THE COMPUTER SIMULATION OF PERCEPTION DURING MOTION IN THE URBAN ENVIRONMENT

by

Nicholas Negroponte

Submitted in Partial Fulfillment of the Requirements
for the Degree of Master's of Architecture
at the
Massachusetts Institute of Technology

July, 1966

Signature of Author...

Certified by ....

90 Pembroke Street
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Dean Lawrence B. Anderson
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Dear Sir:

I submit this thesis, The Computer Simulation of Perception During Motion in the Urban Environment, in partial fulfillment of a Master's Degree in Architecture.

Sincerely yours,

Nicholas Negroponte

Signed by: Lawrence B. Anderson ______________________
Dean of the Department of Architecture

ACKNOWLEDGEMENTS

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For technical advice, I have gratefully relied upon Professor Steven Coons, Professor Aaron Fleisher and Wren McMains, all of whom have tolerated the optimisms and naïvetes of a novice.

It is difficult to acknowledge those who have contributed over a long period of time, where academic osmosis replace theories, facts, and figures, and stimulates a way of thinking. I have worked for two years as the 'liability' of Professor Imre Halasz and Leon Groisser and it will be difficult for me to return in gratitude the obligations I have incurred.

The graphics, typing, and production of this entire paper are due only to the resilience and assistance of Elaine Audet and Carla Naylor.

PREFACE

Architecture is not solely the creation of wonderful buildings and spaces. Historically, the architect is responsible for the physical form of the environment; providing poetry and shelter, or merely executing the financial whims of an affluent client; all in the guise of the 'masterpiece object'. This role of henchman is acceptable in a textbook of Renaissance churches or sixteenth century boudoires.

Today, who is the Client? Does he wear a pin-striped suit? How does he live? What are his tastes? You never meet him. The problem is severe as it has come upon us so quickly. Within twenty years; from an architect will evolve an interior decorator, from a city planner will evolve a social worker. A new profession will evolve that must take the responsibility of handling the urbanization of millions and millions.

As a profession we have made few preparations and have done little research. All this work must take place within the academic world as we have no General Motors or NASA to sponsor philanthropic research. However, schools of architecture are still trade schools by nature and not compatible, at this moment, with the process of research. The design process for the student is usually not a serious synthesis or analysis process, rather it is the execution of disjointed ideas and feelings.

The thesis is an attempt at architectural research. There are no accompanying plans, sections, elevations, or models. The research has compelledme to become more involved with the university and delve into other disciplines, some of them rarely associated with architecture. In certain cases this sort of work has proved superficial and provides only a procedural retreading for the next act.

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Boston, Massachusetts

June 15, 1966

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INTRODUCTION

This report has been written for the Architect assuming that he knows nothing about computers, little about the pscyhology of perception, and only basic mathematics. The four chapters are arranged in such a manner that the person versed in perception can skip Cahpter I, while those knowledgeable in computers can pass directly from Chapter I to Chapter III.

To the psychologist, mathematician, or computer engineer, sections of this report will be irritatingly simplified. The author has used his newly acquired knowledge of these fields to present manifest impressions that were not so self-evident.

The study has a 'double-barrelled' nature, aiming at the psychology of perception, on one hand; Computer Aided Design on the other. The bridge, although not emphasized, is indubitable. The report attempts to define and examine the variables of the perceptual process as a function of the environment. With a basic understanding of the factors, reproduction of the process is examined in conjunction with the formulation of the variables. A certain amount of programming is performed in connection with this area.

The area of reproduction and formalization bears upon simulation in terms of axioms of transformation. The properties of perspective transformations are examined and treated as potential feedback to the design process as a part of a larger tool -- Computer Aided Design.

The general conclusion of this study is that perceptual transformations are not significant enough to be treated as variables. People with diverse backgrounds, aims, or educations 'see' things the same way. The variable is attention. Perspective transormations are used to simulate a visual sequence

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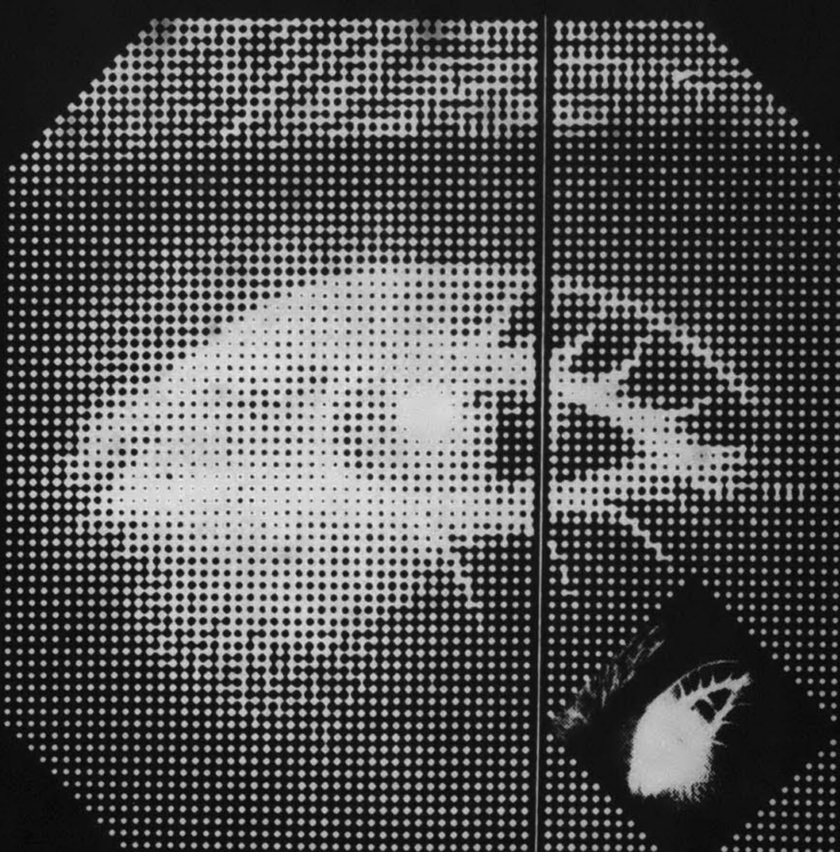
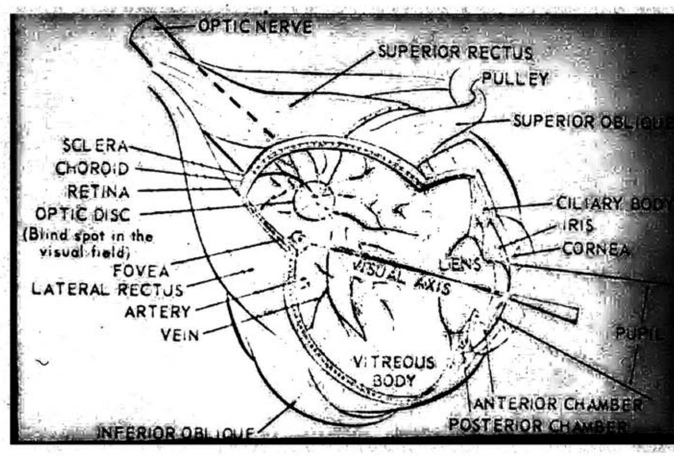
and 'controlled' random determinants are used to simulate attention. A series of many trips, no two the same, creates an ultimate 'image'. This is technically discussed in Appendix B along with the major program that accompanies this thesis.



chapter 1



PHYSIOLOGY OF SEEING

In an era of remarkable machines, one cannot overlook a one-inch ball that can detect the flare of a match ten miles away on a clear night[1] and detect the presence of a wire, 1/16 inch in diameter, at a distance of a half mile.[2] This section, however, is not a biological treatis on the eye, but a study of its role as an identifier and discriminator of form.

Unfortunately, our detection acuity is about ten times as accurate as our form acuity[3] and it is the latter that is most important for everyday tasks. The popular idea of the otical process is that a picture is formed on the retina of each eye; we all know what a picture is; thus, we are content with no further explanation. The eye and the mind work like a com-

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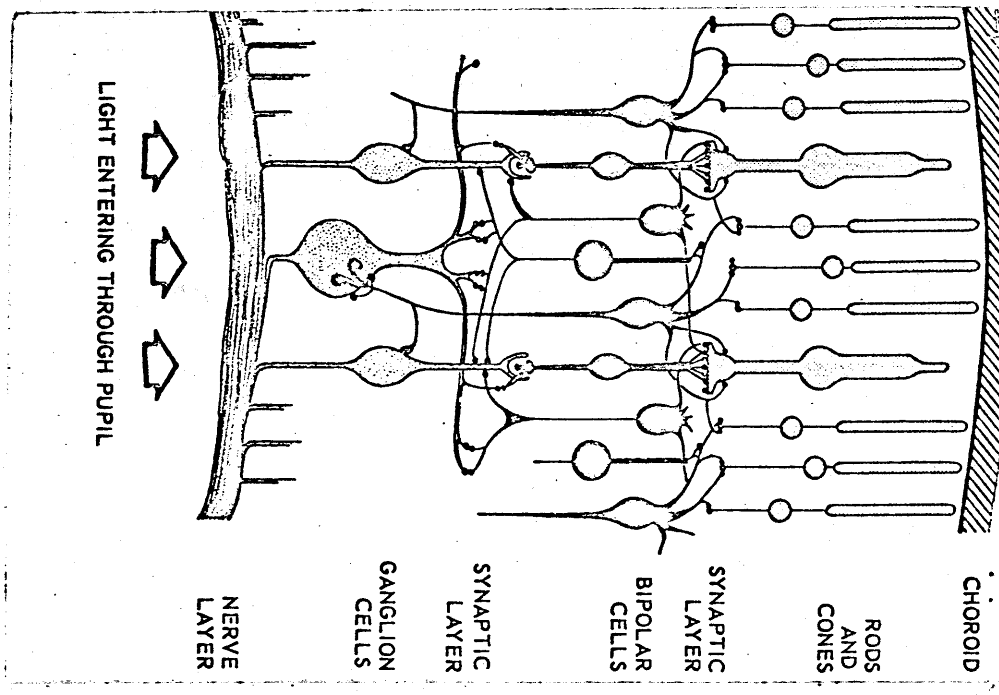
1 Larson, T. C., (editor) SER 1, Univ. of Mich., 1965.

2 Campanis, A., et al, Applied Experimental Psychology, John Wiley & Sons, New York, 1949.

3 Larson, Op. Cit.



[5]

puter, proceeding through a complicated process of input, working on the information and finally organizing it to be intelligible output, at a much faster rate than the most sophisticated data process equpment.

The image in light rays falls first on nerve fibers, traverses these and two layers of cells before reaching the primary light-sensitive cells or the rods and cones. There are many more rods than cones but there are only cones in the fovea -- the small area of the retina responsible for the sharpest vision.[4] This area of the eye is also responsible for colour, vision and vision at higher levels of illumination. The rods, meanwhile, are able to handle lower light intensities and rapid

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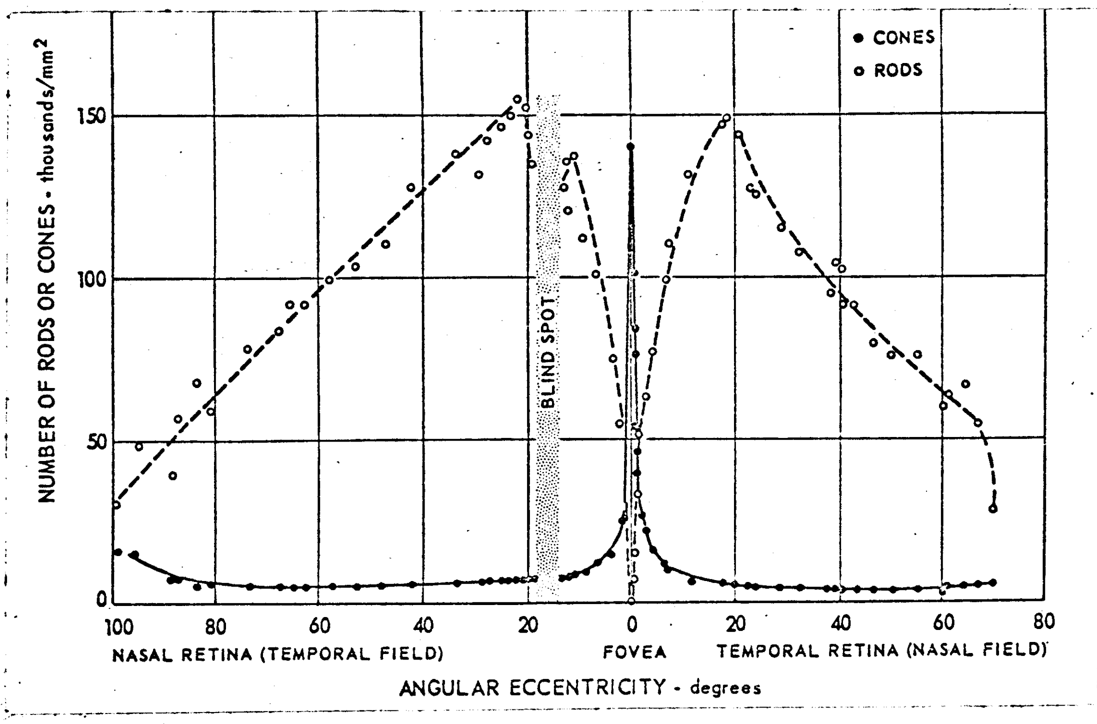
4 Webb, P., M.D., (editor), NASA Bioastronautics Data Book, Wash., D.C., 1964.



movement.[5] The density of these two kinds of cells varies from 160,000 per square millimeter at the center of the retina to less than 2000 per square millimeter at the outer edge, thus accounting for the decrease in visual acuity.

Maximum acuity under daylight conditions is obtained when objects are in direct line of vision, this is zero degrees from the fovea, dropping off to approximately fifteen degrees out from the axis of vision, where the visual acuity is about fifteen percent of the maximum. The acuity of objects decrease with their movement; rapid movement ultimately causes a loss of visual image.

Visual acuity measures the degree of detail discrimination; it

5 Gibson, Op. Cit.

is not a rating of clearness or sharpness in the retinal image. For a person with 'so-called' 20/20 vision, an angle of at least one minute must be subtended in order to be seen. This means that an object must be at least 3.5 inches higher to be seen at a distance of 1000 feet and at the same time permit you to thread a needle at close range. The effect on the moving viewer is to increase this minimum angle of detail and thus increase the size of the smallest object that can be seen.[6] Experiments with higher signs indicate that letters must be at least eighteen inches higher in order to read them at a distance of 1000 feet. This requirement may appear large, but it actually corresponds to one eighteen thousandth of an inch at read-

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6 A detailed study of Dynamic and Static Visual Acuity was done in conjunction with an MIT High Speed Intraurban Transportation Study in collaboration with William Small (See appendix).

distance.[7]

The eye acts as the input device and then passes on the information to the mind. The two mechanisms together form the visual apparatus:

> The visual apparatus is not a cinematographic camera registering motion tracks, but rather in close analogy with a computer capable of calculating and summing differentials and integrals of motion vectors inherent in "real" motion tracks of proximal stimulus [8]

The reaction time of the eye including information processing is approximately two hundredths of a second.[9]

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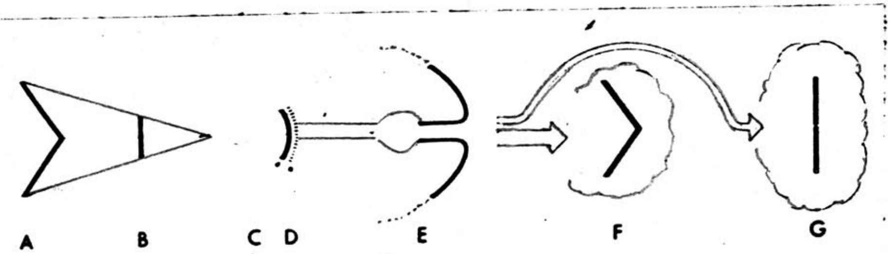
7 __________, Man Made America, in the Chapt. "The Paved Ribbon".

8 Johansson, G., "Rigidity, Stability, and Motion in Perceptual Space", Acta Psychol., 14, 359-370, 1958.

9 Ludvigh, E.J., "Visual and Stereoscopic Acuity for Moving Objects", in Spigel's Reading in the Study of Visually Perceived Motion, Harper and Row, N.Y., 1965.



The Sequence of Transformations in the Process of Visual Perception

A. The physical environment: a wedge-shaped physical object, reflecting light. B. A "picture" of the physical environment: a plane projection of the light reflected from the physical object. C. The retinal image (the proximal stimulus for vision): a curved projection of the light reflected from the physical object. D. The pattern of excitation: a mosaic of photosensitive receptors. E. The brain process: a bifurcated and oddly-shaped projection of excitations on the rear surfaces of the hemispheres. F. The visual world, or phenomenal experience: the experience of a wedge-shaped object. G. The visual field, or the color-sensations obtained by introspection: the impression of two flat patches of color adjacent to one another.

The mental process is that stage which converts the physiology seeing to the psychology of perception. An example of visual data processing is a bicyclist riding by a window waving his hand. During the moments the cyclist is in the field of vision his hand projects a wavy curve on your retina: a summation of his movement forward and the up and down motion of his hand. Meanwhile, the eye has received other information from the same images instructing it to segregate the two motions in order to produce the proper perceptual response. If the rider passes the window on a dark night with only the waving light, you would perceive a light moving in a curve. This is due to the lack of necessary information to perceive otherwise.

The difference being that one has been able to undergo psychological transformations while the other has not. These transformations occur in the brain, where visual information can no longer be thought of as an image, and even less, as a literal picture. It is an event composed not of light, but of nerve-cell discharges.[10] The information is handled strictly on the basis of whether or not the nerve cell is active. The binary

Without going through all the intermediate stages, let us come back to the eye-muscle feedbacks in man. Some of these are of purely homeostatic nature, as when the pupil opens in the dark and closes in the light, thus tending to confine the flow of light into the eye between narrower bounds than would otherwise be possible. Others concern the fact that the human eye has economically confined its best for and color vision to a relative small fovea, while its perception of motion is

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10 Gibson, Op. Cit.

> better on the periphery. When the peripheral vision has picked up some object conspicuous by brilliancy or light contrast or color or above all motion, there is a reflex feedback to bring it into the fovea. This feedback is accompanied by a complicated system of interlinked subordinate feedbacks, which tend to converge the two eyes so that the object attracting attention is in the same part of the visual field of each, and to focus the lens so that the outlines are as sharp as possible.
>
> Norbert Wiener

information is purely a yes/no, on/off format; simulation of perception.

HISTORICAL

Euclid's Optics is the first recorded observation of perception, however, it does not treat motion. It was not until 1759 that Porterfield, in A Treatise on the Eye, reported that objects moving at a constant velocity varied inversely in their phenomenal velocities with their distances from the observer.[11] In 1857, Czermak[12] observed, by successively comparing the velocities of the second hand of his watch, (fixating first the center of the minute hand, then the center of the second hand) that the visual perception of velocity is phenomenally slower in the periphery than the same movement observed in the center of the field of vision.

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11 The bulk of this Historical comes from J. F. Brown "The Visual Perception of Velocity", Psychol. Forsch. 14, 199-232, 1931. and De Silva, Op. Cit., 293-295, 1923.

12 Czermak, "Ideen zu einter Lehre vom Zeitsinn", published in his Ges. Schriften, 1,421, 1857, 1879.

Only in the late nineteenth century did people such as Aubert[13] and Exner[14] mathematically calculate different thresholds of vision. They proved that motion perceived during fixation appeared faster than when followed by eye movement. This area of research was neglected until 1904, when, for the first time references were made to 'apparent movement' and its relation to 'real movement'. Hamann[15] considered the psychological basis of movement and devoted a section of his paper to the perception of velocity. Besides some logical theorizing, he made one new observation: a rider crossing a field seems to

13 Aubert, H., "Die Bewegungsempfindung", Pflugers Arch., 39, 347, 1886.

14 Exner, S., "Uber optische Bewegungsempfindung", Biol. Zbl., 8, 437, 1889.

15 Hamann, R., Z. Psychol., 45, 231-254, 341-377, 1907.

double his velocity as he enters the woods.

In 1922, Filhene[16] investigated how movement was perceived. He concluded that when movement was observed with pursuit of the eye, there was an apparent movement of the background in the opposite direction. He believed this to be the cause of apparent slower motion. This was further researched by Metzger[17], in 1927, who used the nature of the environment as the main determinate. He observed that broad figures seem to move faster than narrow figures at like physical

16 Filhene, W., "Uber das optische Wahrnehmen von Bewegungen., Z. Sinnesphysiol., 53, 134-145, 1922.

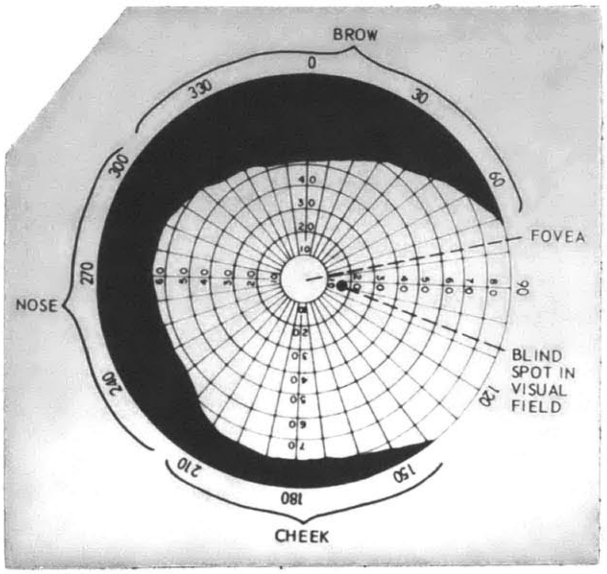
17 Metzger, W., "Uber Vorstufen der Verschmelzung von Figuenreihen", Psychol. Forsch., 8, 114-221, 1926.

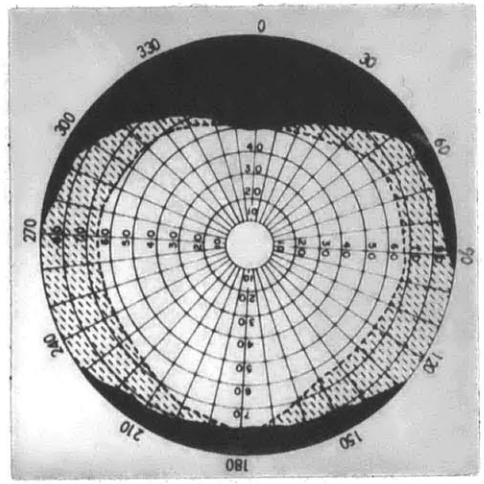
velocities.

At this point, the entire Gestalt movement, acting as organizing agents, combined the existing theories under a larger heading -- psychology of perception. Wertheimer, Wallach, Koffka, and Kohler combined the major forces of this movement. They turned increasingly to theoretical speculation as a basis for the perceptual process. As a result, the apparently clear outlines of Gestalt psychologists became blurred and dimmed. It seems, perhaps, that their experimental results and theories did not indicate a fundamental basis for the understanding of the nature of perception; rather, a one-sided exaggeration of certain features by no means the most important factors in perceiving.[18]

18 Vernon, M. D., A Further Study in Visual Perception, Cambridge University Press, 1952.

Recently, the available literature has mushroomed and become accordingly totally contradictory, redundant, and confusing. Throughout this study the recent works of J. J. Gibson have been used as the framework for any speculation, as they are the most abundant and organized. Although his work is strongly tied with Gestalt effects, it is reasonably up to date and implements contemporary situations. His work is by no means the most avant-guard approach to the perception of motion, and has been used more as a blue chip stock of psychological material.





THE VISUAL FIELD

Very few otherwise observant people "observe" that their nose is in their visual field. Although shadowy, it has always been there and its discovery only illustrates the difference between this kind of seeing and everyday perception.[19] The diagram above, on the left, shows the visual field of one eye -- the monocular field. On the right, the binocular visual field of a normal pair of eyes. The central white portion represents the region seen by both eyes. The shaded areas represent the respective regions seen by only one eye, and the black area demarks the bounds of the visual field caused by the brows, cheeks and nose. (In both illustrations the head and eyes are motionless.)

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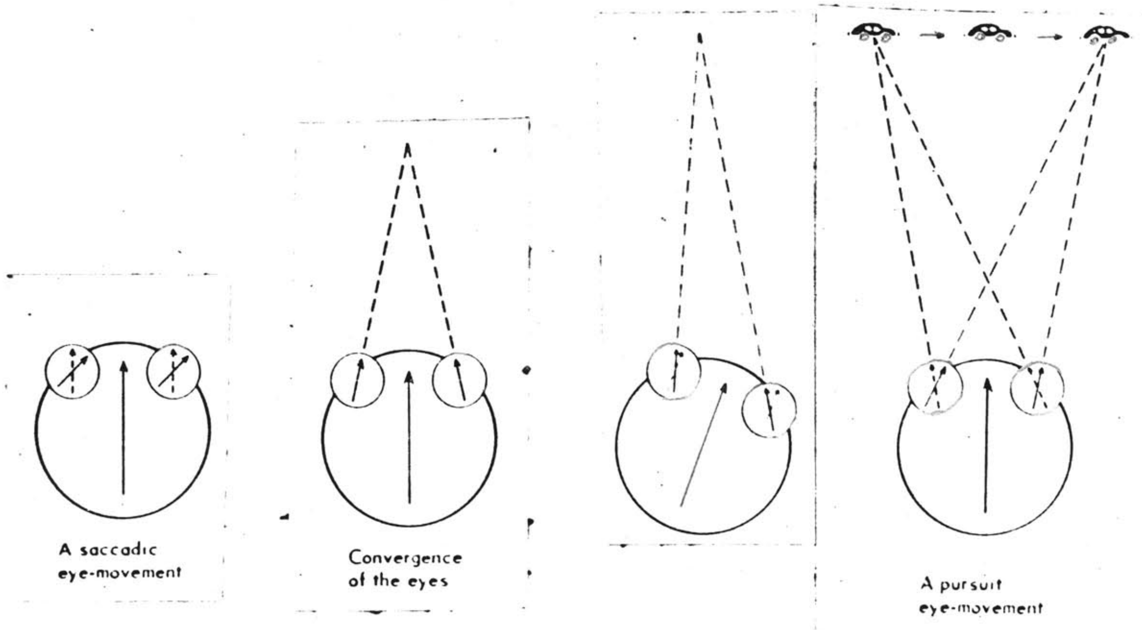
19 Gibson, Op. Cit.

The visual field is roughly oval shaped, extending 180° laterally and 150° vertically. It is the visual field that generates the retina image, thus its clarity depends on the gradient distribution of the rods and cones. This gradient of clarity can be described on the visual field as the logical extension of the retina image: it is sharp, clear and fully detailed at the center and becomes progressively vague and less detailed towards its boundaries.

It is helpful at this point to define two words:

> STIMULUS: the physical light energy in the environment to which we have the potential of differentially responding.
>
> CUES: stimulus combinations that have orienting value.

The visual world is composed of cues, which in turn, are



composed of stimuli. Only those cues that lie within the visual field are perceived. The visual field shifts whenever the eyes move from one fixation point to another. Scanning in rapid jerks of brief duration, (saccadic eye movement), permits us to put more of the visual world within our visual field and, similarly, more of the visual field within the fovea, The head also moves if the shifts of fixation are wide, shifting the boundaries of vision.

THE VISUAL WORLD

One becomes aware of the visual field only by introspective analysis -- long-term experience[20] -- the visual world. The visual world consists of solid, stable objects localized in an unbounded or panoramic space. The visual world needs characterization rather than a definition or diagram. The most obvious characteristic of the visual world is its stability. The world does not rotate when you turn around.[21] This stability is very obvious and equally important is when the visual field is radically divorced from the visual world, stability disappears and movement becomes ambiguous. The example we have all experienced is waiting on a train for its departure: as soon as movement is perceived we have no

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20 M. D., Vernon, A Further Study of Visual Perception, Cambridge University Press, 1952.

21 Gibson, J. J., The Perception of the Visual World, Cambridge, Mass., 1950.

way of telling which is moving, our train or the adjacent. The visual field is blocked from the visual world. (It is only when the kinesthetics of the movement itself, vibrations or acceleration, are acute enought to be sensed, that we can disambiguate. However, looking out the opposite window, the station is perceived and thus the visual world regained.

One important deception may be mentioned which seems to result from the tendency to preceive the environment as being stable and consistent. Vernon[22] points out that it is almost universally assumed that what we perceive is really "there"; that what is "there" is persistent and invariable, whoever

22 Vernon, Op. Cit.

perceives it; and that therefore we must all, ipso facto, perceive the same at any one moment of time and in any one part of space. The only differences between the perceptions of different people for which we normally allow are those ascribed to difference of "attention". It is difficult to prove or refute this assumption, because the differences that might cause people to perceive differently, in mind structure as related to experience, would also cause them toremember and communicate (store and output information) differently.

> Those specialed vertebrates who have sacrified panoramic vision and developed the ability to respond to simultaneous disparity of pattern in two overlapping fields of view are relatively latecomers in the evolutionary series.[23]

PERCEPTION OF DEPTH AND DISTANCE

The mystery of depth perception is that a three-dimensional world is derived from a pair of two-dimensional retinal images.[24] The following are a list of the variables determining the perception of depth and distance (after Dember):[25]

Binocular Cues:	convergence retinal disparity
Monocular Cues:	proximal size brightness texture linear perspective interposition movement paralax

None of these variables singularly determine the perception of depth.

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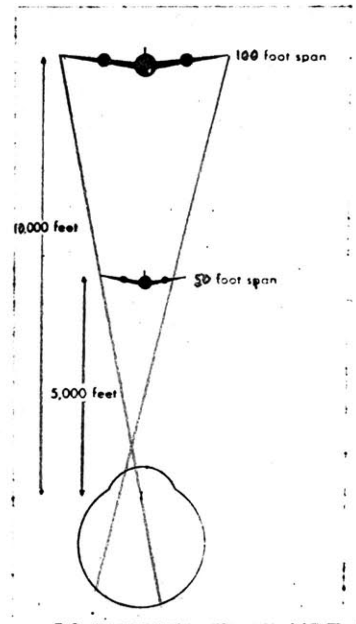
23 Gibson, J. J., "Research on the Visual Perception of Motion and Change", in Spigel's Readings in the Study of Visually Perceived Movement, Harper & Row, N. Y., 1965.

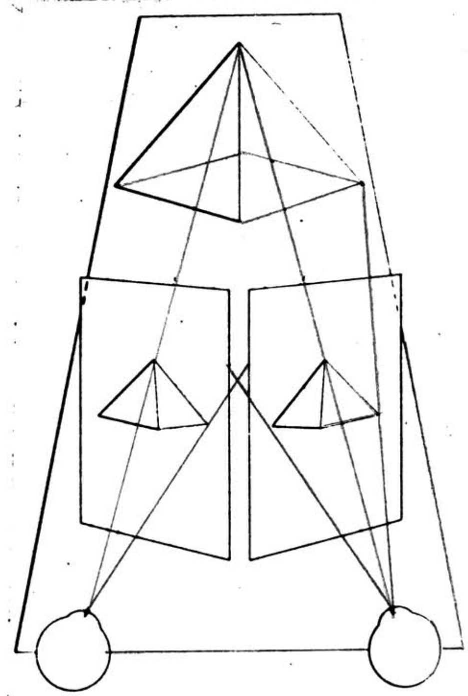
24 Benton, S.

25 Dember, W. H., The Psychology of Perception, N. Y., 1960.



Binocular cues are most meaningful at close ranges. They are more important in the motor skills of the human than in his perception of the environment. Convergence is a binocular cue that must be credited as far back as 1790 to Bishop Berkeley's New Theory of Vision. The convergence of the eyes approaches a zero limit at about fifty feet. Thus, beyond fifty feet the axes of vision are parallel.

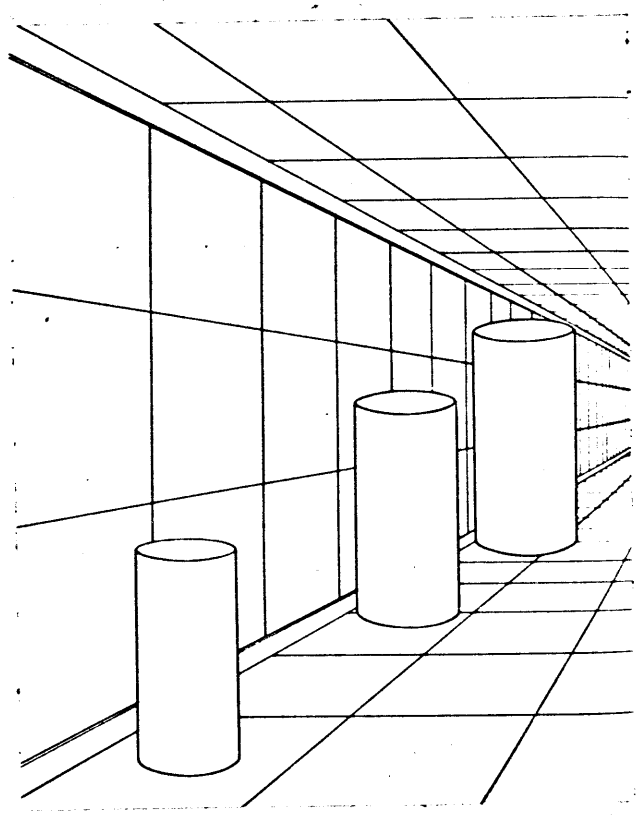
Retinal disparity is also an old theory of vision (Wheatstone 1833) and is strikingly verified with stereograms. Anyone who looks at a stereoscope and then removes the illustration will notice that two unlike images produce a third -three-dimensional image. To do this, the two illustrations must have properly calculated deviations and accordingly set up the mechanism. The eye does this for all retinal images.



The illustration above shows a three dimensional pyramid that is transformed into two diagramatic retinal images. The disparity of the two images decreases the further away the viewer is in the relation to the object. Beyond 2500 feet, one eye is sufficient for perceiving depth.

Proximal size is one of the strongest determinants of distance. This is true only with a previous familiarity pertaining to objects in visual field.

Despite previous knowledge, a trompe l'oeil situation is possible, illustrating that more than one variable is necessary to satisfy depth perception. For viewing objects at a given distance, we possess a subjective size scale such that we can immediately judge size fairly accurately as well as relative



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size.[26] The reverse holds true: perceived size is a cue to distance and perceived distance is a cue to size.[27] Gruber[28] does not attribute this to a direct relationship, but rather to a built-in "size-distance paradox": When size is underestimated, perceived distance is overestimated.

Brightness is presummed to be a cue since objects necessarily appear darker as their distance from the eye increases. This is based on the known fact that a point source of light yields an intensity at the eye which decreases in proportion to the distance

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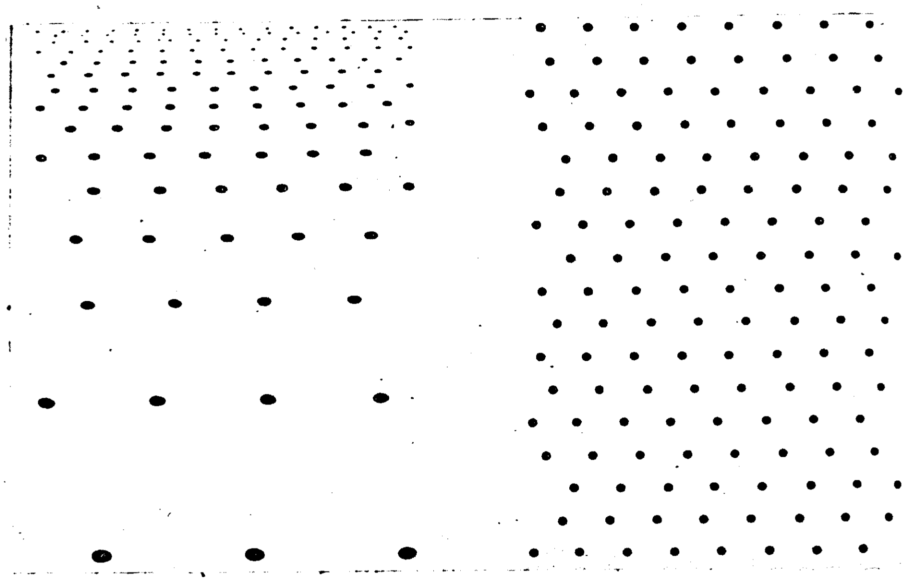
26 Gibson, Op. Cit.

27 Dember, Op. Cit.

28 Gruber, H. D., "The Relation of Perceived Size to Perceived Distance", Amer. Jl. Psychol., 67, 411-426, 1954.



squared. Again the relationship is not direct. Helmholtz[29] (1896) found that if the illumination intensity of a visual field were changed, the apparent brightness would not change in the same way or to the same extent as the light. The above diagrams are self-explanatory. The texture gradient on the right yields no impression of depth, as opposed to the one on the left. This cue combined with "proximal size" becomes very important: What is a discrete object at close range, becomes part of a texture at a distance, (example: a brick in a wall).

Linear perspective comprises the bulk of other sections in this report and will only be mentioned briefly. We are all acquainted with perspective in pictures and photographs --

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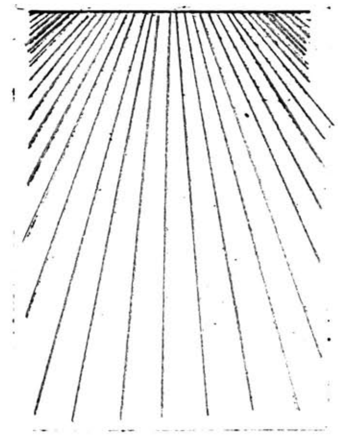
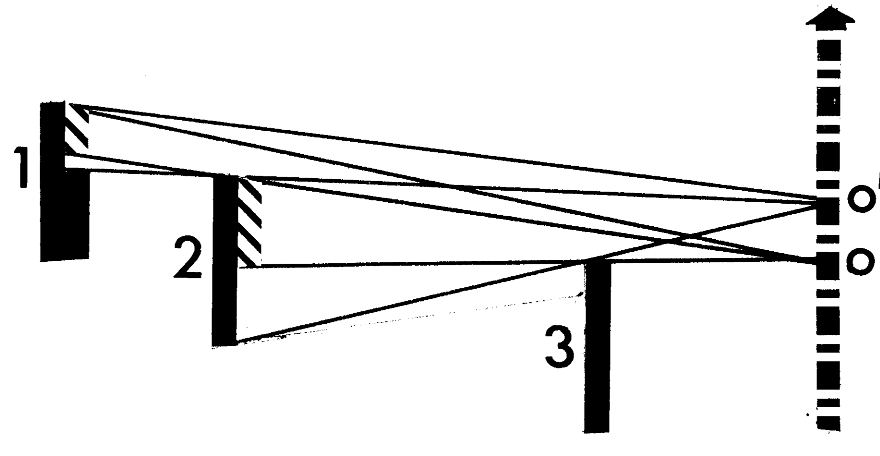
29 von Helmholtz, H., Handbuch der Physiologischen Optik, 3rd Edition, 1910.



stimuli to which we have been exposed since childhood. Kitchen floors, tiled ceilings and paved sidewalks are all part of our daily experience and provide the most rigid examples of linear perspective. To be a meaningful cue, the visual field must primarily be orthogonally structured within its boundaries. In a visual world of only hills, lakes and clouds, linear perspective alone would provide no cue to the perception of depth and distance.

Interposition and movement paralax can be dealt with simultaneously for they are merely the static and dynamic aspects of the same determinant. When one object in the visual field is partially hidden by a second object, one can assume that the second object is closer. Strictly speaking, this does provide a cue for depth. This cue becomes many times more



meaningful with movement. If observer '0' sees three objects '1', '2', and '3', and notices that '2' is partially hidden by '3' and that '1' is behind '2', he can determine their relative order in space; although he cannot determine how far '2' is behind '1', and '3' behind '2'. As soon as he moves to a new position '0', he can see all object '2', but still not much more of object '1'. Assuming for a moment that all motion is relative, what has happened is, object '3' has moved 'backwards', in order to uncover object '2', and object '2' has performed the same 'backwards' motion to uncover part of object '1'. Only a small amount of object '1' has been uncovered in the same time it took to make visible the remaining portion of object '2'. Therefore, we can say that object '3' has moved at a higher backwards speed than object '2'. This understanding is crucial for the formulation and formalization of motion perception and will be referred to constantly as the velocity gradient of the visual field.

