the meeting but not able to be published in the Journal of the Association.

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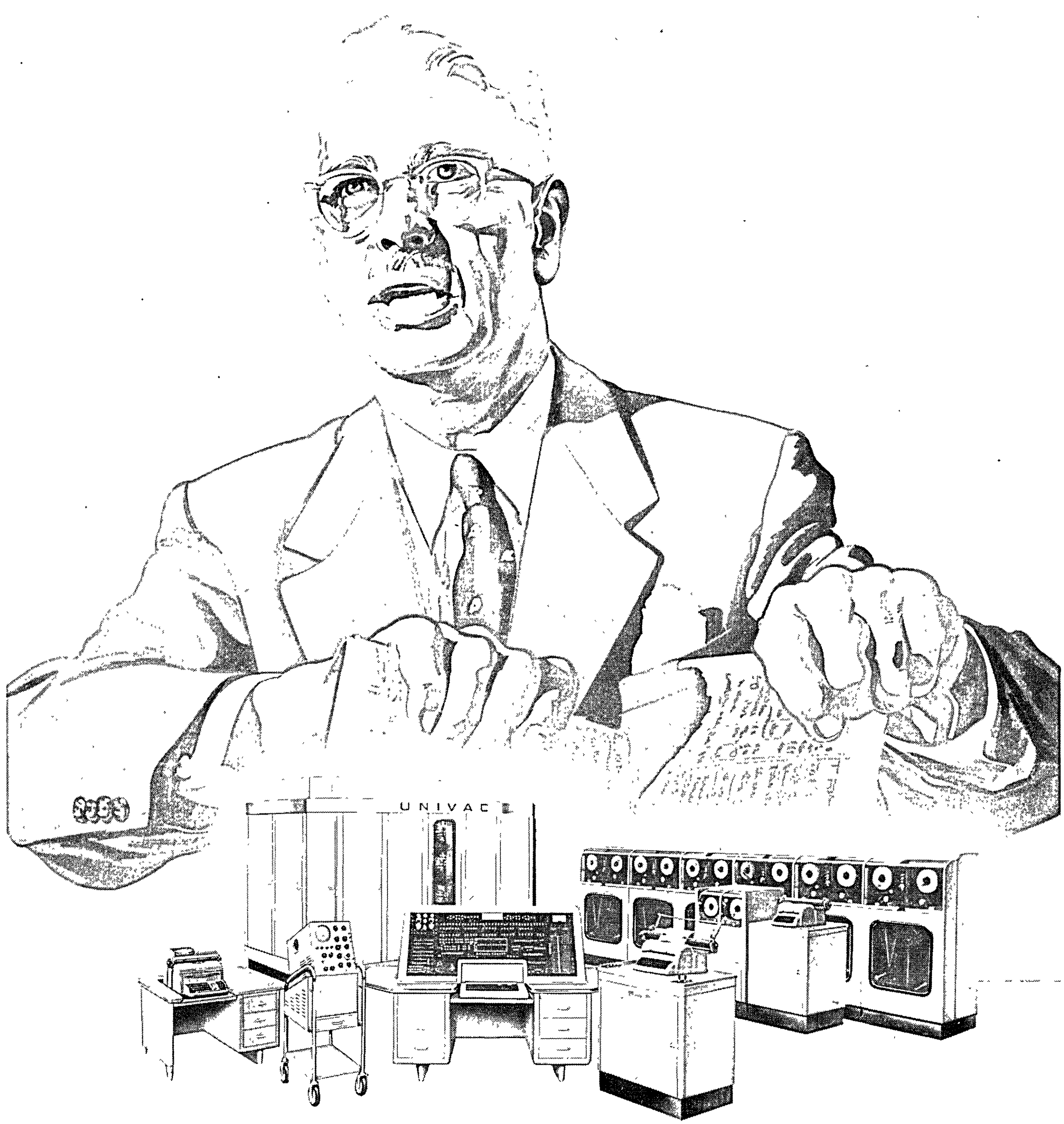
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THE BRAIN AND LEARNED BEHAVIOR

Dr. Harry F. Harlow
Director, Primate Laboratory
University of Wisconsin
Madison, Wisc.

The human brain is anatomically analyzable into a vast number of neurones, which are joined and interrelated by a complexity of fiber processes that baffle comprehension. But the essential structural element, the neurones, differ primarily in diversity and to some extent in quantitative complexity from the neurones that characterize the brains of all vertebrates and many invertebrates. Structural development strongly suggests that only quantitative changes have taken place for almost countless millions of years.

Likewise, the arrangement and patterning of the neurones, and the plexuses of axones and dendrites which they form in the brain, show evidence of progressive and orderly differentiation, but the changes appear to be continuous and quantitative rather than discontinuous and qualitative. The brains of rats, monkeys, and men differ in the number of subdivisions that may be identified in the six basic neocortical layers, the profusion of short vertical chains and tangential fibers, and the wealth of dendritic and axonic processes, but again these anatomical differentiae appear to have developed in a continuous and quantitative manner. Detailed physiological studies indicate that the percentage of the brain's cortical mantle, which mediates simple sensory and motor processes, progressively decreases as we ascend within the class of mammals from rats to man, and there is reason to think that these changes result from the continuous differentiation and expansion of the associated areas.

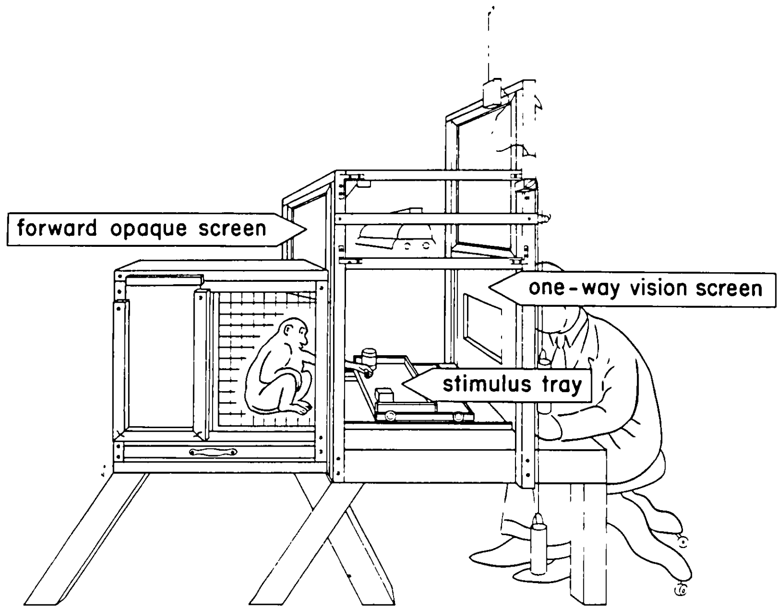
In contrast to the apparent continuity in development of the brain as measured by anatomical and physiological tests, are the changes in behavioral capacities, which increase so dramatically even within the class of mammals as to lead many men to believe that the differences are not quantitative but qualitative. In this regard we should recognize that superficial examination of the brain of the fish or even the rat would suggest that qualitative differences exist between these brains and those of man. The essential similarities are only disclosed by careful and detailed analysis. The same conditions may hold when we analyze in detail behavioral capacities of animals throughout the phyletic scale -- seemingly qualitative differences may upon careful analysis prove amenable to description in quantitative terms.

It is, of course, proper for the scientist to feel equal concern for the differences in behavior between monkey and man and between monkey and rat; the role of the comparative psychologist is to amass all possible behavioral data and relate them in terms of the most logical theoretical system.

Unfortunately, comparative psychologists have made detailed and comprehensive studies on the learning and thinking processes of only four animals, man, the chimpanzee, the rhesus monkey, and the white rat. The behavioral capabilities of even the domestic dog and cat have been subjected to only limited and incomplete scientific analysis.

The author's researches have been largely limited to the analysis of the behavior of the rhesus monkey. In many ways this choice now appears to be fortunate. The differences in behavior of man and rat show such diversity that only superficial analogies are immediately obvious. But the behavior of the monkey is of enough complexity to suggest striking analogies to that of man, and of enough simplicity to indicate clear-cut continuity with that of the rat.

There is a common conception that mere speed of learning differentiates animals intellectually. Actually, there is no evidence that such a principle holds for simple problems, at least insofar as mammals are concerned, and very likely other classes within the chordate phylum. Men, chimpanzees, monkeys, dogs, cats, rats, probably pigeons, and possibly frogs, can learn some conditioned responses in a single trial — not all conditioned responses, but some -- and there is no reason to believe that conditioning per se is more rapid in man than it is in a score of other animals. Nor does man appear to be more efficient in the learning of simple position habits — the location of positions or sequences of positions in space. One eminent investigator compared the learning ability of college students and rats on mazes of identical patterns and found an amazing amount of overlapping between the



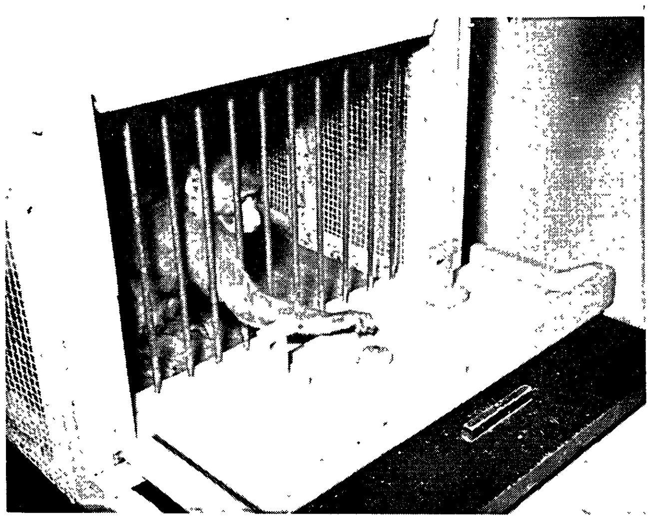
WISCONSIN GENERAL TEST APPARATUS

Showing: Stimulus tray

One-way vision screen in lowered position

Forward opaque screen in raised position

Figure 1 -- General test apparatus for monkeys



Figures 2 and 3 -- Correct responses by a monkey tested on the oddity problem. -- "In the oddity problem, two different pairs of identical stimuli are used, but only three stimuli are presented on any given trial. The odd stimulus, the stimulus singly represented is rewarded, and trial sequences are so arranged that a member from each pair of stimuli is odd on half the test trials. To solve this problem the animal must frequently disregard not only the position of the stimulus last correct, but also the actual object last rewarded. Neither position nor object is consistently correct, and the animal must respond to the general principle of dissimilarity."

two groups -- and it is rumored that an occasional cockroach has surpassed some college freshmen on maze-learning tests.

A more complex problem than position discrimination is that of discrimination between objects. In this type of problem, the animal must, if it is to receive a reward, consistently choose a particular object regardless of the position that it occupies. It is doubtful if the completely naive man, chimpanzee, or monkey would surpass the completely naive rat or pigeon in speed of solution of the first problem of this kind that he ever encountered -- indeed, some data indicate that the rat might surpass any of the primates. But, as we shall see later, if the primates are presented long series of problems of this difficulty level, they eventually attain nearly perfect performance, an achievement that has not been demonstrated in any subprimate form.

As we pass from object discrimination problems, we come to another class of problems whose solution involves response to a general principle. On strictly logical grounds these problems are to be regarded as more complex. At this stage of problem difficulty, we approach a separation of primate and nonprimate. In the oddity problem, which is representative of this class, two different pairs of identical stimuli are used, but only three stimuli are presented on any given trial. The odd stimulus, the stimulus singly represented, is rewarded, and trial sequences are so arranged that a member from each pair of stimuli is odd on half the test trials. To solve this problem the animal must frequently disregard not only the position of the stimulus last correct, but also the actual object last rewarded. Neither position nor object is consistently correct, and the animal must respond to the general principle of dissimilarity.

Monkeys learn oddity with difficulty. They take from 500 to 1500 trials to master their first problem. But lest we assume that ability to solve this problem sharply differentiates monkey and man it may be noted that we tested a group of nursery school children from three to five years of age. All the children except one failed -- and he solved the problem by cheating. I do not mean to imply that monkeys are smarter than five-year-old children for the monkeys were more highly motivated, better trained in laboratory discipline, and better mannered. It is significant, however, that on this problem involving the use of a logically abstract principle, we cannot differentiate all men from all subhuman primates. No subhuman primate has ever been reported to have solved problems of this type with any facility, but limited solutions by rats and even by pigeons strongly support the view that the fundamental differences in intellectual ability between the primate and the subprimate orders are quantitative and graded, rather than qualitative and saltatory. Furthermore, there is every reason for believing that some subprimate animals -- perhaps the dog, the cat, the raccoon -- could solve problems of this level of complexity.

The oddity problem is by no means the most difficult intellectual task that can be solved by the monkey or the chimpanzee. A problem of striking difficulty, described as the Weighl-type test and adapted from a test used clinically to measure organic brain injury in human beings, has been solved by subhuman primates. One form of this test is a complication of the oddity test. Three unlike objects are presented on each trial, of which two have the same color and two the same form. When such objects are presented on an orange tray, the monkey must choose the object odd in respect to color. When the objects are presented on a yellow board, the subjects must choose the object odd in respect to form.

Solution of this problem is difficult for both monkeys and chimpanzees. Some monkeys and some chimpanzees never learn it -- and some human beings never would either. But most monkeys and probably most chimpanzees -- if they do not lose their motivation -- will learn to solve this problem after a few thousand training trials. Furthermore, they will come to generalize the problem and appropriately choose odd color or odd form when combinations of new and previously unseen objects are presented to them. We have never tested young children on this problem, since we have never found a kindergarten teacher who was willing to alter the school schedule radically enough to make the study feasible.

A task of the same general type as oddity is matching-from-sample because, like oddity, it involves a relationship, the relationship of similarity. In the basic problem, the test tray is divided into two compartments, a sample compartment and a choice compartment. The monkey is trained first to displace the single object in the sample compartment, where he finds a food reward. He must then choose the identical members from the choice compartment, to obtain a second reward. His problem is to match the choice stimulus with the sample stimulus regardless of the position of the choice stimulus, and regardless of the nature of the sample stimulus, which frequently changes from trial to trial. At Wisconsin some years ago we trained a group of four monkeys to solve the matching problem and went on from there to see how complex a problem they could solve. In the phase of the problem next learned there is no food under the sample, and when the monkey discovers this, he must select the choice object which does not match the sample in order to get food. In other