MOTION AND MOVEMENT

"Happenings attract us more spontaneously than things do, and the prime characteristic of a happening is motion.[30]" The experience of motion presupposes that two systems are seen as being displaced with respect to each other. This displacement must belong to the family of rigid motion or non-rigid motion.

Newton (1642-1727) summarized his conception of motion in three principles (Newton's Laws of Motion). These laws concern rigid motion, (translation and rotation) and involve no geometrical transformations. Translation and rotation imply a single change in direction or position within any instant of time, a phenomena that is very difficult to see in its pure form. Nevertheless, motion is popularly thought of as

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30 Arnheim, R., "Art and Visual Perception", Univ. of Calif., 1954.

being solely a change in position. Rigid motions account for velocity and acceleration. These properties, although impor-tand in physics, have less meaning in the psychology of perception.[31]

Non-rigid motions are elastic transformation that necessitate a geometrical change in shape. This family of motions is rare in the physical world, but so common in the visual world, that we do not tend to consider them as motion. There are three types of non-rigid motion:[32]

1. Size transformation
2. Perspective transformation
3. Deformation

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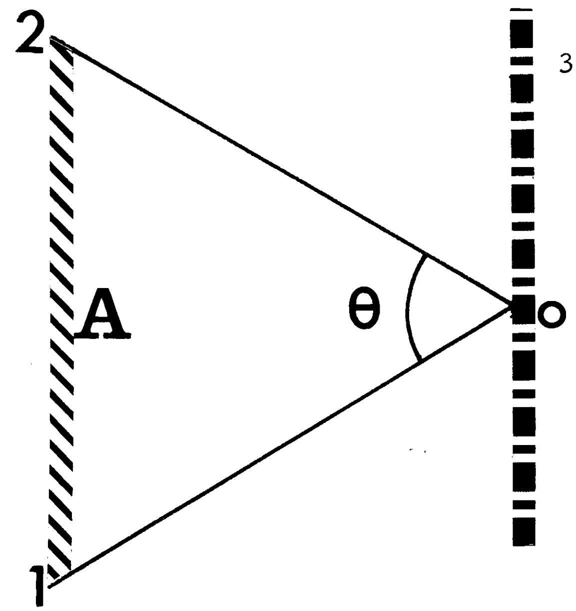
31 Gibson, J. J., and Smith, O.W., "The Perception of Motion in Space", Symp. of Physiol. Psychol., Pensacola, Fla., ONR Symposium Report ACR-1, March 10-11, 1955, 117-124.

32 Gibson, J.J., "The Visual Perception of Objective Motion and Subjective Movement", Psychol. Rev., 61, no. 5, 304-314, 1954.



These three motions provide the cues for optical motions. The retinal tracing of physical movement although the simple optical motion is not comparable to the simplest physical motion. Optical motions are described in two dimensions rather than three, and measured in units of visual angle rather than length. Newton's "uniform motion in a straight line", produces a retinal image that is a function of angular displacement of a moving object with respect to the viewer. The above diagram illustrates this function. If an observer is at point '0' and perceives an object moving from position '1' to position '2' in one sec, he experiences an optical motion of θ degrees per second. This angular velocity becomes the perceptual tool used to estimate the physical displacement of the moving object: In this case, the eye translates the distance A into an angle θ and the mind retranslates the angle θ into the distance A with a certain amount of error. The further away the observer is from the line of movement, the smaller the angle consequently a decreasing rate of change of the angle -- angular velocity. Even though the physical velocity of the object does not change, its angular velocity changes as a function of its position with respect to the observer.[33, 34]

Consider the eye to be motionless at first: then is is easy to see the retinal image as a sheaf of moving light rays travel-

33 Graham, C. H., Baker, K. E., Hecht, M., and Lloyd, V. V., "Factors Influencing Thresholds for Monocular movement Paralax", Jl. Exp. Psychol., 38, 205-223, 1948.
Also: Graham, C. H., "Visual Perception" in Handbook of Experimental Psychology, N.Y., Wiley, 868-920, 1951.

34 Brown, R. H., Reprint: Visual Sensitivity to Difference in Velocity, March 1961.

ing relative to a stationary background image of the environment. The stimulus for visual movement is retinal movement. This definition fails, however, as soon as rotation of the eye occurs to permit pursuit of the object to keep its image fairly precisely on the fovea. In this case, the background image moves accross the eye and the object is stationary. Why does one perceive, in this situation, a motion of the object in the environment instead of a motion of the environment? The answer is that which differentiates our visual system from a camera: our built-in data processor collects from memory and other inputs the necessary information to rectify the image. Indeed, if an alien to our visual world were set in motion along a frictionless track at constant velocity, he would probably see the visual field as moving and changing about him.

This problem of stability during motion has many theoretical answers and an equal number of practical contradictions. The Gestalt psychologists explain this phenomena in terms of the "figure-ground" relationship of objects: figures move and the ground is still. The appearance of the moon through drifting clouds provides a common contradiction. In this case the clouds provide an extended background to the moon, and the motion of the moon is unequivocal. (This subject is experimented with at length by Dunker).[34] The experience of active locomotion (voluntary or guided movement by the observer) becomes too great a psychological problem to handle in this study. For this reason, all motions have been considered

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[34] Dunker, K., "Uber induzierte Bewegung", Psychol. Forsch., 12, 180-259, 1929.

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void of the kinesthetic experience. The induced problems of pursuit tasks, reaction time, and individual psychological structure are primary forces. They are not being explored despite knowledge that a perception study is incomplete without treating sensory relationships.[35] In relation to this topic, this means that the "perception of motion in the urban environment" is the same as "the perception of the urban environment during motion".

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35 Held, R., "Sensory Deprivation and Visual Speed", Science, 130, 860-61, 1959.

PERCEIVED VELOCITY

"We cannot tell whether a turtle, which leads a slow life, sees things move at a greater speed than we do. But the traffic of the City does look faster after we have been away from it for a while"[36] At the same time, we cannot see a child grow, but if we meet an acquaintance after a lapse of time, we can in a split second see him grow tall by means of a stroboscopic motion that takes place between the memory trace and the perception of the present moment.

The perception of movement rate and directional change is crucial to the survival of many species, yet we have no satisfactory framework within which to organize the conceptual data

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36 Arnheim, <u>Op. Cit.</u>

bearing on this problem.[37] There seems to be dissension as to whether velocity is perceived directly. Brown asserts that the velocity of moving objects is perceived directly and does not depend upon indirect judgements.[38] However:

> Both movement and time perceptions have been considered to be, in their essentials, independent of the properties of the particular organs of sense and thus almost wholly dependent upon the mental nervous system.[39]

In such a survey as this report, it is difficult to choose sides. The answer becomes one of professional relevance rather

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37 Spigel, I. Wm., Readings in the Study of Visually Perceived Movement, Harper & Row, N.Y., 1965.

38 Mandrioat, F. J., Mintz, D., and Notherman, J., "Visual Velocity Discrimination", In Spigel's Study, (Op. Cit.).

39 Boring, E. G., Sensation & Perception in the History of Experience Psychology, N. Y., (Appleton-Century) 1942.

one of phenomenological importance. More important, however, is the psychological effect of different velocities. Speed is estimated more accurately than duration and duration is estimated more accurately than distance.[40] This is important, because the dimensional units of space, (distance', are least accurately perceived by our visual system.

An important effect is the kappa phenomena : Two trips of equal duration would not necessarily appear to take the same time. Our perceptual system attributes longer duration to the trip of high speed (longer distance): increased speed induces increased perception of duration.[41] This effect can pro-

40 Cohen, J., and Coper, P., "Durre, Longeur et Vitess Apparentes d'un Voyage", Annee Psychol., 1963, 63(1), 13-28.

41 Fraisse, P., "Influence de la Vitesse des Mouvements sur l'Estimation de leur Durre", Annee Psychol., 1962, 62(2), 391-399.

duce an error of 25%, depending upon the speed and length of the trip. Of all velocities, thirty miles per hour is estimated with the least error.[42] The following list is a summary of factors affecting velocity (taken primarily from the works of Brown[43]).

DISTANCE: Increase in the distance of the observer from the moving field decreases the phenomenal velocity and consequently raises all the various visual thresholds.

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42 Cohen, Op. Cit.

43 Brown, J. F, "Uber Gesehene Geschwindigkeit", Psychol. Forsch. 10, 84-101, 1927.

__________, "The visual Perception of Velocity", Psychol. Forsch., 14, 199-232, 1931.

__________, "On Time-Perception in Visual Movement", Psychol. Forsch., 14, 233-268, 1931.

__________, "Threshold for Visual Movement", Psychol. Forsch., 14, 249-268, 1931.

SIZE OF VISUAL FIELD: A small visual field will produce higher phenomenal velocities. An example of this is viewing of traffic through a small window in comparison to standing outside.

FIELD STRUCTURE: There are two catagories of structure: homogeneous and nonhomogeneous. Phenomenal velocity increases with the decrease of homogeneity.

SIZE OF MOVING OBJECTS: Decrease in size of moving figures increases the phenomenal velocity and lowers the visual thresholds.

OBJECT ORIENTATION: Oblong figures whose greater length is oriented with the direction of movement are seen as phenomenally faster. In terms of spaces, experimentation allows us to think that with short spaces there is a perception of greater

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speed as compared with long spaces.[44]

DIRECTION OF MOVEMENT: Vertical movement appears faster than the same horizontal movement. In turn, upward movement seems faster than downward movement.[45] The discrepancy can vary as high as 30%.

BRIGHTNESS: Decrease in illumination of the moving field increases phenomenal velocity. This over-estimation can be as high as 30%. At the same time, a decrease in brightness

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44 Bonnet C., "The Vitesse Percue et la Relation V=E/T", Annee Psychol., 64(1), 47-60......"En comparant l'estimation de la vitesse a celle qui peut etre calculee a patir des estimation de l'espace et du temps on trouve peu ou pas de difference entres ces valeurs", 1964.

45 Gibson, (ONR Report) Op. Cit.

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reduces the effect of directional movement.[46]

MODE OF OBSERVATION: During fixation of the eye, velocity appears greater than during pursuit. This can have a 50% effect.

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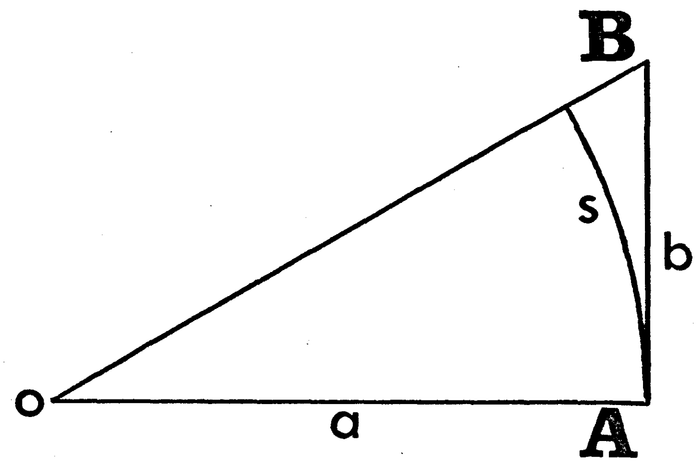
46 Kunnapas, T., "The Vertical-Horizontal Illusion and the Visual Field", Jl. Exp. Psychol., 53, 405-407, 1957.



ANGULAR VELOCITIES

The change of visual angle per unit time (angular speed) is the basic variable considered in experiments with the visual perception of motion. Its derivation has been explained as being a function of distance and speed. Its wide use is due to this function: angular velocity combines the two variables, distance and speed, into one, facilitating the comparison of data obtained under different conditions. The above diagram reillustrates this angle in terms of a displacement from A to B'. The radius of rotation is given by the distance from the observer to A. The line of regard, '0A', can be assumed to be a rotating line involving fixation on the moving object.

As a stimulus rotates about the reference point '0', (the observer) its instantaneous angular speed (w) is given by:

$$w = \frac{\text{change in angle}}{\text{change in time}} = \frac{d\theta}{dt}$$

Where θ is the angle swept by the radius vector x' ' in the time 't'. The value of θ is given by:

$$\frac{s}{a} \text{ in radians} \qquad \frac{57.3 \times s}{a} \text{ in degrees}$$

Angular speed is not used most advantageously for rotational motion. Tangential motion is more important. The rectilinear distance 'b', represented in the figure, is a close approximation to the arc s for angular displacments.[47]

For uniform angular motion, when w is constant:

$$w = \frac{\theta}{t}$$

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47 Brown, Op. Cit.

Substituting our previous definition of θ:

$$w = \frac{s}{t}$$

As an approximation for small angular displacements, we may substitute 'b' for 's' to obtain:

$$w = \frac{d}{a\,t} = \frac{v}{a} \quad \text{(in radians per unit time)}$$

$$w = \frac{57.3\,v}{a} \quad \text{(in degrees per unit time)}$$

where the uniform linear speed 'v' and the distance 'r' are expressed in consistent units.

The approximation produces an error of 1% for a θ of 10°. To eliminate this error θ must be defined as equal to:

$$\text{arc} \ \tan \frac{d}{a}$$

Using this as a definition of θ, points in the visual field can be defined as having angular velocity constants. Each point has an 'a' and 'b' relationship to the instantaneous position of a traveler. Accordingly, θ can be calculated and incorporated with the necessary constants to provide an overall angular velocity constant that would describe the angular velocity of any point in the visual field in terms of any given physical velocity.

The following derivation was used to formulate a table of constants:

$$\tan \theta \quad \frac{a}{b}$$

$$\frac{d}{dt} \tan \theta = \sec^2\theta \ \frac{d\theta}{dt}$$

$$= \frac{da}{dt} \times \frac{1}{b} - \frac{1}{b^2} \times \frac{db}{dt}$$

$$d\theta = \left(\frac{da}{dt} \times \frac{1}{b} \quad \frac{1}{b^2} \times \frac{db}{dt}\right) / \ \sec^2\theta$$

since $\frac{da}{dt}$ is equal to 0 and $\frac{db}{dt}$ equal the physical velocity

$$d\theta = \left(\frac{av}{b^2}\right) / \sec^2 \theta$$

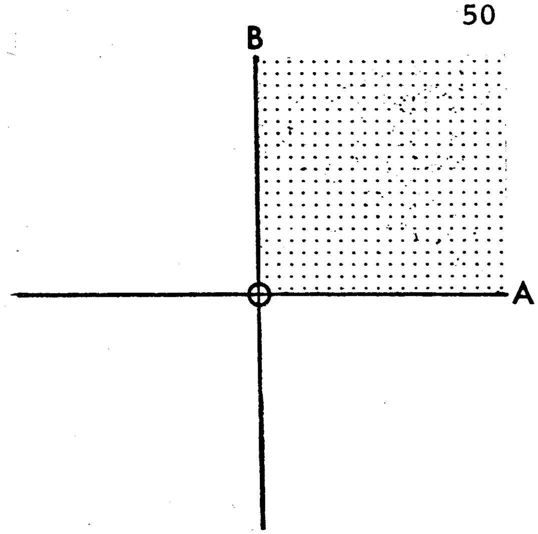
$$\sec^2 = \frac{a^2+b^2}{b^2} \qquad \text{therefore:}$$

$$\text{angular velocity} = \frac{d\theta}{dt} = v \times \frac{a}{a^2+b^2}$$

To change radians to degrees the constant 57.283 is used and to change miles per hour to feet per second .682 is necessary. This equation describes the angular velocity contant for any point in the visualfield with respect to a direction of travel:[48]

$$\text{CONSTANT} = ((57.283 \times a) / (a^2 + b^2)) \times (.682)$$

48 This equation was derived primarily by Prof. Aaron Fleisher, M.I.T.



This figure is more important as a scale than as a constant. To a moving person everything around him is in motion. "Nearby objects move most rapidly, so that closely spaced verticals on a railing, for example, completely disappear from sight, and shrubs become just a blur, Objects in the medium distance can be observed only for a short time."[49] Only distant objects such as the moon remain stable and have any degree of permanence. The above equation provides the ratios of object movements in the field. The formula has been incorporated into an elementary computer program[50] and calculated for points in one quadrant of the visual field.

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49 "Development of Freeway Form", in Man Made America, p. 171.

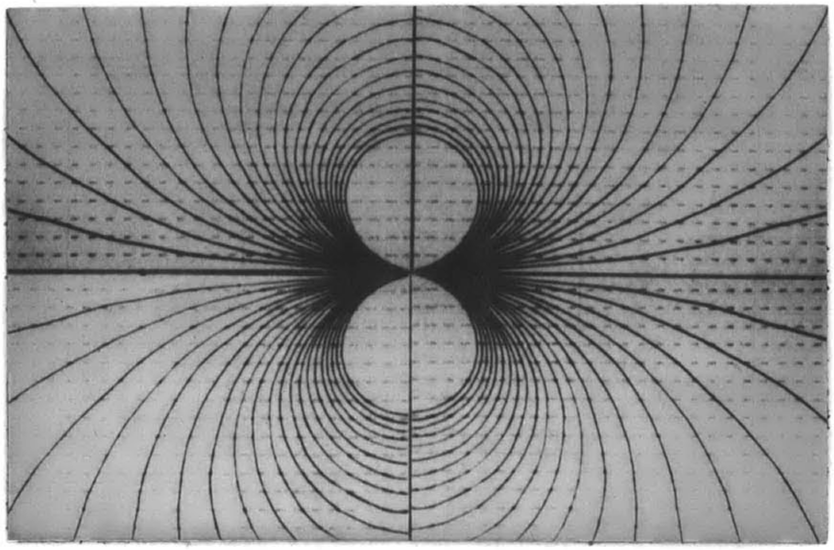
50 This work was done at MIT's Computation Center, Job. No. M4977 (See Appendix A for Listing).

The following two pages demonstrate sample output in terms of 'a' and 'b' coordinates of the visual field. Examining this table, it is evident that the angular velocity constants drop off to zero faster in the 'b' direction than in the 'a' direction. For a scale of movement in the visual field (a, b) take point 30, 5 (30 feet to the side of the viewer and 5 feet ahead) and use it as an arbitrary base. It is apparent that the point 60, 10 has exactly half the value and, thus, would appear to move at half the speed. In turn, both points 1, 10 and 100, 10 have approximately half again as small an angular velocity constant. More important, note, that the point 3, 0 in this case has a relative velocity of over ten times the base value. These tables then re-calculated for equal increments of 'a' and 'b' by having the computer print the data with proper

ANGULAR VELOCITY CONSTANTS
A IS THE DISTANCE IN FEET PERPENDICULAR TO LINE OF MOVEMENT
B IS DISTANCE IN FEET PARALLEL TO LINE OF MOVEMENT

CONSTANT TIMES LINEAR VELOCITY IN MPH EQUALS ANGULAR VELOCITY IN DEGREES PER SECOND

A	VALUES OF B							
	0	1	2	5	10	20	50	100
0 1	39.0670	19.5335	7.8134	1.5026	.3868	.0974	.0156	.0039
0 2	19.5335	15.6268	9.7668	2.6943	.7513	.1934	.0312	.0078
0 3	13.0223	11.7201	9.0155	3.4471	1.0752	.2866	.0467	.0117
0 4	9.7668	9.1922	7.8134	3.8114	1.3471	.3756	.0621	.0156
0 5	7.8134	7.5129	6.7357	3.9067	1.5627	.4596	.0774	.0195
0 6	6.5112	6.3352	5.8601	3.8427	1.7235	.5376	.0924	.0234
0 7	5.5810	5.4694	5.1598	3.6955	1.8354	.6091	.1073	.0272
0 8	4.8834	4.8082	4.5961	3.5116	1.9057	.6736	.1219	.0311
0 9	4.3408	4.2878	4.1365	3.3170	1.9426	.7310	.1362	.0349
0 10	3.9067	3.8680	3.7564	3.1254	1.9534	.7813	.1503	.0387
0 20	1.9534	1.9485	1.9340	1.8384	1.5627	.9767	.2694	.0751
0 30	1.3022	1.3008	1.2965	1.2670	1.1720	.9015	.3447	.1075
0 40	.9767	.9761	.9742	.9616	.9192	.7813	.3811	.1347
0 50	.7813	.7810	.7801	.7736	.7513	.6736	.3907	.1563
0 60	.6511	.6509	.6504	.6466	.6335	.5860	.3843	.1724
0 70	.5581	.5580	.5576	.5553	.5469	.5160	.3696	.1835
0 80	.4883	.4883	.4880	.4864	.4808	.4596	.3512	.1906
0 90	.4341	.4340	.4339	.4327	.4288	.4137	.3317	.1943
0 100	.3907	.3906	.3905	.3897	.3868	.3756	.3125	.1953
0 200	.1953	.1953	.1953	.1952	.1948	.1934	.1838	.1563
0 300	.1302	.1302	.1302	.1302	.1301	.1296	.1267	.1172
0 400	.0977	.0977	.0977	.0977	.0976	.0974	.0962	.0919
0 500	.0781	.0781	.0781	.0781	.0781	.0780	.0774	.0751
0 600	.0651	.0651	.0651	.0651	.0651	.0650	.0647	.0634
0 700	.0558	.0558	.0558	.0558	.0558	.0558	.0555	.0547
0 800	.0488	.0488	.0488	.0488	.0488	.0488	.0486	.0481
0 900	.0434	.0434	.0434	.0434	.0434	.0434	.0433	.0429
0 1000	.0391	.0391	.0391	.0391	.0391	.0391	.0390	.0387
0 2000	.0195	.0195	.0195	.0195	.0195	.0195	.0195	.0195
0 3000	.0130	.0130	.0130	.0130	.0130	.0130	.0130	.0130
0 4000	.0098	.0098	.0098	.0098	.0098	.0098	.0098	.0098
0 5000	.0078	.0078	.0078	.0078	.0078	.0078	.0078	.0078
0 6000	.0065	.0065	.0065	.0065	.0065	.0065	.0065	.0065
0 7000	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056
0 8000	.0049	.0049	.0049	.0049	.0049	.0049	.0049	.0049
0 9000	.0043	.0043	.0043	.0043	.0043	.0043	.0043	.0043
010000	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039



line spacing. It was then possible to arrange the angular velocity constants such that the decimal points of the numbers formed a square. The next step involved mounting the output on a large board (3' x 6') and connecting all points of equal velocity constant, thus producing lines of equal apparent velocity. By producing four photographs of the layout and filling in all four quadrants, a diagram was obtained of the entire visual field. The above illustration is thirty fold reduction of this diagram.

ANGULAR VELOCITY THRESHOLDS

During motion, the visual field moves along the isometric lines of angular velocity, such that each point passes from one apparent velocity to another higher velocity during its approach to the observer. Similarly its velocity decreases after passing the point of origin. This way of visualizing the visual field returns to the assumption that the moving observer can be replaced by a stationary observer within a moving visual field.

Points in the visual field that change from one angular velocity to another, go through different states of potential visual perception. The hour hand of a clock cannot be observed moving nor can the blades of an airplane propeller. Such states of perception exist in the moving visual field. There are four relevant states of motion considered in this

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report and it is their boundary conditions that are referred to as thresholds. These thresholds are a function of perceived velocity and vary in the same manner as subjective velocity.

State I is the condition under which no immediate movement is distinguished, yet some measure displacement is noted over a period of time. The upper limit of this State, Threshold I, is about 1/50 degree per second. (An angular velocity experienced by the horizon or the moon).

State II is the condition which applies to most elements in the visual field. In this state, contours are clearly visible making objects projected on the retina merely dynamic images of the same static projection. In this condition there is no distortion of perceptual transformation due to motion. The upper limit of this varies from 13 to 30 degrees per second.[51] The most important determinant of this angular velocity range is whether or not the object in question is viewed before perceivable motion (State I), since a retinal image is combined with visual feedback from the memory trace.

After this state, blur occurs and a physical transformation alters the perceived form. A loss of sharp contour perception occurs first, followed by a loss of clearness. The limit of this condition is total disappearance of the object, threshold III. This occurs at angular velocities of over 220 degrees per second.[52]

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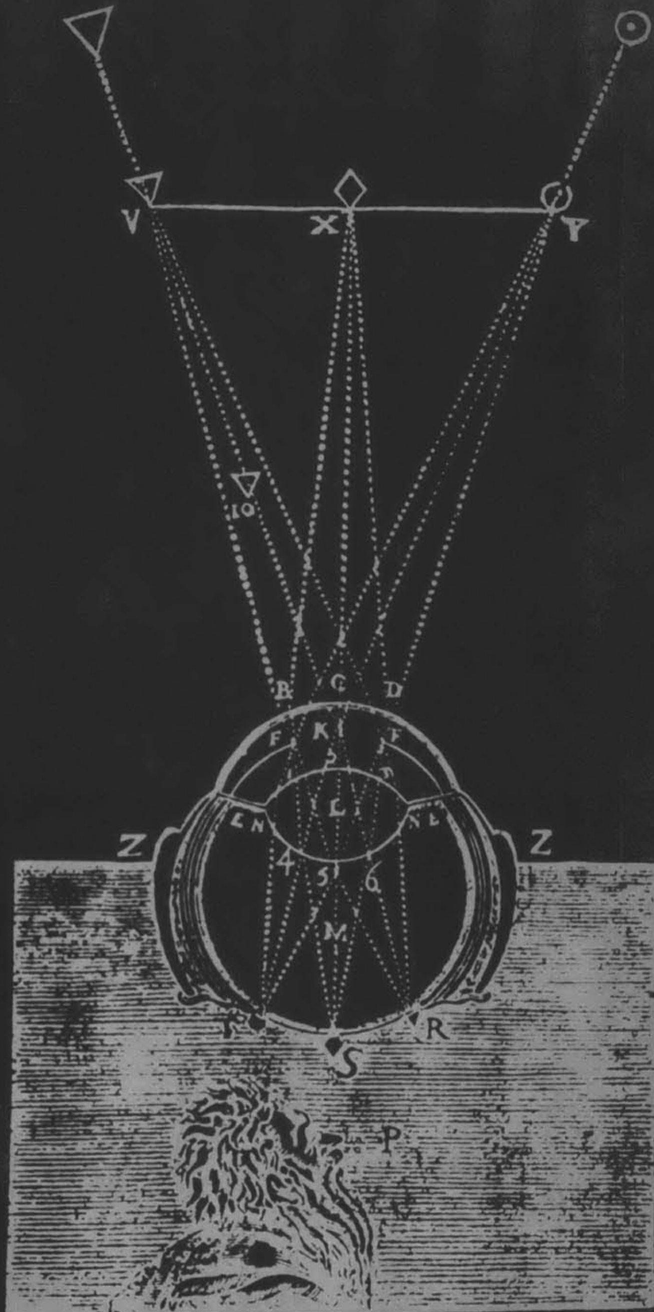
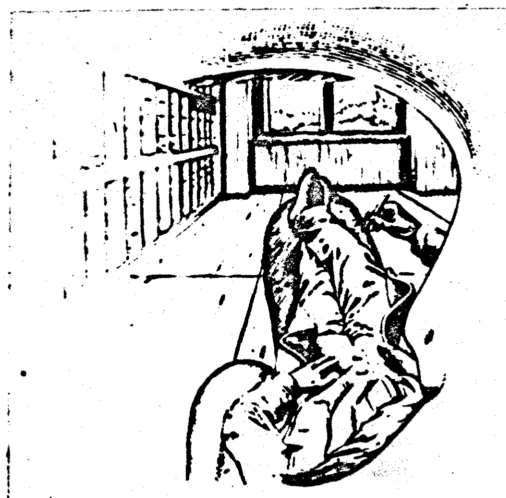
51 Smith, K. U., and Gulick, W. L., "Visual Contour and Movement Perception, Science, 124, 316-137, 1956.

52 Ludvigh, E., and Miller, J. W., Dynamic Visual Acuity, USN Pensacola, Florida.

State IV is the perceptual transformation of disappearance. This is commonly experienced in vehicles where rail posts and cyclone fences, close to the roadway, pleasantly vanish. It is necessary to re-emphasize that these constants and thresholds of visual angular velocity are not solely a function of speed. A plane traveling at thousands of miles per hour enters State IV, if the observer is within several hundred feet of its path. On ther other hand, a fly enters the same state traveling less than one mile per hour when passing in front of the observer's nose.



chapter 2



SEEING 'SEEING'

"Perception of the environment is a process of creating a visual hypothesis, the building of an organized mental image which is based on the experience and purposes of the observer, as well as the stimuli which reach his eye."[53] The stimuli which reach his eye are easily observed in a laboratory. A human subject is chosen, his head is medievally clamped in a binder, and he is exposed to flashes of white paper on a black background. From this comes all the referenced data in the last chapter.

When viewing perception of the urban environment this cannot be accomplished as the stimulus is not the visual field, but the visual world. The problem is one of looking at what is seen. Ernst Mach analyzed his visual sensations by closing

53 Lynch, K., Site Planning, MIT Press, Cambridge, Mass. 84, 1962.

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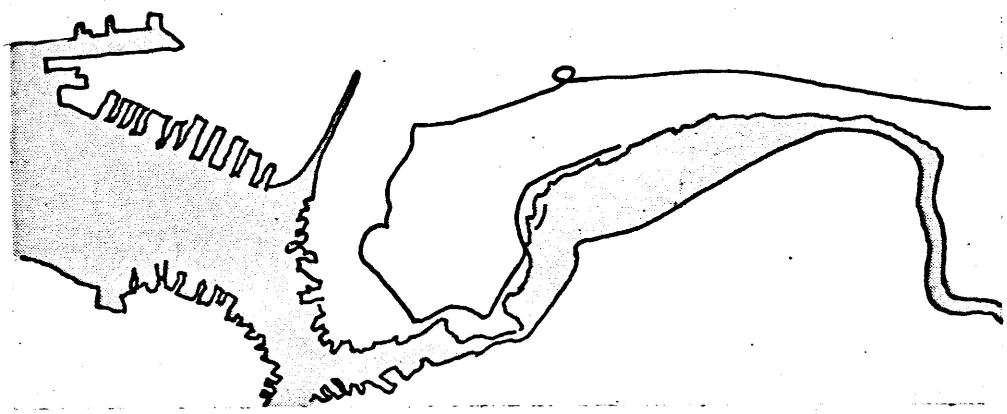
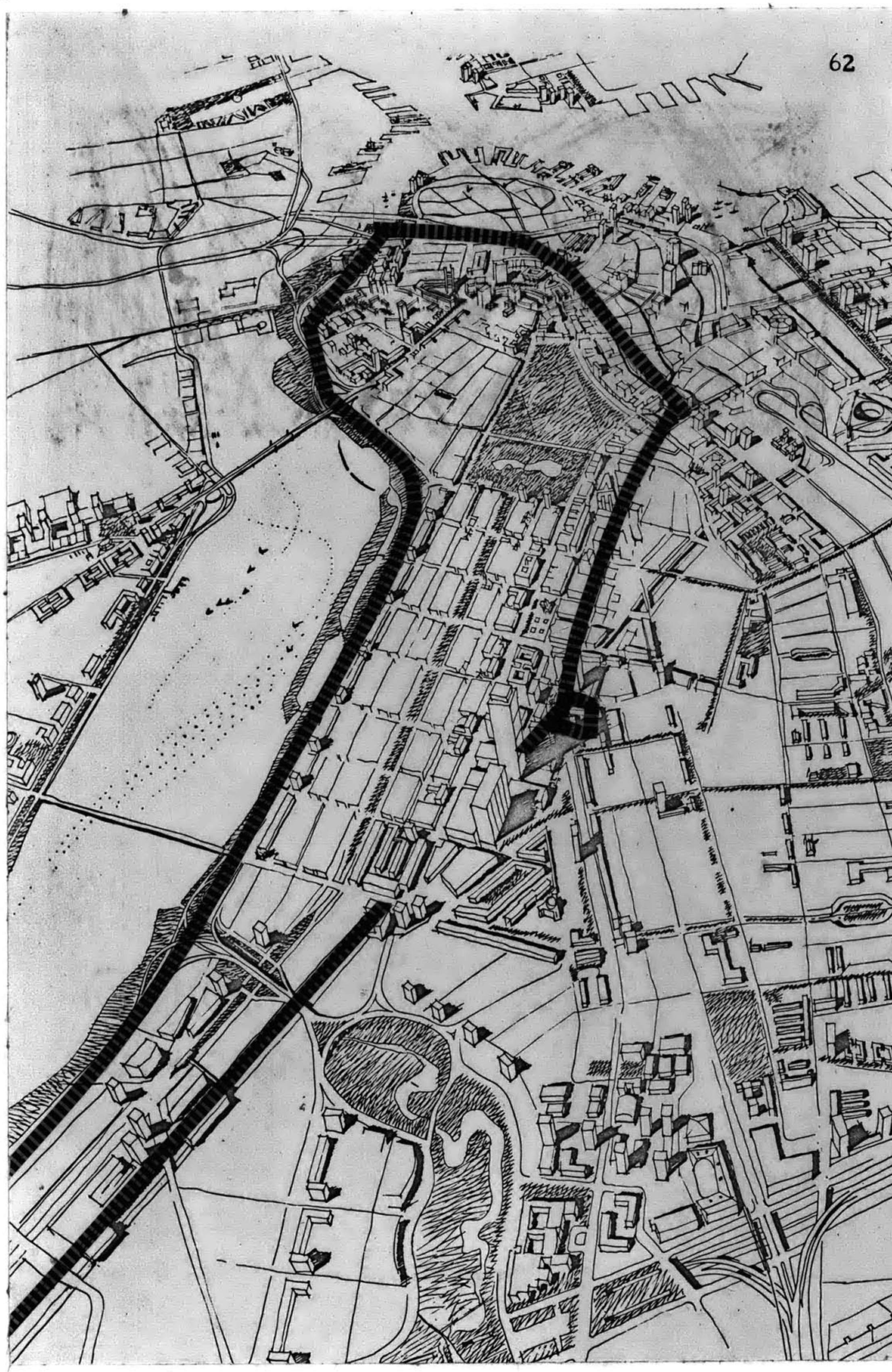
his right eye, reclining on a chaise longue, and drawing what he saw. His nose delimited the field on the right and his moustache appeared below. His body and the room are drawn in full detail, though he could not have seen them clearly without moving his head or wrenching his eyes. In fact, only the center of the field should be shown definite and clear.

In this study, two methods are used to observe the visual world. Neither attack is much better than Mr. Mach's system; the only difference being that the processes are dynamic illustrations of perception. The first method employs variable filming speed through the use of a 16mm movie camera attached to the left hand side of a car. By traveling a route and varying the filming speeds, it is possible to ob-



tain movies at speeds ranging from 50 to 1000 miles per hour. Over 1500 feet of film have been shot modifying one variable at a time. The above map of Boston shows one of the selected sequences. The following page shows the same sequence illustrated as a birds-eye view, in order to point out some visual characteristics. A series is made, keeping the camera aligned with the direction of travel, varying only the speed. A second series is made with the camera set at 45 degrees, and another with the camera at 90 degrees. Later, lumination, another variable is introduced: shots are taken at night. This condition facilitates homogeneity throughout the visual field. Finally, a series is made varying the type of motion by using a straight path and a sinuous one.

The movies confirm the empirical data. The homogeneous environment indeed causes a slower, apparent velocity and the



movie.

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90 degree viewing imposes a higher subjective velocity. In each case, however, the movie is technically incorrect, as a camera does not have peripheral vision. The film emulsion reacts similarily to the foveal section of the retina, and therefore, the film cannct be viewed in the same manner as it is taken. Technically, what, position-wise is peripheral in the movie will be peripheral in the visual field of only one viewer. (under these conditions the 'foveal nature' of the film is not overbearing.)

A second technical problem exists with no practical solution. The camera speed is slowed down in order to effectively speed up thedisplayed velocity. For example, a film is taken at 2 frames per second[54] traveling at 30 miles per hour. It is

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54 16-18 frames per second is the normal speed of a silent movie.
24 frames per second is the normal speed for a sound movie.

then projected back at 16 frames per second, eight times as many frames per second as the filmed speed thus reproducing a velocity of 240 miles per hour. What happens is a decrease in the camera speed causes a decrease in the shutter speed. This causes a longer film exposure (which is compensated by closing down the lens) permitting objects of extreme high angular velocity to cast blurred traces on the film. This is extremely evident at night, where foreground light s stretch out into lines. In reproducing high visual speed, blur is introduced by the method itself: upon examining one frame of the movie blurred areas exist indeed. This can be desirable and more valuable than a time lapse film (where each frame is a sharp image) because the film is a smooth speeding up of the physical velocity rather than a slapstick comedy of events. The problem is that there is no practical

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way to correlate the blur to the actual state of vision in conjunction with the speed of ultimate projection.

The second method involves a still camera mounted in the same manner as the movie camera. This method, appears as a step down in sophistication, but has more interesting significance than the film method. A picture is taken at a chosen point, at a specific velocity and at some shutter speed and making the necessary light compensations. In this manner, the camera acts as a retina, upon which an image is cast over an extended period. Projected angular velocities appear higher with slow shutter speeds. With the same restriction of a total foveal field apparent velocities can be reproduced as high as 5000 miles per hour. This method permits you to 'zero in' on one object and observe its transformations as a function of speed, rather than as a part of the entire visual field.

This system of observation has the same technical drawbacks as the movie: the whole image is foveal in nature and does not correlate the exact shutter speed with the reproduced apparent velocity. The pictures do give a clear demonstration of elements moving from one threshold to the next with a change of speed as opposed to distance. Furthermore, the illustrations are meaningful as two dimensional diagrams of a four dimensional system: they trace a projection of a three dimensional system over a period of time. This system extended could have important significance in relation to seeing 'seeing'.

> Here we merely have another exemplification of the fact that must by now be familar to the reader, that living mechanisms tend to have a much smaller space scale than the mechanisms best suited to the techniques of human artificers, although, on the other hand, the use of electrical techniques gives the artificial mechanism an enormous advantage in speed over the living organism.
>
> Norbert Wiener

COMPUTER PROCESSES

A mysterious anthropomorphism has created distrust and confusion in understanding the functions of a computer. Memory, nerve center, and brain are common terms for parts of the computer that p form humanlike functions: when a bent card causes the machine to tear up a whole deck of cards, the machine is said to have "gobbled them up". This sort of jargon camouflage has lead to a situation of extremism where people either know nothing about computers, or else a great deal.

This section will briefly attempt to present an 'in-between' state of knowledge of data-processing equipment, assuming that the reader knows little about the subject and the author's knowledge is new enough to be understanding of those "obvious things" that are not so obvious.

A computer (7094 model) can perform in 1/100,000 of a second[55] an elementary operation that would take a clerk about ten seconds. A great deal of work (not accounted for in this flabbergasting figure) is involved in making this operation possible. The information has to be read into the machine, translated, stored, restored, retranslated, and read back. All this is accomplished under the restrictive capability of only counting to one. The core of the machine accepts 0's and 1's (binary information) since elements of the electric circuitry can be in one of two states: ON or OFF. Our decimal number system must be made compatible with the binary system. This is done via a third number system (Octal numbers) that only accepts digits from '1' to '7'.

55. Alexander, C., "A Much Asked Question about Computers and Design", Architecture and the Computer, B.A.C., Boston, December 1964.

When decimal number is part of a computer operation it passes through stages of change from decimal-to-octal-to-binary............binary-to-octal-to-decimal. The sequence of numbers in the three systems is derived in exactly the same way. In the octal system, a number higher than '7' is achieved by introducing a new digit, always omitting '8's' and '9's':
1, 2, 3, 4, 5, 6, 7, 10, 11, 12, ...16, 17, 20, 21, 22, ...26, 27, 30, 31, 32, ...36, 37, 40, 41, 42, ...46, 47, 50, ...57, 60, ...
67, 70, ...77, 100, ...107, 110, etc. Accordingly the same is done in the binary system where '1' is the highest digit:
0, 1, 10, 11, 100, 101, 110, 111. Counting to '7' simultaneously with the three number systems superimposed describes the elementary relationships:

		0	1	2	3	4	5	6	7
	Decimal	0	1	2	3	4	5	6	7
Set (1)	Octal	0	1	2	3	4	5	6	7
	Binary	000	001	010	011	100	101	110	111

going above seven:

	Decimal	8	9	10	11	12	13
Set (2)	Octal	10	11	12	13	14	15
	Binary	001000	001001	001011	001011	001100	001101

The binary numbers described in the first set are used as the digits in translation from octal to binary in the second set. In this manner, by first translating it into octal, any decimal can be expressed within a limited size in the binary system. Besides numbers, the machine can operate on letters and instruc-

---

tions. Letters and certain basic operations are always assigned octal numbers (plus, minus, multiply, divide).