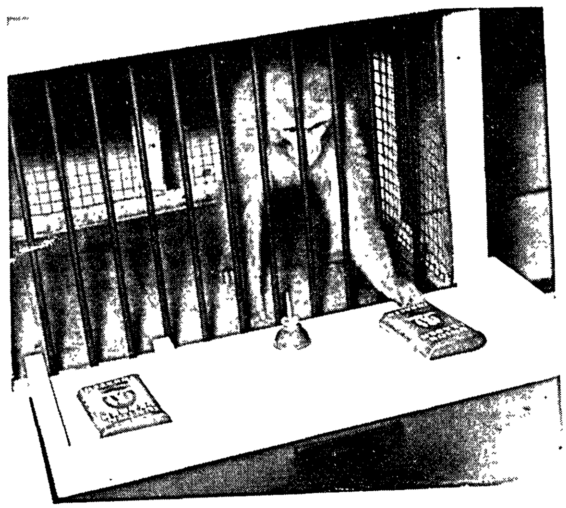


Figure 4

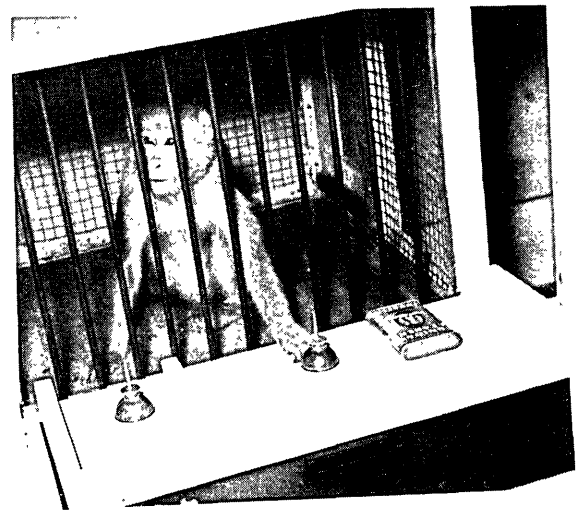


Figure 5

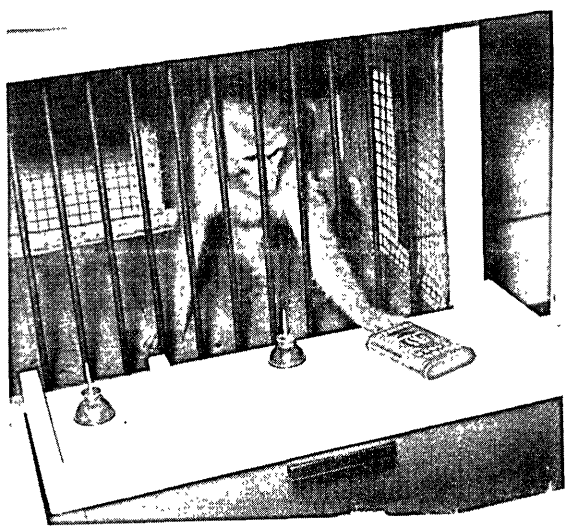


Figure 6

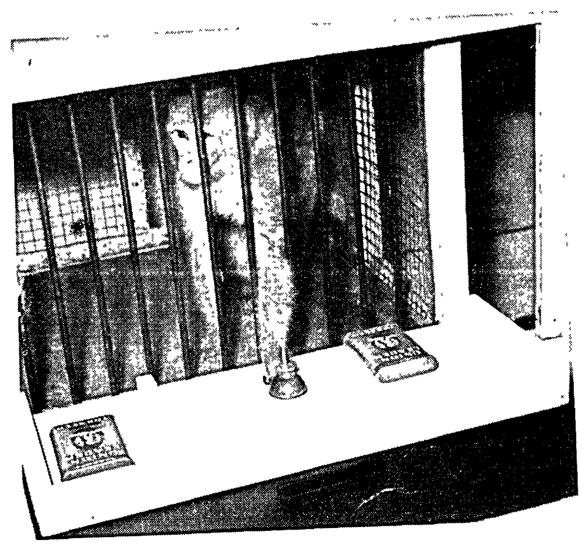


Figure 7

Figures 4, 5, 6, 7 -- The matching and nonmatching problems: "In the basic problem the test tray is divided into two compartments, a sample compartment and a choice compartment. The monkey is trained first to displace the single object in the sample compartment, where he finds a food reward. He must then choose the identical member from the choice compartment, to obtain a second reward. His problem is to match the choice stimulus with the sample stimulus and regardless of the nature of the sample stimulus. ... In the phase of the problem next learned, there is no food under the sample, and when the monkey discovers this, he must select the choice object which does not match the sample in order to get food." Figures 4 and 5: food under sample: choice object like sample is correct. Figures 6 and 7: no food under sample: choice object unlike sample is correct.

words, his choice must now be made on the basis of difference, not similarity. This is followed by two absolutely arbitrary problems in which the choice objects are identical and neither one matches the sample. If food is under the sample now, the monkey must go to the more distant choice object. If food is not under the sample, the monkey must now go to the closer choice object. Solution of these problems was followed by training on two additional arbitrary problems. Sample and choice objects are now identical. If there is food under the sample object, the monkey must choose the closer choice object. If there is no food under the sample object, the monkey must choose the farther object. Step by step these problems are learned and combined until in the end the situations appropriate to all problems are being presented in a predetermined, irregular order. This results in a performance of rather bewildering complexity even by human standards, yet all four of our monkeys learned this to the the point of practically errorless performance. We used to show movies of monkeys doing these problems, but we never do any more since many members of the audience find that the monkeys are doing better than are they, a fact needlessly leading to the formation of feelings of inferiority.

The next test to be described is one devised by Dr. Winsten at the Wisconsin Laboratory. It also involves the matching technique. It is a kind of test that might appropriately be described as involving concept formation, since in its final stage the monkey responds to a sign that has no physical resemblance to the stimuli to be subsequently selected. In early training, as many as eight objects were placed on a tray, the monkey was handed one object, the sample, and his problem was to pick out all identical objects, leaving unchosen all objects which were different. In the most complicated form of the test the monkey was given an unpainted circle, as a sign to pick out all blue objects, and an unpainted triangle, as a sign to select all red objects. Several monkeys have learned to do this problem with a high degree of success. One monkey even learned to respond almost perfectly. Given a circle, he would pick every object with any blue on it, ignoring all other stimuli; given a triangle, he selected all objects with any red coloration, leaving all other objects untouched. After he made his choices he would frequently push the tray away and turn his back to the whole situation.

We neither know nor particularly care to know the minimal mental age that children would have to attain before they could learn tests of the type we have just described. Certainly they appear to be well beyond the difficulty of mental test items measuring mental ages of four and five, and the problems might well try the patience of seven-and eight-year-olds. Again, we are not trying to prove that the rhesus monkey is a kind of misunderstood low- or middle-grade imbecile. The data interest us because they suggest that proper test conditions reveal intellectual capacities in a monkey far beyond those that anyone would have predicted fifteen years ago. Certainly such data can be interpreted, and very probably would have been interpreted by Darwin and Huxley, as indicating that no inseparable gulf exists between the "minds of men and monkeys" -- and that such intellectual differences as exist are quantitative, not qualitative.

These tests are also of interest for comparing monkey and rat. The rat is as incapable of solving the Weigl problem, the complex matching-from-sample sequence, or the complex color concept problem as the monkey is incapable of solving differential equations, performing piano sight-reading, or writing "The Descent of Man." From the point of view of maximal complexity of performance a qualitative difference exists between men and monkeys and also between monkeys and rats; from the point of view of process and mechanism, the differences in performance among the three species appear quantitative and the development probably continuous.

So far, we have described the comparison of the abilities of animals with varying complexities of brain structure to solve problems of varying degrees of complexity. Another extremely interesting type of comparison is that of the ability of various animals lying at different levels along the phyletic series to profit from the solution of multiple problems of a single, basic type, i.e., the ability of animals to transfer from problem to problem of a particular type and to form generalized problem solutions.

Detailed, systematic researches on this process were initiated at the Wisconsin Laboratory about five years ago, the original studies being made on the ability of monkeys to learn series of object discrimination problems -- problems whose solution requires the animals to select consistently one of two objects regardless of position. In this experiment eight monkeys were trained on a series of 344 problems utilizing a different stimulus pair for every discrimination. Each of the first 32 problems was 50 trials long; the next 200 problems, 6 trials; and the last 112 problems, an average of 9 trials. Learning curves, showing the percentages of correct responses on the first six trials of these discriminations, were constructed. The curves demonstrate progressive improvement in the ability of the monkeys to solve discriminations; from problem to problem the animals learned how to learn discriminations with progressively greater facility, a process designated by the term learning set. The very form of the learning curve changes for successive blocks of problems. The initial curves are S-shaped -- the type described in psychological literature as typical "trial-and-error" curves. The final curves are discontinuous at Trial 2 -- the type frequently referred to as "insight" curves. For the monkeys the discrimination learning sets changed a problem which could be solved only after many errors, into one which was usually solved with no unnecessary errors.

Recently at Wisconsin a similar problem was tried using cats as subjects. The cats also showed evidence of forming discrimination learning sets -- but the cats never attained or even closely approached immediate, insightful discrimination learning. In terms of process, cats and monkeys differed only quantitatively, since both formed learning sets; but in terms of performance, cats and monkeys differed qualitatively, since cats failed to learn insightfully. Again and again, we see this principle illustrated, namely: qualitatively different performances are produced by underlying processes which differ only quantitatively, i.e., differ only in degree.

Detailed studies have shown that monkeys form highly efficient learning sets for many problems, including the oddity problem already described, and a very interesting type of problem called discrimination reversal. Each discrimination-reversal problem starts as a discrimination problem with one of a pair of stimuli consistently rewarded regardless of position. After a predetermined number of trials, in our experiments, 7, 9, or 11, the reward values of the stimuli are reversed, with no cue being given to the animal other than that of the reversed reward values. Discrimination-reversal learning-set curves were determined on the data from eight monkeys. The phenomena demonstrated in the formation of discrimination learning-set curves were again demonstrated here. The first discrimination-reversal learning problems are acquired gradually; but eventually the monkey comes to make practically no errors after the first "informing" trial at the point of reversal.

Recently North has reported data on rats trained on a long series of discrimination-reversal problems. The rats gave evidence of the formation of learning sets, since improvement was noted from problem to problem, but the rats -- like the cats and unlike the monkeys -- never attained or even approached perfect, insightful reversal in a single trial.

Nine nursery school children at the Wisconsin Laboratory were tested on discrimination-reversal learning-set formation under conditions almost identical to those for the monkeys, except that the children were rewarded with macaroni beads instead of peanuts, and missed test days because of colds and measles -- and temper tantrums. Their composite discrimination learning curves were determined and these data suggest that even the immature human primate "learns how to learn" with great efficiency.

The newness of this technique and its present limited application to subhuman species necessitates caution of interpretation. But the limited extant data indicate that it will prove to be a powerful tool enabling us to assay the nature of both similarities and differences in intellectual abilities of various genera, families, and probably orders.

Man in his infinite wisdom and even more infinite anthropocentrism has prided himself on being the "thinking" animal and has ascribed to himself a process "reason" which he has denied to animals. Reason has always been regarded as an ability to see through problems, independently or relatively independently of experience.

The psychologist, Hebb, has recently suggested that the completely naive primate may well be inferior to many lower animals in his ability to solve problems -- perhaps any problem. It is only through prolonged experience, or, in terms of our theoretical position, it is only after he has formed efficient learning sets, that man's rational powers attain and then gradually but progressively far surpass those of any other animal. If, as is not unlikely, reason and thought can be efficiently described in terms of an extension of relatively simple learning phenomena, additional evidence will be obtained to indicate the essential continuity of evolutionary development of the human being's higher mental processes.

Hebb noted that rats deprived of all visual experience early in life show little evidence of any deficit when first presented a visual discrimination problem. Much more serious visual learning deficit has been found by Riesen in monkeys and chimpanzees given their first problems following prolonged deprivation of visual experience. These subhuman data find confirmation in the clinical descriptions by Senden of human beings whose first opportunity for detail vision followed operations for congenital cataracts after many years of visual deprivation.

Such data suggest that human mental powers arise only after prolonged experience and intensive training. And again, there is every reason to believe that the essential mechanisms progressively evolve as we pass from subprimate to primate forms, and in turn from subhuman primate to human forms. No careful, Figures 8, 9, and 10 -- Typical instrumental problem solutions by a cebus monkey at the Wisconsin Laboratory

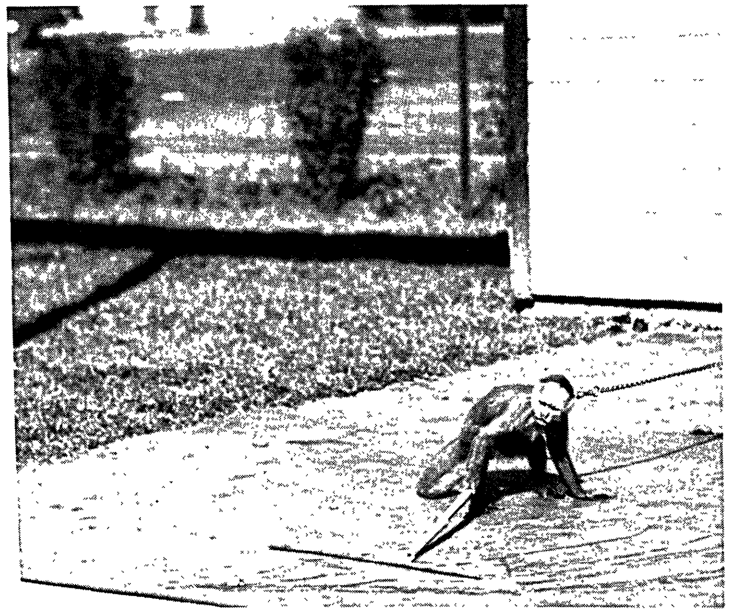


Figure 8

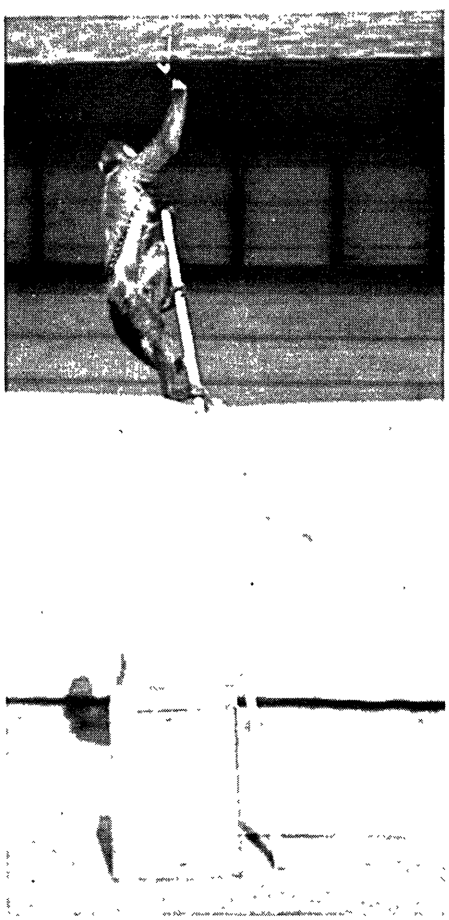


Figure 9

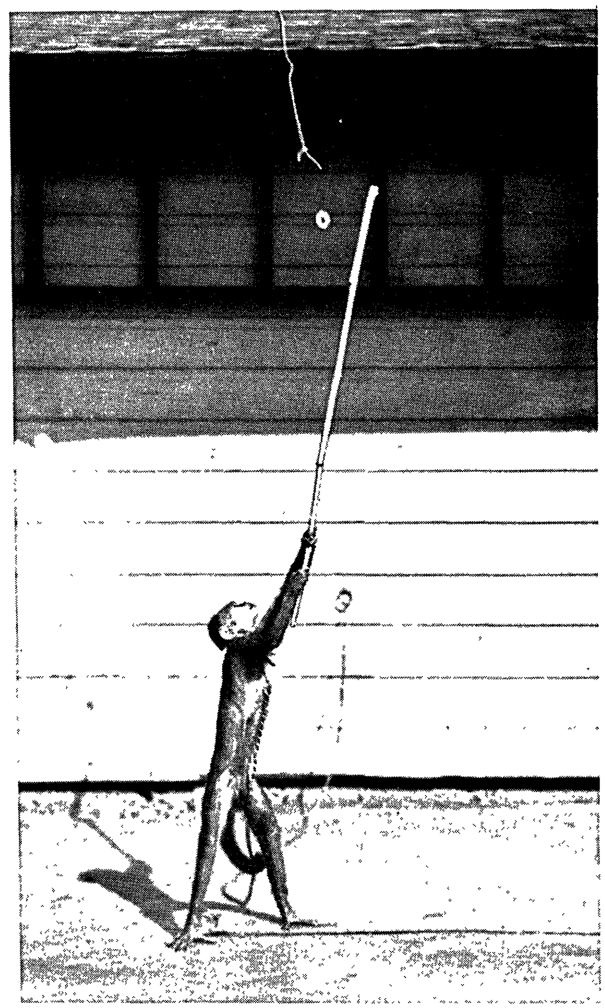


Figure 10

detailed, psychological test has ever given any indication of intellectual discontinuity at any adequately tested point in the phyletic series.

There was a time when man thought of himself as the tool-using animal, and the advent of tool-using was regarded by some as a great saltatory step in intellectual achievement. The human being's instrumental intellectual isolation had to be discarded after Kohler's brilliantly integrated series of observations proved that the chimpanzee was capable of utilizing tools in a wide variety of ways. Through the assumption that these problems were solved by insight learning -- defined as a sudden perceptual reorganization of a complex situation — the chimpanzee was almost humanized; but within the last 15 years it has been demonstrated by Klüver, deHaan, and others, that the cebus monkey was almost as facile with tools as was the chimpanzee. Limited types of instrumental problem solutions have also been described in subprimates -- and no one would <u>now</u> suggest that tool-using abilities separate man from the lower animals.

But of far greater theoretical interest than the fact of tool utilization by subhuman animals is the manner in which all animals, including man, attain the ability to effect instrumental problem solutions. Kohler's assumptions that the chimpanzee's initial solutions were sudden and insightful are, without question, incorrect, and he was misled through lack of knowledge of the life histories of his subjects.

An intensive investigation of instrumental problem solving in 25 chimpanzees of one to fifteen years of age was conducted by Schiller, using a series of 12 stick problems of graduated difficulty. All the subjects, including the oldest, learned gradually and by "specific experience." The one- to two-year-olds required several hundred trials to master each of the easiest problems, and they never solved problems of even intermediate difficulty. Their performance appeared to Schiller to resemble conditioning. The three- to four-year-olds learned in the same manner, requiring about 100 trials to master each of the simple problems and problems of intermediate difficulty, and they never mastered problems beyond this level. Even the nine- to fifteen-year-olds failed on initial presentation to solve their first problem -- the straight stick with food behind it. All reached for the food beyond the stick and picked up the stick only after hesitation. At first, they pulled the stick without reference to the food, licked it, smelled it, and chewed it. Only much later did they put the stick out and push toward the food.

Essentially similar results have been obtained by every investigator who has worked with children two to four years of age. Such solutions as occur usually follow extensive manipulation and exploration, and even when very simple tool situations are presented, less than five per cent of the solutions are sudden or immediate. Since most of the children tested had undoubtedly had extensive previous play experience with blocks, chairs, boxes, and sticks, and probably had used at least some of these objects as tools to obtain treasures beyond arm's reach — the similarity of the children's, the chimpanzees', and the monkeys' behavior is obvious.

The history of research into instrumental abilities in animals thus resembles the history of many problems that have been subjected to analytical investigation. The more precise and better controlled the studies, the more conclusive becomes the evidence for continuity of process -- rather than discontinuity of process -- within the phylogenetic scale. Tool-learning behavior becomes strikingly similar to object discrimination learning. When first faced with a problem of either kind, the individual -- human or subhuman -- learns slowly, ineffectively, and by trial and error. Sudden, insightful, rational learning only appears after many problems of a particular type have been mastered -- after the solution of many related problems has made this originally difficult learning simple.

At the start of this paper we emphasized that the differentiation of the cortex appears to have resulted from a continuous process. The "so-called" associative areas gradually expanded and differentiated from the so-called sensory and motor areas. Throughout the paper we have reiterated the gradual and continuous differentiation of the learning-thinking process and have emphasized that this continuity could be properly comprehended only if stress were laid upon the importance of the role of the learning variable.

Experiments on the effect of cortical lesions provide evidence on evolutionary theory. At the same time the effect of cortical lesions on intellectual processes can only be properly evaluated if the three basic principles of gradual differentiation of associative areas, continuity of the learning-thinking process, and progressive importance of the role of learning, are always kept in mind.

The importance of these principles is emphasized in the results of a comprehensive and long-term experiment we have conducted on the effects of cortical lesions on the learned behavior of monkeys. Twelve animals have been used in this investigation, four normal controls and eight operated subjects, and the learning experiences of all 12 have been kept constant throughout the five years of experimentation thus far completed.

The first operation was carried out on all eight experimental subjects and involved destruction of all the neocortical associative areas of one hemisphere. Shortly after this operation the monkeys showed some loss on delayed reaction tests, on discrimination tests, and on discrimination-reversal tests. But the really striking data are those which indicate the vast amount of recovery by the operated monkeys on discrimination and discrimination-reversal retests following a year of continual postoperative education on other laboratory problems. The same results obtain for delayed response.

Two years after the first operation, the experimental monkeys were divided into two equally matched groups. In one group the lateral surface of the contralateral frontal associative areas was destroyed, and in the other, a vast lesion in the contralateral posterior association areas was produced. The Frontal group a few months after operation showed very serious loss on delayed reaction tests --which may measure memory and/or attention. There was little loss on discrimination tests. The Posterior group showed slight loss on delayed reaction tests but very serious loss on discrimination tests shortly after the operation. But, again, the striking data are those obtained during the course of testing over a two-year period. During this time, the Frontal group performed with reasonable efficiency on some delayed reaction tests, and the Posterior group showed complete, or almost complete, recovery on simple discrimination tests. Residual discrimination deficit could, however, still be shown by the introduction of new and more difficult discrimination tests.

Approximately four years after the original operation the four Frontal animals were subjected to the posterior cortical lesion, and the Four Posterior animals to the frontal lesion. Since less than a year of continuous testing has intervened after operation, our analysis must be regarded as tentative and incomplete, but the results are striking and, even to us, somewhat unexpected. These animals, with only islands of associative cortex remaining, showed amazing ability to solve intellectual problems. Their performance on discrimination tests was highly efficient, even though it was inferior to the performance of the normal controls at the five per cent confidence level. The same results were found on the more complex discrimination-reversal test. Three out of 6 surviving operated animals performed efficiently on delayed reaction tests, and the performance of one animal, which made only five per cent errors, overlapped that of the normal monkeys! Such data suggest that we should rename the "associative areas." Furthermore, the results provide strikingly suggestive support to Lashley's brilliant hypothesis that sensory and motor cortical areas also mediate associative functions.

It still remains for us to test monkeys following total destruction of the neocortical associative areas. We believe that when this is done there will be even more conclusive evidence supporting the position that the associative areas have gradually evolved from the sensory-motor areas, that there is continuity of the learning-thinking intellectual processes, and that the key to understanding mental evolution and cortical functioning lies in the detailed analysis of the learning process.

- END -

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SPECIAL ISSUES OF "COMPUTERS AND AUTOMATION"

The issue of "Computers and Automation" in June, 1955, was a special issue: "The Computer Directory, 1955", 164 pages, containing: Part 1, Who's Who in the Computer Field; Part 2, Roster of Organizations in the Computer Field; and Part 3, The Computer Field: Products and Services for Sale. It is expected that the next Computer Directory issue will be June, 1956.

The next two special issues will be December, 1955, and January, 1956. The December issue will be mainly devoted to useful information for people who have been in the computer field for some time: a "Glossary of Terms", and also cumulative editions of other pieces of reference information.

The January, 1956, issue will be mainly devoted to useful information for people who have newly entered the computer field: an introduction to computers (and to "Computers and Automation"); and reprints and revisions of some of the more introductory articles and papers that "Computers and Automation" has published.

Automatic Programming: The A 2 Compiler System — Part 2

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(Part 1 was published in the September, 1955 issue of "Computers and Automation")

Index of Figures

A detailed description of the running memory layout follows:

ABSOLUTE MEMORY ADDRESSES	UTILIZATION
000 to 059	CONTROL BLOCK These memory locations are reserved for Univac instructions produced by the compiler. These instructions auto-

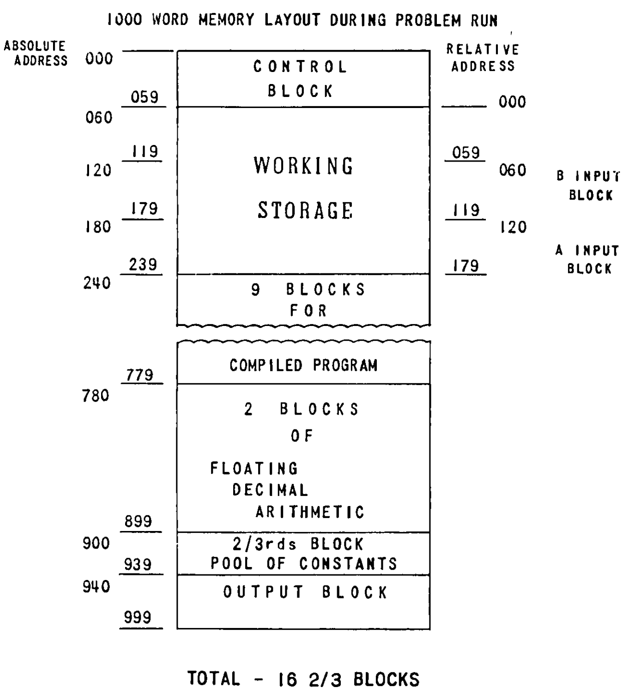

Figure 1

WORKING STORAGE

RELATIVE ADDRESS					STARTING VALUES
000	-99	000	000	000	X = -.99
	000	000	000	000	
002	010	000	000	000	ΔX = .01
	-00	000	000	001	
004	010	000	000	000	L_x = 1.0
	000	000	000	001	
006	020	000	000	000	Power of x = 2.0
	000	000	000	001	
008	050	000	000	000	C = 5.0
	000	000	000	001	
010	043	429	448	190	$Log_{10} e$ = .43429448190
	000	000	000	000	
012					
014					

Figure 3

matically read computational instructions into the memory as required. The writer of pseudo-instructions need not be concerned with this area of the memory.

060 to 119 WORKING STORAGE. These 60 locations in the Univac memory are used for storage of constants and intermediate results during execution of the program. The person utilizing the compiler is responsible for the layout of this area of memory.

120 to 179 INPUT DATA BLOCK B. This group of storage locations is set aside for problem data read in from tape. In use, a block (60-words) of problem data is brought into an input block. As the raw data is processed, it is removed from the input block in successive groups of words called items. In Fig. 1 it will be noted that the memory layout contains space for two input blocks. This permits information to be brought into the calculation from more than one reel of magnetic tape. Input block B is normally considered a second or auxiliary input data storage block. If only one input block is required, block A (see Fig. 1) should be used in preference to block B; block B under this circumstance can serve as additional working storage.

180 to 239 INPUT DATA BLOCK A. The function of input block A is described above. This block may be used for working storage as well.

240 to 779 RUNNING PROGRAM. Instructions produced by the compiler system occupy this area of the memory, and these locations contain instructions necessary to execute the solution of the problem. It will be noted that this area contains space for nine blocks (nine 60 word units) of instructions. If the solution of a problem requires more than this number of instructions the compiler automatically provides for retention of the excess instructions on tape until summoned into the memory by the Control Block instructions. These nine (or less) blocks of instructions are called <u>one segment</u>.

780 to 899 FLOATING DECIMAL ARITHMETIC. This area contains all the C-10 instructions necessary to perform the most commonly used floating decimal operations of addition, subtraction, multiplication, and division. Storage of these instructions eliminates the necessity for repeating them in the finished C-10 instructions produced by the compiler. The writer of pseudo-code instructions will seldom be concerned with the specific contents of this area of the memory.

900 to 939 POOL OF CONSTANTS. Common constants frequently required by the various operations in the finished running program produced by the compiler are stored here. Fig. 2 contains a complete list of these constants.

940 to 999 OUTPUT BLOCK. Final results are stored here. As mentioned previously, Univac reads and writes in blocks of sixty words each. When 60 Univac words of final results have been accumulated in this area of the memory the block is automatically written on magnetic tape.

SAMPLE PROBLEM

A sample problem at this point will best illustrate how the A-2 Compiler System may be utilized to prepare a program for solution by Univac.

<u>Statement of the Problem</u>. Tabulate $y = e^{-x^2} \sin cx$, where x ranges between −.99 and +.99 in increments of $\Delta x = .01$. It is required that y be determined for each of the 199 values of x throughout the given range. Finally it is desired to print in tabular form the values of x in one column and the corresponding values of y in the next column.

<u>Analysis and Method of Solution.</u> Analysis of the problem for solution consists of setting down a series of operations according to the method of solution.

	OPERATION NO.	DESCRIPTION
Starting Values	0	Input -- It must be decided at this time what initial values are necessary for the computation in this operation. Provision is made for reading these values into the computer.
Intermediate Results	1	Calculate x^2
	2	Obtain $-x^2$
	3	Calculate e^{-x^2}
	4	Calculate cx
	5	Calculate sin cx
	6	Calculate $e^{-x^2} \sin cx$
	7	Since there are a number of values of y to be calculated in this problem, it is desirable to put beside each y result the appropriate x value used in its solution. During this operation the value of x (in working storage) will be placed next to the value of y (in working storage) just calculated to facilitate later removal to magnetic tape.

8 In order that the results may be printed out in desired form an editing operation must be performed.

9 Each x and its corresponding y must be stored for subsequent recording on the result tape. When a sufficient number of these values have been accumulated, (one block) they will automatically be written on tape.

10 The first value of y has now been calculated. Operations 1 through 10 must be repeated with a new value of x obtained by adding the increment of ($\Delta x = .01$) to the previous value of x. This cycle (an iteration) must be repeated until the last value of x has been calculated. When this occurs, operation No. 11, should be performed.

11 The last output block may be only partially filled with the values of x and y. Operation 11 will fill the rest of the block with non-numeric characters and write this last block on tape.

12 This operation will terminate the program by rewinding the magnetic tapes and stopping the computer.

Layout of Working Storage. When writing pseudo-code in the sequence dictated by the analysis and method of solution it is customary to proceed just as though the computation were taking place at the time. Hence, before the actual computational steps can be written in pseudo-code, the initial or starting values must be located in working storage and relative addresses assigned to them. All floating decimal values (two-word units) are stored and transferred in pairs. When referring to any values in the working storage, only the relative address of the first word of the pair need be indicated since the second word always travels along with it. The values required to begin this computation are:

x -- the variable

Δx -- the increment

Lx -- the upper limit of the range of x

2 -- the power of x

C -- the constant

$LOG_{10}e$ -- constant needed by a sub-routine to calculate e^{-x^2}

These are written in floating decimal form and located in the working storage block as shown (Fig. 3). The order and location of these values in working storage is arbitrary and left to the discretion of the coder.

The six starting values must be recorded (unityped) on tape in the arrangement shown (Fig. 3) before they can be brought into the computer. When the data is "read" into the computer from tape it is deposited in an input block. Then, as many values as are needed are transferred into the working storage in the locations desired by the coder. In order for the computer to perform this operation it requires instructions in its own language. Ordinarily, the coder would have to write 84 C-10 instructions and be certain that the logic of the relationship of one instruction to another would cause the computer to correctly perform the desired operation. With compiler pseudo-code only one instruction need be written. This one pseudo-instruction directs the compiler to produce (in C-10 code) the 84 logically related instructions. The pseudo-instruction must be in a prescribed form. All the pseudo-instructions currently available with the compiler are shown in Figure 4. In Figure 4, the variables (in the pseudo-instructions) to be supplied by the coder have been underlined (in the original manual they are printed in red ink); but note also that capital letter O (oh) is distinguished from cipher 0 (zero) in that capital O is underlined. Figure 4 is a master key to coding with pseudo-instructions; continual reference to it is needed to understand this discussion.

In the analysis Operation 0 is an input operation. Under the column titled "Description" look for the word input. In the first line find "Input Generator". To the left of this under "Instructions" is the pseudo-instruction covering this operation, namely:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	I	0	(t)	(A/B)	0	(s	)	(	m	)

Copy everything "black" (not underlined) on the first line of the coding sheet in the corresponding digit positions:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	I	0			0					

It is the coder's responsibility to supply the variables noted in underlining.

The coder is first required to fill in a tape or Uniservo number for "t". This (t) is the number of the tape-handling unit which will hold the data tape when solution of the problem is being done after compilation.

Uniservo 1 is always reserved for the compiled program during solution. Therefore, Uniservos 2 through 9 and -- (uniservo number 10) are available for data and result tapes. Since number 2 is the next unused "servo" it will be assigned to hold the data. So in place of t write 2:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	I	0	2		0					

A or B (digit position 6) is to be filled in next. This designates what input block in the running memory is to be used to store the data block when it is read from Uniservo number 2. When one input block is needed use block A. This problem has only one data tape so only one input block is required. In the sixth digit position fill in A:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	I	0	2	A	0					

The next thing to be supplied is a two digit value for "s" (digit positions 8 and 9). The block of data has been read from Uniservo #2 into input block A. Now "s" number of words are to be transferred from the beginning of this block into working storage. It was decided previously that six values were needed immediately. Since each value is expressed by two words there are then 12 words to be transferred. Consult note 2 to see if an "item size" of 12 is allowable: It is, therefore the coder writes 12 in the appropriate spaces:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	I	0	2	A	0	1	2			

The last piece of information concerns "m" (digit positions 10, 11, 12). Since m covers an area of 3 spaces, a relative working storage address is required (see note 1) . It was decided to have the six values in working storage starting at relative address 000. For "m" fill in 000:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	I	0	2	A	0	1	2	0	0	0

The pseudo-instruction for the input is now completed. When the compiler interprets this pseudo-instruction,it will "call" the Input Generator (a subroutine) from the Library and supply the pseudo-instruction to it. The generator, on the basis of the variables supplied, will generate 84 C-10 instructions (a subroutine) which will become the first part of the compiled program.