Numbers are stored in designated registers that comprise 36 binary numbers (36 bits of information), which are 12 octal numbers. The register holds the information through 36 on/off switches.* In a sequential operation (a program) these numbers are removed from their storage register as prescribed, placed one at a time in the calculating part of the machine (the accumulator), processed, and returned to their storage register.

The sequence of operations is specified by the program. As there are three different number systems, similarly there are

---

* Where, for example, the number 13 (decimal) would look like: off, off, on, on, off, on, (justified to the right the remaining switches off).

```
WHENEVER A .G. B
 TRANSFER TO CITY
OR WHENEVER A .L. B
 TRANSFER TO SUBURB
OTHERWISE
 TRANSFER TO HOME
END OF CONDITIONAL
```

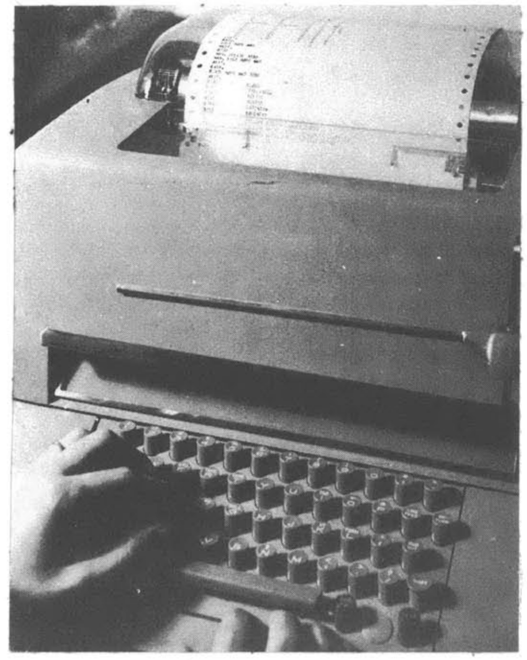
three different levels of sequence specification (language). The lowest order language is machine language, where the operation instructions are in binary form. Programs are rarely written at this language level. The next highest language is octal based, (for example FAP). Programs are translated into this language level before entering the machine. Programs can be written in this middle order language, which is neither concise nor easy to manipulate.

The final level of language is a problem oriented language, where instructions begin to represent gramatical statements. Precise knowledge of how information is to be stored and labeled is not necessary at this level of communication, Conventions are established, the language is defined, and a person of no programming background can set up an operation.

To communicate an operation (the input/output process) two methods are available: Batch processing and time-sharing. Batch processing is the familar card feeding operation, where information is described by the presence of absence of punched holes. A program is written on a series of cards (a deck) and submitted to a dispatcher. He takes the program and returns it with the printed results, (this can take anywhere from one hour to five days). There is no programmer contact with the machine. The "black-box" image is reinforced. The method, however, allows a non-programmer to be a user.

The second method, time-sharing, is relatively new and undergoing much change and research. This system of input/output involves direct communication with the machine. Teletype units are used to transmit the number and character in-

1 - Cathode ray tube, display unit
2 - Teletype unit, program input device
3 - Globe, to manually cause rotation of the image
4 - Keyboard, buttons assigned function as desired
5 - Control Panel
6 - 'Pre-computer', to perform small tasks without time-sharing off the large computer
7 - Light pen, drawing tool and pointer



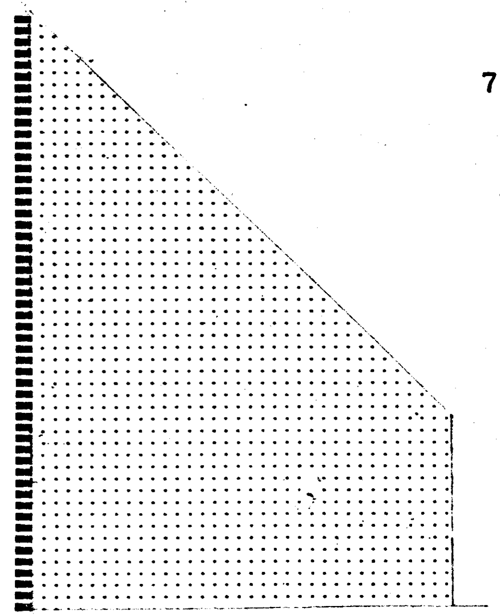
formation over whatever distance away the user is from the machine. This permits the programmer to work 'at home' and be one of many subscribers. The technicalities of the system are unimportant, however, the man-machine interaction is crucial. With this process, a feedback system exists where misinformation or wrong language structure is discerned, (a two day period is not necessary to discover a missing '.' or ',').

```
   X
      X  XXX
      X  XXX
       XXXXX           XXXX
     XXXXXXX          XXXXX
          XXXXXXXXXXXXX
               XXXXXX  XXXX
       XXX     XXXXX   XXXX
       XXX     XXXX    XXXX
       XXX
      XXX  XXXX  XXXX  XXXX
      XXX  XXXX  XXXX  XXXX
 X    XXX  XXXX  XXXX  XXXX
       XXX                    X
       XXX                    X
       XXX
```

BATCH FORMALIZATION

Computer batch processing is used to formalize the perceptual process. This method was prompted partly by default, since the display console of the time-sharing system is not ready for such use. However, this working procedure permits complex programming to be preframed within a small scope of computation knowledge.

The raw materials are limited with card punch inputs: only the standard typographical material is available. The first step is to create a graphic language composed of numbers, letters, blanks, and punctuation marks. Simple conventions are used: For the visual fields 'x's' represent the presence of solids and blanks denote voids. (It must be noted that this solid/void relationship is two dimensional (see the above illustration).



A step-by-step process is used in writing the programs that accompany this thesis. The first stages are simplified situations used as scaffolding for further extension. The final programs are summations of smaller pieces (subroutines): interchangeable elements that operate on the main program. Three steps in this programming hierarchy will be covered in this chapter.

The first program investigates straight line movement in relation to half of a hypothetical visual field. Following the convention, the field is described, using seventy horizontal spaces and a fifty vertical. A scale of one space equalling ten feet is used to dimension the field (700 feet by 500 feet). The scale is a variable and can be changed with the input. The route, described by dots (periods), follows the left hand side of the field, in a downward direction.

The question asked is: what is the most critical point in the visual field at each ten foot interval of the trip, with a given velocity? (Critical is defined as the highest angular velocity.)

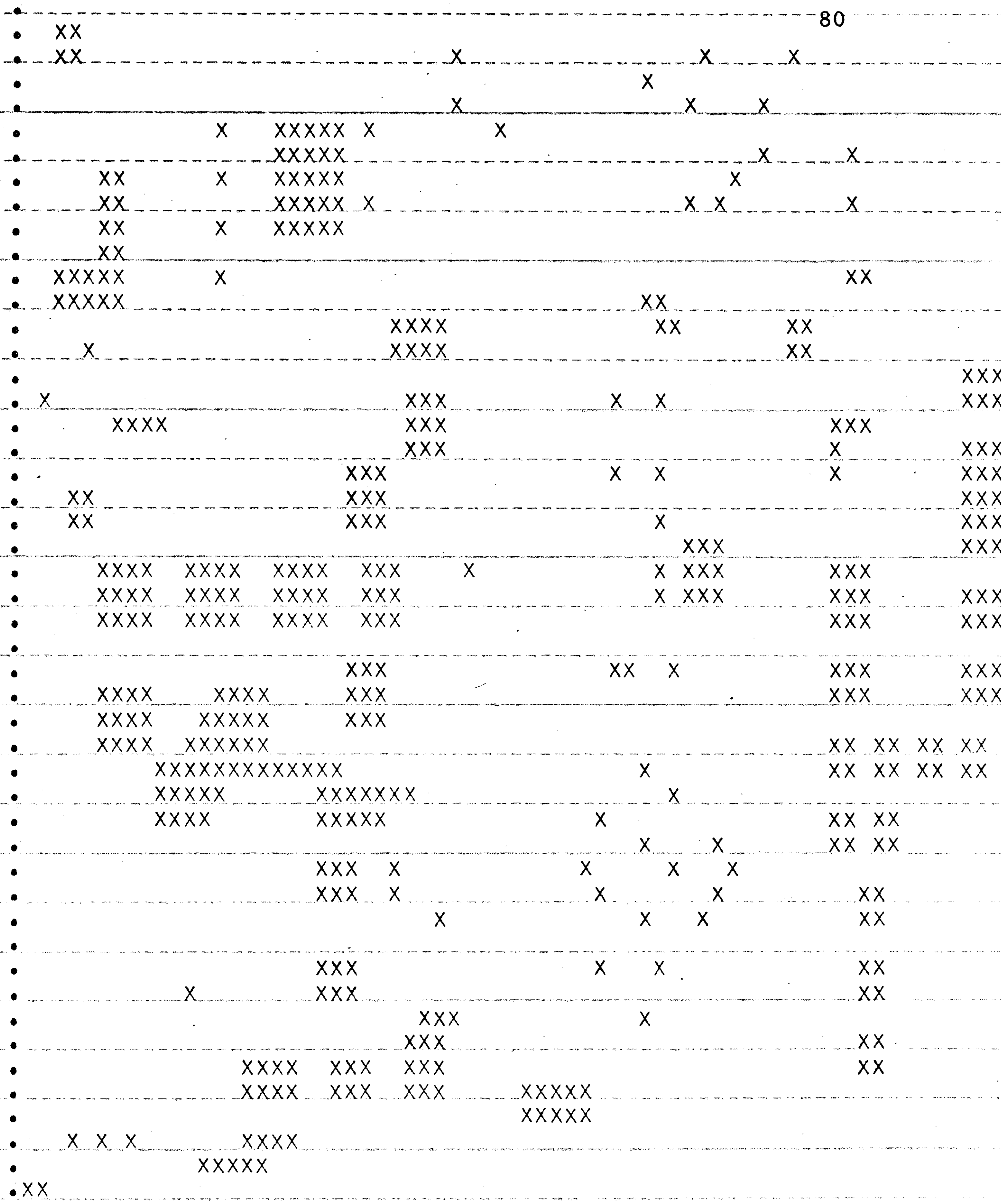
The sequence of operations:

1. READ ONLY POINTS IN A 45^{o} FIELD OF VISION
2. FIND FIRST POSITION
3. READ FIRST POINT IN LINE
4. CALCULATE ITS ANGULAR VELOCITY
5. STORE RESULT
6. READ NEXT POINT ON LINE
7. CALCULATE ITS ANGULAR VELOCITY
8. STORE RESULT IF HIGHER THAN RESULT ALREADY STORED
9. TRANSFER BACK TO '6', UNLESS END OF LINE (70)
10. MOVE VIEWING POSITION TO NEXT LINE

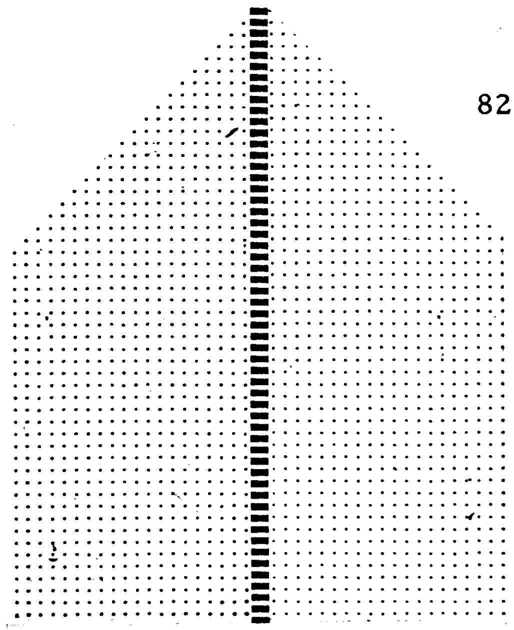
11. VIEW ONLY THE FIELD IN FRONT
12. TRANSFER BACK TO '3', UNLESS END OF ROWS (100)
13. PRINT THE MAXIMUM ANGULAR VELOCITY, COORDINATES OF CRITICAL POSITION, COORDINATES OF PRESENT VIEWING POSITION.
14. MOVE TO NEXT POSITION ON ROUTE, AND TRANSFER TO '3', UNLESS END OF TRIP (100)
15. PRINT OUT IMAGE OF THE VISUAL FIELD (INPUT)

The above flow chart is an instruction sequence that has been translated into a high level language (MAD)[56] Sample output is demonstrated on the following pages, (The size of type necessitates bisecting the printout material, thus awkwardly segregating the calculated material from the visual field.

[56] A listing of this program is in Appendix A.


80

65.1117	(40, 30)	(10, 0)
27.9050	(90, 70)	(20, 0)
32.5558	(90, 60)	(30, 0)
32.5558	(100, 60)	(40, 0)
32.5558	(110, 60)	(50, 0)
32.5558	(120, 60)	(60, 0)
32.5558	(130, 60)	(70, 0)
39.0670	(130, 50)	(80, 0)
48.8338	(130, 40)	(90, 0)
65.1117	(130, 30)	(100, 0)
65.1117	(140, 30)	(110, 0)
27.9050	(190, 70)	(120, 0)
26.9428	(180, 20)	(130, 0)
39.0670	(180, 20)	(140, 0)
60.1031	(180, 20)	(150, 0)
97.6675	(180, 20)	(160, 0)
39.0670	(220, 50)	(170, 0)
48.8338	(220, 40)	(180, 0)
48.8338	(230, 40)	(190, 0)
32.5558	(260, 60)	(200, 0)
32.5558	(270, 60)	(210, 0)
24.4169	(300, 80)	(220, 0)
27.9050	(300, 70)	(230, 0)
32.5558	(300, 60)	(240, 0)
32.5558	(310, 60)	(250, 0)
32.5558	(320, 60)	(260, 0)
12.7047	(420,120)	(270, 0)
13.7884	(420,120)	(280, 0)
14.9778	(420,120)	(290, 0)
16.2779	(420,120)	(300, 0)
11.4903	(480,170)	(310, 0)
12.2084	(480,160)	(320, 0)
12.2084	(490,160)	(330, 0)
13.0223	(490,150)	(340, 0)
13.9525	(490,140)	(350, 0)
15.0258	(490,130)	(360, 0)
16.8938	(480, 80)	(370, 0)
19.0571	(480, 80)	(380, 0)
21.5542	(480, 80)	(390, 0)
24.4169	(480, 80)	(400, 0)
27.5767	(480, 60)	(410, 0)
32.5558	(480, 60)	(420, 0)
38.1142	(480, 40)	(430, 0)
48.8338	(480, 40)	(440, 0)
26.9428	(500, 20)	(450, 0)
39.0670	(500, 20)	(460, 0)
60.1031	(500, 20)	(470, 0)
97.6675	(500, 20)	(480, 0)
195.3350	(500, 10)	(490, 0)
0.	(0, 0)	(500, 0)



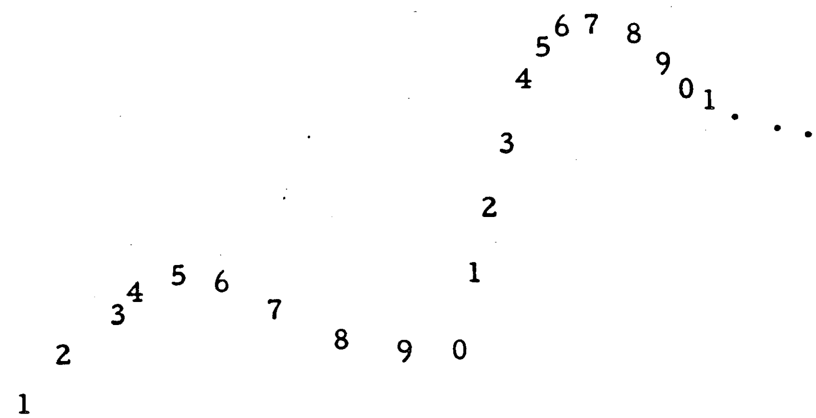
Sophistication of this program (Stage 2) involves three additions: (1) the potential of traveling down a straight line through any point in the field; (2) indication as to how many times any point in the visual field passes a specified angular velocity threshold; (3) the potential of describing an infinitely long route.

The first step involves having the computer be able to 'look' right and left. The complication involved stems from describingtwo boundaries of the visual field (assuming a ninety degree wide field of perception). The second step merely replaces the 'x's' of certain angular velocity with the number '1'. If the 'x' has already been replaced, the number is augmented by one (after 9 is reached, a zero is indicated, and no further additions are performed). Step three permits an economy of storage registers. Of the 32,000 available registers, the programs uses about 16,000 leaving only half the 'memory' for data storage, thus limiting field size.

To avoid this limitation, a subroutine is added that reads 100 cards of field description, monitors the processing of 50, readjusts the storage of the remaining fifty, reads a new 50 cards, and checks to see how far the program is from the end. The following pages show the visual field used as input, the data output, and the altered visual field output. (Due to space confinement, the processing of a long deck has not been demonstrated in the example.)

```
                                            .
                                            .
           XX                               .
           XX                          X    .           X     X
                                            .       X
                                       6    .          X    X
                       X  XXXXX  X        7 .
                          XXXXX             .               X     X
              XX       X  XXXXX             .             X
              XX          XXXXX  X          .          X X        X
              XX       X  XXXXX             .
              XX                            .
           XXXXX       X                    .                     XX
           XXXXX                            .      33
                                   3321     .       33        XX
             X                     3321     .                 XX
                                            .                            XXX
          X                         321     .     1 3                    XXX
                XXXX                321     .                    XXX
                                    321     .                    X       XXX
                                333         .     1 3            1       XXX
            XX                  333         .                            XXX
            XX                  333         .       3                    XXX
                                            .          334               XXX
              XXXX   9011  3333  333    0   .        3 334       109
              XXX2   9011  3333  333        .        3 334       109     XXX
              XXX2   9011  3333  333        .                    109     XXX
                                            .
                                333         .     12  3          109     XXX
              XXX2     1123     333         .                    109     XXX
              XXX2    01123     333         .
              XXX2   901123                 .                    10 86 XX XX
                   68901123333334           .      3             10 86 XX XX
                   68901      3433333       .         3
                   6890       34333         .    1               10 86
                                            .       3    4       10 86
                              343  3        .   0     3   3
                              343  3        .    1       4         98
                                      1     .       3  3           98
                                            .
                              343           .    1  3              98
                     9        343           .                      98
                                     211    .       3
                                    321     .                      98
                         2333  433  321     .                      98
                         2333  433  321     .6790
                                            .6790
             X X X       2333               .
                      01123                 .
          XX                                .
```

39.0670	(300, 60)	(10,350)	44.99
47.6427	(300, 60)	(20,350)	44.99
57.4515	(300, 60)	(30,350)	44.99
67.3569	(300, 60)	(40,350)	44.99
97.6675	(330, 70)	(50,350)	44.99
156.2680	(330, 70)	(60,350)	44.99
195.3350	(330, 70)	(70,350)	44.99
31.2536	(430,140)	(80,350)	44.99
35.1164	(430,140)	(90,350)	44.99
39.0670	(430,140)	(100,350)	44.99
45.0773	(290,150)	(110,350)	44.99
52.0893	(290,150)	(120,350)	44.99
58.6005	(290,150)	(130,350)	44.99
63.3519	(290,150)	(140,350)	44.99
65.1117	(290,150)	(150,350)	44.99
65.1117	(290,160)	(160,350)	44.99
63.3519	(290,180)	(170,350)	44.99
65.1117	(290,180)	(180,350)	44.99
65.1117	(290,190)	(190,350)	44.99
65.1117	(290,200)	(200,350)	44.99
65.1117	(410,210)	(210,350)	44.99
62.5072	(310,250)	(220,350)	44.99
78.1340	(310,250)	(230,350)	44.99
91.9224	(310,250)	(240,350)	44.99
97.6675	(310,250)	(250,350)	44.99
52.0893	(410,290)	(260,350)	44.99
58.6005	(410,290)	(270,350)	44.99
63.3519	(410,290)	(280,350)	44.99
65.1117	(410,290)	(290,350)	44.99
42.8132	(430,330)	(300,350)	44.99
47.6427	(400,350)	(310,350)	44.99
57.4515	(400,350)	(320,350)	44.99
67.3569	(400,350)	(330,350)	44.99
75.1289	(400,350)	(340,350)	44.99
78.1340	(400,350)	(350,350)	44.99
91.9224	(390,370)	(360,350)	44.99
97.6675	(390,370)	(370,350)	44.99
78.1340	(400,380)	(380,350)	44.99
67.3569	(400,410)	(390,350)	44.99
75.1289	(400,410)	(400,350)	44.99
78.1340	(400,410)	(410,350)	44.99
75.1289	(300,430)	(420,350)	44.99
78.1340	(300,430)	(430,350)	44.99
97.6675	(370,460)	(440,350)	44.99
195.3350	(360,460)	(450,350)	44.99
390.6700	(360,460)	(460,350)	44.99
390.6700	(360,470)	(470,350)	44.99
24.4169	(190,480)	(480,350)	44.99
21.7039	(170,490)	(490,350)	44.99
11.8385	(20,500)	(500,350)	44.99



STOCHASTIC SIMULATION

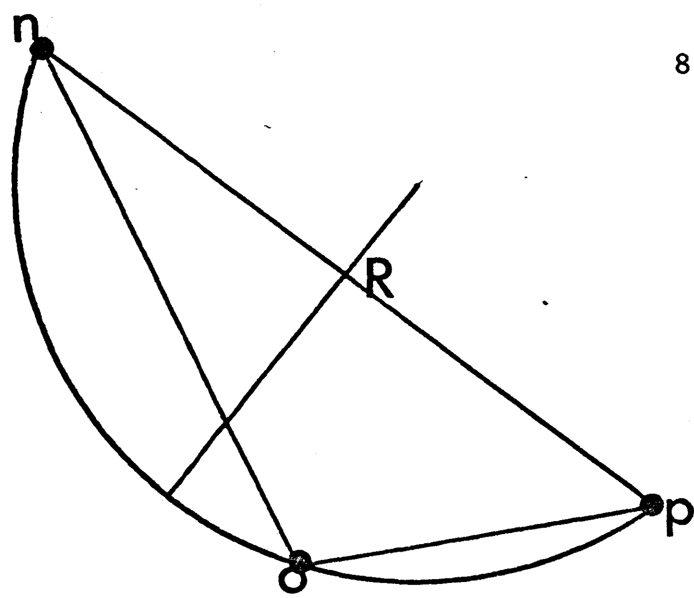
The final sophistication provides a generalized program that can be applied to study any given route. Three important additions provide the necessary flexibilities: (1) a subroutine that permits discription of a non-straight route and accounts for the induced physical angular velocities; (2) a subroutine that changes the field 'numeral' from the number of times critical to the number of seconds critical, (in accordance with the distance between specified points); (3) a subroutine that controls a random number generator to simulate saccadic head and eye movements.

The first subroutine (NOP) imposes new conventions. The delineation of a sinuous route is achieved by sequentially labeling successive points along a path with numerals from '0' to '9'. (See illustration above.)

```
ERROR.................................  87
ERROR HAS OCCURRED. THE NEXT POINT HAS
NOT BEEN FOUND. IS IT WITHIN THE 10X14
SEARCHING RECTANGLE OR HAVE YOU FORGOTTEN
TO PLACE A 'Z' AT THE END OF THE TRIP
THE TWO LAST RECOGNIZED POSITIONS WERE
AT LOCATIONS ( 3,54) AND (2,61)
..............END OF COMMENT
```

The point of departure is indicated with the character A; the termination is denoted with Z . NOP first locates A, then 'looks' for '2'. In order that it not locate a wrong '2', it searches a specified area. This area is denoted by seven positions to the right or left of the present point (A), and five positions backwards or forewards. Should this 'rectangle of search' exceed the boundaries of the visual field, the visual field boundaries are over-riding and force a smaller rectangle of search. In the event that the next position is not found within this area, the program is halted and the error indicated, (see above illustration).

After three points have been found, NOP finds the length of radius for the circle that passes through them (radius of curvature). This radius has to be positively or negatively accounted for in the angular velocity.



The second addition merely restructures data to provide a constant that converts "times critical" to "seconds critical". The constant is found by averaging the distances from the last point and to the next.

This value (PLUS)[57] is used as a fact or to determine the number of times critical as a function of distance traveled between trial positions. For example, in the above diagram, when at point '0', PLUS is the average of the distances 'NO' and 'OP'. From point '0', a critical 'X' is given the value 'PLUS'; should the point already have a numerical value, (having been critical beforehand) it is incremented by 'PLUS'. At the end of the program, the final numerical results are re-examined and divided by a second constant (SPCALE):

SPCALE = SCALE / (SPEED x . 682)

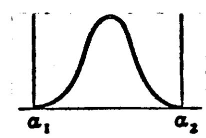
57 In higher level languages, constants as well as instructions, can be assigned names. These names, in machine language, refer to the storage register containing the numerical constant.

This converts the number of unit times critical into seconds. The final development removes the air of mathematical gamesmanship and provides a probabilistic 'real-world' nature. This subroutine accounts for factors of attention, expectation and the urban visual structure.

Asking, in itself, for the probability of an event implies some degree of doubt as to its occurrence; that is, it implies the possibility that the event may never occur. Of course, there are certain causative of controlling factors which determine whether or not the event will occur.[58] Divine intervention is not anticipated: and with sufficient information the answer to the question would be either "It is certain to occur" or "It is certain not to occur". This last subroutine generates evenly

58 Fry, T. C., "Probability and Its Engineering Uses," N. Y. Van Nostrand, 1928.

distributed random numbers (normal rectangular) and introduces the causative and controlling factors.



CAUSATIVE AND CONTROLLING FACTORS

Appraising causality is an area of cognitive studies that requires a great deal of experimentation. No original experimentation has been dealt with in connection with this thesis. This section is a speculation on the causative determinants. The random number (stochastic variable) is first generated in such a way that the occurance probability of any number between two specified bounds (A1 and A2) is equal, (normal rectangular). This number distribution is then changed to a normal (Pearson)form, whereby the distribution curve (frequency curve) is a variable.[59] The above illustration demonstrates a variable frequency curve (type I, Pearson). The above curve shows a height variation (y); a dimension of freedom that is used to massage the curve in relation to the travel velocity. For example: If the generated normal random number dictates a change in axis of vision, (to simulate

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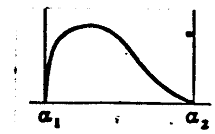
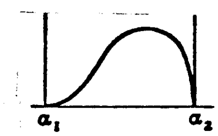
59 Elderton, W. P., Frequency Curves, London, 1910.





saccadic eye and head movements), a change in the curve height will cause a higher probability of occurence for numbers in the central region. By assigning these numbers small values of 'change', theheight of the curve becomes a function of speed, the higher the speed, the greater the tendency to look straight foreward. In turn, a low curve, will even the probability of change in visual axis and be appropriate for slow moving conditions, where the observer meanders, gazing from right to left. (Quantitative values have not been ascribed.)

The above curves illustrate variations that effect the average probability (the mean). These deviations are associated with the position of the observer's visual field. If the 'simulated observer' at last position was looking forty-five degrees to the right, in the next instant, the probability of his looking forty-five degrees to the left is low. However, the sudden or startling event must be accounted for by leaving a small probability of such an occurrence. By warping the curves and deviating from the mean, probabilities of occurrence can become much higher on one side.

A deviation of mean can account for another controlling factor -- importance. Elements and element clusters of greatest visual interest have been permitted to generate forces upon the frequency curve. Should a dominant element be situated to the left of an urban sequence, determinants force the random 'vision' to acknowledge its location. This is achieved by ranking specific elements in the field. Seven degrees of dominance are used to do this.[60]

60 This list has been taken directly from the work of S. Carr and G. Kurilko: Vision and Memory in the View from the Road, Joint Center for Urban Studies (MIT and Harvard University) May 25, 1964.

---

7 - Singular, large, vertical without competition from other non-continuous elements

6 - Large, vertical, with some competition

5 - Large, vertical, with strong competition; large horizontal with no competition; two or more large competing elements.

4 - Large, horizontal with some competition; small but significant vertical, skyline or panorama without competition.

3 - Small vertical, skyline or panorama with some competition; large horizontal with strong competition.

2 - Small vertical, skyline or panorama with strong competition; small but significant horizontal.

1 - the remainder of the field.

This list removes the two dimensional nature built into this method of programming. Total accomodation of such factors becomes too messy with normal batch processing and, in accordance, necessitates a sophistication of tools. For this

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reason, allowance has been made for these factors but not tested. A purely graphical means of communication is required to fully tax the computer with the problem of visual field structure.

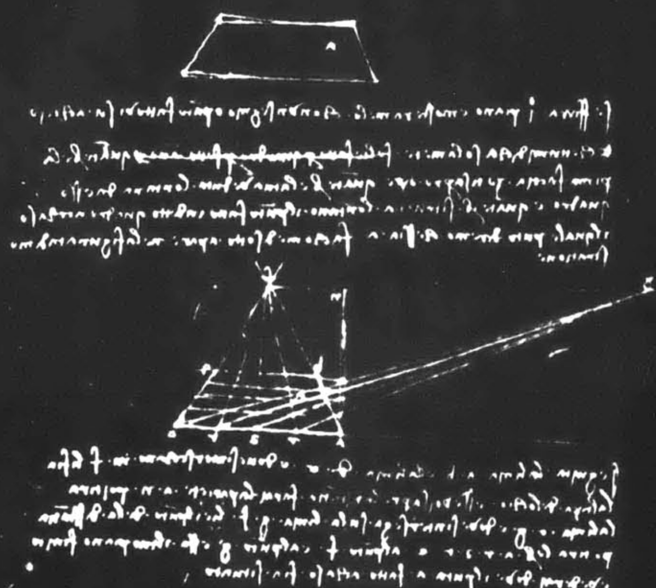

FIG. 38 THE COSTRUZIONE LEGITTIMA AS IT WAS DRAWN BY LEONARDO

chapter 3

```
W 341.4
EXECUTION.
HELLO, HOW ARE YOU.
I  AM FINE, HOW ARE YOU...
I FEEL GREAT.
THAT'S TO BAD, ... GOODBY...
  EXIT CALLED. PM MAY BE TAKEN.
R  5.516+1.000
```

ON INTERACTION

"Man-machine interaction" has become a cliche because it is so vital to the interface of the designer and his tools. If the creative process is to be assisted by the computer, the machine has to act reciprocally and simultaneously to produce a smooth dialogue. For an urban designer this conversation must be graphical. His entire training, practice, and design process are graphical: A progression from 'doodles' to finished plans.

If the architect's use for the computer revolves solely around the role of draftsman or according to Christopher Alexander[61] is the same as a huge army of clerks, it is time to stop this sort of research. It would probably be cheaper and more efficient to hire this armada of 'pencil pushers'.

---

61 Alexander, <u>Op. Cit.</u>

```
MAD TEST3
W 027.5
 ***** ERROR 24173 IN STATEMENT BEGINNING ON CARD
       NO WAY TO REACH THIS STATEMENT.
       TRANSLATION ERROR
R 1.950+.800
```

A man-computer system has to be internally compatible with its own operators: common language and standard conventions are necessary. A transformation occurs in the nature of both parties. The architect becomes more knowledgable of computer sciences; the computer, likewise, learns something about the architect and his idiosyncracies. Of course, the computer will undergo greater adapting as it is psychologically more stable than the architect. ! !

The computer must communicate graphically, a facility that cannot be overstressed or compromised. Total graphical intercourse must be the first step in the study of the architect's process of synthesis in relation to the computer.[62]

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62 Professor Steven Coons, M.I.T., is presently involved in this type of study. This section is primarily a summary of points brought out in his Computer Aided Design Course, (Spring 1966).

THE KLUDGE

A breakthrough has occurred in the area of graphical communication with the birth of a new input/output device. The new breed is still in early childhood and undergoing many growing pains. The device, by nature, is a household television set whose cathode ray tube is activated by the user's instructions. This display console is connected with several manual controls and a teletype to form a complete input/output mechanism -- the Kludge.[63]

The illustration on the following page[64] shows the basic unit. There is also a duplicate display monitor (Slave) and the actual

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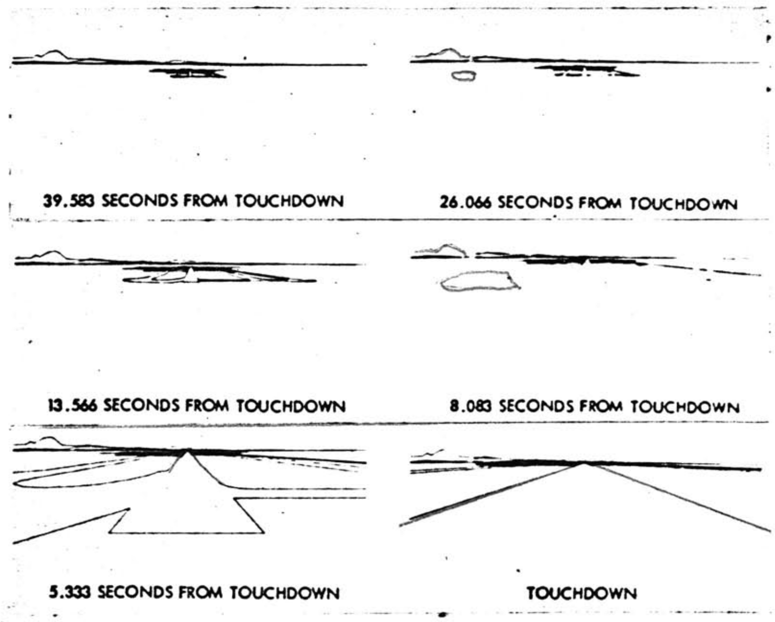
63 The term is of mysterious origin. One explanation: it came from a group of Californian engineers who referred in 'shop talk', to any system with wires handing out and engineers hanging to the wires, as a 'Kludge.' The term was brought to M.I.T. by Robert Stotz, director of the Kludge at Project MAC, M.I.T.

64 This photograph has been taken from MAC memorandum Operating Manual for the ESL Display Console, by R. Stotz and E. Ward, March 9, 1965.

```
            T=PLOT.(LIN.(DX,DY))
PROC(23)    T = PLOT.(CIRCLE.(X,Y,X1,Y1,X2,Y2,0))
PROC(12)    SET=PLOT.(INVIS.(SETPT.(A(18),A(17))))
            TRANSFER TO L1
```

computer (7094) that are not shown. Many movies using the Kludge or similar unit, have been presented at architectual conventions and meetings. These movies have led to a misunderstanding: the hardware itself does not draw lines, make circles or move images around without being programmed. For example, initially, it can take many weeks of programming the Kludge to draw a simple line, make a dot, or plot a circle. Stored programs (subroutines) are required for the subscriber. Employing conventions, these programs (software) are made available to be incorporated as instructions in the user's main program. To manipulate and solve his problems each user has different requirements. One of the architect's main requirement is the psychological and practical divorce from non-graphical communication. As a result, it is tantamount that general purpose software be provided for the architect. The software must permit the problem solving by computer manipulation rather than programming, per se. A program of high efficiency, good for solving one problem, is not compatible with the creative process used in solving general problems.

One role of such a program will be the generation of three-dimensional representations. In connection with perception, the problem constitutes the constructing of a sequential visual trip -- simulating perception. For example, in the design process the user is able to 'sketch' his thoughts in two-dimensions, (plans and sections), delineate a line of travel, press a button, and receive a perspective illustration of the chosen starting point. At this point he presses a second button and starts a trip through the described sequency by means of a



series of different perspective views along the route. The designer can survey the world he has created, if these perspectives can be calculated fast enough to produce an animated film effect.

Under normal circumstances, this type of feedback is not spontaneous. The architect goes through the design process, 'draws up' the results, builds a model, and three weeks later makes a movie of some specified route. The result provides good analytical material but is useless in the design process because, by this stage, the project is in a period of refinement rather than germination.

It should be noted that perspective transformations have already been achieved using computer graphics. The above diagram is an example of the work being performed at the

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Boeing Company, California, by William Fetter.[65] The project simulates the perception of a pilot during touchdown. Hundreds of perspectives were plotted and filmed, frame-by-frame, giving the general impression of a continuous movement through space. Again, this process is not spontaneous. Moreover, it requires a great deal of computer time, and the input is not graphical.

The area of perspective transformations with graphical input is an intimate part of this thesis. This thesis is a progress report and 'ground work' for studies being currently undertaken at Project MAC. The fulfillment of this task is not part of the thesis and completion will take at least another year.

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65 Fetter, William, Computer Graphics in Communication, McGraw-Hill, 1965.

66 This work is being done at Project MAC under job number T331, in conjunction with Wren McMains and Professor A. Fleisher.

This chapter, however, represents material gathered and produced as a point of departure in the area of perspective transformations.

LETTER II.

London, 17*th February*, 1807.

Dear Madam,

• • • • Having now finished the business on which I addressed you, I will begin to fulfil the promise that I made in my last letter, and will do what I can to deserve the thanks you have given me for my offer.

It will be necessary for Eliza to understand a few geometrical definitions, which I will endeavour to render easy to her.

A point exists only in the imagination, being a quantity which is indivisible, and has not any breadth, length, or depth.

A line is formed by the motion of a point; and therefore has length, but neither breadth nor depth.

A superficies, or surface, is formed by the motion of a line, and has extension, without depth.

A straight

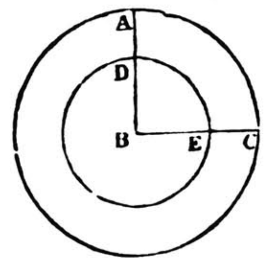
A straight line is the shortest distance between two points.

A plane is a superficies, or surface, which is flat or even throughout, having breadth and length, but no depth or thickness.

A circle is formed by the motion of a point in a plane, entirely round another point in the same plane at one given distance. The circumference, or bounding line, of every circle, is supposed to be divided into 360 equal parts, called degrees. All straight lines drawn from the centre point to the circumference, are equal.

An angle is formed by the meeting of two straight lines, which would cross each other if produced or lengthened; and the point where they meet is called the centre of the angle. If you put one foot of your compasses on the centre of the angle, and describe part of the circumference of a circle with the other foot, meeting the two sides of the angle, this portion of the circumference is called the arch of the angle; and the number of degrees which it contains is the size of the angle: and this will be the same whether you open your compasses much or little, which will appear plain from the annexed figure, where A B C is a right angle, and the arches A C and D E

D E are both of 90 degrees, or the quarter of a circle.

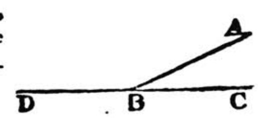


In your case of instruments you will find a half circle, in brass, by which you can readily measure the size of any angle. When the arch or size of any angle is 90 degrees, it is called a right angle; and its sides are perpendicular, or square, to each other.

Two straight lines are parallel to each other when a third line can be drawn perpendicular or square to both of them; and, however lengthened, they will continue at the same distance from each other.

All straight lines which are not parallel or perpendicular, are said to incline or lean towards each other; and the smallest of the angles formed

ed by their meeting is called the angle of their inclination. Thus A B inclines to D C, and A B C is the angle of inclination.

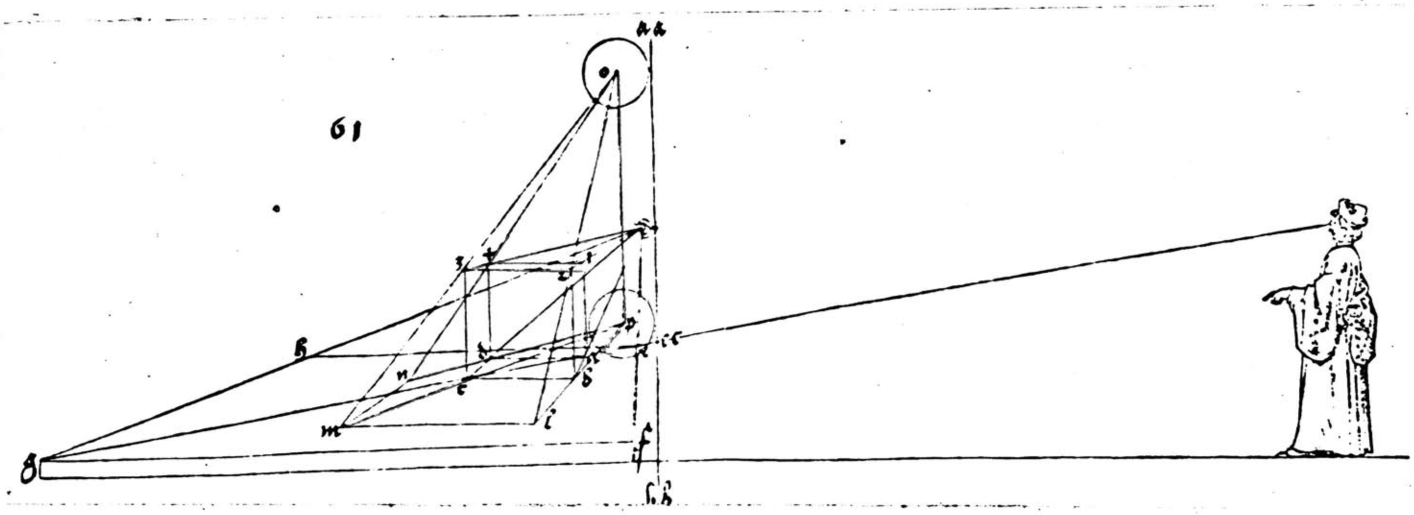


As planes are flat or even throughout, straight lines can be drawn through any two given points in them, and continue throughout in such planes; consequently planes are parallel, perpendicular, and inclined to, and form angles with, each other.

With these geometrical definitions, I shall close my first lesson.

Very truly yours,

W. D.



HISTORICAL

By running one's fingers along a simple molding, awareness of parallism is acquired through touch; there is no question of the sensuous return -- parallel lines do not meet. If, however, awareness of parallism is attained through sight, as when looking down a corridor; there is no doubt that parallel lines do converge and will meet if extended far enough.

Euclid was well aware of this phenomena[67] and explicit about the fact in his fifth postulate.[68] It was not until the seventeenth century that, for the first time, mathematicians adopted convergence at infinity as the basis for defining parallel lines.

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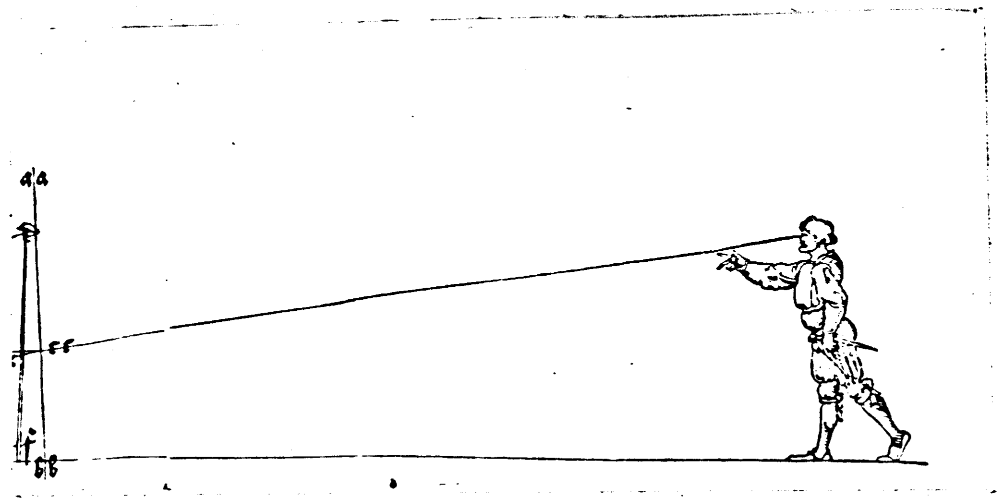
67 Ivans, W. M., On the Realization of Sight, N. Y., 1938.

68 Euclid's fifth postulate is today best known through its eighteenth century equivalent: only one line may be drawn through a given point parallel to a given line.

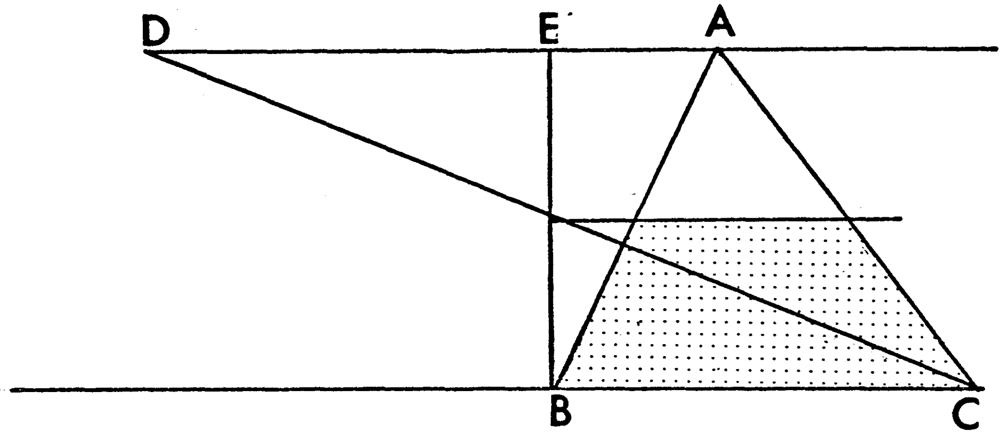


Leone Battista Alberti is generally acknowledge as the first to provide coherent and logical systems of perspective representation.[69] Alberti says: "We may imagine the visual rays as though they were very fine threads lightly bound together in a bunch as by an iron band within the eye....almost like a pollard of all the rays, the node of which shoots its bound branches straight and fine against any opposing surface."[70] The boundaries of the visual field determine the end of these 'threads,' creating a pyramid of vision. Pictoral perspective is the illustration of a panel of glass cutting across the pyramid of vision at a given distance from the eye.[71]

69 Alberti, L. B., Della Pittura Libre Tre, 1435-1436.

70 "Et noi qui inmaginiamo i razzi quasi essere fili sottilissimi da uno capo quasi come una mappa molto stretissimi legati dentro all 'occhio...quasi come troncho di tutti i razzi, quel nodo extenda dritissimi et sottilissim suoi virgulti per sino all opposita superficie."

71 "Se non che in questa superficie si presentino le forme della cose vedute, non altrimenti, che se essa fusse di vetro tralucente, tale che la piramide visiva indi trapassasse, posto una certa distantia."



Alberti's construction of a square in perspective (above diagram) proceeds as follows. BC is the near side of the square to be projected. The vanishing point A is anywhere above BC, and as high above it as the observer's eye is above the plane of the square. The projected right and left sides of the square lie along CA and BA. A perpendicular is erected through B, cutting DA at E (DE is the distance of the observer from the 'picture plane', that passes through the pyramid of vision). The fourth side of the square is determined by the intersection of BE and DC.

This construction is expanded by Viator[72] and Durer[73]; codified by Leonardo de Vinci. Graphic constructions are the principle tool of their efforts. Mathematics are not applied until the seventeenth century,[74] and later.[75]

72 Viator, De Artificile Perspective, 1502.

73 Durer, Unterweysung der Messung, 1525.

74 Desargue de Lyons, G. Brouillon Project d'une Atteinte, 1646.

75 Poncelet, J. V., Traite des Proprietes des Figures: Ouvrage Utile a Ceux Qui S'occupent des Amplications de la Geometrie Descriptive et des Operations Geometrique sur le Terain.

"An object is given in perception by a continuous family of perspective transformations, and that the difference between one object and another is given in perception by a single and usually discontinuous non-rigid transformation."[76]

DYNAMIC PERSPECTIVE

How can optical motions be described or specified? One method is to identify each point by a pair of coordinates and describe the motions of all the points by successive pairs of values. In this manner, direction and speed are characterized at successive moments of time.[77] In the same way as angular velocities were plotted on a two dimensional field, optical motions can be plotted within a three dimensional field.

This system describes the motion of a point in space as a function of its distance (in three dimensions) from the observer. The description permits a straight-forward interpretation of the visual world as a visual field -- the way the world appears

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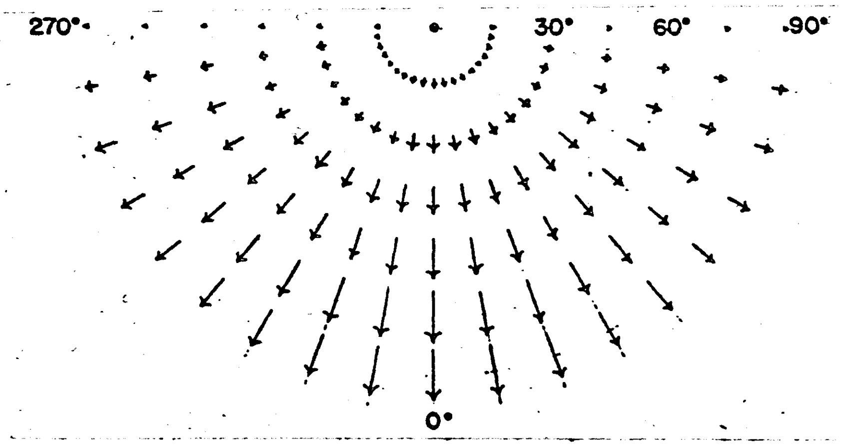
76 Gibson, J. J., Motion Perception, Symposium of Physiological Psychology, Pennsicola, Fla., ONR Symposium Rpt., 1958.

77 Gibson, J. J., Olum, P., and Rosenblatt, F., (Cornell Univ.), "Paralax and Perspective During Aircraft Landings" J. Exp. Psychol., 1959, 58, 40-51.

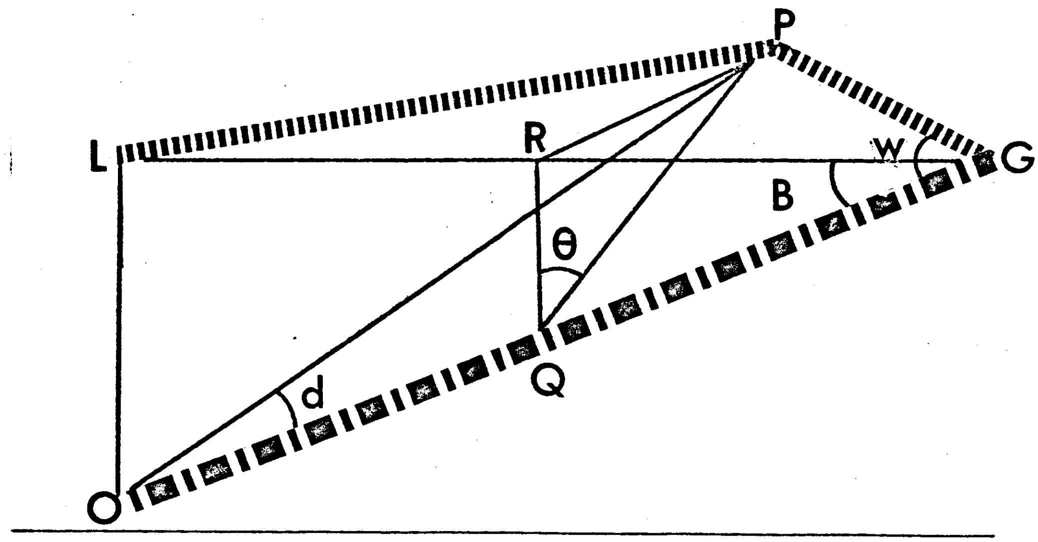


when viewed as a 'picture'. Through consecutive changes, the picture becomes a family of patterns (continuous perspective transformations) undergoing non-rigid motions (polar transformations).[78]

An exact statement of motion perspective is best illustrated by Gibson. The above diagram demonstrates the pattern of velocities during level flight. The radius represents the visual angle d and the circumference represents the angle θ . The following is a mathematical analysis of these two angles and a formulation of their rates of change (three dimensional angular velocities).[79]

78 Gibson, J. J., "Optical Motions and Transformations as Stimuli for Visual Perception", Psychol. Rev., 64, 288-295, 1957.

79 The derivation has been taken from some of Gibson's work, added to and altered for application to an urban sequence.



0 is the observer's eye moving toward point G.

OL is perpendicular to the earth's surface.

B is the uphill or downhill grade of the environment.

$B = 0^{o}$ for horizontal motion

$B = 90^{o}$ for vertical motion

P is the point in question, any point (other than G) in the plane of LG (which is parallel to the earth).

d is the angular separation of the 'light rays' from P and G.

θ is the angular displacement of P in the plane perpendicular to the line of travel.

As 0 approaches G, the angle d increases; the ray from G is motionless (the center of the previous illustration) and the ray from P always moves away from the center; consequently, the radial motion of P, and the apparent expansion of the distances GP, RP, and OP.

θ remains fixed during motion.

change in d divided by the change in time (t) = the expansion vector.

w is an auxilliary variable.

$s = OG$

$\delta s/\delta t$ = velocity

$\cot d = OQ/PQ = (s - PQ \cot w) / PQ = (s/PQ) - \cot w$ (1)

$\cos \theta = PQ/PQ = (PQ \cot w \tan B) / PQ = \cot w \tan B$ (2)

Join (1) and (2):

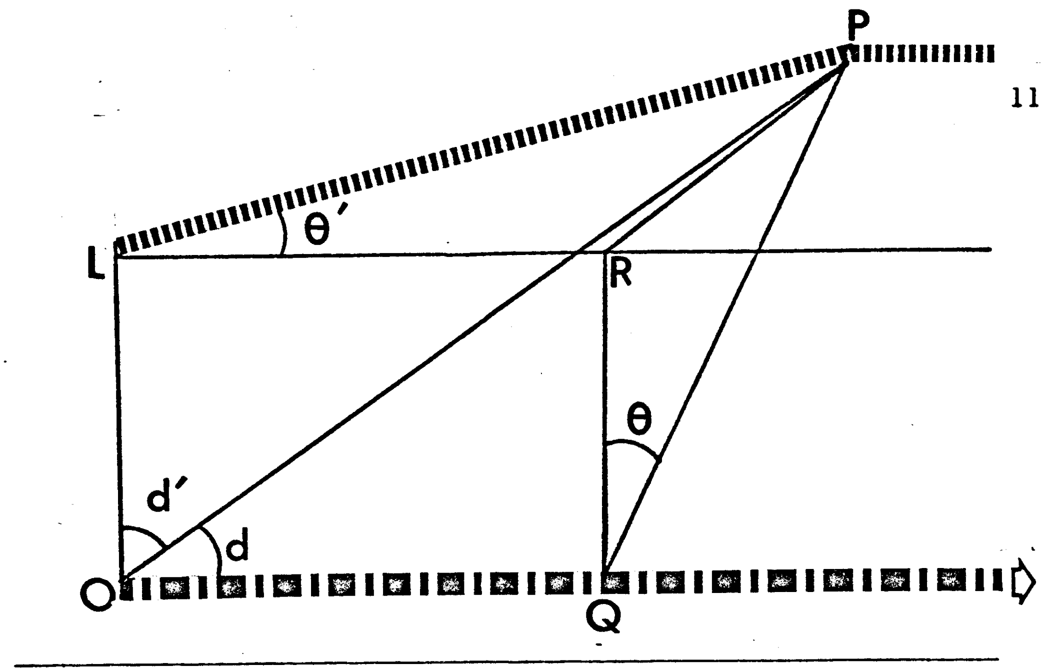
$\cot d = (s/PQ) - \cos \theta \cot B$

Differentiating:

$-\csc^2 d\ (\delta d/\delta t) = (1/PQ)\ (\delta s/\delta t)$

$\delta d/\delta t = v\ (\sin^2 d/PQ)$

from above:



$1/PQ = (\cot d + \cos\theta \cot B) \,/\, s$

Therefore:

$$\delta d/\,\delta t - \frac{v}{s}\ (\sin d \cos d + \sin^2 d \cos \theta \cot B) \qquad (3)$$

For the special case, most relevant to an urban situation, $B = 0$, the case of travel parallel to the surface of the earth:

replace s by $h\csc B$, where $h = OL$

B goes to 0

from (3):

$$\delta d/\,\delta t = \frac{v}{h}\ (\sin^2 d \cos \theta) \qquad (4)$$

$QP = s \tan d$

Knowing the rate of change of d, we therefore can construct a rate of change for QP as a member of a gradient field of angular velocities.

A mathematical analysis has been presented in terms of op-

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tical flow patterns reflected from the surface to the eye. The variables are not only specific to the surface 'depth' but also to the observer's movement. Assuming that these variations are stimuli for perception, they can not only determine the experience of the stable tridimensional world, but also provide a basis for judgements required for the control of locomotion in that world.[80]

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80 Gibson, Op. Cit.

MATRIX CONSTRUCTION

This section is a resume of the "Coons Method"[81] of perspective construction. The method relies on a knowledge of matrix manipulation and mathematics. The method is open-ended as there are many tangential problems and extensions that remain to be examined. The importance of this section is in relation to the programming of perspective transformations;[82] the method, as explained, does not account for hidden lines.

A point in space may be represented by the matrix:[83]

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

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81 Professor S. Coons's method is an intimate part of the SKETCHPAD Project. This section has been taken from the author's notes of Professor Coons's Computer Aided Design Course.

82 Using this geometry, work has been done at MIT by C. Opitz and M. Bergmeyer in relation to plotting perspective drawing.

83 The coordinates are 'right-handed'. For the picture plane: x = horizontal, z = vertical, y = depth.

A set of points is represented by $\begin{bmatrix} x(1) & x(2) & x(3) \ldots\ldots & x(n) \\ y(1) & y(2) & y(3) \ldots\ldots & y(n) \\ z(1) & z(2) & z(3) \ldots\ldots & z(n) \end{bmatrix}$

The matrix provides a geometrical description for points in space. In the last section, these points are attributed expansion vectors as a function of the respective values of x, y, z. However, this method from the beginning involves an inverse assumption ultimately leading to the same solution: Instead of considering the picture plane moving through a gradient, the observer and the picture plane remain still, with rotations and translations (rigid motions) occurring behind. At each instant, a projection of the 'state' is determined, producing, in effect, successive perspective transformations. This referencing, although compatible with the displaying of perspectives on the KLUDGE is in consistent with methods of psychological experimentation.

To treat a set of points in space, 'homogeneity' must be established by adding a fourth member. A point in space:

$$\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

A point can be in one of fours states: motionless, translating, rotating, translating and rotating. For each state there exists the appropriate matrix or matrices of multiplication.

The identity matrix:
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Displacement matrix:
$$\begin{bmatrix} 1 & 0 & 0 & A \\ 0 & 1 & 0 & B \\ 0 & 0 & 1 & C \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Rotation about Z-axis:
$$\begin{bmatrix} a & b & 0 & 0 \\ -b & a & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Rotation about Y-axis:
$$\begin{bmatrix} c & 0 & d & 0 \\ 0 & 1 & 0 & 0 \\ -d & 0 & c & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Rotation about X-axis:
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & e & f & 0 \\ 0 & -f & e & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Multiplication by all three rotation matrices is generally unnecessary. Rotation about the X-axis, in effect, provides a three point perspective. This is relevant only while looking up or down from great heights. Multiplication of point coordinates by any one or multiple of the above matrices establishes a new point matrix:

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} \quad \text{or} \quad \begin{bmatrix} x(1)' & x(2)' & x(3)'\ldots\ldots x(n)' \\ y(1)' & y(2)' & y(3)'\ldots\ldots y(n)' \\ z(1)' & z(2)' & z(3)'\ldots\ldots z(n)' \end{bmatrix}$$

From this new point-matrix, a perspective is obtained by finding a new matrix that satisfies the coordinates of the projected image. D is the observer's distance from the picture plane and remains fixed during the successive matrix manipulations of the perspective transformations. The form of the perspective matrix is:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1/D & 0 \end{bmatrix}$$

It should be noted that when D is very large, 1/D approaches 0 and the transformation matrix becomes an identity matrix: The perspective projection becomes an axiometric.

The final matrix has the following structure:

$$\begin{bmatrix} A & B & C & E \\ F & G & H & I \\ J & K & L & M \\ J/D & K/D & L/D & (M/D+1) \end{bmatrix}$$

$\begin{bmatrix} A & B & C \\ F & G & H \\ J & K & L \end{bmatrix}$ is the matrix after rotation and/or translation. The sums of the squares in rows and columns must equal zero to

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provide orthogonality. Dividing a column by its last member gives a coordinate of the vanishing point: $\begin{bmatrix} A \\ F \\ J \end{bmatrix} /$ J/D. If either J/D, K/D, or L/D equals zero, the vanishing point is at infinity. At infinity a one point perspective has two vanishing points, a two point perspective has, one, and a three point perspective has none.

Finding vanishing points has an interesting extention. For example: the horizontal line y = 1 has the following matrix structure:

Point on Line

$$\begin{array}{c} X \\ Y \\ Z \\ w \end{array} \begin{bmatrix} 1 \\ 1 \\ Z \\ 1 \end{bmatrix} \qquad \begin{array}{c} = \\ = \\ = \\ = \end{array} \qquad \begin{bmatrix} 1 \\ w \\ Z \\ w \end{bmatrix}$$

By changing the value of w, P can be slid along the horizontal line:

Example: w=1/2, $\begin{bmatrix} 1 \\ 1/2 \\ Z \\ 1/2 \end{bmatrix}$, normalized: $\begin{bmatrix} 2 \\ 1 \\ 2Z \\ 1 \end{bmatrix}$

To push point P toward infinity (the location of vanishing point) w must equal zero: Therefore, the coordinates at infinity:

$$\begin{bmatrix} 1 \\ 0 \\ Z \\ 0 \end{bmatrix}$$

Where E = 1/D:

$$\begin{bmatrix} 1/ZE \\ 0 \\ 1/E \\ 1 \end{bmatrix}$$

In terms of x and y coordinates:

$$\begin{array}{c} X \\ Y \end{array} \begin{bmatrix} 1/ZE \\ 0 \end{bmatrix}$$

Where D = 1/E:

$$\begin{array}{c} X \\ Y \end{array} \begin{bmatrix} D/Z \\ 0 \end{bmatrix}$$

Though perhaps perentetic, this extension provides a check and correspondence that should have interesting connotations in programming the KLUDGE.

PERSPECTIVE IN THE DESIGN PROCESS

The term 'perspective' is usually associated with rendering a fine image for the viewer. A view point is chosen, horizon line established, vanishing points fixed, and the artist 'draws up' the information from a set of plans and elevations. There exist many standard methods of perspective drawing[84] involving construction lines or coordinates. In each case, the perspective acts as a medium for presentation, carrying overtones of 'handsomeness' and 'salesmanship'.

Another application of perspective commonly appears on envelope backs, margins of books, or even matchbox covers. Here the designer is 'playing' with ideas. Within present architectural habits, this type of sketching provides the closest analogy to the proposed use of perspective transformations.

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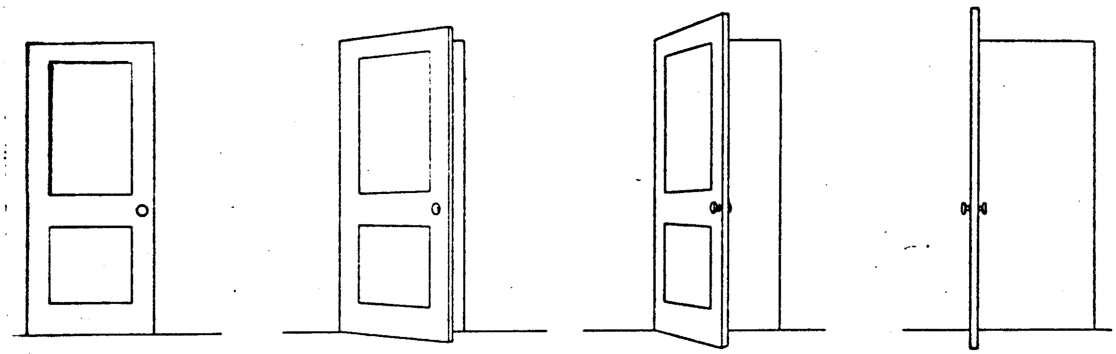
84 Ventris, M., "Coordinate Perspective", The Arch. Assoc. J., April 1946, p. 67.

The designer possesses a three-dimensional tool to express a three-dimensional idea:

> The brain is a three-dimensional organ and the neural process of dynamic organization is in a three-dimensional field... visual perception is tridimensional from the onset.[85]

The system furnishes a by-pass. The designer need not transform an image from three dimensions (in the mind) to two dimensions (e.g. in plans) back to three dimensions (e.g. in model of reality). The economy of transformations provides a minimum change of stage of an idea.

As proposed thus far, perspective transformations provide the change from a bidimensional to a tridimensional state. There is no doubt that the computer can perform this role faster and more efficiently than the designer. There is skepticism, however, as to whether the computer can effectively handle the first change of state. If it is possible to work in three-dimensional conversation with the computer through the whole design process, the computer is a valuable design tool.



AS A DESIGN TOOL

The Kludge can be used in transition from the three-dimensional idea to the bidimensional formalization. In this light, the Kludge is merely a 'super-pencil' that draws in three dimensions.

The affirmation of this function depends on the software. Programs, drawing routines,[86] exist that permit three-dimensional manipulation. For example: the designer can draw a square, rotate it 90° making it appear as a line, and from it draw a new square. In this manner cube can be constructed. The cube can then be scaled down, translated, or rotated in any dimension. If necessary the cube can be labelled and stored in memory, and re-called by pointing the light pen to a desired location.

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86 Wren McMains and the Author have pieced together a rough version of such a program. At the same time, Project MAC has a demonstration program that can be used (BOBCAL).

'Building blocks' are provided by retrieving many copies.

The emphasis on drawing routines may appear out of context, However, perspective transformations can be thought of as one command in a drawing routine and in this context, a powerful instruction. These instructions are the design tools; the Kludge is pencil and paper.[87]

Tangential to this role, the computer can perform the jobs of supervisor and bookkeeper. Cataloguing is a self-evident usage: construction standards, building codes, and mechanical requirements can be structured as explicit or implicit library of information Each faculty can be endowed with the nature

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87 It should be remembered that the screen of the Kludge is about a square foot. When considering the scaling potential, this area is effectively a quarter of a mile square. Displayed information can be plotted on paper. Plotters exist that are capable of using four foot wide rolls of paper.

of a 'genie' where relevant information will be summoned or the image altered. Thus, the computer induces 'external' constraints.

Meanwhile, 'internal' constraints are imposed by the designer The drawing routine possesses the flexibility to enable the designer to call for 'rules' of procedure. For example: "lines must be straight; lines are parallel or perpendicular to the 'drawing surface'; all lines meet at 90°; all rotations of the image are 90°." Such constraints allow the designer freedom to sketch 'loosely', while maintaining an accurate drawing.[88] If the designer self-imposes, for example, the constraint that

88 Dr. Sutherland's Sketchpad has many examples of such constraints. Also: Johnson, E. E., M.S. Thesis, M.I.T., <u>3-D Graphical Communication with a Digital Computer.</u> <u>Mechanical Engineering Dept., June 1963.</u>

that "all lines meet at 90^{o}", and proceeds to draw a line that meets at 80^{o}, the computer will force the line to 'wander' into the correct position.[89]

[89] The above is a brief survey of a large area of study. The author will be spending the next few years concentrating solely on this problem. The above statements should not be considered concrete examples or definite statements, but rather as samples of general context for perspective transformations.

chapter 4

FEEDBACK

> A great number of Architects hold that programming, model building, and computer use in particular are the tools of the devil, the enemies of humanism, art, diversity, and beauty. But to keep up the myth of conflict between 'rationality and inspiration' in an age of accelerated change is one of the great absurdities in our time. Rationality as a system of procedure does not exclude inspiration. Inspiration is a special moment in the rational process.[90]

Research risks being invalid if not fed back to the rational process from hence it came. Without frequent testing, information becomes pedantic and esoteric, with little value in effecting the original molding forces. This chapter is an effort to relate the areas of this study to architecture and architectural processes. A great deal of optimistic speculation is involved in the illustrations.

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90 Chermayeff, Serge; quote from "Computers Add an Apprehensive New Client", Fortune, 180, Feb., 1965.

The design of a sample situation has not been undertaken, as the research presented is only a small piece of the design procedure. Knowledge of computers and perception in itself does not make a better designer. These tools can be missused or ignored. Nevertheless, with new facilities, old dilemmas are resolved with evident answers. Intangible tasks lend themselves to manipulation unfolding new problems as well as new answers. The invention of the bulldozer provides a tool to move tons of encumbrant earth, and can destroy effortlessly dwelling units, trees, and the general landscape.

> For the case of the stationary observer in a stationary world it seems tenable that the synthesis of stimulus variables for accurate visual orientation in three-dimensional space is largely an activity of the observer. For the case of the moving observer in a stationary world the synthesis of stimulus variables is largely environment and therefore requires less active synthesis by the observer for active visual orientation. The latter situations involves a kind of self-organizating quality of the visual world, typical of Gestalt theory.[91]

SEQUENCES

A sequence demands duration: "Time as such, no more represents a principle of order for a sequence than the mere distribution of parts in space organizes a work of architecture.[92] No bound of time connects elements to create order... it is order that creates time.[93] The temporal order of our perceptions is not part of the composition when observing a static environment, as it is during motion.

A complex relation of heirarchies describes the visual field. Order is created in one dimension. Time is the dimension of change. As in a piece of music, a meaningful sequence can break down into mere disorganized succession. Unlike a piece

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91 Pfeiffer, M. G., "Visual Orientation in Three-Dimensional Space", Perceptual and Motor Skills, 16(3), 887-892, 1963.

92 Arnheim, Op. Cit.

93 Ibid.

of music, a visual sequence in an urban context must be interruptable and reversible. A visual sequence must work backwards as well as forwards, be able to commence in the middle, and be capable of integration as a part of a different sequence.

Ubiquitous order demands a general framework that does not rely on a few melodic experiences enmeshed among hundreds of discordant occassions. The ingredients for this order are perceptual and the variable is velocity. Velocity has physical properties that must be acknowledged kinesthetically; accordingly they are recognized visually:

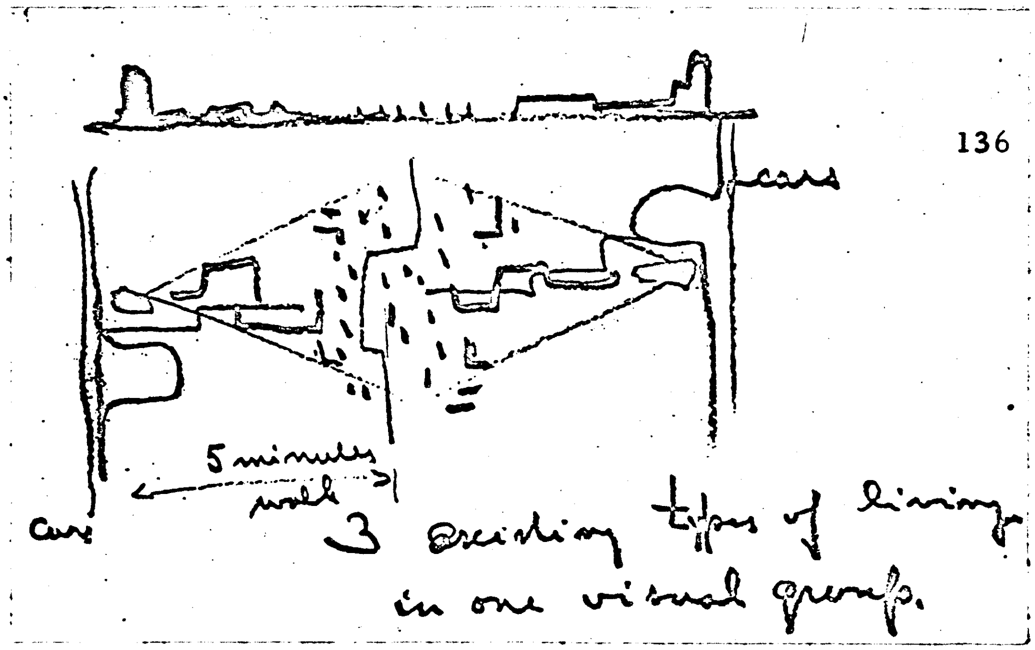
1. The higher the velocity ... the straighter the route
2. The higher the velocity ... the longer the route
3. The slower the velocity ... the more interruptions
4. The slower the velocity ... the more detail

5. The higher the velocity ... the higher the anonymity

The criteria is built-into the physical nature of speed. It is not as self evident in the physical nature of form.

A sequencial array of structures poses perceptual consequences in relation to the rate of travel. Large edifices distantly spaced become meaningful and coherent at high velocities whereas an intimate small scaled environment becomes absurd. This provides a design relationship or criteria for physical form:

velocity of travel .... scale of environment.

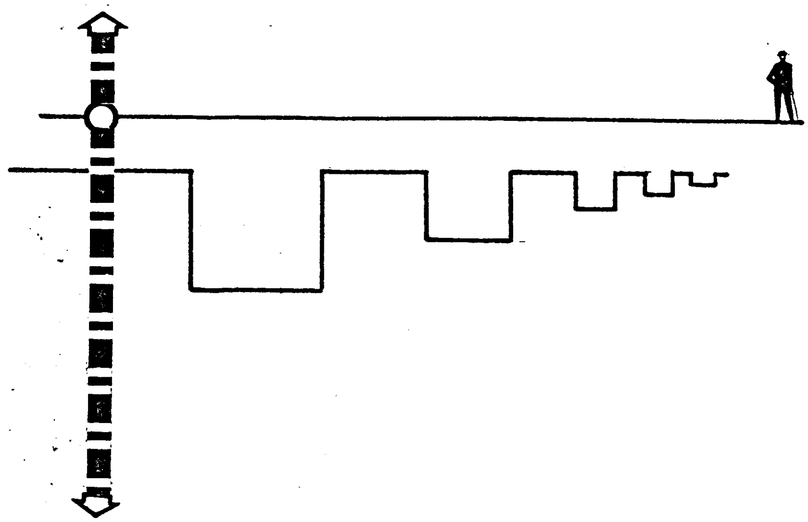


SCALE

The scale of environment has physical properties. A 'human constant' is recognized for light and air (solid-to-void ratio): Large scale structures need adjacent open space to maintain constancy of the solid-to-void ration.

"There are more conditions of this sort. A small scale house is characterized by having a garden which acts as an extension of the house. A highrise apartment needs to be situated within a bigger space at a certain distance from the small scale houses, so that the seventy or hundred families in the apartment do not overlook Mr. Jones who is drinking coffee in his garden. This requires a distance of 600 feet between the apartments and the individual houses. But this space can be occupied by other forms of housing which serve as transitional elements."[94]

94 Bakema, J. B., Ekistics, "Some thoughts about Relationships between Buildings and Cities", August-September 1962.



With the perceptual and form relationships, an abstract model is formulated (the Bakema model). The form of the city acknowledges rates of movement, intensity of interaction, and human needs. A sequence of large elements-high speed and small elements-low speeds composes the order.