It will be capable of reading a data block from Uniservo #2 (t) into input block A or B (in this case A) then transfer "s" words (12) from the beginning of the input block to the working storage starting at relative address 000 (m). In the event that more data would be needed from the input block, (not the case in this problem) control is transferred back to the GMI operation number and it would transfer the next 12 words to the same place as working storage. Each time the GMI subroutine is executed it transfers the next successive "s" words to working storage. When the input block is exhausted GMI will read another data block from tape into the same input block and transfer the first "s" words in the block to working storage.

The beginning values are now in working storage in the arrangement decided on in the layout of Working Storage. Operation 1 — Calculate x^2. This operation requires that the variable "x" be raised to the second power. Under Description, look for the proper routine. In the eleventh line find "Raise to a Whole Power". To the left the pseudo-instruction is:

1	2	3	4	5	6	7	8	9	10	11	12
A	P	N	(	A	)	(	N	)	(	B	)

Copy the black characters in the second line of the coding sheet. The relationship of A, N, and B are explained in the column to the left labeled "FORM". It shows $A^n = B$. Since each of these covers three digits, relative working storage addresses are to be supplied (see note 1). An inspection of the working storage shows that the variable X is in relative location 000. Since A represents the address for X write 000:

1	2	3	4	5	6	7	8	9	10	11	12
A	P	N	0	0	0						

N is the notation for the address of the power to which the variable is to be raised. In this problem, the value of the power is 2. It is contained in the working storage. The relative address of 2 is 006. For N, fill in 006. See note 4 concerning limits of values A and N. The values used in this problem are allowable.

1	2	3	4	5	6	7	8	9	10	11	12
A	P	N	0	0	0	0	0	6			

B is the relative address of the location in which the result (x^2) of this operation is to be stored. Since the first open location is 012, the result (x^2) is assigned relative address 012. This instructs the routine to place the result in 012 of the working storage.

1	2	3	4	5	6	7	8	9	10	11	12
A	P	N	0	0	0	0	0	6	0	1	2

Operation 1 would require 152 C-10 coded instructions. Utilizing A-2, one instruction suffices. The compiler automatically supplies the necessary coding.

Operation 2: Obtain $-x^2$. Operation 2, (in this case Change Positive quantity to negative), under Description look for change sign. Copy characters in black:

1	2	3	4	5	6	7	8	9	10	11	12
A	N	1				0	0	0			

For A, the coder supplies the address of the value to have its sign changed. It is the value just calculated and placed in 012. Write 012 for "A" on the third line of the coding sheet:

1	2	3	4	5	6	7	8	9	10	11	12
A	N	1	0	1	2	0	0	0	0	1	4

Now, the location in which the value is to be stored after having its sign changed is wanted. The next open location is 014; fill this address in for B. Address 012 could have been used for B since the value x^2 was not needed after the routine removed it from 012 to change its sign. However, since there are many locations left in working storage to more than cover the needs of the problem, the coder can use them rather liberally.

Operation 3: Calculate e^{-x^2}. The constant e is to be raised to the $-x^2$ power. APN may not be used since $-x^2$ is a fractional number. So under Description look for a routine to fit this operation. To the left of "Raise to a Fractional Power" find the pseudo-instruction:

1	2	3	4	5	6	7	8	9	10	11	12
X	+	A	(	N	)	(	Log_{10}	A)	(	B	)

Copy X+A in the fourth line of the coding sheet. The first address wanted is that of N. It is the power to which e is to be raised. The value $-x^2$ has been placed back in 014. For N fill in 014.

1	2	3	4	5	6	7	8	9	10	11	12
X	+	A	0	1	4						

In the column labeled FORM to the left of X+A the mathematical operation is noted. A^n is equivalent to e^{-x^2}. The subroutine that is to calculate A^n requires that A be given in its logarithmic form. Since in our problem e is equivalent to A, the $\log_{10}e$ must be supplied. This was done in the layout of the working storage. The address of this value is 010.

For $\log_{10}A$ fill in 010: (see note 5)

1	2	3	4	5	6	7	8	9	10	11	12
X	+	A	0	1	4	0	1	0			

For B fill in the location in which e^{-x^2} is to be stored in the working storage. The next open location is 016. Fill in 016:

1	2	3	4	5	6	7	8	9	10	11	12
X	+	A	0	1	4	0	1	0	0	1	6

Operation 4 -- Calculate cx. This operation is clearly a multiplication. The pseudo-instruction is:

1	2	3	4	5	6	7	8	9	10	11	12
A	M	0	(	A	)	(	B	)	(	C	)

Again, according to note 1 relative working storage addresses for A, B, and C are needed. The value for C is stored in 008. The value x is still 000, of course. Fill in A and B:

1	2	3	4	5	6	7	8	9	10	11	12
A	M	0	0	0	8	0	0	0			

The product will be placed back in working storage in the next open location, 018:

1	2	3	4	5	6	7	8	9	10	11	12
A	M	0	0	0	8	0	0	0	0	1	8

Operation 5 -- Calculate sin cx. Look for pseudo-instruction for sin. Fill in black characters on coding sheet:

1	2	3	4	5	6	7	8	9	10	11	12
T	S	0				0	0	0			

Note 10 cautions that the angle must be expressed in radians. The quantity cx is certainly in a decimal form. For A, the address of cx is required. It is in location 018. Fill in 018 for A:

1	2	3	4	5	6	7	8	9	10	11	12
T	S	0	0	1	8	0	0	0			

Since this routine needs only one input quantity, digits 7, 8, and 9 are just filled in with zeros. The last three digits are again for the location of the result. Fill in 020:

1	2	3	4	5	6	7	8	9	10	11	12
T	S	0	0	1	8	0	0	0	0	2	0

Operation 6 — Calculate e^{-x^2} sin cx. Both parts of the product are stored in working storage in 016 and 020. A multiply operation is required. Since this operation was written previously, the coder should remember the form and be able to write the pseudo-instruction required at this time with no further explanation:

1	2	3	4	5	6	7	8	9	10	11	12
A	M	0	0	1	6	0	2	0	0	2	4

The product of the multiplication is the first y result. This result has been placed in 024 instead of 022 because if x and y are to be together when they are collected in the output block, x then must be moved next to "y". 022 has been reserved for this purpose.

Operation 7 -- Move x next to y. Under "Description" look for a routine that will move floating decimal quantities. Find "Move FL. Dec. Numbers". To the left the pseudo-instruction is

1	2	3	4	5	6	7	8	9	10	11	12
M	V	0	(	m_1	)	(	n	)	(	m_2	)

m_1 is the location from which the number is to be taken. n as described in Note 1 is the number of values, not words, to be moved. m_2 is the location to which it is to be moved. It is required that x be moved next to y. Since x is in location 000 write 000 for m:

1	2	3	4	5	6	7	8	9	10	11	12
M	V	0	0	0	0						

Only one value (x) is to be moved, therefore, fill in 001 for n:

1	2	3	4	5	6	7	8	9	10	11	12
M	V	0	0	0	0	0	0	1			

x is to be moved to 022; for m_2 fill in 022;

1	2	3	4	5	6	7	8	9	10	11	12
M	V	0	0	0	0	0	0	1	0	2	2

Remember that the value x is not erased when transferred.

Operation 8 -- Editing. It is desired to edit x and y and have them printed in two columns. There will be 198 x's and y's. This number of results is considered a small amount of "output". There is only one 'small volume' editing routine. The pseudo-instruction is found near the bottom of the Instruction sheet:

1	2	3	4	5	6	7	8	9	10	11	12
E	D	U	(	m_1	)	(c)	(n	)	(	m_2	)

C is the number of columns the coder desires converted to printed form. n is the number of values to be edited at one time starting at location m_1. m_2 is the starting location to which n values are to be returned after editing. Values are to be in successive locations beginning with m_1 and will be put back successively starting with location m_2.

In this problem c = 2 since 2 columns are desired. n = 2 because there are two values, x and y, to be edited. m_1 = 022 because this is the address of x, and m_2 = 022 because the edited numbers are to be returned to same locations. The unedited values are no longer desired or needed. The pseudo-instructions should be filled in as follows:

1	2	3	4	5	6	7	8	9	10	11	12
E	D	U	0	2	2	2	0	2	0	2	2

Operation 9 -- transfer of results to "output block". The edited values x and y should now be transferred to the output block. A total of 4 words will be transferred since x and v are expressed by 2 words each. In Figure 4 look for OUTPUT GENERATOR. The pseudo-instruction is:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	0	0	(t)	X	(H/L)	(s	)	(	m	)

On the coding sheet, copy the characters which are in black print:

1	2	3	4	5	6	7	8	9	10	11	12
G	M	0	0		X						

The character in digit position 3 is underlined to distinguish the letter O from a zero. In place of t, the coder is required to supply a Uniservo number that will hold the tape on which the output or results are to be recorded. The next available Uniservo in sequence is number 3. For t fill in 3, (digit position 5):

1	2	3	4	5	6	7	8	9	10	11	12
G	M	O	0	3	X						

In digit position 7 an "H" or "L" is to be written. If EDF or EDT is used, the letter H must be written. If EDU is used, then fill in L. H means record the results at high density (100 characters / inch) on the tape. This will be a tape prepared for the high-speed printer. L means low density (20 characters / inch) and this tape will be prepared for the Uniprinter or low-speed printer.

If none of the edit routines are used, then it is left to the discretion of the coder to fill in the proper letter. It is suggested that if there is a small amount of results to be printed, the uniprinter be utilized. In this case the coder designates L. If the output is large, then write H. In this problem EDU was used, therefore, the coder must write L. (In the 7th digit position fill in L).

1	2	3	4	5	6	7	8	9	10	11	12
G	M	O	0	3	X	L					

For "S" fill in the number of words to be transferred from the working storage to the output block. Since there are 4 (2 for x and 2 for y), S = 4. Consult Note 2 to be sure that 4 is an allowable "item size".

1	2	3	4	5	6	7	8	9	10	11	12
G	M	O	0	3	X	L	0	4			

The last three digits require a relative address. (Note 1). x and y are stored in working storage beginning at location 022. For m fill in 022.

1	2	3	4	5	6	7	8	9	10	11	12
G	M	O	0	3	X	L	0	4	0	2	2

As in the case of GMI, when the compiler interprets this pseudo-instruction, it will call in the OUTPUT GENERATOR subroutine from the library. The generator will take the variables supplied and generate a subroutine which will pick up S words (in this case 4) from the working storage beginning at m (in this case 022) and transfer them to the output block beginning at 940. Upon cycling back through the subroutine, four words will be transferred (beginning at 022) to 944 of the output block. Each time the subroutine is executed it will transfer 4 words from the same place in working storage to the next successive 4 locations in the output block. When the block is full (after 15 transfers in this case) the subroutine will automatically record the contents of the output block on Uniservo t (in this case 3) as required.

Operation 10 -- Increase x by the increment Δx and test to determine if all values of X throughout the range have been used to calculate the y results required.

The description of this operation is "ADD to A LIMIT". The pseudo-instructions are found to the left. Copy everything in black print:

1	2	3	4	5	6	7	8	9	10	11	12
A	A	L									
1	C	N	0	0	0	0					
2	C	N	0	0	0	0					

The first line requires 3 relative working storage addresses. (Note 1) The values needed are x, Δx and Lx (the limit of the range of x) See Note 11. X is known to be in 000; Δx is in 002; Lx is in 004. Fill in as shown below:

1	2	3	4	5	6	7	8	9	10	11	12
A	A	L	0	0	0	0	0	2	0	0	4

On the basis of the first line the routine will add x (in 000) to Δx (in 002) and place the sum (the new x) back in 000. This new x will then be tested against the limit of x (Lx) to determine whether or not the limit has been reached. Since the limit has not been reached ($-.99 + .01 = -.98$; and $-.98 \neq 1.0$) the calculation must be repeated with the new value of x. All the coder is required to do is send "control" back to the beginning and calculate the next y with the new value of x. This is the purpose of the ICN line. The "red" notation in this line reads $\neq$ OPN #, meaning that if the new x is not equal to the limit, control will be transferred to the operation number placed here. Upon looking back in the analysis the coder can see that the actual calculation begins with Operation 1. It is not necessary to go to Operation 0 since the input block contains no more data needed for the solution of the problem. In the 5 digit positions fill in 00001:

1	2	3	4	5	6	7	8	9	10	11	12
1	C	N	0	0	0	0	0	0	0	0	1

Five places have been made available because the compiler can handle up to 99,999 operations.

After 2CN there is the underlined notation OPN #. This signifies that when the limit is reached transfer control to the operation noted in these 5 spaces. The analysis shows that control is to be transferred to the next operation; number 11. So in place of = OPN # write 11.

1	2	3	4	5	6	7	8	9	10	11	12
2	C	N	0	0	0	0	0	0	0	1	1

The complete pseudo-code for this operation is:

1	2	3	4	5	6	7	8	9	10	11	12
A	A	L	0	0	0	0	0	2	0	0	4
1	C	N	0	0	0	0	0	0	0	0	1
2	C	N	0	0	0	0	0	0	0	1	1

Operation 11 -- Fill the "partial" output block with non-numeric characters and record it on tape.

As the output blocks are filled by successive transfers of results from the working storage, they are recorded on tape. When a problem has ended, the output block may not be completely filled with results. The coder at this point might wish to know where the valid results end in this last "partial block". It is the function of this operation to fill in non-numeric characters just after the last valid result up to the end of the block and then record this block on tape. Under description, find "ENDING SENTINEL GENERATOR". The pseudo-instruction is:

1	2	3	4	5	6	7	8	9	10	11	12
G	Z	Z	0	(s	)	0	(Z/E)	0	(H/L)	0	(t)

Much of the information to be filled in must be the same as written for GMO (if the output generator was used). "S" is the number of words transferred to the output block during one output operation. GMO has been used in this problem and, "S" equaled 4. "S" must, therefore, be 4 in GZZ.

1	2	3	4	5	6	7	8	9	10	11	12
G	Z	Z	0	0	4	0		0		0	

If an editing operation has not been performed write Z. If an editing operation has been used, as is the case in this problem, write E:

1	2	3	4	5	6	7	8	9	10	11	12
G	Z	Z	0	0	4	0	E	0		0	

If E is written, the "partial block" will be filled with spaces (Δ) and recorded on tape. Two more blocks will be recorded after the partial block with a word of printer stops (Σ) in the first and last word of each block. The character Σ stops the printer when it is interpreted. If Z is written, the partial block will be filled with Z's and the two blocks following will have a word of Z's in the first and last words of the blocks. (Note 3)

Write H or L depending on what has been written previously in GMO. H means that results will be recorded on tape at 100 characters / inch. L means that results will be recorded on tape at 20 characters / inch. In GMO, L was used. Therefore in GZZ fill in L (digit position 10).

1	2	3	4	5	6	7	8	9	10	11	12
G	Z	Z	0	0	4	0	E	0	L	0	

For t the same number used in GMO must be written in GZZ. This is the uniservo that is controlling the result tape. Write 3 for t in digit position 12.

1	2	3	4	5	6	7	8	9	10	11	12
G	Z	Z	0	0	4	0	E	0	L	0	3

Operation 12 -- Rewind all tapes on Uniservos used and stop the computer. When a problem has come to an end it is necessary to rewind the tapes used in the solution of the problem in order to dismount them from the Uniservo.