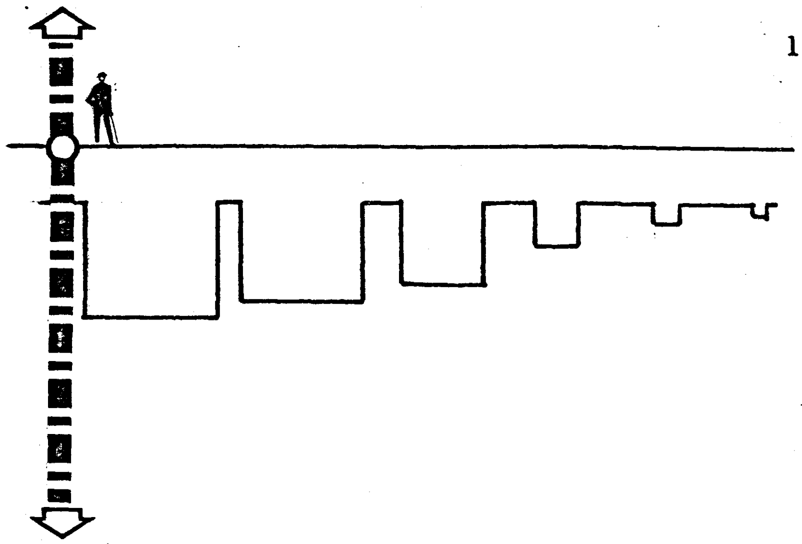
Bakema aligns his model linearly; visual grouping grows from the scale of the pedestrian toward the scale of the 'highway'. In his model:

$$\frac{\text{distance between elements}}{\text{velocity of travel}} = \text{Constant}$$

$$\text{density} = \text{Constant}$$

$$\frac{\text{velocity of travel}}{\text{density}} \neq \text{Constant}$$

These functions furnish a perceptual relation to the physical form and the rate of motion. However, it contradicts our



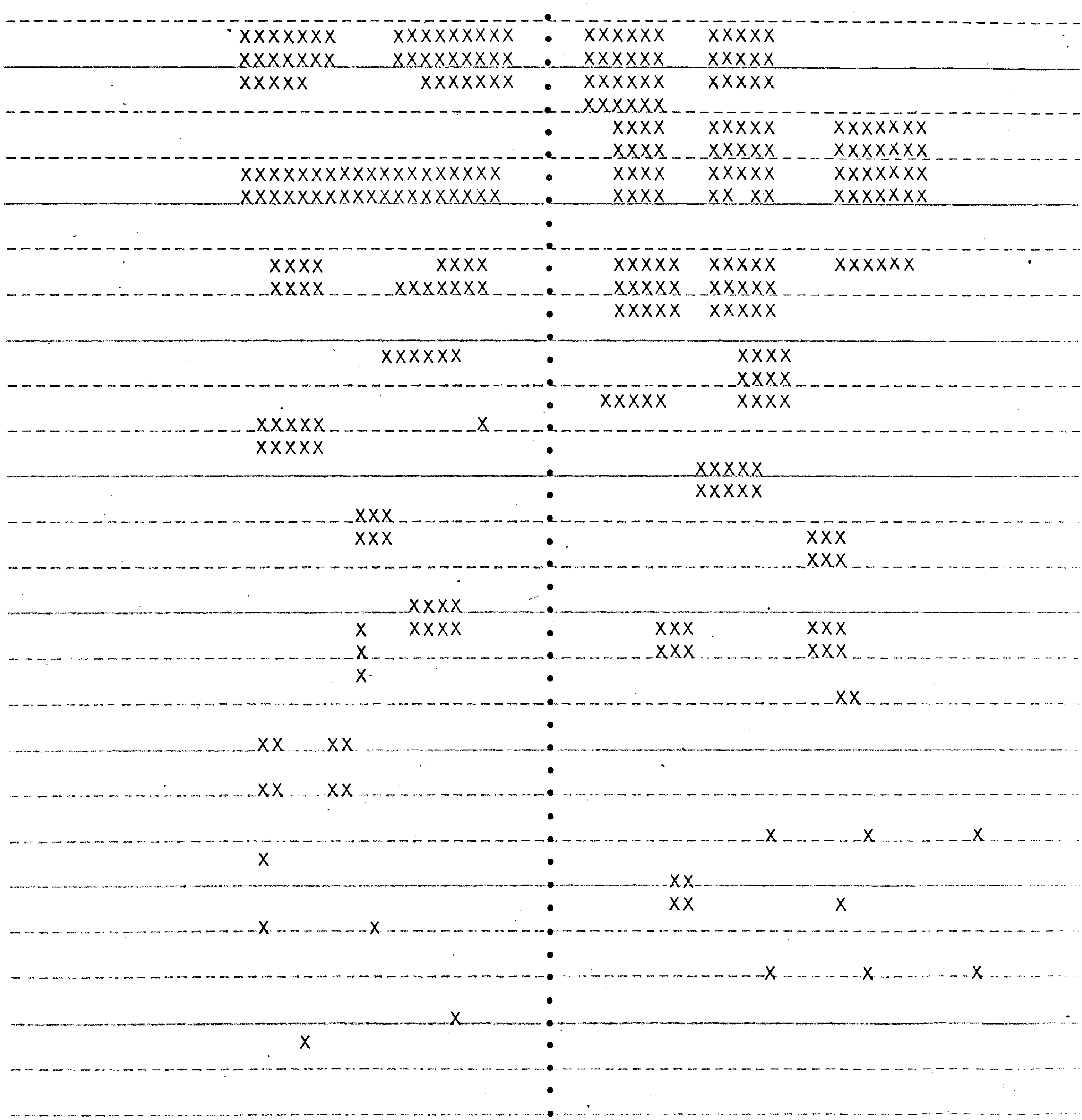
present image of urban structure. The urban environment is composed of large closely spaced buildings that connect directly to high speed lines of transportation. Moving away from the high speed structures become small, houses farther apart, and open spaces larger -- suburbia. In this model, the above relationship are reversed:

$$\frac{\text{distance between elements}}{\text{velocity of travel}} \neq \text{Constants}$$

$$\text{density} \neq \text{Constants}$$

$$\frac{\text{velocity of travel}}{\text{density}} = \text{Constants}$$

The following pages are computer output from programs used to test these two models. Stage II, in batch-processing is altered assuming an angular visual threshold. In this manner, a critical rate of travel is calculated. The first two pages are



MPH	140
115.187	
115.187	
115.187	
191.978	
153.582	
153.582	
230.373	
191.978	
191.978	
191.978	
307.165	
268.769	
230.373	
191.978	
153.582	
468.426	
424.271	
383.956	
345.560	
307.165	
268.769	
268.769	
746.794	
683.441	
623.928	
568.254	
516.420	
468.426	
424.271	
383.956	
345.560	
345.560	
597.874	
529.310	
466.232	
408.639	
356.530	
309.907	
268.769	
10000.000	
10000.000	
10000.000	
10000.000	
10000.000	
10000.000	
10000.000	
10000.000	
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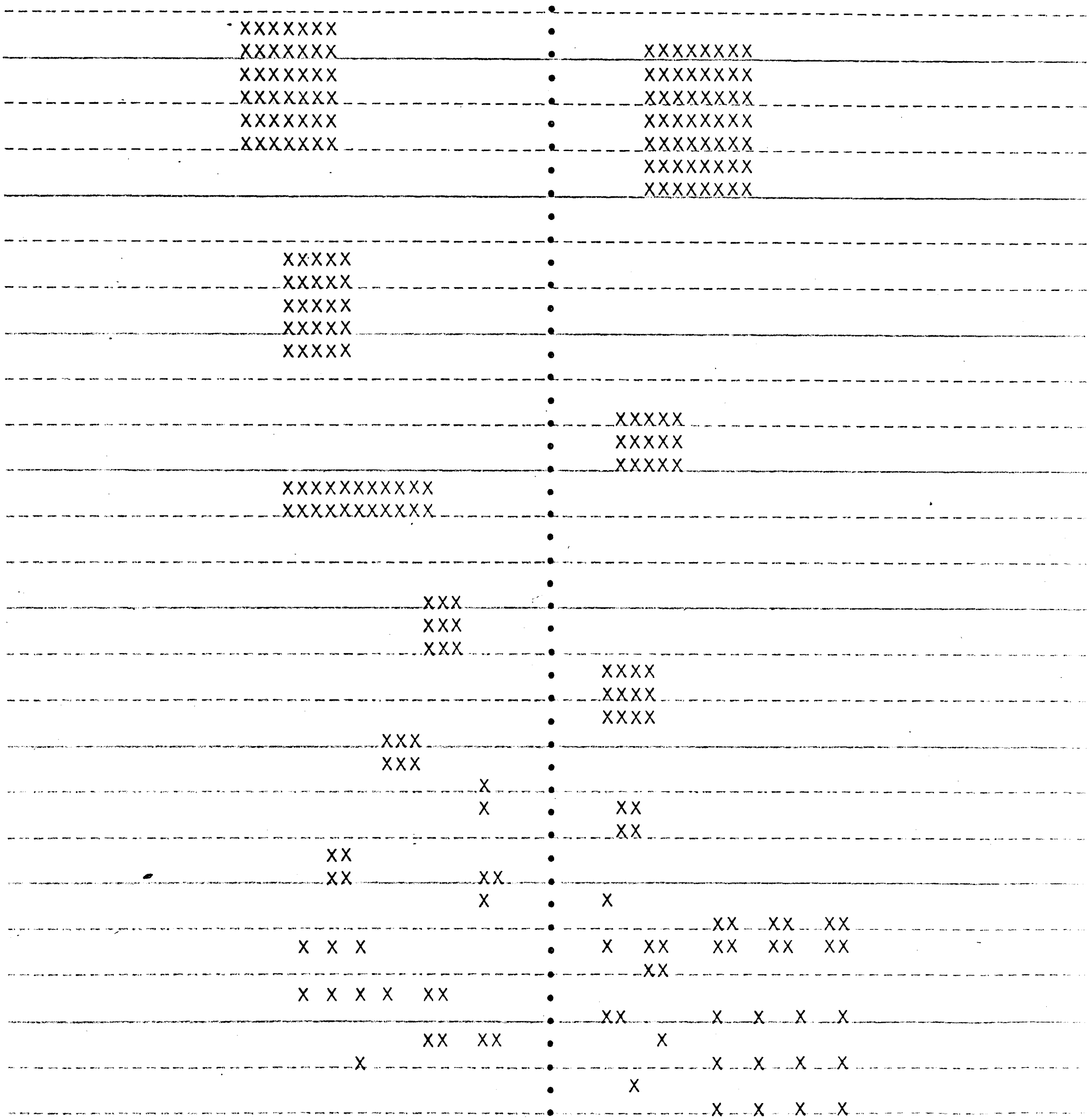

MPH
268.769
268.769
268.769
718.850
652.725
590.865
533.272
479.945
430.884
386.089
345.560
307.165
268.769
230.373
191.978
191.978
191.978
386.089
345.560
307.165
268.769
268.769
268.769
268.769
230.373
191.978
153.582
153.582
153.582
234.213
191.978
191.978
191.978
234.213
191.978
153.582
153.582
196.777
153.582
234.213
191.978
153.582
153.582
10000.000
10000.000
10000.000
10000.000
10000.000
10000.000
10000.000

images of the field used in testing. The two following pages are the respective output. Column one is the rate of travel necessary to maintain everything below thirty degrees per second in the visual field. The second column is the most critical point in the field and the third is the viewer's position.

As soon as the computer locates a point whose angular velocity exceeds thirty degrees per second for one instant, it sets the point as the governing factor until a higher angular velocity is located for the station point, the velocity of travel is assigned. The results must be treated as proportions rather than specific velocities, as the program does not account for duration. A certain percentage of the visual field can be in Stage II without much effect. A second threshold level exists where the proportions of the visual field in State

a) A destructive approach, leading to premature blight and declining values.

III make the visual information incomprehensible, creating aggravation and visual chaos. This factor has not been taken into account, for it varies as a function of personality, experience, and knowledge of the environment. It is, however, approximately proportional to the break in Threshold II.

The results show consistency in the Bakema scheme and contradict the determinates of our present urban fabric. These determinates show a juxtaposition of the pedestration scale of movement and high speed scale of structure. Similarly, the large scale of open space is associated with the small scale of dwelling units. The above illustrations are from a recent Boston Redevelopment Authority publication. The entire question of scale is ignored. One approach is labelled 'destructive, leading to blight and declining values' and the other 'constructive, leading to enjoyment'. These illustrations

b) A constructive approach, leading to full enjoyment of natural amenities and stable values.

can be retitled 'the pedestrian environment' and 'the fifty-mile-an-hour environment'. In each case, unlike the BRA Report claims, the potential for light, air, density, and natural amenities is equal.

A PRECEDENT

From the whole, the part can be withdrawn, analyzed, and remolded. The detail is subjected to laws of perception in the design process and 'plugged' back into the city. However, rather than list perceptual 'rights and wrongs' in a handbook context, speculation is made. The repercussions of computer simulation of perception are surmised, within an overall Computer Aided Design context. Treating perception with dynamic perspectives will have consequences.[95]

"The power generated by Alberti's systematic clarity can be demonstrated by the abrupt change which overtakes the choice of view point in representations of the Piazza della Signoria.

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95 This section is not meant to be associated with the potential of studies encountered in this thesis. It is meant to provide a historical account of repercussions incurred from similar studies. The material should provide assistance in guiding future steps.

In the fourteenth century relief, the Palazzo Vecchio is obliquely set. In the many well known views which have survived from the intervening period, the observer is always either situated on the North side of the piazza, looking straight towards the Loggia dei Lanzi, or standing in the middle of the west side and looking straight forward towards the main facade of the Palazzo. The faces of the buildings are thus made to conform as closely as possible to the axis of an Albertian foreshortened square. No better illustration could be given of the impact of a system of construction upon composition."[96]

Renaissance perspective and optics created an intellectual atmosphere that ascribes to a work of art a segment of the uni-

96 White, J., The Birth and Rebirth of Pictoral Space, N. Y., 1958.

verse from which it is observed by a particular person at a particular time from a particular point.[97] Even the bare summary of a few facts of Alberti's construction reveals the autonomy achieved by the idea of perspective space. Previously it was possible to consider space gradually extending outwards. Now, space is created first, and solid objects arranged within it according to the rules it dictates. "Space now contains the objects by which it was formally created".[98] Frontal flanking elements became a standard feature of Renaissance composition under the influence of the new perspective.[99]

This century, the 'bird's eye view' has played a similar role, strengthening the image of a ground plane with grouped and

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97 Panofsky, W., Perspective as Symbolic Form, N.Y., 1924-25.

98 White, Op. Cit.

99 Ibid.

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composed objects. The Gestalt 'figure-ground' relationship becomes figure oriented with the earth acting as a pedestal for 'towers of art'.

WITHIN THE PROCESS

A Computer Aided Design process incorporating perception simulation can lead to 'ground oriented' urban form. To synthetically experience a design gives the architect a multifold version of what Alberti offered the Renaissance. An ever changing viewpoint can destroy the image of space containing static objects. The object is symbolically destroyed when the ground becomes an element of circulation, and the physical environment emerges from it. Figure-ground relations become complex. What is 'ground' for one 'figure', is 'figure' for another 'ground', creating an environment of spatial relations.

An example of the speculation: The architect receives a commission to redevelop an urban area. Existing structures are destroyed and the land is leveled. The architect studies the program of requirements and preceeds to design. There is not much time and money left for design when considering the structural, mechanical, and cost factors. At first sight, a diverse and interesting environment is too expensive to design, build, and mechanically control. Within structural, mechanical, financial and political limitations, the effort necessary to realize good design is too time consuming and costly. The design of a series of identical buildings is the simplest answer and easiest to refine. Concrete details are scrutinized, facades are studied, and costs per square foot are calculated. The human experience of the environment is not tested.

It is the year 1970. Perspective transformations are part of a Computer Aided Design system, available to all architects. Graphic Standards, Sweets Catalog and Building Codes are stored information. Computer Aided Design is the best of all possible tools. What can happen?

The architect receives the same commission. The existing conditions are read into the Kludge, criteria and assumptions are selected and stored. The designer then proceeds with the computer keeping track of the structural, mechanical and financial factors. Standard parts, study sketches, and random thoughts can be stored for later use. The designer can then spend his time 'designing' to meet conditions of human experience; the computer can meet most of the other conditions. Complicated figure-ground relations can be built up, occassionally 'walking through' the environments. Rate of travel can be simulated stressing the significance of the whole urban experience as opposed to the momentary 'jewel'.

FUTURE STAGES

This thesis is a progress report of a never ending job; each stage is merely a step towards an end that moves farther away. The future steps outlined in this section comprise some of the starting points that the Author will take up in the next several years.

The first step is to program the Kludge to simulate perception through perspective transformation. The main obstacle is not the actual programming of perspective, but the graphical input/output and method of interpolation. From a sketch in plan and/or section the computer must decide what the designer intends. If the designer 'sketches' all the necessary information he must produce working drawings. The computer, meanwhile, is satisfied with only part of the information. In creating transformations it makes mistakes in guessing and must be corrected. Certain design 'rules of transformation' have to be established

to permit the computer to make logical assumptions:
The function is to arrive at a theorem (the output) from axioms (the input) according to specific rules of inference which, when considered in this fashion, are the rules of transformation. Since it is a fortunate characteristic of mathematicians to insist upon precise articulation of their rules of inference, the task of constructing a machine to perform transformation of this sort generally is more or less routine, depending upon the complexity of the axioms and the rules of inference, and upon the 'novelty' desired for the theorem to be proved.[100]

Rules of transformation have to be flexible enough to account for human error as well as bizarre circumstances, in order to have general application. The rules do not have to adhere

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100 Sayre, K., Recognition: A Study in the Philosophy of Artificial Intelligence, University of Notre Dame Press, 1965.

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to psychological phenomena as the psychological rules of transformation are primarily functions of behavior, attention and importance. These variables are taken into account by controlled stochastic processes.[101]

A second step is a design process analysis. With no intent to simulate the process itself, knowledge of it is crucial in designing a compatible tool. The architect receives many inputs to satisfy a synthesis process. In what form do these inputs arrive? What are their importance? How are they manipulated? At what stage in the design process are they most relevant?

These questions are important in creating design routines and establishing work 'modes'. In the process, the designer will concentrate on specific areas. While working on problems of circulation, for example, a button that permits storage of a

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101 Appendix B describes the programming of the final batch-processing routine and contains a brief description of some random variables.

standard building element is of no use. It is necessary to establish modes of design that can summon a redistribution of "button functions"[102].

A simple command or button will have to be capable of transfering the problem to a different mode, for example:

drawing mode

mechanical mode

structural mode

production mode

circulation mode

In this manner, each problem area has the benefit of all the buttons, some prelabeled and others vacant for the user's assignment.

102 The push-button box has thirty-six buttons; the light pen has one.

Another step is the study of hardware or the machine itself. There are certain inherent limitations in existing machines, that do not affect engineering uses, but pose large setbacks on architect-machine compatibility. An immediate problem is the generation of planes.

Presently the Kludge is a cathode ray tube, whose beam is activated by the computer and assigned a horizontal and vertical position. The creation of a line, for example, is achieved by the beam scanning along its length. To generate a plane, normal television scanning (roster-scanning) is necessary. With this system, areas can be activiated at different intensities much like a selection of 'Zip-a-tone' shades. Foreground/background relationships may have tonal correlations, shadows may be cast, and solid-void references may be established.

A final 'next step' is the problem of implementation. All work is futile if due to cost or acceptability a Computer Aided Design system is available only to a few architects. Presently, Kludge units cannot be located far from the main computer. Unlike a console, the display unit needs many wires and cannot afford the energy loss of long distances. Nevertheless, it is reasonable to assume that this will not be true for long. The critical problem is how much of the unit is necessary at the architect's side and how much can be fifteen miles away.

Plotting tables, display units, teletypes, pushbuttons, and rotation globes, under any circumstances will have to be in the designer's 'office'. Is there a market for this to be a package unit? Will such a device be acceptable to a person who has been 'successful' for twenty years without one.

POST-MORTEM

Similar to a computer diagnostic, this brief appendage provides a location to discharge some of the thoughts that have been carried along. Many anxieties exist in formulating the relationship of the architect to research. The following section is stimulated by a recent conference[103] on Urban Design The people referred to in this section composed the panel that discussed this problem.

Louis Winnick[104] described the role of the designer as involved with pleasure; not functions. Aesthetics is the area for research according to Mr. Winnick. This forces research to become an "environmental Elizabeth Arden".

103 "The Design of Education for Design", discussion heading: Post-professional Education - Research and the Ph. D., June 17-18, 1966.

104 Associate Director, Public Affairs Program, Ford Foundation.

On the other hand, if the architect is not merely a dilettante, dabbling in fields where the professional does better, the architect could become the synthesizer of information. Investigations before an architectural project are incidental to the commission.[105] They provide, however, the information that the designer synthesizes to attain physical form. In the same manner, why cannot an architect synthesize information to attain a process?

An empirical methodology is necessary, but the context is the same. The study of design processes or design problems will always have to feed back to actual 'building': no set of words or diagrams have ever produced physical form.

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[105] Howard Fisher, Director of Laboratory of Computer Graphics, Harvard University.

APPENDIX A

INDEX	PAGE

```
*M4977-4526,FMS,DEBUG,5,5,5000,0        N.NEGROPONTE ANGVEL TABLE DEBUG 2
*      XEQ
*           MAD
            DIMENSION AV(150)
            INTEGER A,B,I,J,N
            PRINT COMMENT $1ANGULAR VELOCITY CONSTANTS$
            PRINT COMMENT $0A IS DISTANCE IN FEET PERPENDICULAR TO LINE
           1OF MOVEMENTS$
            PRINT COMMENT $0B IS DISTANCE IN FEET PARALLEL TO LINE OF MOV
           1EMENTS$
            PRINT COMMENT $0                            CONSTANT TIMES L)NE
           1AR VELOCITY IN MPH EQUALS ANGULAR VEOCITY IN DEGREES PER SEC
           1OND$
            THROUGH LOOP, FOR N = 1, 10, N.G.100
            PRINT FORMAT STP, N-1
            VECTOR VALUES STP = $26H1 THE CURRENT VALUE OF B IS, I4, S1,2
           16H PLUS THE VALUE OF B BELOW*$
            PRINT COMMENT $0  A
           1                 VALUES OF B$
            PRINT COMMENT $0              0         1         2         3
           1 4         5         6         7         8         9$
            THROUGH LOOP, FOR I = 1,1,I.G.100
            A = I
            THROUGH PGRM, FOR J = N, 1, J.G. N+9
            B = J-1
 PGRM       AV(J) = ((57.283 *A)/(A.P.2 + B.P.2))*(.682)
 LOOP       PRINT FORMAT ANS, A, AV(N)...AV(N+9)
            VECTOR VALUES ANS = $1H0///, I5, S4, 10F8.3*$
            END OF PROGRAM
```

```
*M4977-4526,FMS,DEBUG,2,2,400,250         NEGROPONTE DEBUG 1
*      XEQ
*              MAD
                                                               163
               DIMENSION AV (600,AD)
               VECTOR VALUES AD = 2,1,14
               INTEGER A, B, I, J
               PRINT COMMENT $1ANGULAR VELOCITY CONSTANTS$
               PRINT COMMENT $0A IS DISTANCE IN FEET PERPENDICULAR TO LINE
              1OF MOVEMENT$
               PRINT COMMENT $0B IS DISTANCE IN FEET PARALLEL TO LINE OF MOV
              1EMENT$
               PRINT COMMENT $0                                CONSTANT TIMES LINE
              1AR VELOCITY IN       MPH        EQUALS ANGULAR VELOCITY IN DEG
              2REES PER SECOND$
               PRINT COMMENT $4  A
              1                VALUES OF B$
               PRINT COMMENT $0                0       1       2       5
              110       20       50       100$
               THROUGH LOOP, FOR I = 1,1,I.G.37
               WHENEVER I.GE.1 .AND. I.LE.10
               A = I
               OR WHENEVER I.GE.11 .AND. I.LE.19
               A = 10*(I-9)
               OR WHENEVER I.GE.20 .AND. I.LE.28
               A = 100*(I-18)
               OR WHENEVER I.GE.29 .AND. I.LE.37
               A = 1000*(I-27)
               END OF CONDITIONAL
               THROUGH PGRM, FOR J = 1,1,J.G.8
               WHENEVER J.E.1
               B = 0
               OR WHENEVER J.E.2 .OR. J.E.5 .OR. J.E.8
               B = 10.P.((J-2)/3)
               OR WHENEVER J.E.3 .OR. J.E.6
               B = 2*10.P.((J-3)/3)
               OTHERWISE
               B = 5*10.P.((J-4)/3)
               END OF CONDITIONAL
     PGRM      AV(I,J) =((57.283 *A)/(A.P.2 + B.P.2)) * (.682)
               PRINT FORMAT ANS, A, AV(I,1)...AV(I,8)
     LOOP      PUNCH FORMAT ANS, A, AV(I,1)...AV(I,8)
               VECTOR VALUES ANS = $1H0, I5, S4,  8F8.4*$
               END OF PROGRAM
```

```
*M4977-4526,FMS,DEBUG,1,1,200,200       NEGROPONTE STAGE 1 FINAL RUN
*      XEQ
*              MAD
                DIMENSION FIELD ( 7000,AD)
                VECTOR VALUES AD = 2,1,70
                INTEGER A,B,I,J,X,Y,C,D,FIELD,CARDS,SCALE,SPEED
               RCARDS IS THE NUMBER OF LINES IN THE INPUT AND IS A MULTIPLE
               1OF 50
                READ FORMAT IN, SPEED,CARDS,SCALE
                VECTOR VALUES IN = $3I10*$
                PRINT FORMAT START, SPEED, CARDS*SCALE
                VECTOR VALUES START = $40HMAXIMUM ANGULAR VELOCITIES TRAVELIN
               1G AT ,I3,20H MPH FROM (0,0) TO (, I5, 5H,0)  *$
                PRINT COMMENT $0DIRECTION OF TRAVEL ORIENTED VERTICAL ON SHEE
               1T OF PAPER$
                PRINT COMMENT $4MAX. ANGVEL (Q)  CRIT P (X,Y)  POSITION (I,J)
               1$
                PRINT COMMENT $0 DEGREES PER SECOND$
                PRINT COMMENT $0
               1    0X0         1X0         2X0         3X0         4X0         5X0
               2    6X0 $
                PRINT COMMENT $0
               1 1234567890123456789012345678901234567890123456789012345678901234567890
               21234567890$
                READ FORMAT INPUT, FIELD (1,1)...FIELD(CARDS,70)
                VECTOR VALUES INPUT = $70C1*$
               RTHIS LOOP MOVES THE POSITION OF THE VIEWER UNITS ALONG ROUTE
                THROUGH PGRM, FOR I = 1,1, I.G.CARDS
                Q = 0.
                C = 0
                D = 0
               RTHIS LOOP MOVES THE OBJECTS BEING SCANNED ALONG THE ROUTE
```

```
              THROUGH LOOP, FOR X = I,1, X.G.CARDS
              THROUGH LOOP, FOR Y = 1,1,Y.G.(X-I) .OR. Y.GE.70
              WHENEVER FIELD (X,Y) .E. $ $, TRANSFER TO LOOP
              A = SCALE*Y
              B = SCALE*(X-I)
              ANGVEL = ((57.283 *A)/(A.P.2 + B.P.2))*(.682)*(SPEED)
              WHENEVER ANGVEL .LE. Q, TRANSFER TO LOOP
              Q = ANGVEL
              C = SCALE*X
              D = SCALE*Y
LOOP          CONTINUE
              PRINT FORMAT OUTPUT,Q,C,D,SCALE*I,SCALE*J,FIELD(I,1)...FIELD
             1(I,70)
              VECTOR VALUES OUTPUT = $1H , F12.4, 4H   (,I4,1H,,I3,6H)    (
             1,I4, 1H,,I3,8H)        .,70C1*$
              PUNCH FORMAT ANS, FIELD(I,1)...FIELD(I,70)
              VECTOR VALUES ANS = $2H ., 70C1*$
PGRM          PUNCH FORMAT AN,Q,C,D,SCALE*I,SCALE*J
              VECTOR VALUES AN = $ S20,F12.4,4H   (,I4,1H,,I3,6H)    (,I4,1
             1H,,I3,1H)*$
              PRINT COMMENT $
             1 1234567890123456789012345678901234567890123456789012345678901234567890
             21234567890$
              PRINT COMMENT $0
             1    0X0        1X0        2X0        3X0        4X0        5X0
             2    6X0$
              END OF PROGRAM
*        DATA
```

```
*M4977-4526,FMS,DEBUG,2,2,200,200        NEGROPONTE  STAGE 2  FINAL RUN
*       XEQ
*          MAD
           DIMENSION FIELD ( 7000,AD)
           VECTOR VALUES AD = 2,1,70
           INTEGER A,B,I,J,X,Y,C,D,FIELD,Z,CARDS,PLACE,SPEED,V,K,SCALE,P
          1OSIT
          RCARDS IS THE NUMBER OF LINES IN THE INPUT AND IS A MULTIPLE
          1OF 50
           READ FORMAT IN, SPEED,CARDS,SCALE,POSIT
           VECTOR VALUES IN = $4I10*$
           PRINT FORMAT START, SPEED, CARDS*10
           VECTOR VALUES START = $41H1MAXIMUM ANGULAR VELOCITIES TRAVELI
          1NG AT ,I3,20H MPH FROM (0,0) TO (, I4, 5H,0)  *$
           PRINT COMMENT $0DIRECTION OF TRAVEL ORIENTED VERTICAL ON SHEE
          1T OF PAPER$
           PRINT COMMENT $4MAX. ANGVEL (Q)  CRIT P (X,Y)  POSITION (I,J)
          1$
           PRINT COMMENT $0 DEGREES PER SECOND$
           PRINT COMMENT $0
          1    0X0        1X0        2X0        3X0        4X0        5X0
          2   6X0      DGRS $
           PRINT COMMENT $0
          1 1234567890123456789012345678901234567890123456789012345678901234567890
          21234567890$
           READ FORMAT INPUT, FIELD (1,1)...FIELD(100,70)
           VECTOR VALUES INPUT = $70C1*$
AA         J=POSIT
           V = SPEED
           THETA = 3.1416/4.0
          RTHIS LOOP MOVES THE POSITION OF THE VIEWER UNITS ALONG ROUTE
           THROUGH PGRM, FOR I = 1,1, I.G.50
           Q = 0.
           C = 0
           D = 0
           DELTA = 0.
           THETA = THETA + DELTA
          RTHIS LOOP MOVES THE OBJECTS BEING SCANNED ALONG THE ROUTE
           THROUGH LOOP, FOR X = I,1, X.G.(I + 50)
           Z = (J-(X/TAN.(THETA)))
           WHENEVER Z .L. 0 , Z=0
           K = (J+(X*TAN.(THETA)))
           WHENEVER K .G. 70, K=70
           THROUGH LOOP, FOR Y = Z,1,Y.G.K
           WHENEVER FIELD (X,Y) .E. $ $, TRANSFER TO LOOP
           A = .ABS.(SCALE*(Y-J))
           B = SCALE*(X-I)
```

```
                B = 10* (X-I)
                WHENEVER A .E. 0  , TRANSFER TO LOOP
                ANGVEL = ((57.283 *A)/(A.P.2 + B.P.2))*(.682)*(V)
               RTHIS SECTION REPLACES THE X'S WITH THE NUMBER OF TIMES CRIT.
                WHENEVER ANGVEL .LE.15., TRANSFER TO TEST
                WHENEVER FIELD (X,Y) .E. $X$
                 FIELD (X,Y) = $1$
                OR WHENEVER FIELD (X,Y) .E. $9$
                 FIELD (X,Y) = $0$
                OTHERWISE
                 FIELD (X,Y) = FIELD (X,Y) + 10000000000K
                END OF CONDITIONAL
    TEST        WHENEVER ANGVEL .LE. Q, TRANSFER TO LOOP
                Q = ANGVEL
                C = SCALE*Y
                D = SCALE*X
                DGRS = 57.283 * THETA
    LOOP        CONTINUE
                PRINT FORMAT OUTPUT,Q,C,D,SCALE*I,SCALE*J,FIELD(I,1)...FIELD
               1(I,POSIT-1), FIELD(I,POSIT+1)...FIELD(I,70),DGRS
                VECTOR VALUES OUTPUT = $1H , F12.4, 4H   (,I4,1H,,I3,6H)    (
               1,I4, 1H,,I3,8H)        , 34C1, 1H., 35C1,3H  (,F5.2,1H)*$
                PUNCH FORMAT AN,Q,C,D,SCALE*I,SCALE*J,DGRS
                VECTOR VALUES AN = $1H ,F12.4,4H   (,I4,1H,,I3,6H)    (,I4,1H
               1,,I3,8H)        ,F5.2*$
    PGRM        PUNCH FORMAT ANS, FIELD(I,1)...FIELD(I,POSIT-1),FIELD(I,POSIT
               1+1)...FIELD(I,70)
                VECTOR VALUES ANS =$1H , 34C1,1H.,35C1*$
                PLACE = 100
                WHENEVER PLACE .GE. CARDS, TRANSFER TO END
                PLACE = PLACE + 50
               RTHIS LOOP TAKES THE LAST FIFTY CARDS LOOKED AT AND DISCARDS
               1THEM, MOVES NEXT FIFTY UP TO BEGINNING AND READS IN A NEW FIF
               2TY.
                THROUGH BB, FOR I=1,1,I.G.50
                THROUGH BB, FOR J=1,1,J.G.70
    BB          FIELD (I,J) = FIELD (I+50,J)
                READ FORMAT INPUT, FIELD(51,1)...FIELD(100,70)
                TRANSFER TO AA
    END         PRINT COMMENT $
               1 1234567890123456789012345678901234567890123456789012345678901234567890
               21234567890$
                PRINT COMMENT $0
               1    0X0       1X0        2X0        0X         47         5X0
               2   6X0     DGRS $
                END OF PROGRAM
   *     DATA
```

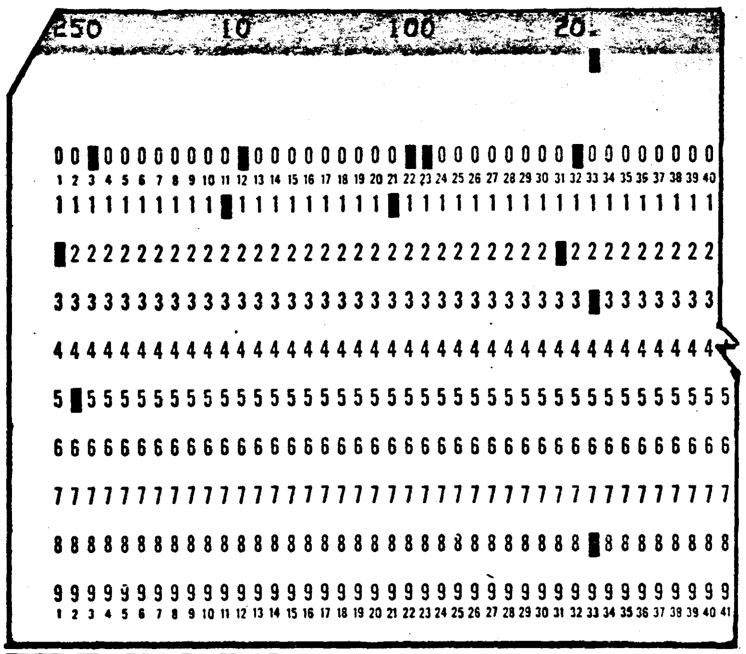
```
*M4977-4526,FMS,DEBUG,1,1,300,200       NEGROPONTE RANDOM NUMBER TEST FINAL
*     XEQ
*            MAD
             INTEGER K, A1, A2
             K = 1
             B = SETU.(45678456)
AA           RECTR1 = RANNO.(X)
             RECTR2 = RANNO.(X)
             K = K+1
             R1 = ((-2*(LOG.(RECTR1))).P.0.5)*(COS.(2.0*3.1416*RECTR2))
             R2 = ((-2*(LOG.(RECTR2))).P.0.5)*(SIN.(2.0*3.1416*RECTR1))
             A1 = 90.*R1
             A2 = 90.*R2
             PRINT FORMAT OUTPUT, RECTR1, RECTR2, R1, R2, A1, A2, K
             PUNCH FORMAT OUTPUT, RECTR1, RECTR2, R1, R2, A1, A2, K
             VECTOR VALUES OUTPUT = $ 4F10.3, 3I10*$
             WHENEVER K .LE. 50, TRANSFER TO AA
             END OF PROGRAM
```

```
*       XEQ
*             MAD
              DIMENSION FIELD ( 3500,AD)
              VECTOR VALUES AD = 2,1,70
              NORMAL MODE IS INTEGER
              READ FORMAT IN,CARDS
              VECTOR VALUES IN = $1I10*$
              READ FORMAT INPUT, FIELD (1,1)...FIELD(CARDS,70)
              VECTOR VALUES INPUT = $70C1*$
              PRINT COMMENT $0
             1    0X0          1X0          2X0          3X0          4X0          5X0
             2    6X0$
              PRINT COMMENT $
             1 1234567890123456789012345678901234567890123456789012345678
             21234567890$
              PRINT FORMAT RD, FIELD (1,1)...FIELD(CARDS,70)
              VECTOR VALUES RD = $S46, 70C1*$
              PRINT COMMENT $
             1 1234567890123456789012345678901234567890123456789012345678
             21234567890$
              PRINT COMMENT $0
             1    0X0          1X0          2X0          3X0          4X0          5X0
             2    6X0$
              OX = 0
              THROUGH AOOB, FOR Y=1,1,Y.G.CARDS
              THROUGH AOOB, FOR X=1,1,X.G.70
AOOB          WHENEVER FIELD (X,Y) .E. $A$, TRANSFER TO AA
AA            NY = Y
              NX = X
              TEST = $1$
FIND          TEST = TEST + 10000000000K
              FIELD (X,Y) = $.$
              STARTY = Y-5
              STARTX = X-7
              WHENEVER STARTY .L.0, STARTY = 0
              WHENEVER STARTX .L.0, STARTX = 0
              ENDY = Y+5
              ENDX = X+7
              WHENEVER ENDY .G. CARDS, ENDY = CARDS
              WHENEVER ENDX .G. 70, ENDX = 70
              THROUGH AOOC, FOR Y = STARTY,1,Y.G.ENDY
              THROUGH AOOC, FOR X = STARTX, 1,X.G.ENDX
              WHENEVER OX.E.0, TRANSFER TO SKIP
              WHENEVER FIELD (OX,OY) .E. $9$, TRANSFER TO SKIP2
              WHENEVER  FIELD(X,Y) .E. TEST, TRANSFER TO CC
              TRANSFER TO LOOP
```

```
SKIP        WHENEVER FIELD (X,Y) .E. TEST, TRANSFER TO BB
            TRANSFER TO LOOP
SKIP2       WHENEVER FIELD (X,Y) .E. $0$, TRANSFER TO CC
LOOP        CONTINUE                                          170
AOOC        CONTINUE
            TRANSFER TO OUT
BB          OX = X
            OY = Y
            TRANSFER TO FIND
CC          PX = X
            PY = Y
            PRINT FORMAT OUTPUT,NX,NY,OX,OY,PX,PY
            VECTOR VALUES OUTPUT = $6I10*$
            NX = OX
            NY = OY
            OX = PX
            OY = PY
            TRANSFER TO FIND
OUT         PRINT COMMENT $0
           1    0X0       1X0       2X0       3X0       4X0       5X0
           2   6X0     DGRS $
            PRINT COMMENT $0
           1 1234567890123456789012345678901234567890123456789012345678901234567890
           21234567890$
            PRINT FORMAT END, FIELD (1,1)...FIELD(CARDS,70)
            VECTOR VALUES END = $S46, 70C1*$
            PRINT COMMENT $
           1 1234567890123456789012345678901234567890123456789012345678901234567890
           21234567890$
            PRINT COMMENT $0
           1    0X0       1X0       2X0       3X0       4X0       5X0
           2   6X0$
            END OF PROGRAM
*      DATA
```

```
*M4977-4526,FMS,DEBUG,2,2,400,200        NEGROPONTE TEST BUCHANNEN
*     XEQ
*           MAD
            DIMENSION FIELD ( 3500,AD)
            VECTOR VALUES AD = 2,1,70
            INTEGER A,B,I,J,X,Y,C,D,FIELD,Z
            PRINT COMMENT $0DIRECTION OF TRAVEL ORIENTED VERTICAL ON SHEE
           1T OF PAPER DESCRIBED BY THE IMPOSED I MARKS$
            PRINT COMMENT $0 VELOCITY   (Q)  CRIT P (X,Y)  POSITION (I,J)
           1$
            PRINT COMMENT $0       MPH
           1    0X0        1X0        2X0        3X0        4X0        5X0
           2   6X0        7X0$
            PRINT COMMENT $0
           1 1234567890123456789012345678901234567890123456789012345678901234567890
           2123456789012$
            READ FORMAT INPUT, FIELD (1,1)...FIELD( 50,70)
            VECTOR VALUES INPUT = $70C1*$
            J = 35
            THROUGH PGRM, FOR I = 1,1, I.G.50
            Q = 10000.0
            C = 0
            D = 0
            THROUGH LOOP, FOR X = I,1, X.G.50
            Z = (J-(X-I))
            WHENEVER (J-(X-I)) .E. 0 , Z = 0
            THROUGH LOOP, FOR Y = Z,1,Y.G.(J+(X-I)) .OR. Y.G.70
            WHENEVER FIELD (X,Y) .E. $ $, TRANSFER TO LOOP
            A = .ABS.(25*(Y-J))
            B = 25* (X-I)
            WHENEVER A .E. 0. , TRANSFER TO LOOP
            V = (30.*(A.P.2 + B.P.2))/((57.283)*(.682)*(A))
            WHENEVER V .GE. Q, TRANSFER TO LOOP
            Q = V
            C = 25*X
            D = 25*Y
LOOP        CONTINUE
            PUNCH FORMAT VEL, Q
            VECTOR VALUES VEL = $ S40, F12.3*$
            PUNCH FORMAT FIEL, FIELD(I,1)...FIELD(I,34), FIELD(I,36)...FI
           1ELD(I,70)
            VECTOR VALUES FIEL = $ 34C1, 1H., 35C1*$
PGRM        PRINT FORMAT OUTPUT,Q,C,D,25*I, 25*J, FIELD (I,1)...FIELD (I,
           134), FIELD (I,36)...FIELD(I,70)
            VECTOR VALUES OUTPUT = $1H , F12.4, 4H   (,I5,1H,,I5,6H)     (
           1,I5, 1H,,I5,8H)        , 34C1, 1H., 35C1*$
            PRINT COMMENT $0
           1 1234567890123456789012345678901234567890123456789012345678901234567890
           2123456789012$
            PRINT COMMENT $0
           1    0X0        1X0        2X0        3X0        4X0        5X0
           2   6X0        7X0$
            END OF PROGRAM
*     DATA
```

APPENDIX B



This appendix describes the main program that accompanies the thesis. A knowledge of the Michigan Algorithm Decoding language (MAD) is necessary to understand the listings. With little familiarity with data processing equipment the program can be understood and easily used.

REQUIRED DATA: The program requires five pieces of information: 1. Number of cards used in defining the field (CARDS); 2. The scale value of each space (SCALE); 3. The velocity of travel (SPEED); 4. The angular velocity threshold (THRESH); 5. The field. The first four inputs are described on one card. CARDS is an integer to be placed anywhere between columns 1 and 10, SCALE is an integer between 11 and 20, speed is an integer between 21 and 30, and THRESH is a decimal (floating point number) to be placed between columns 31 and 35. (As illustrated).

Field, as described, is a matrix of blanks, 'x's' and sequencial numbers. 70 columns are used in width and up to 250 cards can be used in length; this dimension sets the scale value. Should an error be made in punching x's, the machine will process the information as if it were an 'x', but will indicate the wrong 'number of seconds critical' for that one point. A diagnostic will not appear and the program will run smoothly.

OPERATION: The program first locates the starting point (A) and the next two points of the trip. It solves three simultaneous equations to find the radius of curvature and finds the angle of vision with respect to a total field of 360° starting from the vertical, sweeping a counter clockwise arc. This angle represents the position of the right-most boundary of the visual field. The value is subjected to random number distortion, controlled by the rate of travel, angle of eccentric vision, and significance of the field elements (not included in the listing at the end of this section). The program, with an angle of vision established, scans the visual field, keeping tract of the critical points. Each critical point is assigned the value (PLUS) (the average distance between the three points). This information is justified to the right of the accumulator, unlike the 'x's' in the character field which are justified to the left. In other words, if a point is never critical, the information pertaining to it will be left justified in character form, whereas other points will have octal values on the right.

After the visual field is searched the program finds the next point, the new radius, the new PLUS, and the new visual field. This sequence is repeated until the final point (Z) is located, and the program terminates.

RANDOM VARIABLES: There are two methods of generating random variables. The first assumes symetrical distribution and is easy to generate. The second system skews the distribution by having a variable mean and boundary conditions. In connection with the main program the first method is used. The second method is, nevertheless, briefly discussed due to its accuracy. In both cases, however, emprical data is necessary to formulate the distribution. This data is not available and is replaced with theoretical speculation. For example:

a. The higher the velocity the greater the probability of looking straight ahead.

b. When looking to one side, the higher the probability of looking back towards the center.

c. The slower the velocity, the more even the distribution.

d. The more familiar the observer, the less importance the visual field structure.

e. IIf the observer is a passenger, the more even the distribution.

The variables of the first method are tested with a simple program. Two normal rectangular random numbers are generated with the standard random number generator (RANNO.) and subjected to equations of transformation:[106]

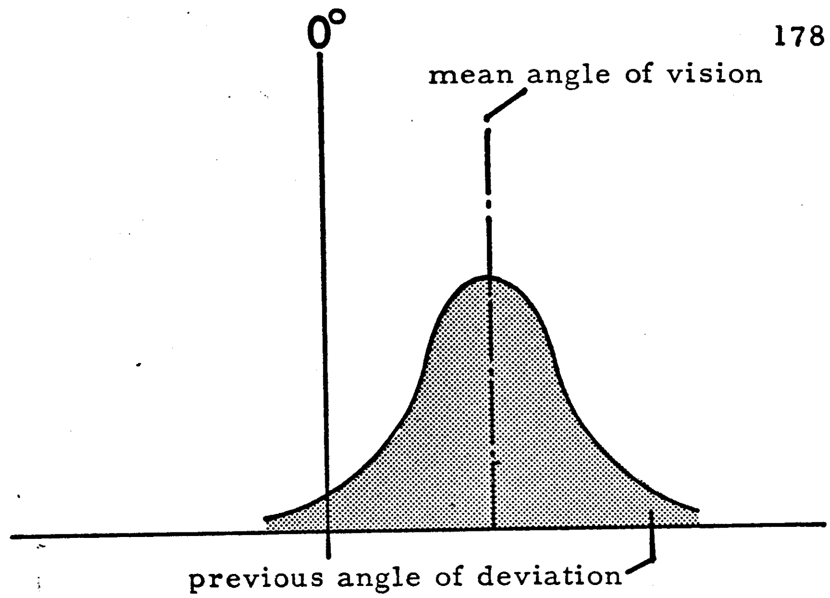
$$R_1 = (-2 \log_e U_1) \quad \cos (2\pi U_2)$$

$$R_2 = (-2 \log_e U_2) \quad \sin (s\pi U_1)$$

U_1 and U_2 are the normal rectangular random numbers. R_1 and R_2 follow a Gaussian distribution. R_1 and R_2 are independent of each other. The following page lists a sample of

106 Taken from Share Program: GC-0009-BOXNO, #1360, Kaercher, A. W., Grumman Aircraft Engineering Corp., April, 1962.

.503	.006	1.172	-.060	105	-5	2
.508	.996	1.164	-.005	104	0	3
.403	.456	-1.298	.718	-116	64	4
.113	.569	-1.899	.691	-170	62	5
.398	.270	-.174	.968	-15	87	6
.042	.820	1.064	.166	95	14	7
.537	.844	.621	-.133	55	-11	8
.234	.811	.637	.644	57	57	9
.756	.239	.054	-1.692	4	-152	10
.624	.598	-.791	-.713	-71	-64	11
.973	.452	-.223	-.213	-20	-19	12
.955	.662	-.159	-.253	-14	-22	13
.378	.310	-.511	1.059	-45	95	14
.453	.931	1.141	.110	102	9	15
.507	.664	-.597	-.038	-53	-3	16
.427	.579	-1.149	.466	-103	41	17
.633	.593	-.798	-.761	-71	-68	18
.854	.793	.150	-.540	13	-48	19
.068	.273	-.340	.671	-30	60	20
.025	.688	-1.025	.135	-92	12	21
.906	.240	.027	-.940	2	-84	22
.288	.565	-1.450	1.039	-130	93	23
.795	.690	-.250	-.827	-22	-74	24
.983	.690	-.068	-.092	-6	-8	25
.291	.537	-1.530	1.079	-137	97	26
.605	.800	.308	-.411	27	-36	27
.350	.904	1.195	.362	107	32	28
.273	.499	-1.611	1.166	-145	104	29
.538	.733	-.122	-.184	-10	-16	30
.558	.752	.014	-.267	1	-24	31
.495	.199	.377	.061	33	5	32
.740	.651	-.454	-.925	-40	-83	33
.248	.630	-1.142	.961	-102	86	34
.553	.648	-.653	-.307	-58	-27	35
.906	.606	-.351	-.559	-31	-50	36
.482	.443	-1.131	.143	-101	12	37
.318	.921	1.332	.369	119	33	38
.667	.708	-.235	-.719	-21	-64	39
.249	.121	1.206	2.054	108	184	40
.489	.839	.635	.043	57	3	41
.637	.271	-.126	-1.225	-11	-110	42
.894	.924	.420	-.245	37	-22	43
.497	.665	-.599	.016	-53	1	44
.517	.114	.866	-.223	77	-20	45
.030	.156	1.470	.365	132	32	46
.664	.580	-.792	-.896	-71	-80	47
.502	.792	.303	-.009	27	0	48
.230	.254	-.039	1.643	-3	147	49
.455	.448	-1.189	.352	-107	31	50
.593	.526	-1.008	-.628	-90	-56	51



these numbers. The columns represent U_1, U_2, R_1, R_2, $90 \times R_1$, and $90 \times R_2$ respectively.

Multiplied by a standard deviate (σ), R_1 or R_2 give the angle of deviation:

$$(\text{mean angle of vision}) + R\sigma = \text{visual angle of deviation}$$

where the mean angle is equal to half the previous angle of deviation. the '½' factor is an estimation and σ is a function of speed and field character.

The second method requires the establishment of a frequency curve derived from Gamma and Beta functions.[107] The curve is derived from:[108]

---

107 These functions have been programmed by Leon Groisser in connection with his own thesis. Their use is only suggested with proper empirical data.

108 Elderton, *Op. Cit.*, See page 59 for derivations.

$$y = y_0\left(1+\frac{x}{a_1}\right)^{m_1}\left(1-\frac{x}{a_2}\right)^{m_2}$$

where $\qquad m_1/a_1 = m_2/a_2$

Origin at mode

The values to be calculated in order are:

$$r = 6(\beta_2 - \beta_1 - 1)/(6+3\beta_1 - 2\beta_2)$$

$$a_1 + a_2 = \mu_2 \;/\; \beta_1(r+2)^2 + 16(r+1)$$

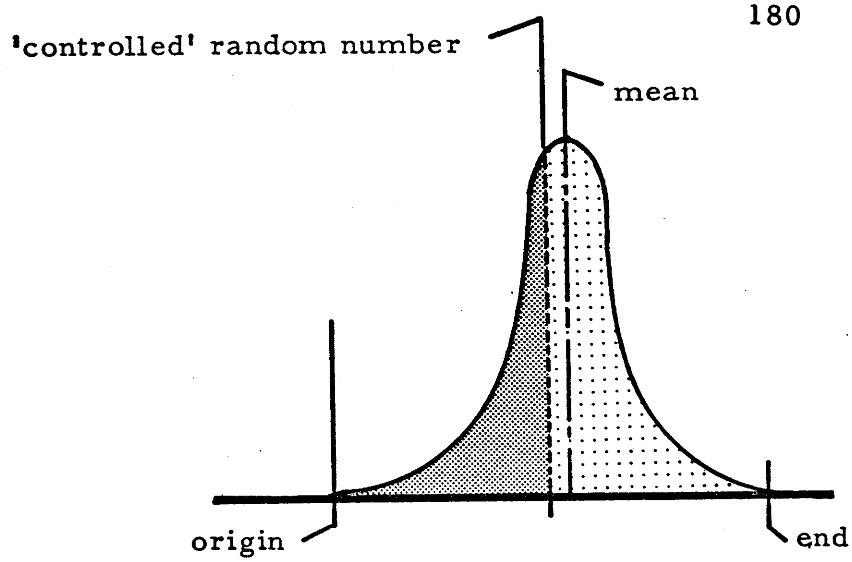
The m's are given by

$$\frac{1}{2}\left(r-2\pm r(r+2)\sqrt{\frac{1}{{}_1(r+2)^2+16(r+1)}}\right)$$

when μ_3 is positive m_2 is the positive root

$$y_0 = \frac{N}{a_1+a_2}\cdot\frac{m_1^{m_1}\,m_2^{m_2}}{(m_1+m_2)^{m_1+m_2}}\cdot\frac{(m_1+m_2+2)}{(m_1+1)\quad(m_2+1)}$$

$$\text{Mode} = \text{Mean} \; - \frac{1}{2}\cdot\frac{\mu_3}{\mu_2}\cdot\frac{r+2}{r-2}$$



The above provides a distribution curve, whose area (by definition) is equal to one. Using the curve's area a normal rectangular random number from RANNO. is taken as the percentage of area. By integrating from origin to some number greater than 'origin' and less than 'end' the percentage of area is found; the number is the 'controlled' random number.

OUTPUT: The output is both printed and punched on cards. The first series of results are: x and y coordinates of each station point, the radii of curvature, the angle of vision. The rows of output are equal to the number of specified sequencial points.

The second output is the field. The sequencial numbers are replaced by '.'s' and the critical 'x's' are replaced by numbers.

The following is a flow chart of these events, followed by a listing of the program as of July 1, 1966 (Revisions are being made until the 15th of July). As the program stands it does not consider hidden lines, random variables, or direction of curvature. Sample data is described. The proportion of the 'X" has elongated the image. The program, however, treats the rectangular area of the 'X' as a square.

```
           X          XX          XXX                                              XXXXXX   X
                      XX          XXX                   XX      5
                         XXXXX  Z   0   9    8     7      6    432109 8
                                                                         7
                                                     XXXX
                    XX            X                  XXXX           6
         XX         A             X                              XXX
         XX                                                      XXX
             2                                                   XXX5
                    3     4          X     X   X X         XXX              4
                                5                          XXX
             X                                             XXX                     3
                         XX       6 X        X X                                   2
                         XX       7                          X X   XXX   9   0   1
                                  8901234      XXXX
                                               XXXX
                                             5     6      7      8
```

3 33 000 3330XX 0
XX 000 06 •
XXXXX Z • • • • • ••••••• •
•
0006
XX 0 0006 •
XX • 0 000
XX 000
• 000•
• • 0 X X X XXX •
• XXX
X XXX •
00 • 0 6 3 •
XX • 0 0 000 • • •
••••••• 3333
3333
• • • •

```
*M4977-4526,FMS,DEBUG,1,1,400,250        NEGROPONTE FINAL TEST1
*        XEQ
*              MAD
               INTEGER CARDS,SCALE,SPEED,FIELD,X,Y,NX,NY,OX,OY,PX,PY,TEST,ST
              1ARTX,ENDX,STARTY,ENDY,AR,K1,K2,K3,DR,ER,FR,H,I,J,M,N,A,B,DGRS
              2,PLUS
               DIMENSION FIELD (1400,AD)
               VECTOR VALUES AD = 2,1,70
               READ FORMAT IN,CARDS, SCALE, SPEED, THRESH
               VECTOR VALUES IN = $3I10, F4.1*$
               SPCALE = SCALE/(SPEED*.682)
               READ FORMAT INPUT, FIELD (1,1)...FIELD(CARDS,70)
               VECTOR VALUES INPUT = $70C1*$
               PRINT RESULTS CARDS
               PRINT RESULTS SCALE
               PRINT RESULTS SPEED
               PRINT RESULTS THRESH
               PRINT RESULTS SPCALE
               PRINT COMMENT$                                  OX        OY      RADIU
              1S    DEGREES $
               OX = 0
               THROUGH LOOK, FOR X=1,1,X.G.CARDS
               THROUGH LOOK, FOR Y=1,1,Y.G.70
 LOOK          WHENEVER FIELD (X,Y) .E. $A$, TRANSFER TO NEXT
 NEXT          NY = Y
               NX = X
               TEST = $1$
               FIELD (X,Y) = $.$
 NOP           TEST = TEST + 10000000000K
               STARTX = X-5
               STARTY = Y-7
               WHENEVER STARTY .L.0, STARTY = 0
               WHENEVER STARTX .L.0, STARTX = 0
               ENDX = X+5
               ENDY = Y+7
               WHENEVER ENDX .G. CARDS, ENDX = CARDS
               WHENEVER ENDY .G. 70, ENDY = 70
               THROUGH FIND, FOR X = STARTX, 1,X.G.ENDX
               THROUGH FIND, FOR Y = STARTY,1,Y.G.ENDY
               WHENEVER OX.E.0, TRANSFER TO SKIP
               WHENEVER TEST .E. 126060606060K, TRANSFER TO SKIP2
               WHENEVER  FIELD(X,Y) .E. TEST, TRANSFER TO CC
               TRANSFER TO DUMMY
 SKIP          WHENEVER FIELD (X,Y) .E. TEST, TRANSFER TO BB
               TRANSFER TO DUMMY
 SKIP2         TEST = $0$
               WHENEVER FIELD (X,Y) .E. $0$, TRANSFER TO CC
 DUMMY         CONTINUE
 FIND          CONTINUE
               TRANSFER TO END
 BB            OX = X
               OY = Y
               FIELD (X,Y) = $.$
               TRANSFER TO NOP
 CC            PX = X
```

```
           PY = Y
           PLUS=(((((NX-OX).P.2.0)+((NY-OY).P.2.0)).P.0.5)+((((OX-PX).P.
          12.0)+((OY-PY).P.2.0)).P.0.5))/2.0
           OMEGA = 0.
           FIELD (X,Y) = $.$
           AR=  (NX*OY)+(OX*PY)+(PX*NY)-(PX*OY)-(OX*NY)-(NX*PY)
           RADIUS = 0.
           WHENEVER AR .E. 0, TRANSFER TO BOUND
           K1 = (NX*NX)+(NY*NY)
           K2 = (OX*OX)+(OY*OY)
           K3 = (PX*PX)+(PY*PY)
           DR= -((K1*OY)+(K2*PY)+(K3*NY)-(K3*OY)-(K2*NY)-(K1*PY))
           ER= -((NX*K2)+(OX*K3)+(PX*K1)-(PX*K2)-(OX*K1)-(NX*K3))
           FR= -((NX*OY*K3)+(OX*PY*K1)+(PX*NY*K2)-(PX*OY*K1)-(OX*NY*K3)-
          1(NX*PY*K2))
           DETER = ((DR.P.2.0)+(ER.P.2.0)-(4*AR*FR))/(4*(AR.P.2.0))
           WHENEVER DETER .GE. 0.
            RADIUS = (DETER).P.0.5
           OTHERWISE
            TRANSFER TO ERROR4
           END OF CONDITIONAL
           OMEGA=(SPEED*.682)/(RADIUS*SCALE)
BOUND      WHENEVER PY-NY.G..ABS.(NX-PX).OR.PX.E.NX+PY-NY
            BETA = 0.
            H = 1
            TRANSFER TO QUAD(H)
           OR WHENEVER NX-PX.G..ABS.(NY-PY).OR.PY.E.NY+NX-PX
            BETA = 1.5708
            H = 2
            TRANSFER TO QUAD(H)
           OR WHENEVER NY-PY.G..ABS.(NX-PX).OR.PX.E.NX-NY+PY
            BETA = 3.1416
            H = 3
            TRANSFER TO QUAD(H)
           OR WHENEVER PX-NX .G..ABS.(NY-PY).OR.PY.E.NY-PX+NX
            BETA = 4.7124
            H = 4
            TRANSFER TO QUAD(H)
           OTHERWISE
            TRANSFER TO ERROR2
           END OF CONDITIONAL
QUAD(1)    WHENEVER NX.G.PX
            THETA = (ATAN.((NX-PX)/(PY-NY+0.0)))+.7854
           OR WHENEVER  NX.LE.PX
            THETA = .7854 -(ATAN.((PX-NX)/(PY-NY+0.0)))
           OTHERWISE
            TRANSFER TO ERROR3
           END OF CONDITIONAL
           I=OY
           J=70
           TRANSFER TO BBODY
SECT(1)    M=OX-((Y-OY)*(TAN.(THETA)))
           N=OX+((Y-OY)/(TAN.(THETA)))
           TRANSFER TO CBODY
QUAD(2)    WHENEVER PY.G.NY
```

```
                THETA=(ATAN.((NX-PX)/(PY-NY+0.0)))-.7854
               OR WHENEVER PY .LE.NY
                THETA=.7854+(ATAN.((NY-PY)/(NX-PX+0.0)))
               OTHERWISE
                TRANSFER TO ERROR3
               END OF CONDITIONAL
               M=1
               N=OX
               TRANSFER TO ABODY
      SECT(2)  I=OY-((OX-X)*(TAN.(THETA)))
               J=OY+((OX-X)/(TAN.(THETA)))
               TRANSFER TO BBODY
      QUAD(3)  WHENEVER OX.G.PX
                THETA=(ATAN.((OY-PY)/(OX-PX+0.0)))-.7854
               OR WHENEVER OX.LE.PX
                THETA=.7854+(ATAN.((PX-OX)/(OY-PY+0.0)))
               OTHERWISE
                TRANSFER TO ERROR3
               END OF CONDITIONAL
               I=1
               J=OY
               TRANSFER TO BBODY
      SECT(3)  M=OX-((OY-Y)/(TAN.(THETA)))
               N=OX+((OY-Y)*(TAN.(THETA)))
               TRANSFER TO CBODY
      QUAD(4)  WHENEVER OY.G.PY
                THETA=(ATAN.((PX-OX)/(OY-PY+0.0)))-.7854
               OR WHENEVER OY.LE.PY
                THETA=.7854+(ATAN.((PY-OY)/(PX-OX+0.0)))
               OTHERWISE
                TRANSFER TO ERROR3
               END OF CONDITIONAL
               M=OX
               N=CARDS
               TRANSFER TO ABODY
      SECT(4)  I=OY-((X-OX)/(TAN.(THETA)))
               J=OY+((X-OX)*(TAN.(THETA)))
               TRANSFER TO BBODY
      ABODY    THROUGH LOOP,FOR X = M, 1, X.G.N
               TRANSFER TO SECT(H)
      BBODY    WHENEVER I.L.0, I=0
               WHENEVER J.G.70, J=70
               THROUGH LOOP, FOR Y = I, 1, Y.G.J
               WHENEVER H.E.2 .OR. H.E.4 , TRANSFER TO DBODY
               TRANSFER TO SECT(H)
      CBODY    WHENEVER M.L.0, M=0
               WHENEVER N.G.CARDS, N=CARDS
               THROUGH LOOP, FOR X = M, 1, X.G.N
      DBODY    WHENEVER FIELD (X,Y).NE. $X$, TRANSFER TO LOOP
               A=.ABS.(SCALE*(Y-OY))
               B=.ABS.(SCALE*(X-OX))
               WHENEVER A .E. 0  , TRANSFER TO LOOP
               ANGVEL =(((57.283 *A)/(A.P.2 + B.P.2))*(.682)*(SPEED))+OMEGA
               WHENEVER ANGVEL .LE. THRESH, TRANSFER TO LOOP
               WHENEVER FIELD (X,Y) .E. $X$
```

```
              FIELD (X,Y) = PLUS
              OTHERWISE
               FIELD (X,Y) = FIELD (X,Y) + PLUS
              END OF CONDITIONAL
LOOP          CONTINUE
              DGRS = 57.283 *(THETA+BETA)
              PRINT FORMAT PGRM, OX, OY, RADIUS, DGRS
              VECTOR VALUES PGRM = $S17, 2I10, F10.3, I10*$
              NX=OX
              NY=OY
              OX=PX
              OY=PY
              X = OX
              Y = OY
              TRANSFER TO NOP
END           THROUGH POSIE, FOR X = STARTX, 1, X.G.ENDX
              THROUGH POSIE, FOR Y = STARTY, 1, Y.G.ENDY
POSIE         WHENEVER FIELD (X,Y) .E. $Z$, TRANSFER TO OUT
              PRINT COMMENT $1ERROR HAS OCCURRED AS THE NEXT PLACE HAS NOT
             1BEEN FOUND. IS NEXT MARK WITHIN THE 10X14 SEARCHING RECTANGL$
              PRINT COMMENT $ OR ELSE YOU HAVE FORGOTTEN TO PLACE A Z AT TH
             1E END OF THE DESCRIBED ROUTE$
              PRINT FORMAT ERR1,OX,OY,PX,PY
              VECTOR VALUES ERR1= $52H THE LAST TWO RECOGNIZED POSITIONS WE
             1RE AT LOCATION(,2I5,16H) AND LOCATION (, 2I5,2H) *$
              TRANSFER TO OUT
ERROR2        PRINT COMMENT $ ERROR HAS OCCURED IN THE LOCATION OF QUADRANT
             1S$
              PRINT COMMENT $ THETA                NX     NY     OX     OY     PX
             1   PY     RADIUS   $
              PRINT FORMAT ERR2,THETA,NX,NY,OX,OY,PX,PY,RADIUS
              VECTOR VALUES ERR2 =$F6.2,S10(6I10,F12.2*$
              TRANSFER TO OUT
ERROR3        PRINT COMMENT $ ERROR HAS OCCURRED IN SELECTION OF QUADRANTS$
              PRINT COMMENT $QUAD NUM.      NX          NY          OX
             1OY          PX          PY$
              PRINT FORMAT ERR3,H,NX,NY,OX,OY,PX,PY
              VECTOR VALUES ERR3 = $7I10*$
              TRANSFER TO OUT
ERROR4        PRINT COMMENT $ ERROR HAS OCCURRED RADIUS VECTOR IS NEGATIVE$
              PRINT COMMENT $    NX       NY       OX       OY       PX       P
             1Y        K1       K2       K3       DR       ER       FR     DETER$
              PRINT FORMAT ERR4,NX,NY,OX,OY,PX,PY, K1,K2,K3,DR,ER,FR,DETER
              VECTOR VALUES ERR4 = $1H , 12I8,F12.4*$
OUT           THROUGH RPLC, FOR X = 1, 1, X.G.CARDS
              THROUGH RPLC, FOR Y = 1, 1, Y.G.70
              WHENEVER FIELD (X,Y) .E. $.$ .OR. FIELD (X,Y) .E. $X$.OR. FIE
             1LD (X,Y) .E. $ $ .OR. FIELD (X,Y) .E. $Z$, TRANSFER TO RPLC
              FIELD (X,Y) = FIELD (X,Y) / SPCALE
              WHENEVER FIELD (X,Y) .G. 9
               FIELD (X,Y) = $0$
              OR WHENEVER FIELD (X,Y) .L. 1
               FIELD (X,Y) = $X$
              OTHERWISE
              FIELD (X,Y) = FIELD (X,Y) .LS. 30
```

```
              END OF CONDITIONAL
   RPLC       CONTINUE
              PRINT RESULTS SPCALE
              PRINT COMMENT $1
             1    0X0       1X0       2X0       3X0       4X0       5X0
             2   6X0$
              PRINT COMMENT $
             1 1234567890123456789012345678901234567890123456789012345678901234567890
             21234567890$
              PRINT FORMAT FINITO, FIELD (1,1)...FIELD(CARDS,70)
              VECTOR VALUES FINITO = $ S47, 70C1*$
              PRINT COMMENT $
             1 1234567890123456789012345678901234567890123456789012345678901234567890
             21234567890$
              PRINT COMMENT $
             1    0X0       1X0       2X0       3X0       4X0       5X0
             2   6X0$
              PUNCH FORMAT HAVE, FIELD (1,1)...FIELD(CARDS,70)
              VECTOR VALUES HAVE = $70C1*$
              END OF PROGRAM
   *      DATA
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SAMPLE OF DATA USED FOR TEST 1
CARDS     SCALE     SPEED     THRESH    EMP1     EMP2
20        10        80        20.       1000.0       2.0
TIMES     SPCR     SPCRT     THRCR     THRCRT
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CARDS=  20  SCALE= 10  SPEED=150 THRESH= 20.0   TIME=  9

          0       00          000                          000000   0
                  00          000             00     .
                      00000  Z   .  .    .    .     .   ...... .
                                                                 .
                                            0000
                16           0              0000         .
         00       .          0                        055
         00                                           055
              .                                       005.

                  .     .       0    0  0 0      000          .

                           .                     000
             0                                   000                .
                      00      . 0       0 0                         .
                      00      .                     0 0  555   .  . .
                              .......    0000
                                         0000
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 10  SPEED=150 THRESH= 20.0   TIME= 10

         0        00         000                          000000   0
                  00         000             00     .
                     00005  Z   .  .    .    .     .   ...... .
                                                               .

                                           0000
                00          0              0000         .
         00      .          0                        005
         00                                          005
             .                                       005.

                 .     .       0    0  0 0      000         .

                          .                     000
             0                                  000               .
                     00      . 0       0 0                        .
                     00      .                     0 0  000  .  . .
                             .......    0000
                                        0000
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  1

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXXX
                XX          X              XXXX         .
         XX      .          X                        XX5
         XX                                          XXX
             .                                       XXX.
                 .     .       X    X  X X      XXX         .
                          .                     XXX
             X                                  XXX               .
                     XX      . X         X X                      .
                     XX      .                     X X  XXX  .  . .
                             .......    XXXX
                                        55XX
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  2

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXXX
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XXX.
                 .     .       X    X  X X      XXX         .
                          .                     XXX
             X                                  XXX               .
                     XX      . 2         X X                      .
                     XX      .                     X X  XXX  .  . .
                             .......    XXXX
                                        55XX
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  3

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .

                                           XXXX
                XX          X              XXXX          .
         XX     .           X                        XXX
         XX                                          XXX
             .                                       XXX.

                 .      .       X    X  X X     XXX          .

                           .                    XXX
             X                                  XXX                .
                     XX       . 2       X X                        .
                     XX       .                     X X XXX   .  . .
                              .......   XXXX
                                        55XX
                                        .     .      .      .


CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  4

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .

                                           XXXX
                XX          X              XXXX          .
         XX     .           X                        XXX
         XX                                          XXX
             .                                       XXX.

                 .      .       X    X  X X     XXX          .

                           .                    XXX
             X                                  XXX                .
                     XX       . X       X X                        .
                     XX       .                     X X XXX   .  . .
                              .......   XXXX
                                        55XX
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  5

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX    .
                     XXXXX  Z  .  .    .    .     .   ...... .
                                                              .
                                           XXXX
                XX          X              XXXX        .
         XX     .           X                           XXX
         XX                                             XXX
            .                                           XXX.

                .     .        X    X  X X      XXX        .

                         .                      XXX
             X                                  XXX              .
                     XX      . X       X X                       .
                     XX      .                     X X  XXX .  . .
                             .......    XXXX
                                        55XX
                                      .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  6

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX    .
                     XXXXX  Z  .  .    .    .     .   ...... .
                                                              .
                                           XXXX
                XX          X              XXXX        .
         XX     .           X                           XXX
         XX                                             XXX
            .                                           XXX.

                .     .        X    X  X X      XXX        .

                         .                      XXX
             X                                  XXX              .
                     XX      . 2       X X                       .
                     XX      .                     X X  XXX .  . .
                             .......    XXXX
                                        55XX
                                      .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  7

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXXX
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XXX.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 2       X X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    XXXX
                                        55XX
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  8

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXXX
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          X33
             .                                       333.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . X       X X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    XXXX
                                        55XX
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME=  9

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXXX
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XXX.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . X       X X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    XXXX
                                        55XX
                                       .     .      .      .



CARDS=  20  SCALE= 50  SPEED= 80 THRESH= 20.0   TIME= 10

         X        XX         XXX                          XXXXXX   X
                  XX         XXX             XX     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXXX
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XXX.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 2       X X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    XXXX
                                        55XX
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  1

         1        22         X33                           1111XX   X
                  XX         X33             X2      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           XXX3
                XX          X              XXXX          .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XX5.

                 .     .       3    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2555
                                        2555
                                       .     .      .      .



CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  2

         1        22         X33                           1111XX   X
                  XX         X33             X2      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           5XX3
                XX          X              XXXX          .
         XX      .          X                        333
         XX                                          333
             .                                       335.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2X55
                                        2555
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  3

         1        22         X33                          1111XX   X
                  XX         X33             X2     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           5XX3
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XX5.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2X55
                                        2555
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  4

         1        22         X33                          1111XX   X
                  XX         X33             X2     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           5XX3
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XX5.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2555
                                        2555
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  5

         1        22         X33                          1111XX   X
                  XX         X33             X2      .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                                .
                                           5XX3
                XX          X              XXXX          .
         XX      .          X                         333
         XX                                           333
             .                                        335.

                 .     .       X    X  X X     XXX            .

                          .                    XXX
             X                                 XXX                 .
                     XX       . 3       1 X                        .
                     XX       .                    X X  XXX    .  . .
                              .......    2X55
                                         2555
                                        .     .      .      .


CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  6

         1        22         X33                          1111XX   X
                  XX         X33             X2      .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                                .
                                           5XX3
                XX          X              XXXX          .
         XX      .          X                         XXX
         XX                                           XXX
             .                                        XX5.

                 .     .       3    X  X X     XXX            .

                          .                    XXX
             X                                 XXX                 .
                     XX       . 3       1 X                        .
                     XX       .                    X X  XXX    .  . .
                              .......    2X55
                                         2555
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  7

         1        22         X33                           1111XX   X
                  XX         X33             X2     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXX3
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XX5.

                 .     .       3    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2555
                                        2555
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  8

                          OX       OY    RADIUS    DEGREES  GAMMA(RADIANS
         1        22         X33                           1111XX   X
                  XX         X33             X2     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXX3
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XX5.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2555
                                        2555
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME=  9

                  XX         X33             X2     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           5XX3
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XX5.

                 .     .       X    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2XX5
                                        2555
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=150 THRESH= 20.0   TIME= 10

         1        22         X33                          1111XX   X
                  XX         X33             X2     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .
                                           XXX3
                XX          X              XXXX         .
         XX      .          X                        XXX
         XX                                          XXX
             .                                       XX5.

                 .     .       3    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     XX      . 3       1 X                        .
                     XX      .                     X X  XXX  .  . .
                             .......    2555
                                        2555
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  1

         1        11         554                             1111XX   4
                  XX         333              22      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           3222
                XX          3              X333          .
         XX      .          4                         1X5
         XX                                           555
             .                                        555.

                 .     .      4    X  X X      XXX          .

                           .                   XXX
             X                                 XXX                  .
                     55      . 3       1 1                          .
                     XX      .                      6 X  666    .  ..
                             .......    1112
                                        1112
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  2

         1        11         554                             1111XX   4
                  XX         333              22      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           3222
                XX          3              X332          .
         XX      .          4                         115
         XX                                           555
             .                                        555.

                 .     .      4    X  X X      XXX          .

                           .                   XXX
             X                                 XXX                  .
                     55      . 3       1 1                          .
                     XX      .                      6 X  666    .  ..
                             .......    1112
                                        1112
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  3

         1        11         554                          1111XX    4
                  XX         333             22     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .

                                           3222
                XX          3              X332         .
         XX      .          X                        115
         XX                                          555
             .                                       555.

                 .     .       4     X  X X     XXX         .

                          .                     XXX
             X                                  XXX               .
                     55      . 3        1 1                       .
                     XX      .                      6 X 666  .  . .
                             .......    1112
                                        1112
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  4

         1        11         554                          1111XX    4
                  XX         333             22     .
                     XXXXX  Z   .  .    .    .     .   ...... .
                                                               .

                                           3222
                XX          3              X332         .
         XX      .          4                        115
         XX                                          555
             .                                       555.

                 .     .       4     X  X X     XXX         .

                          .                     XXX
             X                                  XXX               .
                     55      . 3        1 1                       .
                     XX      .                      6 X 666  .  . .
                             .......    1112
                                        1112
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  5

          1       11         554                            1111XX   4
                  XX         333              22     .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           3222
                XX          3              X332          .
         XX      .          4                         115
         XX                                           555
             .                                        555.

                 .      .      4    X  X X      XXX          .

                          .                     XXX
             X                                  XXX                .
                     55      . 3       1 1                         .
                     XX      .                     6 X  666   .  . .
                             .......    1112
                                        1112
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  6

          1       11         554                            1111XX   4
                  XX         333              22     .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           3222
                XX          3              X332          .
         XX      .          X                         115
         XX                                           555
             .                                        555.

                 .      .      4    X  X X      XXX          .

                          .                     XXX
             X                                  XXX                .
                     55      . 3       1 1                         .
                     XX      .                     6 X  666   .  . .
                             .......    1112
                                        1112
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  7

         1        11         554                             1111XX   4
                  XX         333             22      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           3222
                XX          3              X332          .
         XX      .          X                        115
         XX                                          555
             .                                       555.

                 .     .       4    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     55      . 3       1 1                        .
                     XX      .                     6 X  666  .  . .
                             .......    1112
                                        1112
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  8

         1        11         554                             1111XX   4
                  XX         333             22      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           3222
                XX          3              X332          .
         XX      .          X                        115
         XX                                          555
             .                                       555.

                 .     .       4    X  X X      XXX         .

                          .                     XXX
             X                                  XXX               .
                     55      . 3       1 1                        .
                     XX      .                     6 X  666  .  . .
                             .......    1112
                                        1112
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME=  9

         1        11         554                          1111XX   4
                  XX         333             22      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .

                                           3222
                XX           3             X332          .
         XX      .           X                       115
         XX                                          555
             .                                       555.

                 .     .       4    X  X X      XXX         .

                          .                     XXX
             X                                  XXX                .
                     55      . 3       1 1                         .
                     XX      .                     6 X  666  .  . .
                             .......    1112
                                        1112
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=220 THRESH= 20.0   TIME= 10

         1        11         554                          1111XX   4
                  XX         333             22      .
                     XXXXX  Z    .  .    .    .     .   ...... .
                                                                .
                                           3222
                XX           3             X332          .
         XX      .           4                       115
         XX                                          555
             .                                       555.

                 .     .       4    X  X X      XXX         .

                          .                     XXX
             X                                  XXX                .
                     55      . 3       1 1                         .
                     XX      .                     6 X  666  .  . .
                             .......    1112
                                        1112
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  1

         1        11         555                          155555   4
                  XX         444             11     .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                               .
                                           2221
                XX          3              2221         .
         XX      .          3                        555
         XX                                          555
             .                                       555.

                 .     .       4    3  X X      X55         .

                          .                     XX5
             X                                  X66               .
                     55      . 4       1 1                        .
                     55      .                     6 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  2

         1        11         555                          155555   4
                  XX         444             11     .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                               .
                                           2221
                XX          3              2221         .
         XX      .          3                        555
         XX                                          555
             .                                       555.

                 .     .       4    3  X X      X55         .

                          .                     XX5
             X                                  XX6               .
                     55      . 4       1 1                        .
                     55      .                     6 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  3

         1        11          555                          155555   4
                  XX          444             11     .
                     XXX33   Z   .  .    .    .     .   ...... .
                                                                .
                                            2221
                XX           3              2221         .
         XX       .          4                        555
         XX                                           555
              .                                       555.

                  .     .       4    3  X X      X55         .

                           .                     XX5
             X                                   X66               .
                     55       . 4       2 2                        .
                     55       .                    6 6   666  .  . .
                              .......    2111
                                         2111
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  4

         1        11          555                          155555   4
                  XX          444             11     .
                     XXX33   Z   .  .    .    .     .   ...... .
                                                                .
                                            2221
                XX           3              2221         .
         XX       .          3                        555
         XX                                           555
              .                                       555.

                  .     .       4    3  X X      X55         .

                           .                     XX5
             X                                   X66               .
                     55       . 4       2 2                        .
                     X5       .                    6 6   666  .  . .
                              .......    2111
                                         2111
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  5

         1        11         555                          155555   4
                  XX         444             11     .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                               .
                                           2221
                XX          3              2221         .
         XX     .           3                        555
         XX                                          555
             .                                       555.

                 .     .       4    X  X X      X55         .

                          .                     XX5
             X                                  X66               .
                     55     . 4       1 1                         .
                     55     .                    6 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  6

         1        11         555                          155555   4
                  XX         444             11     .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                               .
                                           2221
                XX          3              2221         .
         XX     .           4                        555
         XX                                          555
             .                                       555.

                 .     .       4    3  X X      X55         .

                          .                     XX5
             X                                  XX6               .
                     55     . 4       1 1                         .
                     55     .                    6 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  7

         1        11        555                           155555   4
                  XX        444             11       .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                                 .
                                           2221
                XX          3              2221                .
         XX      .          4                          555
         XX                                            555
             .                                         555.

                 .     .      4    3  X X      X55          .

                          .                    XX5
             X                                 XX6                  .
                     55      . 4       2 2                          .
                     55      .                    6 6  666  .  . .
                             .......    2111
                                        2111
                                       .     .      .      .

CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  8

         1        11        555                           155555   4
                  XX        444             11       .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                                 .
                                           2221
                XX          3              2221                .
         XX      .          4                          555
         XX                                            555
             .                                         555.

                 .     .      4    3  X X      X55          .

                          .                    XX5
             X                                 XX6                  .
                     55      . 4       1 1                          .
                     55      .                    6 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME=  9

         1        11         555                          155555   4
                  XX         444             11     .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                               .
                                           2221
                XX          3              2221         .
         XX     .           4                        555
         XX                                          555
             .                                       555.

                 .     .       4    3  X X      X55         .

                          .                     XX5
             X                                  X66               .
                     55      . 4       1 1                        .
                     55      .                     6 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .



CARDS=  20  SCALE= 50  SPEED=290 THRESH= 20.0   TIME= 10

         1        11         555                          155555   4
                  XX         444             11     .
                     XXX33  Z   .  .    .    .     .   ...... .
                                                               .
                                           2221
                XX          3              2221         .
         XX     .           4                        555
         XX                                          555
             .                                       555.

                 .     .       4    3  X X      X55         .

                          .                     XX5
             X                                  X66               .
                     55      . 4       2 2                        .
                     X5      .                     6 6  666  .  . .
                             .......    2111
                                        2111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  1

         1        11         222                             555555   5
                  XX         444             11     .
                     33333  Z   .  .    .    .     .   ...... .
                                                               .
                                           1111
                XX          5              1111         .
         XX     .           5                        555
         XX                                          553
             .                                       333.

                 .     .       5    4  3 1      555         .

                          .                     255
             X                                  225               .
                     55     . 4       3 2                         .
                     55     .                      5 6  666  .  . .
                             .......    2222
                                        2222
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  2

         1        11         222                             555555   5
                  XX         444             11     .
                     33333  Z   .  .    .    .     .   ...... .
                                                               .
                                           1111
                XX          5              1111         .
         XX     .           5                        555
         XX                                          553
             .                                       333.

                 .     .       5    4  3 1      555         .

                          .                     255
             X                                  225               .
                     55     . 4       3 2                         .
                     55     .                      5 6  666  .  . .
                             .......    2222
                                        2222
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  3

         1        11         222                           555555   5
                  XX         444              11     .
                     33333  Z    .  .    .    .     .   ...... .
                                                                .
                                            1111
                XX          5               1111         .
         XX      .          5                         555
         XX                                           553
              .                                       333.

                  .     .       5    4  3 1      555         .

                          .                      255
              X                                  225               .
                     55       . 4       3 1                        .
                     55       .                     5 6  666  .  . .
                              .......    1111
                                         1111
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  4

         1        11         222                           555555   5
                  XX         444              11     .
                     33333  Z    .  .    .    .     .   ...... .
                                                                .
                                            1111
                XX          5               1111         .
         XX      .          5                         555
         XX                                           553
              .                                       333.

                  .     .       5    4  3 1      555         .

                          .                      255
              X                                  225               .
                     55       . 4       3 1                        .
                     X5       .                     5 6  666  .  . .
                              .......    1111
                                         1111
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  5

         1        11         222                             555555   5
                  XX         444              11      .
                     33333  Z    .  .    .    .     .   ...... .
                                                                .

                                            1111
                XX          5               1111         .
         XX      .          5                         555
         XX                                           553
             .                                        333.

                 .     .       5    4  3 1      555         .

                           .                    255
             X                                  225                  .
                     55      . 4        3 1                          .
                     55      .                     5 6  666     .  . .
                             .......    1111
                                        1111
                                        .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  6

         1        11         222                            555555   5
                  XX         444              11      .
                     33333  Z   .  .    .    .     .   ...... .
                                                               .

                                           1111
                XX          5              1111         .
         XX       .         5                          555
         XX                                            553
             .                                         333.

                 .     .       5    4  3 1      555         .

                          .                     255
             X                                  225               .
                     55      . 4       3 1                        .
                     55      .                     5 6  666    .  .
                             .......    1111
                                        1111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  7

         1        11         222                          555555   5
                  XX         444             11     .
                     33333  Z   .  .    .    .     .   ...... .
                                                               .
                                           1111
                XX          5              1111         .
         XX     .           5                       555
         XX                                         553
             .                                      333.

                 .     .       5    4  3 1      555         .

                          .                     255
             X                                  225               .
                     55     . 4       3 2                         .
                     X5     .                      5 6  666  .  . .
                             .......    2222
                                        2222
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  8

         1        11         222                          555555   5
                  XX         444             11     .
                     33333  Z   .  .    .    .     .   ...... .
                                                               .
                                           1111
                XX          5              1111         .
         XX     .           5                       555
         XX                                         553
             .                                      333.

                 .     .       5    4  3 1      555         .

                          .                     255
             X                                  225               .
                     55     . 4       3 2                         .
                     55     .                      5 6  666  .  . .
                             .......    2222
                                        2222
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME=  9

         1        11         222                          555555   5
                  XX         444             11     .
                     33333  Z   .  .    .    .     .   ...... .
                                                               .
                                           1111
                XX          5              1111         .
         XX     .           5                        555
         XX                                          553
             .                                       333.

                 .     .       5    4  3 1      555         .

                          .                     255
             X                                  225               .
                     55     . 4       3 1                         .
                     55     .                     5 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=360 THRESH= 20.0   TIME= 10

         1        11         222                          555555   5
                  XX         444             11     .
                     33333  Z   .  .    .    .     .   ...... .
                                                               .
                                           1111
                XX          5              1111         .
         XX     .           5                        555
         XX                                          553
             .                                       333.

                 .     .       5    4  3 1      555         .

                          .                     255
             X                                  225               .
                     55     . 4       3 1                         .
                     55     .                     5 6  666  .  . .
                             .......    1111
                                        1111
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  1

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     2 5  666  .  . .
                             .......    3322
                                        3322
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  2

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     1 1  116  .  . .
                             .......    3311
                                        3311
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  3

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     2 5  666  .  . .
                             .......    3311
                                        3311
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  4

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          133
             .                                       133.

                 .     .       5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     1 1  116  .  . .
                             .......    3311
                                        3311
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  5

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .

                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    4  4 3      155         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     1 1  116  .  . .
                             .......    3322
                                        3322
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  6

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .

                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     2 5  666  .  . .
                             .......    3322
                                        3322
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  7

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     1 1  116  .  . .
                             .......    3322
                                        3322
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  8

         5        11         222                          555555   5
                  X3         555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     1 1  116  .  . .
                             .......    3322
                                        3322
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME=  9

         5        11          222                          555555   5
                  X3          555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .      .      5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     1 1  116  .  . .
                             .......    3322
                                        3322
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=430 THRESH= 20.0   TIME= 10

         5        11          222                          555555   5
                  X3          555             11     .
                     33344  Z   .  .    .    .     .   ...... .
                                                               .
                                           1115
                XX          5              1155         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .      .      5    4  4 3      122         .

                          .                     112
             X                                  111               .
                     55      . 5       4 3                        .
                     55      .                     1 1  116  .  . .
                             .......    3311
                                        3311
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  1

         5        11         111                          555555   5
                  33         555             11     .
                     44444  Z   .  .    .    .     .   ...... .
                                                               .
                                           5555
                33          5              5555         .
         XX      .          5                        133
         XX                                          133
             .                                       133.

                 .     .       5    5  4 4      111         .

                          .                     111
             X                                  222               .
                     55     . 5        4 4                        .
                     55     .                      2 1  111  .  . .
                             .......    4433
                                        4333
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  2

         5        11         111                          555555   5
                  33         555             11     .
                     44444  Z   .  .    .    .     .   ...... .
                                                               .
                                           5555
                33          5              5555         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    5  4 4      111         .

                          .                     111
             X                                  111               .
                     55     . 5        4 4                        .
                     55     .                      1 1  111  .  . .
                             .......    4433
                                        4333
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  3

         5        11         111                          555555   5
                  33         255             11      .
                     44444  Z    .  .    .    .     .   ...... .
                                                                .

                                           5555
                33          5              5555          .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .      .       5    5 4 4      111          .

                           .                    111
             X                                  222                .
                     55       . 5      4 4                         .
                     55       .                    2 1  555   .  . .
                              .......   4433
                                        4333
                                        .     .      .      .


CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  4

         5        11         111                          555555   5
                  33         555             11      .
                     44444  Z    .  .    .    .     .   ...... .
                                                                .
                                           5555
                33          5              5555          .
         XX      .          5                        333
         XX                                          333
             .                                       333.

             X                                  222                .
                     55       . 5      4 4                         .
                     55       .                    2 1  111   .  . .
                              .......   4433
                                        4333
                                        .     .      .      .

                 .      .       5    5 4 4      111          .
```

```
CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  5

         5        11         111                          555555   5
                  33         255             11     .
                     44444  Z   .  .    .    .     .   ...... .
                                                               .
                                           5555
                33          5              5555         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    5  4 4      111         .

                          .                     111
             X                                  222               .
                     55      . 5       4 4                        .
                     55      .                     2 1  555  .  . .
                             .......    4433
                                        4333
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  6

         5        11         111                          555555   5
                  33         555             11     .
                     44444  Z   .  .    .    .     .   ...... .
                                                               .
                                           5555
                33          5              5555         .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    5  4 4      111         .

                          .                     111
             X                                  111               .
                     55      . 5       4 4                        .
                     55      .                     1 1  555  .  . .
                             .......    4433
                                        4333
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  7

         5        11         111                           555555   5
                  33         555              11     .
                     44444  Z    .  .    .    .     .   ...... .
                                                                .
                                           5555
                33          5              5555          .
         XX      .          5                         333
         XX                                           333
             .                                        333.

                 .      .      5     5 4 4      111            .

                           .                    111
             X                                  111                .
                     55      . 5       4 4                         .
                     55      .                     1 1  555   .  . .
                             .......    4433
                                        4333
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  8

         5        11         111                           555555   5
                  33         225              11     .
                     44444  Z    .  .    .    .     .   ...... .
                                                                .
                                           5555
                33          5              5555          .
         XX      .          5                         333
         XX                                           333
             .                                        333.

                 .      .      5     5 4 4      111            .

                           .                    111
             X                                  111                .
                     55      . 5       4 4                         .
                     55      .                     1 1  111   .  . .
                             .......    4433
                                        4333
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME=  9

         5        11         111                            555555   5
                  33         555             11      .
                     44444  Z    .  .    .    .     .   ...... .
                                                                .
                                           5555
                33          5              5555          .
         XX      .          5                        333
         XX                                          333
             .                                       333.

                 .     .       5    5  4 4      111             .

                          .                     111
             X                                  111                .
                     55       . 5         4 4                      .
                     55       .                    1 1  111     .  .
                              .......     4433
                                          4333
                                       .     .      .      .


CARDS=  20  SCALE= 50  SPEED=500 THRESH= 20.0   TIME= 10

         5        11         111                            555555   5
                  33         555             11      .
                     44444  Z    .  .    .    .     .   ...... .
                                                                .
                                           5555
                33          5              5555          .
         XX      .          5                        133
         XX                                          133
             .                                       133.

                 .     .       5    5  4 4      111             .

                          .                     111
             X                                  111                .
                     55       . 5         4 4                      .
                     55       .                    1 1  555     .  .
                              .......     4433
                                          4333
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  1

         5        55         155                          555555   5
                  44         555             55     .
                     44555  Z   .  .    .    .     .   ...... .
                                                               .
                                           4453
                33          5              4441         .
         XX      .          5                        333
         XX                                          336
             .                                       222.

                 .     .       5    5  5 4      311         .

                          .                     311
             X                                  322               .
                     55      . 5       5 4                        .
                     55      .                     2 2  111  .  . .
                             .......    4444
                                        4444
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  2

         5        55         155                          555555   5
                  44         555             55     .
                     44555  Z   .  .    .    .     .   ...... .
                                                               .
                                           4453
                33          5              4441         .
         XX      .          5                        333
         XX                                          336
             .                                       322.

                 .     .       5    5  5 4      311         .

                          .                     311
             X                                  322               .
                     55      . 5       5 4                        .
                     55      .                     2 2  122  .  . .
                             .......    4444
                                        4444
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  3

         5        55         155                          555555   5
                  44         555             55      .
                     44555  Z   .  .    .    .     .   ......  .
                                                                .
                                           4453
                33          5              4441          .
         XX      .          5                        333
         XX                                          223
             .                                       222.

                 .     .       5    5  5 4      311          .

                          .                     311
             X                                  311                .
                     55      . 5       5 4                         .
                     55      .                     1 1  122   .  . .
                             .......    4444
                                        4444
                                       .     .       .      .
```

```
CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  4

         5        55         141                          555555   5
                  44         255             55      .
                     44555  Z   .  .    .    .     .   ......  .
                                                                .
                                           4453
                33          5              4441          .
         XX      .          5                        133
         XX                                          226
             .                                       222.

                 .     .       5    5  5 4      311          .

                          .                     311
             X                                  311                .
                     55      . 5       5 4                         .
                     55      .                     1 1  122   .  . .
                             .......    4444
                                        4444
                                       .     .       .      .
```

```
CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  5

         5        55         115                          555555   5
                  44         555             55     .
                     44555  Z   .  .    .    .     .   ...... .
                                                               .
                                           4453
                33          5              4441         .
         XX      .          5                        333
         XX                                          223
             .                                       222.

                 .     .       5    5  5 4      311           .

                          .                     311
             X                                  311               .
                     55      . 5       5 4                        .
                     55      .                     1 1  122  .  . .
                             .......    4444
                                        4444
                                       .     .      .      .



CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  6

         5        55         141                          555555   5
                  44         225             55     .
                     44555  Z   .  .    .    .     .   ...... .
                                                               .
                                           4453
                33          5              4441         .
         XX      .          5                        133
         XX                                          136
             .                                       222.

                 .     .       5    5  5 4      311           .

                          .                     311
             X                                  322               .
                     55      . 5       5 4                        .
                     55      .                     2 2  122  .  . .
                             .......    4444
                                        4444
                                       .     .      .      .
```

```
CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  7

        5         55          111                          555555   5
                  44          255              55     .
                     44555  Z    .  .    .    .     .   ......  .
                                                                 .
                                             4453
                33          5                4441       .
        XX        .         5                        333
        XX                                           223
            .                                        222.

                  .     .       5    5  5 4       311          .

                           .                      311
            X                                     311               .
                     55       . 5       5 4                         .
                     55       .                     1 1  122  .   . .
                              .......   4444
                                        4444
                                        .     .      .      .


CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  8

        5         55          145                          555555   5
                  44          255              55     .
                     44555  Z    .  .    .    .     .   ......  .
                                                                 .
                                             4453
                33          5                4441       .
        XX        .         5                        333
        XX                                           323
            .                                        222.

                  .     .       5    5  5 4       311          .

                           .                      311
            X                                     311               .
                     55       . 5       5 4                         .
                     55       .                     1 1  122  .   . .
                              .......   4444
                                        4444
                                        .     .      .      .
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```
CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME=  9

         5        55         115                          555555   5
                  44         555             55     .
                     44555  Z   .  .    .    .     .   ...... .
                                                               .
                                           4453
                33          5              4441         .
         XX     .           5                        333
         XX                                          336
             .                                       322.

                 .     .       5    5  5 4      311         .

                          .                     311
             X                                  311               .
                     55     . 5       5 4                         .
                     55     .                      1 1  111  .  . .
                             .......    4444
                                        4444
                                       .     .      .      .



CARDS=  20  SCALE= 50  SPEED=570 THRESH= 20.0   TIME= 10

         5        55         115                          555555   5
                  44         555             55     .
                     44555  Z   .  .    .    .     .   ...... .
                                                               .
                                           4453
                33          5              4441         .
         XX     .           5                        133
         XX                                          123
             .                                       222.

                 .     .       5    5  5 4      311         .

                          .                     311
             X                                  311               .
                     55     . 5       5 4                         .
                     55     .                      1 1  111  .  . .
                             .......    4444
                                        4444
                                       .     .      .      .
```