The pseudo-instruction to the left of "REWIND TAPES AND STOP" is:

1	2	3	4	5	6	7	8	9	10	11	12
R	W	S	tape		nos.		in		order		

Copy characters in black:

1	2	3	4	5	6	7	8	9	10	11	12
R	W	S									

Write, in ascending order, the numbers of the Uniservos that are to have their tapes rewound. Uniservos 1, 2, and 3 have been used:

1	2	3	4	5	6	7	8	9	10	11	12
R	W	S	1	2	3	0	0	0	0	0	0

Fill in zeros in all unused spaces.

The last pseudo-instruction has been written to completely describe the solution of the problem to the compiler. An ending word must now be written which tells the compiler that there is no more pseudo-code for it to interpret. Under "description" the last line reads "END OF INFORMATION". To the left is the word that must be written just as it appears:

1	2	3	4	5	6	7	8	9	10	11	12
E	N	D	Δ	C	O	D	I	N	G	Δ	Δ

The complete pseudo-code for the sample problem can be found in Fig. 5 . This pseudo-code sheet is given to a unitypist and she will record it on Univac metallic magnetic tape by means of the UNITYPER. She will type only the 12 character pseudo-instructions from left to right, digit by digit until all 16 instructions have been recorded. She will then fill the rest of the block with zeros. Since the computer will only accept information from tape in groups of 60 Univac words, the unitypist must fill out the rest of the block. It is customary to use zeros as the "fill characters". When the tape is returned to the coder it should be mounted on a printer and the pseudo-code printed out and proof-read against the original to be sure that no transcription errors have occurred.

At the same time, the data tape should be prepared. For this problem it is written as shown in Fig. 6 . The same procedure is followed in preparing this tape. When it has been proof-read, the tape should be set aside and kept for the computational run.

Compilation. The pseudo-code tape should be mounted together with the compiler instruction tape, the library tape, and 4 blank tapes, on Uniservos designated in the "OPERATING INSTRUCTIONS FOR COMPILING" located in the appendix.* By following these operating instructions, the Univac operator will initiate the compiling process. If any print-outs occur during compilation other than the normal four described in "PHASES OF COMPILATION", consult the page in appendix* entitled "Compiling Print-outs".

When the compilation has been completed, as evidenced by the print-out "ENDCOMPILE", the compiled program is on Uniservo 4. This tape should be taken off and a ring inserted in the center of the reel. All other tapes should then be removed. Always mount the compiled program on Uniservo number 1. In this problem Uniservo 2 was assigned the data tape. Mount on Uniservo 2 the data tape which has previously been prepared. Mount a blank reel of tape on Uniservo 3. This tape will receive the final results. The operator follows the "OPERATING INSTRUCTIONS FOR PROBLEM RUN". Univac may now proceed with the problem solution.

When the computation is finished, the results will be on tape on Uniservo 3. This tape should then be mounted on the Uniprinter since EDU was used to edit the results during the computation.

(Note: This concludes the extract from "The A-2 Compiler System" published currently. For more information, see the original manual obtainable from Remington Rand, 315 Fourth Ave., New York 10, N.Y.)

*The appendix of the original manual.

- END -

* —————— * —————— *

THE EDITOR'S NOTES

(continued from page 4)

omitting the two outermost extremes), the variation in "the range of mental abilities is around 3 to 1". This statement may mean that the highest human I.Q. (about 200) is about three times the lowest I.Q. (about 67).

But can intelligence (or composite mental abilities) be measured objectively on a unidimensional scale, in which a unit in one part of the scale is geometrically equal to a unit in any other part of the scale (as is the case with height measured in units of inches)? It does not seem so. If any reader can throw light on the measurement of intelligence, on a comparable basis for animals, men, and machines, whether stupid, average, or brilliant, he is invited to write us.

- END -

POOL OF CONSTANTS

STORED IN MEMORY DURING PROGRAM RUN. FOR USE BY SUB-ROUTINES

900	R 904	U 901	This goes to 000	920	ZZZZZZ	ZZZZZZ	
901	C 905	B 904		921	050000	000000	
902	A- 939	C 904	Generalized Overflow	922	099999	999999	
903	B 905	00 000		923	000000	000060	
904	[00 000	U(///]		924	016666	666667	1/3!
905	[contents	of rA]		925	041666	666667	1/4! x 10
906	000800	000000		926	083333	333333	1/5! x 10^2
907	003000	000000	Required by the special read in- structions	927	013888	888889	1/6! x 10^2
908	002000	000000		928	019841	269841	1/7! x 10^3
909	001000	000000		929	024801	587302	1/8! x 10^4
910	040000	000000		930	000000	U00000	
911	000000	000000		931	027557	319224	1/9! x 10^5
912	-00000	000000		932	078539	816340	$\pi/4$
913	010000	000000		933	015915	494309	$1/2\pi$
914	-10000	000000		934	025052	108385	1/11! x 10^7
915	001000	000000		935	020876	756988	1/12! x 10^8
916	000001	000000		936	000111	000000	
917	000000	000001		937	000000	000111	$LOG_{10}e$
918	000001	000001		938	043429	448190	$LOG_{10}e$
919	020000	000000		939	000000	000001	OF constant

Figure 2

OPERATION NUMBER													
0	G	M	I	0	2	A	0	1	2	0	0	0	READ IN STARTING VALUES
1	A	P	N	0	0	0	0	0	6	0	1	2	CALCULATE x^2
2	A	N	1	0	1	2	0	0	0	0	1	4	OBTAIN $-x^2$
3	X	+	A	0	1	4	0	1	0	0	1	6	CALCULATE e^{-x^2}
4	A	M	0	0	0	8	0	0	0	0	1	8	CALCULATE cx
5	T	S	0	0	1	8	0	0	0	0	2	0	CALCULATE sin cx
6	A	M	0	0	1	6	0	2	0	0	2	4	CALCULATE y (e^{-x^2} · sin cx)
7	M	V	0	0	0	0	0	0	1	0	2	2	MOVE x NEXT TO y
8	E	D	U	0	2	2	2	0	2	0	2	2	EDIT x AND y
9	G	M	0̲	0	3	X	0	0	4	0	2	2	TRANSFER x AND y TO OUTPUT
10	A	A	L	0	0	0	0	0	2	0	0	4	$x + \Delta x \longrightarrow x_1$ TEST x_1 AGAINST Lx
	1	C	N	0	0	0	0	0	0	0	0	1	IF ≠ GO TO OPERATION 1
	2	C	N	0	0	0	0	0	0	0	1	1	IF = GO TO OPERATION 11
11	G	Z	Z	0	0	4	0	E	0	L	0	3	FILL PARTIAL BLOCK WITH Δ's
12	R	W	S	1	2	3	0	0	0	0	0	0	REWIND TAPES 1, 2, AND 3 STOP!
	E	N	D	Δ	C	0̲	D	I	N	G	Δ	Δ	
					FILL		ZEROS						
					TO	END	OF						
						BLOCK							

Figure 5 -- Complete Pseudo-Code for the Problem

DATA TAPE LAYOUT

												STARTING VALUES
-	9	9	0	0	0	0	0	0	0	0	0	x = -.99
0	0	0	0	0	0	0	0	0	0	0	0	
0	1	0	0	0	0	0	0	0	0	0	0	Δx = .01
-	0	0	0	0	0	0	0	0	0	0	1	
0	1	0	0	0	0	0	0	0	0	0	0	Lx = 1.0
0	0	0	0	0	0	0	0	0	0	0	1	
0	2	0	0	0	0	0	0	0	0	0	0	Power of x = 2.0
0	0	0	0	0	0	0	0	0	0	0	1	
0	5	0	0	0	0	0	0	0	0	0	0	c = 5.0
0	0	0	0	0	0	0	0	0	0	0	1	
0	4	3	4	2	9	4	4	8	1	9	0	$LOG_{10}e$ = .43429448190
0	0	0	0	0	0	0	0	0	0	0	0	
			FILL			ZEROS						
			TO	END		OF						
				BLOCK								

Figure 6

EXPLANATION OF NOTES

NOTE 1: ALL SYMBOLS OCCUPYING 3-DIGITS REFER TO EVEN MEMORY ADDRESSES IN WORKING STORAGE IN RELATIVE FORM EXCEPT:
m_1 & m_2 IN **GMM** WHICH ARE ABSOLUTE ADDRESSES AND MAY BE ANYWHERE IN MEMORY;
n IN **MVO** WHICH IS NUMBER OF VALUES NOT WORDS.
n IN **SUM** WHICH IS NUMBER OF VALUES NOT WORDS.
m IN **QZO** WHICH IS THE RELATIVE ADDRESS IN WORKING STORAGE BUT MAY BE ODD;
c IN **EDU** WHICH IS THE NUMBER OF COLUMNS DESIRED ON THE FORMAT
m IN **GMI** AND **GMO** WHICH IS THE RELATIVE ADDRESS IN **W.S.** BUT NOT ALWAYS EVEN. SEE NOTE 2

NOTE 2: t MAY BE 2 THRU 9 OR –; **A** IS 180 BLOCK; **B** IS 120 BLOCK; **X** IS 940 BLOCK; m IS ADDRESS OF FIRST WORD OF ITEM **S**; **S** MAY BE 1, 2,3,4,5,6,8,10,12,15,20 OR 30; $S > 1$, m MUST BE EVEN; $S > 9$, m MUST BE DIVISIBLE BY 10; $S = 8$ THERE ARE 7 ITEMS/BLOCK AND LAST 4 WORDS ARE ZEROES; END OF DATA AND END OF TAPE TESTS ARE NOT INCLUDED. **H** IS FOR HIGH DENSITY OR HIGH SPEED PRINTER. **L** IS FOR LOW DENSITY OR UNIPRINTER.

NOTE 3: **Z** FILLS PARTIAL BLOCK WITH **Z's** AND/OR LAST TWO BLOCKS WITH a WORD OF **Z's** IN FIRST AND LAST WORD OF EACH BLOCK. **E** IS FOR EDITED OUTPUT FILLING PARTIAL BLOCK WITH SPACES AND/OR LAST TWO BLOCKS WITH A WORD OF PRINTER STOPS IN FIRST AND LAST WORD OF EACH BLOCK. **H** AND **L** IS SAME AS NOTE 2.

NOTE 4: $-99 \leq N \leq 99$. FOR $-99 > N > 99$, **LARGE EXP.** AND POWER PRINTS OUT - PROBLEM STOPS. IF **N** IS NOT A WHOLE POWER, **FRACT. EXP** AND POWER PRINTS OUT - PROBLEM STOPS. IF $A = 0$ AND $N < 0$, **G 0 DIVISOR** PRINTS OUT - PROBLEM STOPS. IF $A = N = 0$, **INDEF FORM** PRINTS OUT - PROBLEM STOPS.

NOTE 5: THE PRODUCT OF $N \log_{10} A$ MUST NOT HAVE AN EXPONENT EXCEEDING + 10.

NOTE 6: $-9 \leq N \leq 9$. FOR $A < 0$, **N** MUST BE ODD.

NOTE 7: **A** MUST BE GREATER THAN ZERO.

NOTE 8: QUANTITIES x_i ARE STORED CONSECUTIVELY STARTING WITH X_0 AND ENDING WITH X_n.

NOTE 9: COEFFICIENTS MUST BE STORED CONSECUTIVELY IN **W.S.** STARTING AT C_n THRU C_0. C_0 MUST BE FOLLOWED BY ONE WORD OF Δ's.

NOTE 10: ALL ANGLES MUST BE EXPRESSED IN RADIANS.

NOTE 11: L_x MUST BE ONE INCREMENT LARGER THAN LARGEST x TO BE OPERATED ON.

NOTE 12: FOR HIGH SPEED PRINTER ONE TO ONE BOARD. BLOCK SUBDIVIDER MUST BE DEPRESSED DURING EDITING. FORM IS ±.xxxx xxx xxx xΔ (± xx x) ΔΔΔΔ. FOR EXPONENT > |999|, PRINTS ON **SCP**, **EXP. OUT OF RANGE** FOLLOWED BY UNEDITED NUMBER. UNEDITED NUMBER WILL GO ON TAPE.

NOTE 13: SAME AS **EDF** EXCEPT AS FOLLOWS: FOR UNIPRINTER. NO BLOCK SUBDIVISION. IF MEETS WORD OF **Q'S**, INSERTS 4 CARRIAGE RETURNS. IF MEETS WORD OF **Z's**, INSERTS PRINTER BREAKPOINT. $1 \leq c \leq 8$

NOTE 14: SAME AS **EDF** EXCEPT AS FOLLOWS: FOR EXPONENT > |10|, PRINTS ON **SCP**, **EXP OUT OF RANGE** FOLLOWED BY UNEDITED NUMBER. UNEDITED NUMBER WILL GO ON TAPE. FOR EXPONENT OF 0 THRU -10 (ie:-4), FORM IS ± .0000xxxxxxxxxx0000. FOR EXPONENT OF 1 THRU + 10 (ie +4), FORM IS ± xxxx.xxxxxxx0000000.

FORM

A BLOCK FROM TAPE t TO BLOCK A OR B THEN S WORD ITEM TO W.S. AT m

n WORDS GO FROM m_1 **absolute** TO m_2 **absolute**

n NUMBERS STARTING AT m_1 IN **W.S.** GO TO m_2 IN **W.S.**

S WORD ITEM AT m IN **W.S.** GOES BLOCK X WHEN X FILLED TO TAPE t

S WORD ITEM. Z OR E SENTINEL. H OR L DENSITY. OUTPUT TAPE t

$A + B = C$

$A - B = C$

$A \times B = C$

$A \div B = C$

$-(\pm)A = (\mp)\ B$

$A^N = B$

$A^N = B$

$\sqrt{A} = B$

$\sqrt[N]{A} = B$

$\text{LOG}_B A = B$

$\Sigma x_i = \Sigma x$ WHERE i GOES FROM 0 TO n

$\Sigma C_i x^i = P$ WHERE i GOES FROM 0 TO n

SIN A = B

COS A = B

ARCTAN A = B

$x_i + \Delta x \quad x_{i+1}$

IF $x_{i+1} \neq L_x$ GO TO ≠ **OPN #**

IF $x_{i+1} = L_x$ GO TO = **OPN #**

IF $A = B$ GO TO = **OPN #**

IF $A \neq B$ GO TO NEXT **OPN #**

IF $|A| = |B|$ GO TO = **OPN #**

IF $|A| \neq |B|$ GO TO NEXT **OPN #**

IF $A > B$ GO TO > **OPN #**

IF $A \leq B$ GO TO NEXT **OPN #**

IF $|A| > |B|$ GO TO > **OPN #**

IF $|A| \leq |B|$ GO TO NEXT **OPN #**

GO TO OPN #

IF m ≠ WORD OF Z's GO TO ≠ **OPN #**

IF m = WORD OF Z's GO TO = **OPN #**

REPEAT ALL OPERATIONS
from OPN #
up to OPN #
then go to OPN #

TYPE 4 WORDS INTO m_a, m_{a+1}, m_b, m_{b+1}
PRINT OUT 4 WORDS FROM m_a, m_{a+1}, m_b, m_{b+1}

TAKE n VALUES STARTING m_1 EDIT, AND PLACE IN m_2

SAME AS **EDF** EXCEPT c IS NUMBER OF COLUMNS IN FORMAT

SAME AS **EDF**. SEE NOTES

IF ALL ZEROS, STOPS COMPUTER ONLY

AUTOMATIC UNLESS INSERTED BETWEEN OPERATIONS

MUST FOLLOW LAST PSEUDO-INSTRUCTION

Figure 4

NOTE	PSEUDO-INSTRUCTIONS 1	2	3	4 5 6 7 8 9 10 11 12	DESCRIPTION
1,2	G	M	I	0 (t) (A/B) 0 (S) (m)	INPUT GENERATOR
1	G	M	M	(m_1 abs.) 0 (n) (m_2 abs)	MOVE GENERATOR
1	M	V	0	(m_1) (n) (m_2)	MOVE FL. DEC. NUMBERS
1,2	G	M	O	0 (t) X (H/L) (S) (m)	OUTPUT GENERATOR
3	G	Z	Z	0 (S) 0 (Z/E) 0 (H/L) 0 (t)	ENDING SENTINEL GENERATOR
1	A	A	0	(A) (B) (C)	ADD
1	A	S	0	(A) (B) (C)	SUBTRACT
1	A	M	0	(A) (B) (C)	MULTIPLY
1	A	D	0	(A) (B) (C)	DIVIDE
1	A	N	I	(A) 0 0 0 (B)	CHANGE SIGN
1,4	A	P	N	(A) (N) (B)	RAISE TO A WHOLE POWER
1,5	X	+	A	(N) (LOG_{10} A) (B)	RAISE TO A FRACT.POWER
1	S	Q	R	(A) 0 0 0 (B)	SQUARE ROOT
1,6	R	N	A	(A) (N) (B)	ROOT
1,7	L	A	U	(A) (LOG_{10} B) (C)	LOGARITHM
1,8	S	U	M	(x_0) (n) (Σx)	SUM
1,9	P	O	L	(x^1) (C_n) (P)	POLYNOMIAL SUM
1,10	T	S	0	(A) (0 0 0 (B)	SINE
1,10	T	C	0	(A) 0 0 0 (B)	COSINE
1,10	T	A	T	(A) 0 0 0 (B)	ARCTAN
1,11	A	A	L	(x_i) (Δx) (Lx)	
	1	C	N	0 0 0 0 (≠ OPN #)	ADD TO A LIMIT
	2	C	N	0 0 0 0 (= OPN #)	
1	Q	U	0	(A) (B) 0 0 0	EQUALITY TEST
	1	C	N	0 0 0 0 (= OPN #)	(ALGEBRAIC)
1	Q	U	A	(|A|) (|B|) 0 0 0	EQUALITY TEST
	1	C	N	0 0 0 0 (= OPN #)	(ABSOLUTE)
1	Q	T	0	(A) (B) 0 0 0	GREATER THAN TEST
	1	C	N	0 0 0 0 (> OPN #)	(ALGEBRAIC)
1	Q	T	A	(|A|) (|B|) 0 0 0	GREATER THAN TEST
	1	C	N	0 0 0 0 (> OPN #)	(ABSOLUTE)
	U	0	0	0 0 0 0 0 0 0 0 0	UNCONDITIONAL
	1	C	N	0 0 0 0 (to OPN #)	TRANSFER
1	Q	Z	0	(m) 0 0 0 0 0 0	
	1	C	N	0 0 0 0 (≠ OPN #)	SENTINEL TEST
	2	C	N	0 0 0 0 (= OPN #)	
	C	S	T	0 0 0 0 0 0 0 0 0	
	1	C	N	0 0 0 0 (from OPN #)	OPERATION
	2	C	N	0 0 0 0 (up to OPN #)	REPEATER
	3	C	N	0 0 0 0 (go to OPN #)	
1	B	T	I	(m_a) (m_b) 0 0 0	TYPE IN
1	Y	T	O	(m_a) (m_b) 0 0 0	PRINT OUT
1,12	E	D	F	(m_1) 0 (n) (m_2)	LARGE OUTPUT EXPONENTIAL EDIT
1,13	E	D	U	(m_1) (c) (n) (m_2)	SMALL OUTPUT EXPONENTIAL EDIT
1,14	E	D	T	(m_1) 0 (n) (m_2)	LARGE OUTPUT CONVERSION & EDIT
	R	W	S	(tape nos. in order)	REWIND TAPES AND STOP
	S	E	G	M E N T Δ Δ Δ Δ Δ	SEGMENT
	E	N	D	Δ C O D I N G Δ Δ	END OF INFORMATION
	1	2	3	4 5 6 7 8 9 10 11 12	

Figure 4

WHO ARE MANNING THE NEW COMPUTERS?

John M. Breen
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Not long ago, a large utility company announced the completion of their study and programming effort preparatory to the installation of a large electronic computer. In all, to analyze applications and to prepare and debug programs, had required twenty man-years. Their experience has been duplicated by many other organizations, and, while the details are slightly different, the story is the same -- a massive task requiring decades of man-years successfully completed.

Where have they found the trained personnel to do this? John W. Carr, III, in "Computers and Automation" of November, 1953, raised a similar question at a time when relatively few experienced persons were available. At that time he estimated that from five to fifty operators and programmers would have to be provided for each computer. During 1955, about two hundred medium-sized and fifty large computer installations will have been completed. It follows, then, that in the short period of two years from three to four thousand men and women have not only learned the necessary skills but have put them to use with remarkable effect.

The background and preparation of most of the members of this small army might seem surprising in view of frequently expressed opinions that mathematical or scientific training would be needed for this type of work. Most of the companies which will use computers have repeatedly stated: "It is much easier to teach our personnel to program than to teach outside experienced programmers the details of our business." The value of a thorough knowledge of a company's procedures, gained over a period of years, has generally far outweighed the more specialized knowledge of programming or computer operation which could be gained in a few months. Consequently, most of the personnel now planning the applications of data processing equipment in business are methods men, punched card specialists, accountants and similar employees of the firms interested. Many of them are "old dogs" learning new tricks. The utility company mentioned above formed a computer group of employees with an average of twenty-four years service in the company.

The training of the company computer crew has been as direct, simple, and effective as their selection. They have attended courses conducted by the manufacturers in the operation and programming of computers, and have then put their learning to work immediately on selected company tasks. Generally, the basic training has been supplemented by advanced instruction on the job as the analysis and programming of applications progressed. Close liaison with manufacturers at all phases of the task until programs had been debugged and were ready for use has greatly expedited the completion of the training. A great effort has been required, but the complications encountered have not been as formidable as might have been predicted two years ago.

An obvious question arises: Is it, then, so easy? Will the computers simply be manned by company men with little mathematical or scientific knowledge? Are methods experience and punched card know-how the principal prerequisites? Although the short-run answer is "yes", the long-run answer would seem to be "no". To see why this is so, two important factors which have been operating must be noted.

The first of these is economic. As a rule, computers have been accepted as capital equipment which is expected to perform a task at a saving. Although in a few cases a small or medium-sized computer has been installed as an experiment merely to gain experience, in general each job to be processed by a computer must be done more cheaply by the computer than by the present method, and the savings must be demonstrated by comparative figures. The business applications selected for computers are usually those which have been "mechanized" on punched cards, such as payroll, inventory control, billing, and the like. The costs of electric accounting machine processing are well known, and provide a good standard of measurement for management. Other applications which are either beyond the capacity of present machines or which require new and advanced techniques have been postponed, since the standards of cost do not exist and savings would not be easily demonstrated.

The second factor is a direct consequence of the first. The obvious source of personnel to program these applications is the group to be responsible for their performance. Considered in this light, the attitude of most firms toward recruitment of personnel outside the firm is both understandable and logical. To

(continued on page 36)

WHO'S WHO IN THE COMPUTER FIELD

(Supplement No. 2 to the Second Edition
published June 1955, information as of Sept. 3, 1955)

This is Supplement No. 2 to the second edition of "Who's Who in the Computer Field", published in "The Computer Directory, 1955", the June 1955 issue of "Computers and Automation", pp 6 to 102. Supplement No. 1 appeared in the June issue pp 148 and 150.

The purpose of this Who's Who is to give some information about every person who is interested in one phase or another of the computer field. The source of the following information is correspondence or completed forms sent to us since the closing of "The Computer Directory". We invite additions, updating, and revisions of any information which we publish. If your entry in "The Computer Directory" or here is incomplete, inaccurate, or missing, please send us information (see the Who's Who entry form which appears elsewhere in this issue on the sheet "Roster Entry Forms").

Entries. A full entry consists of: name / title, organization, address / interests (the capital letter abbreviations are defined below) / year of birth, college or last school (background), year of entering the computer field, occupation, other information (distinctions, publications, etc.) / code. In the code, the digit (such as 5) denotes the year ('55), when the information in the entry was received. In cases where no information was given, a "-" denotes omission. The entry of a person in the Who's Who does not depend in any way upon his subscribing to "Computers and Automation" although of course his subscription is welcome.

Abbreviations. Since a great deal of information is to be presented, abbreviations have been extensively used. Nearly all these abbreviations can be easily guessed like those in a telephone book. The letters "A, B, C, D, E, L, M, P, S" stand for main interests "Applications, Business, Construction, Design, Electronics, Logic, Mathematics, Programming, Sales" respectively.

Allen, Jack H / Engrg Methods Mathn, Temco Aircraft Corp, P O Box 6191, Dallas, Texas / AMP / '23, St Mary's Univ, '52, mathn, paper on stepwise integration / 5r

Allen, Wade / Physicist, The Upjohn Co, Kalamazoo, Mich / CD, incorporation of computers in scientific instruments / -, -, -, physicist / 5

Alves, Walter L / Mngt Consultant, Arthur Young & Co, One N LaSalle St, Chicago, Ill / ABP / '09, Pace College, '54, mngmt surveys / 5

Andersin, Hans E / Diplomingenier (Engr), Finnish Board for Comp Machinery, Abrahamink, 1-5, Helsinki, Finland / ACDLMP / '30, -, '54, engrg / 5

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Astrahan, Morton M / Devt Engr, IBM Engrg Lab, Poughkeepsie, N Y / ACDP / '24, Northwestern Univ, '49, desgn & constrn of dig comprs / 5

Atchison, William Franklin / Res Assoc, Prof, Rich Elecnc Compr Ctr, Georgia Inst of Tech, Atlanta, Georgia / M / '18, Univ of Illinois, '52, mathn, co-author, "Analytic Geometry", "Statistical Compn of Mean Dimension of Macromolecules" / 5

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Becker, W E / Elecncs Engr, Bureau of Ships, Dept of the Navy, Washington, D C / ACD / '25, Syracuse Univ, '54, elecnc engr / 5r

Belcher, Wallace E Jr / Appln Engr, Brown Division, Minneapolis-Honeywell Reg Co, Philadelphia 44, Pa / ABLP, data reduction & tabulating / '15, Harvard College, '48, engr / 5

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Bennett, Carl A / Specialist, Operations Res, Hanford Atomic Products Operation, General Elec Co, Richland, Wash / ABM / '21, Univ of Michigan, '52, statistician / 5

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Brown, Richard M / Res Asst Prof, Control Sys Lab, Univ of Illinois, Urbana, Ill / ADELP /'24, Harvard, '52, physicist / 5

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Charp, Solomon / Sr Staff Engr, The Franklin Inst, Philadelphia 3, Pa / ADE / '20, Univ of Penn, '44, elec engr / 5r

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Faass, Donald L / Physicist, Shell Devt Co, Houston, Texas / CDEL / '29, Univ of Houston, '54, jr physicist / 5r

Fairthorne, R A / -, Royal Aircraft Establishment, South Farnborough, Hampshire, England / ALM / '04, -, '38, mathl techn, publns on aerodynamics, compg, info theory, etc / 5

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Finnigan, Dennis M / Systems Analyst, Stanford Res Inst, Menlo Park, Calif / ABP / '28, Stanford Univ, '54, appld res / 5

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Fogarty, John D / Sr Engr, Eckert-Mauchly Div, Remington Rand Inc, 2300 Allegheny Ave, Philadelphia 29, Pa / CDE / '28, Mass Inst of Tech, '54, elec engr, publr "TVI Generator" / 5r

Fraser, W C G / Defense Scientific Service Officer, Defense Res Board, Ottawa, Ont, Canada / M / '17, Univ of Toronto, '53, prgmr, publn on Laplace transforms / 5

Gaddis, Arden H / Asst Devt Engr, Burroughs Corp Res Ctr, Paoli, Pa / CDEL / '21, Univ of Illinois, '50, engr / 5

Gaschnig, G R / Elec Engr, Dept 598, RCA, Front & Cooper Sta, Camden, N J / DEL / '27, Drexel Inst of Tech, '53, engr / 5r

Gengelbach, Joachim H / Elecnc Scientist, Holloman Air Devt Ctr, Holloman, New Mexico / A, aerodynamics / '13, Techn Univ (Darmstadt, Germany), '40, - / 5r

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Goldman, William / Owner, B G Radio & Electric, -, - / CDE / -,-,-, applicance sales & service / 5r

Goodlin, Ronald L / Mathn-Numerical Analyst, Numerical Analysis Univ, General Elec Co, 713 Bldg, 700 Area, Richland, Wash / ALMP / '20, College of Idaho, Univ of Washington, '51, mathn / 5

Gourrich, George Elihu / Sys Chief Engr, Telecomputing Corp, 12838 Saticoy St, North Hollywood, Calif / ABDLMP / '28, UCLA, '48, systems engr, arrangements chrmn 1955 Western Compr Conf /5r

Graham, Beardsley / Asst Director, Stanford Res Inst, Menlo Park, Calif / AE / '14, Univ of Calif, '47, engr / 5

Gravel, J P J / Engr, Analog Compr Sys, Computer Sec, Gen Engrg Lab, General Elec Co, Schenectady, N Y / D / '25, Renssalaer Polytech Inst, '52, elecnc engr / 5

Graves, J M / Procedures Analyst, Procedures Unit, General Elec Co, Richland, Wash / ABLP / '27, Univ of Washington, '52, analyst / 5

Graves, William J / Mathn, U S Naval Prvng Grds, Dahlgren, Va / MP / '23, Univ of North Carolina, '54, prgmg / 5

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Haislip, Thelma / Mathn, U S Naval Prvng Grd, Dahlgren, Va / P / -, E Carolina College, '50, mathn / 5

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Mutter, Walter E / Proj Engr, IBM Corp, Poughkeepsie, N Y / E / '21, Mass Inst of Tech, '49, physicist / 5r

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- END -

CORRECTIONS

In the August issue, on the front cover, the name of the author of the third article should be corrected to read "Ned Chapin". The title of the fourth article should be corrected to read "Charting on Automatic Data Processing Systems." On page 21, at the bottom of the right hand column, the following should appear "continued on page 27".

On page 19 in the left hand column in the middle, the sentence reading "Finding better ways....in the office" should read:

"Finding better ways of combining labor, supplies, and equipment is often known as industrial engineering when applied to work in the shop and as systems analysis when applied to work in the office."

WHO ARE MANNING THE NEW COMPUTERS?
(continued from page 28)
the outsider the procedures and controls in common use seem to constitute a tangled maze leading to confusion rather than a rational solution to a problem. The old-timer in the company however threads his way through them with an understanding, respect, and ease born of long familiarity.

The success of this approach has highlighted an important and sometimes neglected point: the computer is an instrument. Its operation can be taught, up to a point, just as can that of the slide rule. Like its older brother it can be used by businessmen to compute simple percentages or by engineers to solve complex problems. But the complexity of the problem and the sophistication of the method are outside the instrument, and the solution reflects this fact more than it does the qualities of the instrument itself.

As the instrument becomes known and confidence is gained in its operation, the user relies on it to aid in more difficult work. This, undoubtedly, will be the case with computers. It is a good thing that for the present the applications are familiar and simple. Their successful processing will provide valuable experience, build up confidence in computers, and dispose businessmen to investigate their use in new management techniques which seek mathematical solutions to business problems. When this point has been reached, a new and very different situation will arise. The approach which has proved successful to date will not be abandoned, because present methods will be with us in relatively unchanged form for a long time to come. But a new type of "mathematical methods man," familiar with advanced mathematics, will also be needed.

In this second phase, the universities will of necessity have to play a greater part. They will have to supply the bright young graduates in mathematical economics, or "retread" methods men of today with courses in linear programming, game theory, operations research, and the like. To do this, the universities will need to clear their students' minds of a possible misunderstanding that a course or series of courses in computer programming or operation alone will fit them for this future. It has become increasingly evident that a basic command of mathematics must be coupled with a knowledge of the economics of the firm.

- END -

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BULK SUBSCRIPTION RATES

These rates apply to subscriptions coming in together direct to the publisher. For example, if 5 subscriptions come in together, the saving on each one-year subscription will be 25 percent, and on each two-year subscription will be 33 percent. The bulk subscription rates, depending on the number of simultaneous subscriptions received, follow:

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4	3.75, 17	7.00, 22
3	4.00, 11	7.50, 17
2	4.25, 5	8.00, 11

For Canada, add 50 cents for each year; outside of the United States and Canada, add $1.00 for each year.