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	301	-.23966
11	18	11.402	11	-.39220
11	24	8.310	36	.07098
13	27	0.	20	.15408
15	30	2.549	100	-.19141
16	30	0.	326	.19559
17	30	.707	9	.16324
17	31	0.	53	.14496
17	32	0.	52	.12324
17	33	0.	45	.00284
17	34	0.	65	.36663
17	35	0.	66	.36689
17	36	6.021	35	.20985
19	40	11.402	38	.09246
19	46	0.	30	-.25464
19	53	0.	56	.20008
19	60	5.701	84	.36305
16	62	3.504	67	-.14453
16	65	0.	27	-.30463
16	67	1.118	74	.04476
15	67	0.	136	.02653
14	67	4.031	209	.31916
11	61	0.	198	.00059
9	57	3.579	154	-.33742
6	57	4.473	11	.37447
4	64	3.837	54	-.29109
3	63	2.236	210	.06204
3	61	0.	226	.02081
3	60	0.	205	-.34008
3	59	0.	229	.08087
3	58	0.	239	.26252
3	57	0.	211	-.23599
3	56	6.519	210	-.01262
2	53	2.236	225	.00114
3	52	5.000	231	-.03046
3	46	0.	238	.23186
3	41	0.	228	.06066
3	36	0.	218	-.11717

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	300	-.24390
11	18	11.402	37	.06525
11	24	8.310	26	-.10134
13	27	0.	2	-.16135
15	30	2.549	12	.21073
16	30	0.	328	.24341
17	30	.707	94	-.08097
17	31	0.	37	-.13547
17	32	0.	40	-.07643
17	33	0.	56	.19591
17	34	0.	49	.08612
17	35	0.	47	.04760
17	36	6.021	38	.26353
19	40	11.402	42	.15236
19	46	0.	38	-.11934
19	53	0.	35	-.16528
19	60	5.701	59	-.06300
16	62	3.504	79	.06701
16	65	0.	57	.20991
16	67	1.118	82	.19412
15	67	0.	131	-.05342
14	67	4.031	183	-.13634
11	61	0.	187	-.18314
9	57	3.579	158	-.26931
6	57	4.473	3	.21900
4	64	3.837	49	-.39126
3	63	2.236	205	-.01651
3	61	0.	242	.30245
3	60	0.	234	.17182
3	59	0.	205	-.34311
3	58	0.	224	-.01655
3	57	0.	216	-.15400
3	56	6.519	210	-.01142
2	53	2.236	218	-.11873
3	52	5.000	224	-.14975
3	46	0.	216	-.15528
3	41	0.	199	-.45000
3	36	0.	228	.06096

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	334	.34641
11	18	11.402	21	-.20662
11	24	8.310	38	.10049
13	27	0.	27	.28887
15	30	2.549	14	.25987
16	30	0.	302	-.21785
17	30	.707	12	.22523
17	31	0.	40	-.07305
17	32	0.	44	-.00965
17	33	0.	58	.24387
17	34	0.	47	.04156
17	35	0.	31	-.24102
17	36	6.021	23	.00829
19	40	11.402	37	.06974
19	46	0.	32	-.21715
19	53	0.	44	-.00700
19	60	5.701	67	.07988
16	62	3.504	84	.15460
16	65	0.	62	.30310
16	67	1.118	64	-.13102
15	67	0.	129	-.09316
14	67	4.031	207	.29016
11	61	0.	203	.08221
9	57	3.579	161	-.21524
6	57	4.473	3	.23201
4	64	3.837	68	-.05044
3	63	2.236	211	.08926
3	61	0.	237	.21684
3	60	0.	227	.04822
3	59	0.	224	-.01621
3	58	0.	214	-.18612
3	57	0.	227	.04643
3	56	6.519	217	.10863
2	53	2.236	215	-.16045
3	52	5.000	223	-.17279
3	46	0.	237	.21511
3	41	0.	232	.12620
3	36	0.	235	.17978

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	324	.17172
11	18	11.402	9	-.42720
11	24	8.310	25	-.12127
13	27	0.	31	.34874
15	30	2.549	91	-.02889
16	30	0.	312	-.03733
17	30	.707	29	.50799
17	31	0.	47	.04396
17	32	0.	48	.06119
17	33	0.	40	-.07889
17	34	0.	38	-.12186
17	35	0.	39	-.08748
17	36	6.021	33	.17938
19	40	11.402	60	.47042
19	46	0.	49	.07152
19	53	0.	29	-.27408
19	60	5.701	75	.20227
16	62	3.504	47	-.50340
16	65	0.	26	-.33115
16	67	1.118	8	.46802
15	67	0.	116	-.31463
14	67	4.031	202	.19304
11	61	0.	219	.37561
9	57	3.579	174	.01267
6	57	4.473	73	-.12667
4	64	3.837	85	.24724
3	63	2.236	208	.03391
3	61	0.	231	.11885
3	60	0.	250	.44692
3	59	0.	231	.11530
3	58	0.	212	-.22245
3	57	0.	215	-.17291
3	56	6.519	206	-.07076
2	53	2.236	212	-.22425
3	52	5.000	222	-.18188
3	46	0.	215	-.17029
3	41	0.	204	-.35316
3	36	0.	200	-.42241

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	332	.30802
11	18	11.402	20	-.23043
11	24	8.310	49	.30406
13	27	0.	22	.20015
15	30	2.549	92	-.04507
16	30	0.	315	.01093
17	30	.707	22	.39544
17	31	0.	63	.31876
17	32	0.	49	.08385
17	33	0.	43	-.02102
17	34	0.	33	-.20506
17	35	0.	39	-.10370
17	36	6.021	18	-.08596
19	40	11.402	18	-.25696
19	46	0.	48	.06611
19	53	0.	22	-.39202
19	60	5.701	50	-.23126
16	62	3.504	60	-.27562
16	65	0.	28	-.27970
16	67	1.118	77	.10604
15	67	0.	127	-.13604
14	67	4.031	181	-.16304
11	61	0.	273	-.37631
9	57	3.579	172	-.01357
6	57	4.473	75	-.09106
4	64	3.837	81	.17450
3	63	2.236	191	-.26422
3	61	0.	222	-.03560
3	60	0.	224	-.01658
3	59	0.	209	-.27567
3	58	0.	203	-.37274
3	57	0.	221	-.06563
3	56	6.519	212	.02515
2	53	2.236	223	-.02365
3	52	5.000	231	-.03138
3	46	0.	236	.20667
3	41	0.	204	-.36237
3	36	0.	214	-.17845

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.06493
11	18	11.402	15	-.30947
11	24	8.310	30	-.03662
13	27	0.	90	-.20636
15	30	2.549	5	.08789
16	30	0.	321	.11596
17	30	.707	9	.16137
17	31	0.	39	-.10310
17	32	0.	62	.31237
17	33	0.	23	-.37085
17	34	0.	33	-.20907
17	35	0.	54	.17389
17	36	6.021	40	.29619
19	40	11.402	56	.40439
19	46	0.	42	-.03786
19	53	0.	23	-.36910
19	60	5.701	43	-.35357
16	62	3.504	83	.12942
16	65	0.	60	.27152
16	67	1.118	60	-.19497
15	67	0.	138	.05862
14	67	4.031	204	.22440
11	61	0.	215	.30408
9	57	3.579	177	.06564
6	57	4.473	85	.08051
4	64	3.837	68	-.05126
3	63	2.236	214	.13937
3	61	0.	235	.18397
3	60	0.	212	-.21057
3	59	0.	217	-.12443
3	58	0.	229	.07927
3	57	0.	220	-.07882
3	56	6.519	227	.28361
2	53	2.236	232	.13791
3	52	5.000	250	.29963
3	46	0.	218	-.10661
3	41	0.	216	-.15076
3	36	0.	238	.22813

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.03479
11	18	11.402	33	-.01185
11	24	8.310	7	-.42725
13	27	0.	4	-.11829
15	30	2.549	6	.10882
16	30	0.	320	.09810
17	30	.707	2	.04316
17	31	0.	52	.13030
17	32	0.	51	.11080
17	33	0.	46	.02745
17	34	0.	39	-.09320
17	35	0.	66	.37479
17	36	6.021	27	.06947
19	40	11.402	27	-.11608
19	46	0.	60	.27324
19	53	0.	46	.02864
19	60	5.701	49	-.23935
16	62	3.504	58	-.30470
16	65	0.	34	-.18370
16	67	1.118	59	-.20818
15	67	0.	123	-.19320
14	67	4.031	201	.18604
11	61	0.	188	-.17232
9	57	3.579	150	-.40357
6	57	4.473	88	.14589
4	64	3.837	85	.24065
3	63	2.236	212	.10433
3	61	0.	228	.05418
3	60	0.	239	.25858
3	59	0.	241	.29057
3	58	0.	226	.02647
3	57	0.	215	-.15726
3	56	6.519	225	.25746
2	53	2.236	223	-.01950
3	52	5.000	213	-.33853
3	46	0.	200	-.41868
3	41	0.	219	-.10334
3	36	0.	221	-.06721

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	309	-.08696
11	18	11.402	42	.15065
11	24	8.310	24	-.14383
13	27	0.	1	-.16494
15	30	2.549	93	-.05748
16	30	0.	320	.09377
17	30	.707	5	.09185
17	31	0.	50	.10072
17	32	0.	62	.30203
17	33	0.	38	-.12061
17	34	0.	54	.17231
17	35	0.	37	-.13925
17	36	6.021	31	.14342
19	40	11.402	27	-.10808
19	46	0.	36	-.14775
19	53	0.	38	-.11364
19	60	5.701	73	.17281
16	62	3.504	88	.22704
16	65	0.	40	-.07819
16	67	1.118	5	.42321
15	67	0.	123	-.20400
14	67	4.031	195	.08158
11	61	0.	280	-.51069
9	57	3.579	90	.11759
6	57	4.473	87	.12539
4	64	3.837	77	.10041
3	63	2.236	227	.37038
3	61	0.	220	-.07522
3	60	0.	222	-.05024
3	59	0.	215	-.17165
3	58	0.	233	.15760
3	57	0.	204	-.34961
3	56	6.519	210	-.00979
2	53	2.236	210	-.24512
3	52	5.000	231	-.03447
3	46	0.	224	-.00589
3	41	0.	205	-.33133
3	36	0.	219	-.09554

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	331	.29570
11	18	11.402	51	.31830
11	24	8.310	33	.01259
13	27	0.	91	-.22020
15	30	2.549	98	-.14286
16	30	0.	308	-.12014
17	30	.707	0	.00594
17	31	0.	54	.17016
17	32	0.	39	-.09638
17	33	0.	40	-.07164
17	34	0.	71	.46319
17	35	0.	25	-.33790
17	36	6.021	4	-.32165
19	40	11.402	35	.03000
19	46	0.	40	-.07959
19	53	0.	22	-.38858
19	60	5.701	76	.22554
16	62	3.504	82	.10712
16	65	0.	47	.05217
16	67	1.118	0	.32514
15	67	0.	150	.27243
14	67	4.031	199	.14061
11	61	0.	195	-.05422
9	57	3.579	179	.10053
6	57	4.473	79	-.01845
4	64	3.837	69	-.02931
3	63	2.236	220	.24314
3	61	0.	216	-.14129
3	60	0.	230	.10020
3	59	0.	233	.14260
3	58	0.	214	-.17859
3	57	0.	207	-.30755
3	56	6.519	222	.19750
2	53	2.236	244	.34606
3	52	5.000	237	.06929
3	46	0.	237	.22722
3	41	0.	226	.02486
3	36	0.	225	.00787

CARDS= 20 SCALE= 10 SPEED= 80 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	308	-.11425
11	18	11.402	38	.08441
11	24	8.310	25	-.11748
13	27	0.	0	-.18160
15	30	2.549	5	.08979
16	30	0.	299	-.27607
17	30	.707	91	-.03260
17	31	0.	62	.30454
17	32	0.	35	-.15897
17	33	0.	48	.06389
17	34	0.	51	.10543
17	35	0.	44	-.01192
17	36	6.021	28	.09884
19	40	11.402	43	.16476
19	46	0.	57	.21905
19	53	0.	36	-.14520
19	60	5.701	65	.04301
16	62	3.504	68	-.13198
16	65	0.	52	.13470
16	67	1.118	67	-.06669
15	67	0.	123	-.20889
14	67	4.031	221	.52778
11	61	0.	194	-.07052
9	57	3.579	171	-.04559
6	57	4.473	83	.04644
4	64	3.837	72	.01696
3	63	2.236	213	.12211
3	61	0.	243	.31799
3	60	0.	233	.15580
3	59	0.	215	-.16511
3	58	0.	235	.19043
3	57	0.	232	.12993
3	56	6.519	219	.15274
2	53	2.236	224	-.00343
3	52	5.000	208	-.43306
3	46	0.	221	-.06412
3	41	0.	232	.13585
3	36	0.	234	.16580

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.01215
11	18	11.402	29	-.07574
11	24	8.310	27	-.09389
13	27	0.	15	.06961
15	30	2.549	3	.05631
16	30	0.	313	-.03254
17	30	.707	95	-.09053
17	31	0.	44	-.01078
17	32	0.	49	.08457
17	33	0.	39	-.08973
17	34	0.	47	.03575
17	35	0.	40	-.07758
17	36	6.021	27	.07090
19	40	11.402	44	.18418
19	46	0.	41	-.05478
19	53	0.	52	.12997
19	60	5.701	63	.00190
16	62	3.504	73	-.04509
16	65	0.	38	-.11077
16	67	1.118	75	.06397
15	67	0.	127	-.13022
14	67	4.031	208	.29752
11	61	0.	186	-.20605
9	57	3.579	168	-.08886
6	57	4.473	78	-.03111
4	64	3.837	69	-.03924
3	63	2.236	194	-.21686
3	61	0.	219	-.10249
3	60	0.	226	.02495
3	59	0.	225	.01489
3	58	0.	247	.39216
3	57	0.	222	-.05119
3	56	6.519	206	-.08102
2	53	2.236	227	.04750
3	52	5.000	229	-.06069
3	46	0.	220	-.08482
3	41	0.	220	-.07492
3	36	0.	215	-.17143

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	305	-.15731
11	18	11.402	36	.04515
11	24	8.310	25	-.11867
13	27	0.	7	-.07078
15	30	2.549	92	-.03928
16	30	0.	321	.11863
17	30	.707	93	-.05804
17	31	0.	48	.06099
17	32	0.	57	.22189
17	33	0.	52	.13455
17	34	0.	49	.07121
17	35	0.	43	-.03177
17	36	6.021	14	-.15981
19	40	11.402	25	-.14669
19	46	0.	45	.01680
19	53	0.	35	-.16074
19	60	5.701	65	.04389
16	62	3.504	75	.00065
16	65	0.	44	-.00585
16	67	1.118	77	.10048
15	67	0.	135	.01347
14	67	4.031	192	.02536
11	61	0.	182	-.27284
9	57	3.579	91	.13859
6	57	4.473	79	-.01857
4	64	3.837	66	-.09223
3	63	2.236	201	-.08273
3	61	0.	226	.02802
3	60	0.	218	-.10971
3	59	0.	218	-.11450
3	58	0.	224	-.00554
3	57	0.	221	-.06674
3	56	6.519	217	.11039
2	53	2.236	227	.05160
3	52	5.000	231	-.02195
3	46	0.	231	.12252
3	41	0.	223	-.03216
3	36	0.	222	-.04175

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	314	-.00084
11	18	11.402	45	.21288
11	24	8.310	28	-.07008
13	27	0.	7	-.06844
15	30	2.549	8	.15474
16	30	0.	307	-.13197
17	30	.707	7	.12946
17	31	0.	43	-.01980
17	32	0.	42	-.04119
17	33	0.	51	.12065
17	34	0.	44	-.00501
17	35	0.	43	-.02674
17	36	6.021	24	.01714
19	40	11.402	22	-.18754
19	46	0.	51	.11005
19	53	0.	43	-.03302
19	60	5.701	60	-.04682
16	62	3.504	68	-.13619
16	65	0.	48	.06986
16	67	1.118	75	.06299
15	67	0.	139	.08237
14	67	4.031	191	.00595
11	61	0.	191	-.12448
9	57	3.579	173	.00092
6	57	4.473	78	-.03516
4	64	3.837	76	.08313
3	63	2.236	206	-.00642
3	61	0.	233	.15227
3	60	0.	224	-.00037
3	59	0.	223	-.02017
3	58	0.	219	-.10057
3	57	0.	209	-.27187
3	56	6.519	214	.05611
2	53	2.236	220	-.07218
3	52	5.000	234	.02424
3	46	0.	226	.02594
3	41	0.	224	-.00332
3	36	0.	227	.04938

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	324	.17436
11	18	11.402	27	-.10737
11	24	8.310	33	.01944
13	27	0.	2	-.16049
15	30	2.549	97	-.13895
16	30	0.	308	-.11513
17	30	.707	1	.02585
17	31	0.	47	.05108
17	32	0.	33	-.20521
17	33	0.	44	-.01500
17	34	0.	45	.00575
17	35	0.	42	-.05131
17	36	6.021	29	.10208
19	40	11.402	30	-.05332
19	46	0.	42	-.04012
19	53	0.	46	.02601
19	60	5.701	63	.00414
16	62	3.504	73	-.04424
16	65	0.	44	-.00403
16	67	1.118	71	-.00793
15	67	0.	129	-.09340
14	67	4.031	182	-.14654
11	61	0.	194	-.06499
9	57	3.579	170	-.05064
6	57	4.473	72	-.14835
4	64	3.837	75	.07148
3	63	2.236	213	.12774
3	61	0.	216	-.14127
3	60	0.	229	.07884
3	59	0.	213	-.19227
3	58	0.	221	-.05480
3	57	0.	229	.07397
3	56	6.519	217	.10982
2	53	2.236	217	-.12443
3	52	5.000	237	.07493
3	46	0.	227	.04336
3	41	0.	233	.14072
3	36	0.	225	.01789

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.05348
11	18	11.402	28	-.08807
11	24	8.310	33	.02584
13	27	0.	2	-.14856
15	30	2.549	10	.18360
16	30	0.	318	.05760
17	30	.707	103	-.23354
17	31	0.	49	.07147
17	32	0.	49	.07108
17	33	0.	55	.17643
17	34	0.	39	-.09406
17	35	0.	42	-.05113
17	36	6.021	15	-.12765
19	40	11.402	20	-.22222
19	46	0.	39	-.09771
19	53	0.	40	-.07681
19	60	5.701	74	.18515
16	62	3.504	78	.04604
16	65	0.	49	.07432
16	67	1.118	68	-.05869
15	67	0.	135	.00618
14	67	4.031	192	.02848
11	61	0.	199	.01124
9	57	3.579	91	.13157
6	57	4.473	88	.14655
4	64	3.837	85	.24886
3	63	2.236	200	-.10213
3	61	0.	227	.03609
3	60	0.	216	-.14539
3	59	0.	223	-.02800
3	58	0.	225	.01697
3	57	0.	216	-.14415
3	56	6.519	203	-.12447
2	53	2.236	228	.06818
3	52	5.000	227	-.10182
3	46	0.	241	.29422
3	41	0.	223	-.03324
3	36	0.	214	-.18068

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	319	.07383
11	18	11.402	36	.05348
11	24	8.310	25	-.11477
13	27	0.	12	.01616
15	30	2.549	17	.30494
16	30	0.	318	.05959
17	30	.707	1	.01797
17	31	0.	50	.09480
17	32	0.	45	.00026
17	33	0.	35	-.16174
17	34	0.	40	-.07570
17	35	0.	52	.13221
17	36	6.021	29	.11621
19	40	11.402	23	-.17955
19	46	0.	41	-.06399
19	53	0.	43	-.02182
19	60	5.701	62	-.00856
16	62	3.504	59	-.28934
16	65	0.	38	-.10935
16	67	1.118	65	-.11192
15	67	0.	145	.18979
14	67	4.031	201	.18032
11	61	0.	196	-.03775
9	57	3.579	166	-.11763
6	57	4.473	74	-.09971
4	64	3.837	68	-.04590
3	63	2.236	201	-.08206
3	61	0.	222	-.04833
3	60	0.	222	-.03663
3	59	0.	234	.16390
3	58	0.	228	.07037
3	57	0.	218	-.10821
3	56	6.519	213	.03645
2	53	2.236	220	-.08367
3	52	5.000	227	-.10533
3	46	0.	227	.04378
3	41	0.	232	.12741
3	36	0.	226	.02991

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.06765
11	18	11.402	38	.08234
11	24	8.310	29	-.04849
13	27	0.	17	.10646
15	30	2.549	98	-.15180
16	30	0.	317	.04317
17	30	.707	8	.14191
17	31	0.	44	-.00214
17	32	0.	46	.02410
17	33	0.	46	.02546
17	34	0.	43	-.02412
17	35	0.	54	.16438
17	36	6.021	24	.01487
19	40	11.402	28	-.08944
19	46	0.	56	.20925
19	53	0.	48	.05547
19	60	5.701	56	-.11976
16	62	3.504	69	-.11414
16	65	0.	48	.05486
16	67	1.118	69	-.03655
15	67	0.	143	.14567
14	67	4.031	205	.25615
11	61	0.	205	.12038
9	57	3.579	164	-.16692
6	57	4.473	2	.20967
4	64	3.837	71	.00155
3	63	2.236	202	-.07844
3	61	0.	230	.09706
3	60	0.	228	.05960
3	59	0.	227	.04897
3	58	0.	232	.12718
3	57	0.	239	.25260
3	56	6.519	196	-.25436
2	53	2.236	232	.12328
3	52	5.000	236	.06523
3	46	0.	217	-.13008
3	41	0.	223	-.02487
3	36	0.	224	-.00511

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.03778
11	18	11.402	27	-.11647
11	24	8.310	38	.11220
13	27	0.	7	-.07025
15	30	2.549	102	-.21557
16	30	0.	311	-.06781
17	30	.707	103	-.23550
17	31	0.	35	-.16216
17	32	0.	43	-.02107
17	33	0.	37	-.12489
17	34	0.	48	.06311
17	35	0.	59	.24507
17	36	6.021	22	-.01718
19	40	11.402	26	-.12167
19	46	0.	38	-.10785
19	53	0.	50	.09455
19	60	5.701	62	-.01038
16	62	3.504	73	-.03817
16	65	0.	54	.17304
16	67	1.118	78	.12814
15	67	0.	128	-.11791
14	67	4.031	185	-.10678
11	61	0.	194	-.06330
9	57	3.579	161	-.21635
6	57	4.473	85	.08289
4	64	3.837	83	.20675
3	63	2.236	214	.14197
3	61	0.	227	.04597
3	60	0.	218	-.11549
3	59	0.	220	-.07073
3	58	0.	229	.08315
3	57	0.	225	.00911
3	56	6.519	205	-.08832
2	53	2.236	229	.07926
3	52	5.000	240	.12549
3	46	0.	222	-.05078
3	41	0.	230	.09613
3	36	0.	218	-.10583

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	320	.09043
11	18	11.402	41	.13237
11	24	8.310	21	-.18976
13	27	0.	4	-.11363
15	30	2.549	96	-.11548
16	30	0.	320	.09336
17	30	.707	6	.11044
17	31	0.	51	.10995
17	32	0.	33	-.19685
17	33	0.	45	.00675
17	34	0.	50	.09618
17	35	0.	43	-.01932
17	36	6.021	33	.17422
19	40	11.402	14	-.32803
19	46	0.	46	.03088
19	53	0.	49	.07927
19	60	5.701	55	-.13160
16	62	3.504	72	-.06422
16	65	0.	38	-.10613
16	67	1.118	76	.08857
15	67	0.	131	-.06597
14	67	4.031	181	-.17440
11	61	0.	207	.15991
9	57	3.579	169	-.07670
6	57	4.473	84	.07449
4	64	3.837	78	.12698
3	63	2.236	193	-.21957
3	61	0.	216	-.14574
3	60	0.	221	-.06044
3	59	0.	226	.02564
3	58	0.	236	.20189
3	57	0.	224	-.00381
3	56	6.519	210	.00107
2	53	2.236	222	-.03764
3	52	5.000	246	.22741
3	46	0.	231	.10718
3	41	0.	235	.19019
3	36	0.	218	-.10471

CARDS= 20 SCALE= 10 SPEED=150 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	330	.26976
11	18	11.402	34	.00856
11	24	8.310	33	.01924
13	27	0.	16	.08853
15	30	2.549	7	.13251
16	30	0.	329	.25615
17	30	.707	12	.22271
17	31	0.	49	.08143
17	32	0.	51	.11173
17	33	0.	44	-.00415
17	34	0.	47	.03802
17	35	0.	55	.18829
17	36	6.021	17	-.09707
19	40	11.402	27	-.11370
19	46	0.	34	-.17902
19	53	0.	31	-.22746
19	60	5.701	67	.06735
16	62	3.504	72	-.05576
16	65	0.	46	.03455
16	67	1.118	63	-.14546
15	67	0.	127	-.13486
14	67	4.031	192	.01322
11	61	0.	201	.06010
9	57	3.579	173	-.00804
6	57	4.473	78	-.03051
4	64	3.837	72	.02052
3	63	2.236	204	-.04294
3	61	0.	224	-.00045
3	60	0.	219	-.10255
3	59	0.	227	.03731
3	58	0.	240	.27223
3	57	0.	220	-.07124
3	56	6.519	215	.08393
2	53	2.236	228	.06990
3	52	5.000	242	.16630
3	46	0.	223	-.02286
3	41	0.	221	-.06144
3	36	0.	230	.09449

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	301	-.23966
11	18	11.402	11	-.39220
11	24	8.310	36	.07098
13	27	0.	20	.15408
15	30	2.549	100	-.19141
16	30	0.	326	.19559
17	30	.707	9	.16324
17	31	0.	53	.14496
17	32	0.	52	.12324
17	33	0.	45	.00284
17	34	0.	65	.36663
17	35	0.	66	.36689
17	36	6.021	35	.20985
19	40	11.402	38	.09246
19	46	0.	30	-.25464
19	53	0.	56	.20008
19	60	5.701	84	.36305
16	62	3.504	67	-.14453
16	65	0.	27	-.30463
16	67	1.118	74	.04476
15	67	0.	136	.02653
14	67	4.031	209	.31916
11	61	0.	198	.00059
9	57	3.579	154	-.33742
6	57	4.473	11	.37447
4	64	3.837	54	-.29109
3	63	2.236	210	.06204
3	61	0.	226	.02081
3	60	0.	205	-.34008
3	59	0.	229	.08087
3	58	0.	239	.26252
3	57	0.	211	-.23599
3	56	6.519	210	-.01262
2	53	2.236	225	.00114
3	52	5.000	231	-.03046
3	46	0.	238	.23186
3	41	0.	228	.06066
3	36	0.	218	-.11717

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	300	-.24390
11	18	11.402	37	.06525
11	24	8.310	26	-.10134
13	27	0.	2	-.16135
15	30	2.549	12	.21073
16	30	0.	328	.24341
17	30	.707	94	-.08097
17	31	0.	37	-.13547
17	32	0.	40	-.07643
17	33	0.	56	.19591
17	34	0.	49	.08612
17	35	0.	47	.04760
17	36	6.021	38	.26353
19	40	11.402	42	.15236
19	46	0.	38	-.11934
19	53	0.	35	-.16528
19	60	5.701	59	-.06300
16	62	3.504	79	.06701
16	65	0.	57	.20991
16	67	1.118	82	.19412
15	67	0.	131	-.05342
14	67	4.031	183	-.13634
11	61	0.	187	-.18314
9	57	3.579	158	-.26931
6	57	4.473	3	.21900
4	64	3.837	49	-.39126
3	63	2.236	205	-.01651
3	61	0.	242	.30245
3	60	0.	234	.17182
3	59	0.	205	-.34311
3	58	0.	224	-.01655
3	57	0.	216	-.15400
3	56	6.519	210	-.01142
2	53	2.236	218	-.11873
3	52	5.000	224	-.14975
3	46	0.	216	-.15528
3	41	0.	199	-.45000
3	36	0.	228	.06096