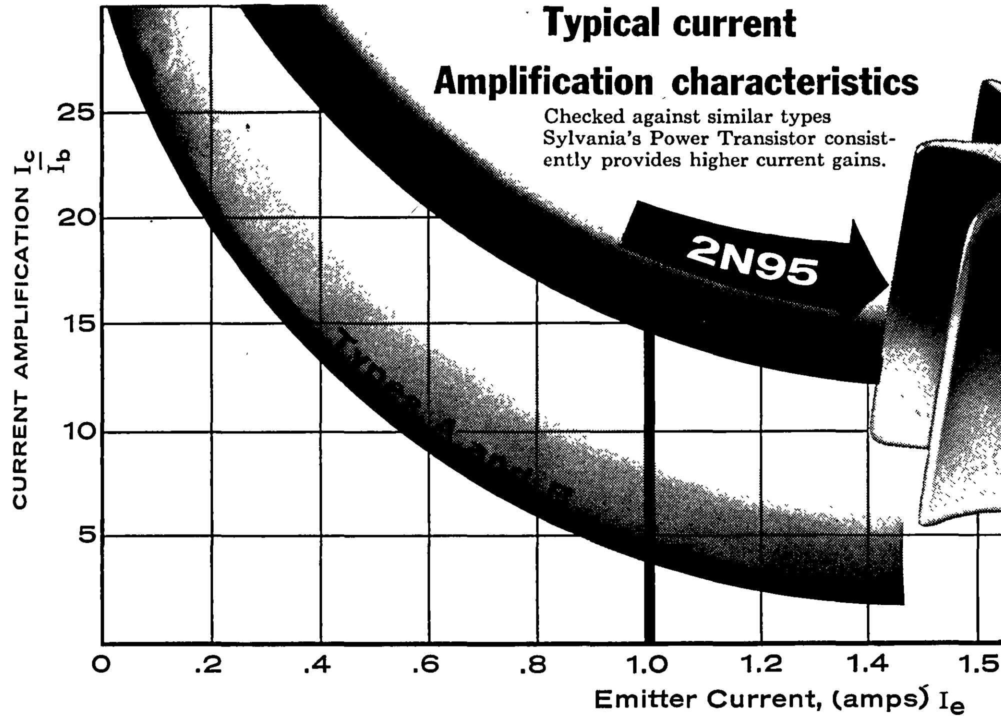
MANUSCRIPTS

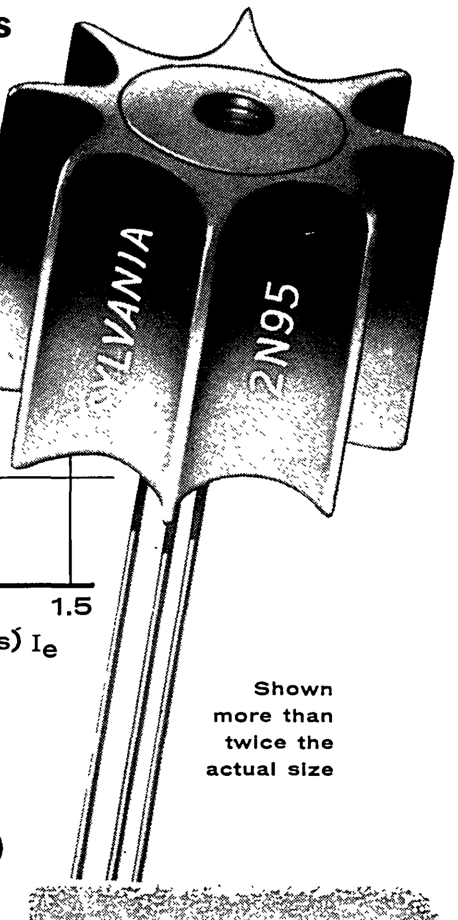
We are interested in articles, papers, and fiction relating to computers and automation. To be considered for any particular issue, the manuscript should be in our hands by the fifth of the preceding month.

Articles. We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it. Consequently a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, details, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. We look particularly for articles that explore ideas in the field of computers and automation, and their applications and implications. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 4000 words, and payment will be, generally, $10 to $40 on publication. A suggestion for an article should be submitted to us before too much work is done

Technical Papers. Many of the foregoing requirements for articles do not necessarily apply to technical papers. Undefined technical terms, unfamiliar assumptions, mathematics, circuit diagrams, etc., may be entirely appropriate. Topics interesting probably to only a few people are acceptable. Payments will be made for papers, generally $5 to $20 on publication, depending on length, etc.

Fiction. We desire to print or reprint fiction which explores scientific ideas and possibilities about computing machinery, robots, cybernetics, automation, etc., and their implications, and which at the same time is a good story. Ordinarily, the length should be 1000 to 4000 words, and payment will be, generally, $10 to $40 on publication if not previously published, and half that if previously published.





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FORUM

AUTOMATIC DATA PROCESSING FORUM, NEW YORK

W. K. Tarrant, New York, N. Y.

The educational forum of the New York Chapter of the National Association of Cost Accountants for the 1955-56 season will be on "Automatic Data Processing". The course will consist of discussions on the latest processing techniques that are designed to solve modern business management problems in tabulating and compiling statistical data. The sessions will extend over a period of 8 months.

The series will comprise discourses on integrated data processing, binary systems, digital computers, storing devices, electronic equipment, automatic computers, tabulators, tape recorders, flexowriters, perforators, transmission devices, and other modern business machines. The plans include floor demonstrations of Burroughs, Remington-Rand, and International Business Machines equipment which will process actual business transactions from paper work to final report. Lectures will be by experts from some of the major equipment, management, and consulting firms and will include prominent specialists in the field of automation.

The forum will be open to both members and non-members of the New York Chapter, NACA. Inquiries should be directed to Willard K. Tarrant, J. K. Lasser & Co., 1440 Broadway, N.Y., who is Director of Education of the New York Chapter, National Association of Cost Accountants (the chapter's address is 215 Fourth Ave., New York).

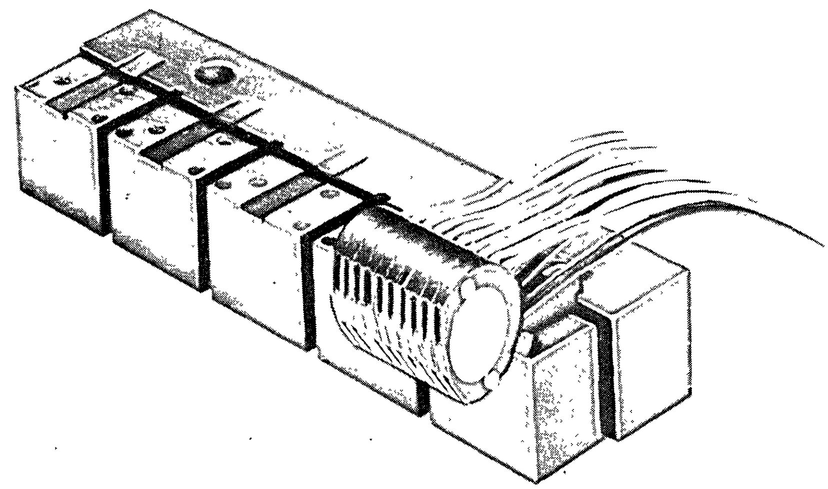
FORUM

THE ADDRESS OF MAPI

From four of our subscribers:

Will you kindly tell us the address of the Machinery and Allied Products Institute, referred to in the article by Ned Chapin in the August issue, "Justifying the Use of an Automatic Computer"?

The address of the Machinery and Allied Products Institute (MAPI) is 120 South LaSalle St., Chicago, Ill., - State 2-6766.



A bank of Monrobot Ring-type Heads on adjustable mounting

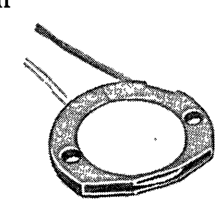
MONROBOT COMPONENTS

Researched and Developed for the Electronics Field

Monroe, for many years a leader in the design and production of desk calculators, is devoting its experience and research facilities to developing not only digital electronic computers but also component parts that are unique for their originality of design and numerous advantages.

The components, illustrated here, are Monrobot Ring-type Read/Record Heads and an adjustable fixture for magnetic drum memory systems.

Monrobot Read/Record Head assemblies have a place in any magnetic storage or arithmetic drum system. Their advantages are many. They are small and compact. Their mounting design permits accurate placement with a minimum of costly machining. When assembled and mounted they permit fine, accurate adjustments both parallel and perpendicular to the drum. They are ruggedly built to last. In their pre-engineered, precision mounting they cost less than similar unmounted head stacks; also replacement of a single head is easily made.



Monrobot Ring-type Head — small, compact

Monrobot components of this kind offer the user of electronic equipment many worthwhile benefits. There's a lot to the Monrobot component story that's worth investigating. Inquiries are invited.

MONROBOT

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MORRIS PLAINS NEW JERSEY

Forum:

COMPUTER APPLICATIONS

Bill Danch
Munich, Germany

" -- Mr. Turing, -- You're a computer man from way back and your research budget is $1,000,000 a year. In the next 6 months, make me a machine to read those reports and tell me what I want to know from them!"

ROSTER ENTRY FORMS

"Computers and Automation" publishes from time to time reference information of the following three types: (1) a who's who or roster of individuals interested in the computer field; (2) a roster of organizations active in the computer field; and (3) a classified directory or roster of products and services offered in the computer field. The last cumulative roster appeared in "The Computer Directory, 1955", the June 1955 issue of "Computers and Automation." If you are interested in sending information to us for these rosters and their supplements, following is the form of entry for each of these three rosters. To avoid tearing the magazine, the form may be copied on any sheet of paper; or upon request we will send you forms for entries.

(1) Who's Who Entry Form

1. Name (please print) ____________
2. Your Address? ____________
3. Your Organization? ____________
4. Its Address? ____________
5. Your Title? ____________
6. YOUR MAIN COMPUTER INTERESTS?

   ( ) Applications
   ( ) Business
   ( ) Construction
   ( ) Design
   ( ) Electronics
   ( ) Logic
   ( ) Mathematics
   ( ) Programming
   ( ) Sales
   ( ) Other (specify): ____________

7. Year of birth? ____________
8. College or last school? ____________
9. Year entered the computer field? ____________
10. Occupation? ____________
11. Anything else? (publications, distinctions, etc.) ____________

(2) Organization Entry Form

1. Your organization's name? ____________
2. Address? ____________
3. Telephone number? ____________
4. Types of computing machinery or components, or computer-field products and services that you are interested in? ____________
5. Types of activity that you engage in:
   ( ) research
   ( ) manufacturing
   ( ) selling
   ( ) consulting
   ( ) other (please explain): ____________
6. Approximate number of your employees? ____________
7. Year when you were established? ____________
8. Any comments? ____________

Filled in by ____________

Title ____________ Date ____________

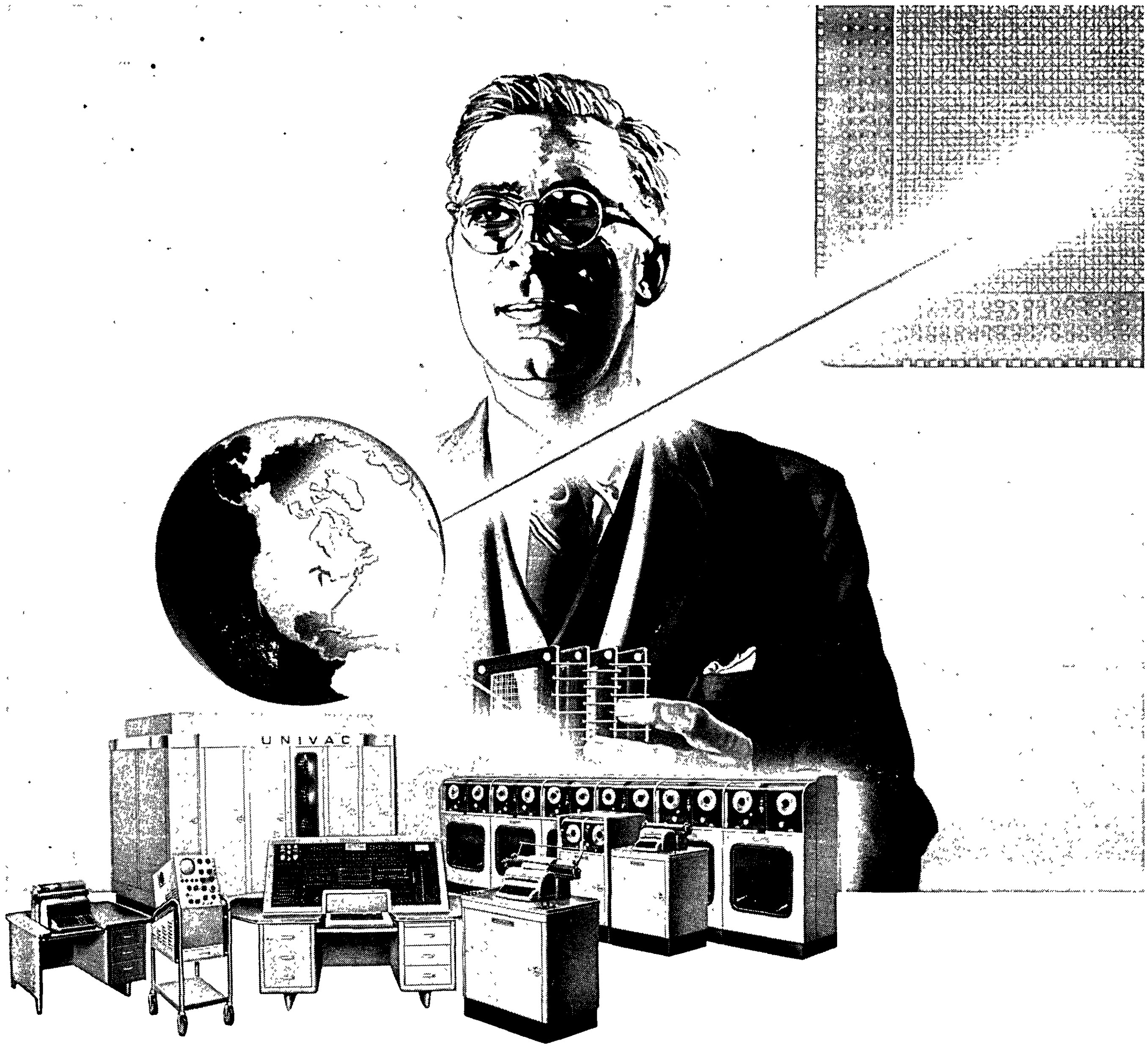
* ——— * ——— *

(3) Product Entry Form

1. Name or identification of product (or service)? ____________
2. Brief description (20 to 40 words)? ____________
3. How is it used? ____________
4. What is the price range? ____________
5. Under what headings should it be listed? ____________
6. Your organization's name? ____________
7. Address? ____________

Filled in by ____________

Title ____________ Date ____________



Doubling Univac's Speed!

The famous Remington Rand Univac® has widened even further its lead over other electronic business computing systems. Univac is still the *only* completely self-checked system...the only one which can read, write, and compute simultaneously without extra equipment. And now, the Univac II adds to these superior features the speed of a magnetic-core memory.

The Remington Rand magnetic-core memory is more than a laboratory promise. It has been in actual customer use for over a year, passing all tests with flying colors in the first commercially available electronic computer to use core storage successfully.

The capacity of the internal memory of Univac has also been doubled, giving instantaneous access to 24,000 numeric characters. (If needed, this can be increased to 120,000 characters.)

Univac's external memory—magnetic tape—now has greater capacity too, increasing input and output to 20,000 characters per second... the equivalent of reading or writing every character on this page more than 1,000 times a minute.

These new Univac developments can be incorporated into any existing installation to double its speed and to increase its economy still further.

ELECTRONIC COMPUTER DEPARTMENT **Remington Rand** ROOM 2038, 315 FOURTH AVE., NEW YORK 10, N. Y.

DIVISION OF SPERRY RAND CORPORATION

MISSILE SYSTEMS

Research and Development

Broad interests and exceptional abilities are required of scientists participating in the technology of guided missiles. Physicists and engineers at Lockheed Missile Systems Division are pursuing advanced work in virtually every scientific field.

■ ■ ■

Below: Missile Systems scientists and engineers discuss future scientific exploration on an advanced systems concept with Vice President and General Manager Elwood R. Quesada. From left to right: Dr. Eric Durand, nuclear physicist, systems research laboratory; Ralph H. Miner (standing), staff division engineer; Dr. Montgomery H. Johnson, director, nuclear research laboratory; Elwood R. Quesada; Dr. Louis N. Ridenour (standing), director, program development; Willis M. Hawkins (standing), chief engineer; Dr. Joseph V. Charyk (standing), director, physics and chemistry research laboratory; Dr. Ernst H. Krause, director, research laboratories.

■ ■ ■

Scientific advances are creating new areas of interest for those capable of significant contribution to the technology of guided missiles.

Lockheed MISSILE SYSTEMS DIVISION

research and engineering staff

LOCKHEED AIRCRAFT CORPORATION • VAN NUYS, CALIF.

COMPUTERS AND AUTOMATION — Back Copies

ARTICLES, ETC.: July, 1955: Mathematics, the Schools, and the Oracle -- Alston S. Householder

The Application of Automatic Computing Equipment to Savings Bank Operations — R. Hunt Brown

The Book Reviewer — Rose Orente

Linear Programming and Computers, Part I — Chandler Davis

August: The Automation of Bank Check Processing—— R. Hunt Brown

Linear Programming and Computers, Part II, — Chandler Davis

Justifying the Use of an Automatic Computer -- Ned Chapin

Charting on Automatic Data Processing Systems — Harry Eisenpress, James L. McPherson, and Julius Shiskin

A Rotating Reading Head for Magnetic Tape and Wire — National Bureau of Standards

Some Curiosities of Binary Arithmetic Useful in Testing Binary Computers -- Andrew D. Booth

September: A Big Inventory Problem and the IBM 702 — Neil Macdonald

Publications for Business on Automatic Computers: A Basic Listing — Ned Chapin

Franchise — Isaac Asimov

Automatic Coding for Digital Computers — G. M. Hopper

Automatic Programming: The A 2 Compiler System -- Part 1

REFERENCE INFORMATION (in various issues):

Roster of Organizations in the Computer Field/ Roster of Automatic Computing Services / Roster of Magazines Related to Computers and Automation / Automatic Computers: List /Automatic Computers: Estimated Commercial Population / Automatic Computing Machinery: List of Types / Components of Automatic Computing Machinery: List of Types / Products and Services in the Computer Field / Who's Who in the Computer Field / Automation: List of Outstanding Examples / Books and Other Publications /Glossary / Patents

BACK COPIES: Price, if available, $1.25 each, except June, 1955, $6.00. Vol. 1, no.1,Sept, 1951, to vol. 1, no. 3, July, 1952: out of print. Vol. 1, no. 4, Oct. 1952: in print. Vol. 2, no. 1, Jan. 1953, to vol. 2, no. 9, Dec. 1953: in print except March, no. 2, and May, no. 4. Vol. 3, no. 1, Jan. 1954, to vol. 3, no. 10, Dec. 1954: in print. Vol. 4, 1955: in print.

A subscription (see rates on page 4) may be specified to begin with the current month's or preceding month's issue.

WRITE TO: Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N. Y.

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N.Y.

1. What is "COMPUTERS AND AUTOMATION"? It is a monthly magazine containing articles, papers, and reference information related to computing machinery, robots, automatic control, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is $4.50 a year in the United States. Single copies are $1.25, except June, 1955, "The Computer Directory" (164 pages, $6.00). For the titles of articles and papers in recent issues of the magazine, see the "Back Copies" page in this issue.

2. What is the circulation? The circulation includes 1900 subscribers (as of Sept. 10): over 300 purchasers of individual back copies; and an estimated 2500 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are people concerned with the field of computers and automation. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. The print order for the Oct. issue was 2400 copies. The overrun is largely held for eventual sale as back copies, and in the case of several issues the overrun has been exhausted through such sale.

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8½" x 11" (ad size, 7" x 10") and produced by photooffset, except that printed sheet advertising may be inserted and bound in with the magazine in most cases. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy. For photooffset, the copy should be exactly as desired, actual size, and assembled, and may include typing, writing, line drawing, printing, screened half tones, and any other copy that may be put under the photooffset camera without further preparation. Unscreened photographic prints and any other copy requiring additional preparation for photooffset should be furnished separately; it will be prepared, finished, and charged to the advertiser at small additional costs. In the case of printed inserts, a sufficient quantity for the issue should be shipped to our printer, address on request.

Display advertising is sold in units of full pages (ad size 7" x 10", basic rate, $170) and half pages (basic rate, $90); back cover, $330; inside front or back cover, $210. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), $290; four-page printed insert (two sheets), $530. Classified advertising is sold by the word (50 cents a word) with a minimum of ten words. We reserve the right not to accept advertising that does not meet our standards.

It is expected that there will be a rate change effective Dec. 1.

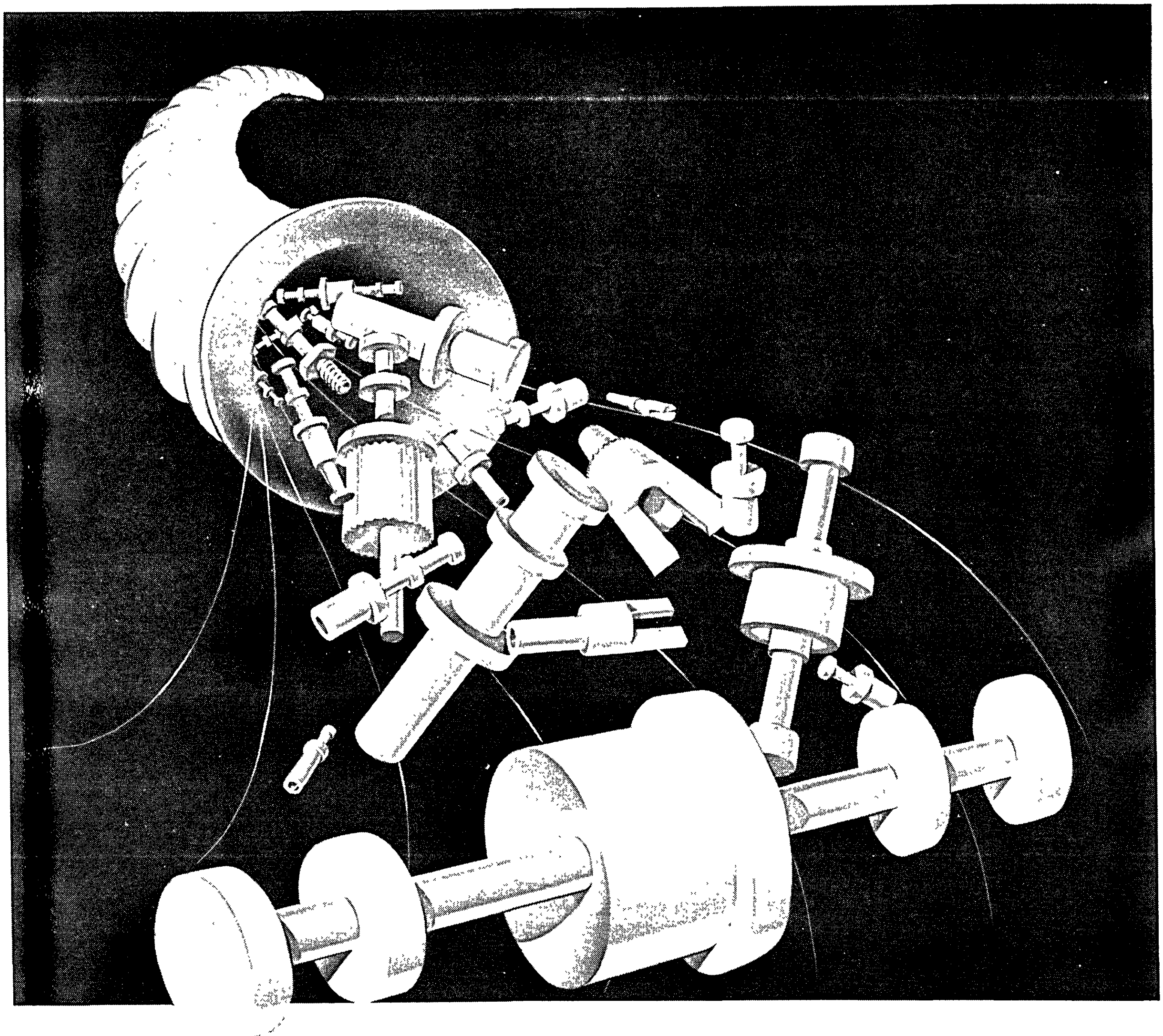
5. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

- The Austin Co.
- Automatic Electric Co.
- Cambridge Thermionic Corp.
- Federal Telephone and Radio Co.
- Ferranti Electric Co.
- Ferroxcube Corp. of America
- General Electric Co.
- Hughes Research and Development Lab.
- International Business Machines Corp.
- Lockheed Aircraft Corp.
- Logistics Research, Inc.
- Monrobot Corp.
- Norden-Ketay Corp.
- George A. Philbrick Researches, Inc.
- Potter Instrument Co.
- Raytheon Mfg. Co.
- Reeves Instrument Co.
- Remington Rand, Inc.
- Sprague Electric Co
- Sylvania Electric Products, Inc.
- Telecomputing Corp.

ADVERTISING INDEX

The purpose of COMPUTERS AND AUTOMATION is to be factual, useful, and understandable. For this purpose, the kind of advertising we desire to publish is the kind that answers questions, such as: What are your products? What are your services? And for each product: What is it called? What does it do? How well does it work? What are its main specifications? We reserve the right not to accept advertising that does not meet our standards.

Following is the index and a summary of advertisements. Each item contains: Name and address of the advertiser / subject of the advertisement / page number where it appears.



The terminal with the right connections

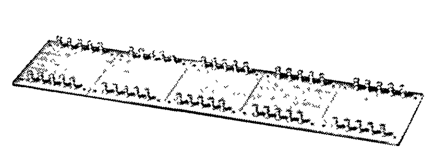
Looking for a special solder terminal? Your special is probably a standard at CTC.

You'll find many terminals that you would normally consider specials included in CTC's 50 types of standard solder terminals. Whether you want regular size or miniature rivet type terminals for printed circuits to be dip soldered, CTC has a complete selection. Whatever your requirements — standard or custom, you can depend on CTC's *guaranteed* components. And there are good reasons for this dependability.

Each manufacturing detail of every CTC terminal is double-checked for material and reliable performance. This *quality control* enables us to offer you *guaranteed* components — whether to government standards or your own.

Standard CTC solder terminals are silver plated brass, coated with water dip lacquer to keep them chemically clean for soldering. Special order finishes include hot tin, electro-tin, electro-tin-lead, tin-zinc, cadmium plate, gold flashing or gold plate. All finishes go through a periodic microscopic inspection for coating thickness and adhesion. This is but one of many ways CTC's *quality control* serves you.

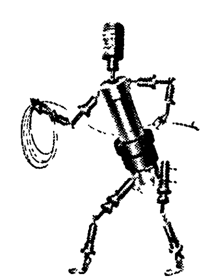
In addition to terminals and boards, our *quality control* pays off for you in CTC capacitors, swagers, insulated terminals, coil forms, coils and a wide variety of hardware. For complete specifications and prices, write to Cambridge Thermionic Corporation, 430 Concord Avenue, Cambridge 38, Mass. West Coast Manufacturers contact: E. V. Roberts, 5068 West Washington Blvd., Los Angeles 16 and 988 Market St., San Francisco, California.



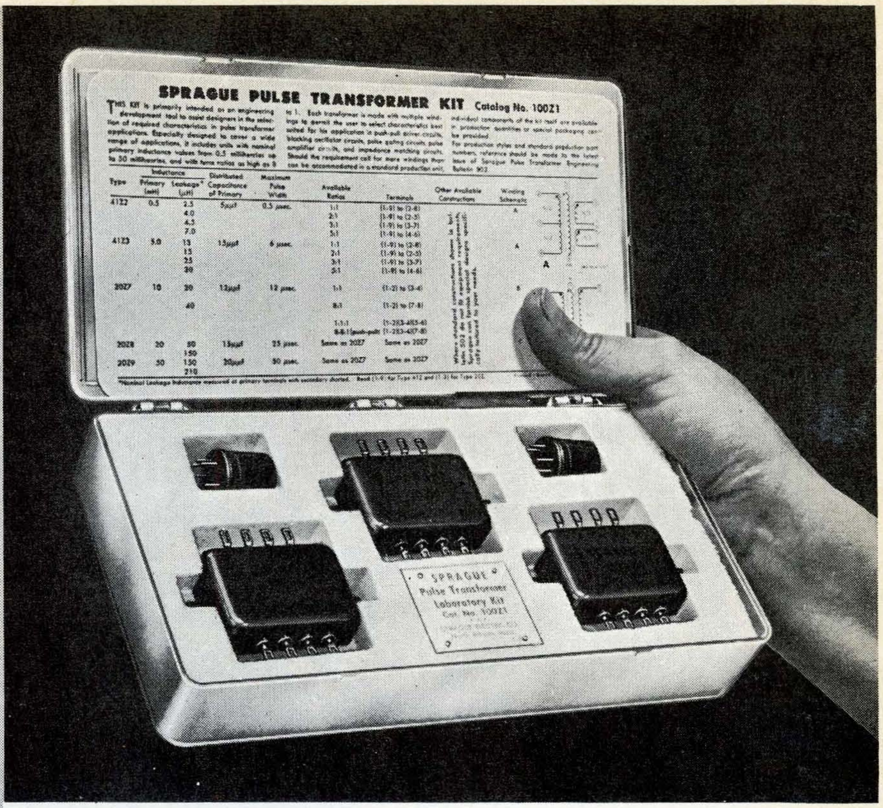
Standard CTC Terminal Boards as well as those made to your own specifications by CTC are available. Standard in cotton fabric phenolic, nylon phenolic or grade L-5 silicone impregnated ceramic. Custom made in cloth, paper phenolic, melamine, or silicone fibreglas laminates, imprinted as required and lacquered or varnished to specifications MIL-V-173 and JAN-T-152 or to commercial standards.

CAMBRIDGE THERMIONIC CORPORATION

makers of guaranteed electronic components,
custom or standard



Sprague Pulse Transformer Kit Simplifies Circuit Design



HERE'S THE IDEAL TOOL FOR ENGINEERING DEVELOPMENT OF CIRCUITS USING PULSE TRANSFORMERS

Sprague's new Type 100Z1 Pulse Transformer Kit contains five multiple winding transformers, each chosen for its wide range of practical application.

Complete technical data on each of the transformers is included in the instruction card in each kit so that the circuit designer may readily select the required windings to give transformer characteristics best suited for his applications . . . whether it be push-pull driver, blocking oscillator, pulse gating, pulse amplifier, or impedance matching. The electrical characteristics of the transformers in the kit have been designed so that they may be matched by standard Sprague subminiature hermetically-sealed pulse transformers shown in engineering bulletin 502B.

For complete information on this kit, as well as the extensive line of Sprague pulse transformers, write to the Technical Literature Section, Sprague Electric Company, 377 Marshall Street, North Adams, Massachusetts.

CHARACTERISTICS OF KIT TRANSFORMERS

Type	Induct. Pri. (μH)	Induct. Leakage (μH)	Dist. Cap. of Pri. (μμF)	Max. Nom. P.W. Range (μsec)	Avail. Ratios
41Z2	0.5	2.5 4.0 4.5 7.0	5	0.5	1:1 2:1 3:1 5:1
41Z3	5.0	13 15 25 30	15	6	1:1 2:1 3:1 5:1
20Z7	10	20 40	12	12	1:1 8:1 1:1:1 8:8:1
20Z8	20	50 150	15	25	same as 20Z7
20Z9	50	150 210	20	50	same as 20Z7

Sprague on request will provide you with complete application engineering service for optimum results in the use of pulse transformers.

SPRAGUE® *the mark of reliability*

Export for the Americas: Sprague Electric International Ltd., North Adams, Massachusetts. CABLE: SPREXINT.