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	334	.34641
11	18	11.402	21	-.20662
11	24	8.310	38	.10049
13	27	0.	27	.28887
15	30	2.549	14	.25987
16	30	0.	302	-.21785
17	30	.707	12	.22523
17	31	0.	40	-.07305
17	32	0.	44	-.00965
17	33	0.	58	.24387
17	34	0.	47	.04156
17	35	0.	31	-.24102
17	36	6.021	23	.00829
19	40	11.402	37	.06974
19	46	0.	32	-.21715
19	53	0.	44	-.00700
19	60	5.701	67	.07988
16	62	3.504	84	.15460
16	65	0.	62	.30310
16	67	1.118	64	-.13102
15	67	0.	129	-.09316
14	67	4.031	207	.29016
11	61	0.	203	.08221
9	57	3.579	161	-.21524
6	57	4.473	3	.23201
4	64	3.837	68	-.05044
3	63	2.236	211	.08926
3	61	0.	237	.21684
3	60	0.	227	.04822
3	59	0.	224	-.01621
3	58	0.	214	-.18612
3	57	0.	227	.04643
3	56	6.519	217	.10863
2	53	2.236	215	-.16045
3	52	5.000	223	-.17279
3	46	0.	237	.21511
3	41	0.	232	.12620
3	36	0.	235	.17978

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	324	.17172
11	18	11.402	9	-.42720
11	24	8.310	25	-.12127
13	27	0.	31	.34874
15	30	2.549	91	-.02889
16	30	0.	312	-.03733
17	30	.707	29	.50799
17	31	0.	47	.04396
17	32	0.	48	.06119
17	33	0.	40	-.07889
17	34	0.	38	-.12186
17	35	0.	39	-.08748
17	36	6.021	33	.17938
19	40	11.402	60	.47042
19	46	0.	49	.07152
19	53	0.	29	-.27408
19	60	5.701	75	.20227
16	62	3.504	47	-.50340
16	65	0.	26	-.33115
16	67	1.118	8	.46802
15	67	0.	116	-.31463
14	67	4.031	202	.19304
11	61	0.	219	.37561
9	57	3.579	174	.01267
6	57	4.473	73	-.12667
4	64	3.837	85	.24724
3	63	2.236	208	.03391
3	61	0.	231	.11885
3	60	0.	250	.44692
3	59	0.	231	.11530
3	58	0.	212	-.22245
3	57	0.	215	-.17291
3	56	6.519	206	-.07076
2	53	2.236	212	-.22425
3	52	5.000	222	-.18188
3	46	0.	215	-.17029
3	41	0.	204	-.35316
3	36	0.	200	-.42241

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	332	.30802
11	18	11.402	20	-.23043
11	24	8.310	49	.30406
13	27	0.	22	.20015
15	30	2.549	92	-.04507
16	30	0.	315	.01093
17	30	.707	22	.39544
17	31	0.	63	.31876
17	32	0.	49	.08385
17	33	0.	43	-.02102
17	34	0.	33	-.20506
17	35	0.	39	-.10370
17	36	6.021	18	-.08596
19	40	11.402	18	-.25696
19	46	0.	48	.06611
19	53	0.	22	-.39202
19	60	5.701	50	-.23126
16	62	3.504	60	-.27562
16	65	0.	28	-.27970
16	67	1.118	77	.10604
15	67	0.	127	-.13604
14	67	4.031	181	-.16304
11	61	0.	273	-.37631
9	57	3.579	172	-.01357
6	57	4.473	75	-.09106
4	64	3.837	81	.17450
3	63	2.236	191	-.26422
3	61	0.	222	-.03560
3	60	0.	224	-.01658
3	59	0.	209	-.27567
3	58	0.	203	-.37274
3	57	0.	221	-.06563
3	56	6.519	212	.02515
2	53	2.236	223	-.02365
3	52	5.000	231	-.03138
3	46	0.	236	.20667
3	41	0.	204	-.36237
3	36	0.	214	-.17845

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.06493
11	18	11.402	15	-.30947
11	24	8.310	30	-.03662
13	27	0.	90	-.20636
15	30	2.549	5	.08789
16	30	0.	321	.11596
17	30	.707	9	.16137
17	31	0.	39	-.10310
17	32	0.	62	.31237
17	33	0.	23	-.37085
17	34	0.	33	-.20907
17	35	0.	54	.17389
17	36	6.021	40	.29619
19	40	11.402	56	.40439
19	46	0.	42	-.03786
19	53	0.	23	-.36910
19	60	5.701	43	-.35357
16	62	3.504	83	.12942
16	65	0.	60	.27152
16	67	1.118	60	-.19497
15	67	0.	138	.05862
14	67	4.031	204	.22440
11	61	0.	215	.30408
9	57	3.579	177	.06564
6	57	4.473	85	.08051
4	64	3.837	68	-.05126
3	63	2.236	214	.13937
3	61	0.	235	.18397
3	60	0.	212	-.21057
3	59	0.	217	-.12443
3	58	0.	229	.07927
3	57	0.	220	-.07882
3	56	6.519	227	.28361
2	53	2.236	232	.13791
3	52	5.000	250	.29963
3	46	0.	218	-.10661
3	41	0.	216	-.15076
3	36	0.	238	.22813

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.03479
11	18	11.402	33	-.01185
11	24	8.310	7	-.42725
13	27	0.	4	-.11829
15	30	2.549	6	.10882
16	30	0.	320	.09810
17	30	.707	2	.04316
17	31	0.	52	.13030
17	32	0.	51	.11080
17	33	0.	46	.02745
17	34	0.	39	-.09320
17	35	0.	66	.37479
17	36	6.021	27	.06947
19	40	11.402	27	-.11608
19	46	0.	60	.27324
19	53	0.	46	.02864
19	60	5.701	49	-.23935
16	62	3.504	58	-.30470
16	65	0.	34	-.18370
16	67	1.118	59	-.20818
15	67	0.	123	-.19320
14	67	4.031	201	.18604
11	61	0.	188	-.17232
9	57	3.579	150	-.40357
6	57	4.473	88	.14589
4	64	3.837	85	.24065
3	63	2.236	212	.10433
3	61	0.	228	.05418
3	60	0.	239	.25858
3	59	0.	241	.29057
3	58	0.	226	.02647
3	57	0.	215	-.15726
3	56	6.519	225	.25746
2	53	2.236	223	-.01950
3	52	5.000	213	-.33853
3	46	0.	200	-.41868
3	41	0.	219	-.10334
3	36	0.	221	-.06721

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	309	-.08696
11	18	11.402	42	.15065
11	24	8.310	24	-.14383
13	27	0.	1	-.16494
15	30	2.549	93	-.05748
16	30	0.	320	.09377
17	30	.707	5	.09185
17	31	0.	50	.10072
17	32	0.	62	.30203
17	33	0.	38	-.12061
17	34	0.	54	.17231
17	35	0.	37	-.13925
17	36	6.021	31	.14342
19	40	11.402	27	-.10808
19	46	0.	36	-.14775
19	53	0.	38	-.11364
19	60	5.701	73	.17281
16	62	3.504	88	.22704
16	65	0.	40	-.07819
16	67	1.118	5	.42321
15	67	0.	123	-.20400
14	67	4.031	195	.08158
11	61	0.	280	-.51069
9	57	3.579	90	.11759
6	57	4.473	87	.12539
4	64	3.837	77	.10041
3	63	2.236	227	.37038
3	61	0.	220	-.07522
3	60	0.	222	-.05024
3	59	0.	215	-.17165
3	58	0.	233	.15760
3	57	0.	204	-.34961
3	56	6.519	210	-.00979
2	53	2.236	210	-.24512
3	52	5.000	231	-.03447
3	46	0.	224	-.00589
3	41	0.	205	-.33133
3	36	0.	219	-.09554

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	331	.29570
11	18	11.402	51	.31830
11	24	8.310	33	.01259
13	27	0.	91	-.22020
15	30	2.549	98	-.14286
16	30	0.	308	-.12014
17	30	.707	0	.00594
17	31	0.	54	.17016
17	32	0.	39	-.09638
17	33	0.	40	-.07164
17	34	0.	71	.46319
17	35	0.	25	-.33790
17	36	6.021	4	-.32165
19	40	11.402	35	.03000
19	46	0.	40	-.07959
19	53	0.	22	-.38858
19	60	5.701	76	.22554
16	62	3.504	82	.10712
16	65	0.	47	.05217
16	67	1.118	0	.32514
15	67	0.	150	.27243
14	67	4.031	199	.14061
11	61	0.	195	-.05422
9	57	3.579	179	.10053
6	57	4.473	79	-.01845
4	64	3.837	69	-.02931
3	63	2.236	220	.24314
3	61	0.	216	-.14129
3	60	0.	230	.10020
3	59	0.	233	.14260
3	58	0.	214	-.17859
3	57	0.	207	-.30755
3	56	6.519	222	.19750
2	53	2.236	244	.34606
3	52	5.000	237	.06929
3	46	0.	237	.22722
3	41	0.	226	.02486
3	36	0.	225	.00787

CARDS= 20 SCALE= 50 SPEED= 80 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	308	-.11425
11	18	11.402	38	.08441
11	24	8.310	25	-.11748
13	27	0.	0	-.18160
15	30	2.549	5	.08979
16	30	0.	299	-.27607
17	30	.707	91	-.03260
17	31	0.	62	.30454
17	32	0.	35	-.15897
17	33	0.	48	.06389
17	34	0.	51	.10543
17	35	0.	44	-.01192
17	36	6.021	28	.09884
19	40	11.402	43	.16476
19	46	0.	57	.21905
19	53	0.	36	-.14520
19	60	5.701	65	.04301
16	62	3.504	68	-.13198
16	65	0.	52	.13470
16	67	1.118	67	-.06669
15	67	0.	123	-.20889
14	67	4.031	221	.52778
11	61	0.	194	-.07052
9	57	3.579	171	-.04559
6	57	4.473	83	.04644
4	64	3.837	72	.01696
3	63	2.236	213	.12211
3	61	0.	243	.31799
3	60	0.	233	.15580
3	59	0.	215	-.16511
3	58	0.	235	.19043
3	57	0.	232	.12993
3	56	6.519	219	.15274
2	53	2.236	224	-.00343
3	52	5.000	208	-.43306
3	46	0.	221	-.06412
3	41	0.	232	.13585
3	36	0.	234	.16580

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.01215
11	18	11.402	29	-.07574
11	24	8.310	27	-.09389
13	27	0.	15	.06961
15	30	2.549	3	.05631
16	30	0.	313	-.03254
17	30	.707	95	-.09053
17	31	0.	44	-.01078
17	32	0.	49	.08457
17	33	0.	39	-.08973
17	34	0.	47	.03575
17	35	0.	40	-.07758
17	36	6.021	27	.07090
19	40	11.402	44	.18418
19	46	0.	41	-.05478
19	53	0.	52	.12997
19	60	5.701	63	.00190
16	62	3.504	73	-.04509
16	65	0.	38	-.11077
16	67	1.118	75	.06397
15	67	0.	127	-.13022
14	67	4.031	208	.29752
11	61	0.	186	-.20605
9	57	3.579	168	-.08886
6	57	4.473	78	-.03111
4	64	3.837	69	-.03924
3	63	2.236	194	-.21686
3	61	0.	219	-.10249
3	60	0.	226	.02495
3	59	0.	225	.01489
3	58	0.	247	.39216
3	57	0.	222	-.05119
3	56	6.519	206	-.08102
2	53	2.236	227	.04750
3	52	5.000	229	-.06069
3	46	0.	220	-.08482
3	41	0.	220	-.07492
3	36	0.	215	-.17143

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	305	-.15731
11	18	11.402	36	.04515
11	24	8.310	25	-.11867
13	27	0.	7	-.07078
15	30	2.549	92	-.03928
16	30	0.	321	.11863
17	30	.707	93	-.05804
17	31	0.	48	.06099
17	32	0.	57	.22189
17	33	0.	52	.13455
17	34	0.	49	.07121
17	35	0.	43	-.03177
17	36	6.021	14	-.15981
19	40	11.402	25	-.14669
19	46	0.	45	.01680
19	53	0.	35	-.16074
19	60	5.701	65	.04389
16	62	3.504	75	.00065
16	65	0.	44	-.00585
16	67	1.118	77	.10048
15	67	0.	135	.01347
14	67	4.031	192	.02536
11	61	0.	182	-.27284
9	57	3.579	91	.13859
6	57	4.473	79	-.01857
4	64	3.837	66	-.09223
3	63	2.236	201	-.08273
3	61	0.	226	.02802
3	60	0.	218	-.10971
3	59	0.	218	-.11450
3	58	0.	224	-.00554
3	57	0.	221	-.06674
3	56	6.519	217	.11039
2	53	2.236	227	.05160
3	52	5.000	231	-.02195
3	46	0.	231	.12252
3	41	0.	223	-.03216
3	36	0.	222	-.04175

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.00084
11	18	11.402	45	.21288
11	24	8.310	28	-.07008
13	27	0.	7	-.06844
15	30	2.549	8	.15474
16	30	0.	307	-.13197
17	30	.707	7	.12946
17	31	0.	43	-.01980
17	32	0.	42	-.04119
17	33	0.	51	.12065
17	34	0.	44	-.00501
17	35	0.	43	-.02674
17	36	6.021	24	.01714
19	40	11.402	22	-.18754
19	46	0.	51	.11005
19	53	0.	43	-.03302
19	60	5.701	60	-.04682
16	62	3.504	68	-.13619
16	65	0.	48	.06986
I6	67	1.118	75	.06299
15	67	0.	139	.08237
14	67	4.031	191	.00595
11	61	0.	191	-.12448
9	57	3.579	173	.00092
6	57	4.473	78	-.03516
4	64	3.837	76	.08313
3	63	2.236	206	-.00642
3	61	0.	233	.15227
3	60	0.	224	-.00037
3	59	0.	223	-.02017
3	58	0.	219	-.10057
3	57	0.	209	-.27187
3	56	6.519	214	.05611
2	53	2.236	220	-.07218
3	52	5.000	234	.02424
3	46	0.	226	.02594
3	41	0.	224	-.00332
3	36	0.	227	.04938

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	324	.17436
11	18	11.402	27	-.10737
11	24	8.310	33	.01944
13	27	0.	2	-.16049
15	30	2.549	97	-.13895
16	30	0.	308	-.11513
17	30	.707	1	.02585
17	31	0.	47	.05108
17	32	0.	33	-.20521
17	33	0.	44	-.01500
17	34	0.	45	.00575
17	35	0.	42	-.05131
17	36	6.021	29	.10208
19	40	11.402	30	-.05332
19	46	0.	42	-.04012
19	53	0.	46	.02601
19	60	5.701	63	.00414
16	62	3.504	73	-.04424
16	65	0.	44	-.00403
16	67	1.118	71	-.00793
15	67	0.	129	-.09340
14	67	4.031	182	-.14654
11	61	0.	194	-.06499
9	57	3.579	170	-.05064
6	57	4.473	72	-.14835
4	64	3.837	75	.07148
3	63	2.236	213	.12774
3	61	0.	216	-.14127
3	60	0.	229	.07884
3	59	0.	213	-.19227
3	58	0.	221	-.05480
3	57	0.	229	.07397
3	56	6.519	217	.10982
2	53	2.236	217	-.12443
3	52	5.000	237	.07493
3	46	0.	227	.04336
3	41	0.	233	.14072
3	36	0.	225	.01789

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.05348
11	18	11.402	28	-.08807
11	24	8.310	33	.02584
13	27	0.	2	-.14856
15	30	2.549	10	.18360
16	30	0.	318	.05760
17	30	.707	103	-.23354
17	31	0.	49	.07147
17	32	0.	49	.07108
17	33	0.	55	.17643
17	34	0.	39	-.09406
17	35	0.	42	-.05113
17	36	6.021	15	-.12765
19	40	11.402	20	-.22222
19	46	0.	39	-.09771
19	53	0.	40	-.07681
19	60	5.701	74	.18515
16	62	3.504	78	.04604
16	65	0.	49	.07432
16	67	1.118	68	-.05869
15	67	0.	135	.00618
14	67	4.031	192	.02848
11	61	0.	199	.01124
9	57	3.579	91	.13157
6	57	4.473	88	.14655
4	64	3.837	85	.24886
3	63	2.236	200	-.10213
3	61	0.	227	.03609
3	60	0.	216	-.14539
3	59	0.	223	-.02800
3	58	0.	225	.01697
3	57	0.	216	-.14415
3	56	6.519	203	-.12447
2	53	2.236	228	.06818
3	52	5.000	227	-.10182
3	46	0.	241	.29422
3	41	0.	223	-.03324
3	36	0.	214	-.18068

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	319	.07383
11	18	11.402	36	.05348
11	24	8.310	25	-.11477
13	27	0.	12	.01616
15	30	2.549	17	.30494
16	30	0.	318	.05959
17	30	.707	1	.01797
17	31	0.	50	.09480
17	32	0.	45	.00026
17	33	0.	35	-.16174
17	34	0.	40	-.07570
17	35	0.	52	.13221
17	36	6.021	29	.11621
19	40	11.402	23	-.17955
19	46	0.	41	-.06399
19	53	0.	43	-.02182
19	60	5.701	62	-.00856
16	62	3.504	59	-.28934
16	65	0.	38	-.10935
16	67	1.118	65	-.11192
15	67	0.	145	.18979
14	67	4.031	201	.18032
11	61	0.	196	-.03775
9	57	3.579	166	-.11763
6	57	4.473	74	-.09971
4	64	3.837	68	-.04590
3	63	2.236	201	-.08206
3	61	0.	222	-.04833
3	60	0.	222	-.03663
3	59	0.	234	.16390
3	58	0.	228	.07037
3	57	0.	218	-.10821
3	56	6.519	213	.03645
2	53	2.236	220	-.08367
3	52	5.000	227	-.10533
3	46	0.	227	.04378
3	41	0.	232	.12741
3	36	0.	226	.02991

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.06765
11	18	11.402	38	.08234
11	24	8.310	29	-.04849
13	27	0.	17	.10646
15	30	2.549	98	-.15180
16	30	0.	317	.04317
17	30	.707	8	.14191
17	31	0.	44	-.00214
17	32	0.	46	.02410
17	33	0.	46	.02546
17	34	0.	43	-.02412
17	35	0.	54	.16438
17	36	6.021	24	.01487
19	40	11.402	28	-.08944
19	46	0.	56	.20925
19	53	0.	48	.05547
19	60	5.701	56	-.11976
16	62	3.504	69	-.11414
16	65	0.	48	.05486
16	67	1.118	69	-.03655
15	67	0.	143	.14567
14	67	4.031	205	.25615
11	61	0.	205	.12038
9	57	3.579	164	-.16692
6	57	4.473	2	.20967
4	64	3.837	71	.00155
3	63	2.236	202	-.07844
3	61	0.	230	.09706
3	60	0.	228	.05960
3	59	0.	227	.04897
3	58	0.	232	.12718
3	57	0.	239	.25260
3	56	6.519	196	-.25436
2	53	2.236	232	.12328
3	52	5.000	236	.06523
3	46	0.	217	-.13008
3	41	0.	223	-.02487
3	36	0.	224	-.00511

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.03778
11	18	11.402	27	-.11647
11	24	8.310	38	.11220
13	27	0.	7	-.07025
15	30	2.549	102	-.21557
16	30	0.	311	-.06781
17	30	.707	103	-.23550
17	31	0.	35	-.16216
17	32	0.	43	-.02107
17	33	0.	37	-.12489
17	34	0.	48	.06311
17	35	0.	59	.24507
17	36	6.021	22	-.01718
19	40	11.402	26	-.12167
19	46	0.	38	-.10785
19	53	0.	50	.09455
19	60	5.701	62	-.01038
16	62	3.504	73	-.03817
16	65	0.	54	.17304
16	67	1.118	78	.12814
15	67	0.	128	-.11791
14	67	4.031	185	-.10678
11	61	0.	194	-.06330
9	57	3.579	161	-.21635
6	57	4.473	85	.08289
4	64	3.837	83	.20675
3	63	2.236	214	.14197
3	61	0.	227	.04597
3	60	0.	218	-.11549
3	59	0.	220	-.07073
3	58	0.	229	.08315
3	57	0.	225	.00911
3	56	6.519	205	-.08832
2	53	2.236	229	.07926
3	52	5.000	240	.12549
3	46	0.	222	-.05078
3	41	0.	230	.09613
3	36	0.	218	-.10583

CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	320	.09043
11	18	11.402	41	.13237
11	24	8.310	21	-.18976
13	27	0.	4	-.11363
15	30	2.549	96	-.11548
16	30	0.	320	.09336
17	30	.707	6	.11044
17	31	0.	51	.10995
17	32	0.	33	-.19685
17	33	0.	45	.00675
17	34	0.	50	.09618
17	35	0.	43	-.01932
17	36	6.021	33	.17422
19	40	11.402	14	-.32803
19	46	0.	46	.03088
19	53	0.	49	.07927
19	60	5.701	55	-.13160
16	62	3.504	72	-.06422
16	65	0.	38	-.10613
16	67	1.118	76	.08857
15	67	0.	131	-.06597
14	67	4.031	181	-.17440
11	61	0.	207	.15991
9	57	3.579	169	-.07670
6	57	4.473	84	.07449
4	64	3.837	78	.12698
3	63	2.236	193	-.21957
3	61	0.	216	-.14574
3	60	0.	221	-.06044
3	59	0.	226	.02564
3	58	0.	236	.20189
3	57	0.	224	-.00381
3	56	6.519	210	.00107
2	53	2.236	222	-.03764
3	52	5.000	246	.22741
3	46	0.	231	.10718
3	41	0.	235	.19019
3	36	0.	218	-.10471

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CARDS= 20 SCALE= 50 SPEED=150 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	330	.26976
11	18	11.402	34	.00856
11	24	8.310	33	.01924
13	27	0.	16	.08853
15	30	2.549	7	.13251
16	30	0.	329	.25615
17	30	.707	12	.22271
17	31	0.	49	.08143
17	32	0.	51	.11173
17	33	0.	44	-.00415
17	34	0.	47	.03802
17	35	0.	55	.18829
17	36	6.021	17	-.09707
19	40	11.402	27	-.11370
19	46	0.	34	-.17902
19	53	0.	31	-.22746
19	60	5.701	67	.06735
16	62	3.504	72	-.05576
16	65	0.	46	.03455
16	67	1.118	63	-.14546
15	67	0.	127	-.13486
14	67	4.031	192	.01322
11	61	0.	201	.06010
9	57	3.579	173	-.00804
6	57	4.473	78	-.03051
4	64	3.837	72	.02052
3	63	2.236	204	-.04294
3	61	0.	224	-.00045
3	60	0.	219	-.10255
3	59	0.	227	.03731
3	58	0.	240	.27223
3	57	0.	220	-.07124
3	56	6.519	215	.08393
2	53	2.236	228	.06990
3	52	5.000	242	.16630
3	46	0.	223	-.02286
3	41	0.	221	-.06144
3	36	0.	230	.09449

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.02524
11	18	11.402	32	-.01797
11	24	8.310	35	.05579
13	27	0.	7	-.06185
15	30	2.549	93	-.06369
16	30	0.	319	.07824
17	30	.707	92	-.05054
17	31	0.	46	.02080
17	32	0.	45	.00435
17	33	0.	48	.05664
17	34	0.	45	.00171
17	35	0.	44	-.00112
17	36	6.021	26	.05948
19	40	11.402	32	-.01901
19	46	0.	34	-.17874
19	53	0.	47	.04366
19	60	5.701	69	.11025
16	62	3.504	78	.04496
16	65	0.	47	.05027
16	67	1.118	61	-.18226
15	67	0.	133	-.01829
14	67	4.031	190	-.01104
11	61	0.	204	.10962
9	57	3.579	173	.00288
6	57	4.473	70	-.17926
4	64	3.837	72	.01907
3	63	2.236	209	.04592
3	61	0.	225	.00379
3	60	0.	217	-.12607
3	59	0.	221	-.05687
3	58	0.	230	.09750
3	57	0.	218	-.11561
3	56	6.519	209	-.03113
2	53	2.236	212	-.20996
3	52	5.000	230	-.04447
3	46	0.	222	-.03690
3	41	0.	226	.02711
3	36	0.	224	-.01559

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.02310
11	18	11.402	36	.04426
11	24	8.310	37	.09318
13	27	0.	17	.10179
15	30	2.549	3	.06858
16	30	0.	315	.01287
17	30	.707	2	.04384
17	31	0.	43	-.02162
17	32	0.	52	.13966
17	33	0.	43	-.01744
17	34	0.	42	-.03942
17	35	0.	39	-.10006
17	36	6.021	23	.01068
19	40	11.402	39	.09317
19	46	0.	47	.04191
19	53	0.	47	.04465
19	60	5.701	63	-.00326
16	62	3.504	75	-.01517
16	65	0.	47	.04062
16	67	1.118	77	.11193
15	67	0.	140	.08832
14	67	4.031	194	.06407
11	61	0.	194	-.07661
9	57	3.579	170	-.05969
6	57	4.473	80	.00190
4	64	3.837	69	-.03768
3	63	2.236	191	-.25415
3	61	0.	223	-.02666
3	60	0.	229	.07876
3	59	0.	223	-.02489
3	58	0.	221	-.05850
3	57	0.	218	-.11430
3	56	6.519	214	.05544
2	53	2.236	229	.08274
3	52	5.000	234	.02556
3	46	0.	220	-.06899
3	41	0.	226	.02880
3	36	0.	221	-.06000

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.02986
11	18	11.402	30	-.06241
11	24	8.310	26	-.11230
13	27	0.	9	-.02532
15	30	2.549	95	-.09010
16	30	0.	322	.13225
17	30	.707	93	-.06052
17	31	0.	40	-.08223
17	32	0.	38	-.10552
17	33	0.	43	-.01924
17	34	0.	41	-.06900
17	35	0.	45	.01346
17	36	6.021	20	-.04719
19	40	11.402	30	-.04998
19	46	0.	44	-.01623
19	53	0.	46	.02954
19	60	5.701	60	-.05392
16	62	3.504	76	.01602
16	65	0.	47	.03608
16	67	1.118	71	-.00066
15	67	0.	139	.07474
14	67	4.031	193	.04353
11	61	0.	200	.04091
9	57	3.579	176	.05341
6	57	4.473	79	-.02410
4	64	3.837	62	-.15147
3	63	2.236	205	-.02551
3	61	0.	224	-.01225
3	60	0.	234	.16010
3	59	0.	215	-.15776
3	58	0.	228	.06415
3	57	0.	223	-.01916
3	56	6.519	213	.05049
2	53	2.236	229	.07098
3	52	5.000	225	-.13478
3	46	0.	227	.04193
3	41	0.	216	-.14971
3	36	0.	222	-.03925

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.02867
11	18	11.402	30	-.05158
11	24	8.310	31	-.01530
13	27	0.	21	.18087
15	30	2.549	6	.10798
16	30	0.	316	.03483
17	30	.707	90	-.00504
17	31	0.	41	-.06324
17	32	0.	56	.19876
17	33	0.	50	.10333
17	34	0.	53	.14429
17	35	0.	37	-.12954
17	36	6.021	18	-.07343
19	40	11.402	25	-.14888
19	46	0.	47	.03840
19	53	0.	46	.03391
19	60	5.701	71	.13649
16	62	3.504	84	.15715
16	65	0.	48	.05310
16	67	1.118	81	.17145
15	67	0.	135	.00087
14	67	4.031	195	.06942
11	61	0.	208	.17534
9	57	3.579	176	.05385
6	57	4.473	83	.04407
4	64	3.837	80	.15209
3	63	2.236	216	.18186
3	61	0.	221	-.05818
3	60	0.	226	.03374
3	59	0.	222	-.04568
3	58	0.	234	.16985
3	57	0.	224	.00001
3	56	6.519	214	.06237
2	53	2.236	231	.11566
3	52	5.000	238	.08857
3	46	0.	227	.04795
3	41	0.	231	.10915
3	36	0.	227	.04957

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.02781
11	18	11.402	30	-.06361
11	24	8.310	31	-.02211
13	27	0.	14	.05463
15	30	2.549	90	-.00786
16	30	0.	314	-.00385
17	30	.707	4	.08572
17	31	0.	44	-.01725
17	32	0.	46	.02128
17	33	0.	41	-.06283
17	34	0.	42	-.04822
17	35	0.	46	.02497
17	36	6.021	17	-.09393
19	40	11.402	35	.02530
19	46	0.	48	.06151
19	53	0.	44	-.01304
19	60	5.701	65	.03476
16	62	3.504	81	.09655
16	65	0.	46	.02063
16	67	1.118	72	.01249
15	67	0.	139	.08460
14	67	4.031	201	.18654
11	61	0.	205	.11843
9	57	3.579	175	.03097
6	57	4.473	80	.00748
4	64	3.837	76	.08999
3	63	2.236	198	-.13768
3	61	0.	225	.00283
3	60	0.	224	-.01591
3	59	0.	228	.06138
3	58	0.	230	.08947
3	57	0.	232	.13692
3	56	6.519	209	-.02972
2	53	2.236	223	-.02217
3	52	5.000	240	.13116
3	46	0.	223	-.03050
3	41	0.	225	.00118
3	36	0.	224	.00036

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	328	.23915
11	18	11.402	32	-.01714
11	24	8.310	30	-.04182
13	27	0.	11	.01166
15	30	2.549	1	.03485
16	30	0.	309	-.09937
17	30	.707	94	-.08729
17	31	0.	40	-.08240
17	32	0.	47	.04119
17	33	0.	48	.05315
17	34	0.	43	-.01995
17	35	0.	45	.00692
17	36	6.021	21	-.03376
19	40	11.402	31	-.03750
19	46	0.	44	-.00563
19	53	0.	41	-.06868
19	60	5.701	56	-.12058
16	62	3.504	82	.11728
16	65	0.	40	-.08249
16	67	1.118	77	.09938
15	67	0.	133	-.02860
14	67	4.031	193	.03554
11	61	0.	193	-.07697
9	57	3.579	173	.00176
6	57	4.473	81	.01894
4	64	3.837	68	-.05221
3	63	2.236	206	.00356
3	61	0.	237	.21860
3	60	0.	226	.02118
3	59	0.	220	-.07594
3	58	0.	219	-.09553
3	57	0.	222	-.04871
3	56	6.519	219	.15031
2	53	2.236	230	.09697
3	52	5.000	235	.04169
3	46	0.	228	.06246
3	41	0.	227	.05200
3	36	0.	225	.00199

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	310	-.07803
11	18	11.402	35	.03924
11	24	8.310	29	-.04346
13	27	0.	2	-.14937
15	30	2.549	4	.07144
16	30	0.	306	-.14426
17	30	.707	93	-.05329
17	31	0.	44	-.00741
17	32	0.	40	-.08688
17	33	0.	39	-.10144
17	34	0.	47	.04697
17	35	0.	44	-.01343
17	36	6.021	30	.13483
19	40	11.402	30	-.05438
19	46	0.	43	-.02591
19	53	0.	38	-.11467
19	60	5.701	65	.04315
16	62	3.504	78	.04952
16	65	0.	61	.29559
16	67	1.118	66	-.08231
15	67	0.	137	.04298
14	67	4.031	190	-.00550
11	61	0.	206	.14166
9	57	3.579	176	.05104
6	57	4.473	79	-.02436
4	64	3.837	66	-.08351
3	63	2.236	207	.02081
3	61	0.	224	-.00357
3	60	0.	226	.02526
3	59	0.	228	.06968
3	58	0.	223	-.02975
3	57	0.	218	-.10534
3	56	6.519	211	.00392
2	53	2.236	222	-.03919
3	52	5.000	234	.01938
3	46	0.	223	-.02785
3	41	0.	227	.04700
3	36	0.	226	.02566

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	309	-.09154
11	18	11.402	36	.05543
11	24	8.310	30	-.03690
13	27	0.	12	.02331
15	30	2.549	94	-.07241
16	30	0.	315	.00794
17	30	.707	3	.06567
17	31	0.	48	.06633
17	32	0.	48	.05913
17	33	0.	45	.00647
17	34	0.	39	-.09590
17	35	0.	45	.01221
17	36	6.021	18	-.08281
19	40	11.402	32	-.02673
19	46	0.	45	.01723
19	53	0.	43	-.02241
19	60	5.701	58	-.08843
16	62	3.504	73	-.04388
16	65	0.	43	-.02321
16	67	1.118	77	.11221
15	67	0.	137	.05135
14	67	4.031	188	-.04478
11	61	0.	200	.04014
9	57	3.579	163	-.17010
6	57	4.473	82	.02973
4	64	3.837	75	.07633
3	63	2.236	211	.09347
3	61	0.	224	-.00888
3	60	0.	222	-.04851
3	59	0.	219	-.09238
3	58	0.	220	-.08004
3	57	0.	222	-.04802
3	56	6.519	207	-.06039
2	53	2.236	222	-.04320
3	52	5.000	234	.02188
3	46	0.	227	.04173
3	41	0.	228	.05604
3	36	0.	226	.03233

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.01250
11	18	11.402	39	.10364
11	24	8.310	29	-.04730
13	27	0.	17	.09975
15	30	2.549	90	-.01254
16	30	0.	320	.09137
17	30	.707	92	-.04894
17	31	0.	46	.01806
17	32	0.	32	-.21882
17	33	0.	48	.06240
17	34	0.	44	-.00941
17	35	0.	42	-.04120
17	36	6.021	20	-.03835
19	40	11.402	33	-.00927
19	46	0.	38	-.11790
19	53	0.	48	.06276
19	60	5.701	67	.07769
16	62	3.504	72	-.05422
16	65	0.	42	-.05161
16	67	1.118	78	.11623
15	67	0.	126	-.14318
14	67	4.031	188	-.05010
11	61	0.	192	-.09585
9	57	3.579	173	.00391
6	57	4.473	74	-.11362
4	64	3.837	70	-.01435
3	63	2.236	205	-.01440
3	61	0.	230	.09859
3	60	0.	241	.28497
3	59	0.	227	.04187
3	58	0.	221	-.05479
3	57	0.	225	.00401
3	56	6.519	219	.14716
2	53	2.236	231	.11888
3	52	5.000	228	-.07868
3	46	0.	231	.12298
3	41	0.	220	-.08358
3	36	0.	224	.00012

CARDS= 20 SCALE= 50 SPEED=220 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.00417
11	18	11.402	32	-.01831
11	24	8.310	33	.01273
13	27	0.	9	-.03392
15	30	2.549	93	-.05647
16	30	0.	319	.08632
17	30	.707	90	-.00131
17	31	0.	41	-.05775
17	32	0.	57	.22332
17	33	0.	47	.04841
17	34	0.	52	.13252
17	35	0.	51	.10812
17	36	6.021	23	.00687
19	40	11.402	34	.00560
19	46	0.	47	.03901
19	53	0.	44	-.00070
19	60	5.701	55	-.13124
16	62	3.504	75	-.01063
16	65	0.	39	-.09182
16	67	1.118	78	.11432
15	67	0.	137	.04102
14	67	4.031	190	-.00543
11	61	0.	200	.03951
9	57	3.579	172	-.01456
6	57	4.473	79	-.01568
4	64	3.837	75	.07542
3	63	2.236	209	.04957
3	61	0.	217	-.12257
3	60	0.	220	-.07623
3	59	0.	225	.00358
3	58	0.	220	-.08265
3	57	0.	224	-.00100
3	56	6.519	213	.05076
2	53	2.236	222	-.03548
3	52	5.000	235	.04511
3	46	0.	224	-.00891
3	41	0.	222	-.04927
3	36	0.	228	.05338

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.00047
11	18	11.402	33	.00390
11	24	8.310	30	-.03675
13	27	0.	16	.09003
15	30	2.549	93	-.05680
16	30	0.	310	-.07961
17	30	.707	90	-.01194
17	31	0.	42	-.04907
17	32	0.	44	-.00973
17	33	0.	44	-.00393
17	34	0.	42	-.03760
17	35	0.	42	-.04586
17	36	6.021	22	-.01324
19	40	11.402	31	-.02939
19	46	0.	47	.05039
19	53	0.	45	.00044
19	60	5.701	63	-.00526
16	62	3.504	71	-.07691
16	65	0.	44	-.00563
16	67	1.118	66	-.08992
15	67	0.	134	-.00965
14	67	4.031	192	.01337
11	61	0.	198	.00081
9	57	3.579	174	.02370
6	57	4.473	83	.04899
4	64	3.837	72	.01130
3	63	2.236	208	.02847
3	61	0.	226	.02582
3	60	0.	224	-.01150
3	59	0.	225	.01703
3	58	0.	216	-.15580
3	57	0.	221	-.05397
3	56	6.519	205	-.09002
2	53	2.236	227	.03925
3	52	5.000	231	-.03062
3	46	0.	223	-.01685
3	41	0.	222	-.03761
3	36	0.	226	.03319

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.01707
11	18	11.402	36	.05500
11	24	8.310	30	-.03689
13	27	0.	12	.01657
15	30	2.549	93	-.06502
16	30	0.	312	-.03977
17	30	.707	91	-.03204
17	31	0.	44	-.01005
17	32	0.	47	.03724
17	33	0.	43	-.01818
17	34	0.	47	.04492
17	35	0.	41	-.06848
17	36	6.021	22	-.00554
19	40	11.402	28	-.08251
19	46	0.	43	-.01850
19	53	0.	43	-.03181
19	60	5.701	61	-.03731
16	62	3.504	84	.14510
16	65	0.	45	.00334
16	67	1.118	70	-.01026
15	67	0.	139	.07680
14	67	4.031	196	.09689
11	61	0.	195	-.05906
9	57	3.579	170	-.04789
6	57	4.473	81	.02302
4	64	3.837	74	.05284
3	63	2.236	208	.02780
3	61	0.	220	-.08162
3	60	0.	223	-.01955
3	59	0.	228	.05701
3	58	0.	226	.02424
3	57	0.	228	.05481
3	56	6.519	200	-.17354
2	53	2.236	223	-.03365
3	52	5.000	226	-.10973
3	46	0.	224	-.00950
3	41	0.	222	-.03548
3	36	0.	222	-.05085

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	312	-.05017
11	18	11.402	29	-.07427
11	24	8.310	32	.00323
13	27	0.	17	.11196
15	30	2.549	2	.03662
16	30	0.	315	.00992
17	30	.707	90	-.01774
17	31	0.	48	.05731
17	32	0.	46	.03410
17	33	0.	42	-.03537
17	34	0.	41	-.06759
17	35	0.	45	.01493
17	36	6.021	18	-.07752
19	40	11.402	37	.05960
19	46	0.	48	.05618
19	53	0.	42	-.04112
19	60	5.701	63	.00818
16	62	3.504	76	.00708
16	65	0.	41	-.06912
16	67	1.118	66	-.09531
15	67	0.	137	.03777
14	67	4.031	188	-.05617
11	61	0.	196	-.03998
9	57	3.579	171	-.02870
6	57	4.473	78	-.02689
4	64	3.837	72	.01669
3	63	2.236	211	.09085
3	61	0.	222	-.04200
3	60	0.	227	.05108
3	59	0.	226	.02799
3	58	0.	222	-.03833
3	57	0.	226	.02714
3	56	6.519	211	.01221
2	53	2.236	215	-.16026
3	52	5.000	233	.01498
3	46	0.	224	-.00420
3	41	0.	221	-.05485
3	36	0.	224	-.01285

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.02249
11	18	11.402	40	.11031
11	24	8.310	29	-.05207
13	27	0.	11	.00562
15	30	2.549	2	.05088
16	30	0.	316	.03213
17	30	.707	0	.01018
17	31	0.	50	.10208
17	32	0.	38	-.12155
17	33	0.	43	-.02763
17	34	0.	38	-.10849
17	35	0.	40	-.07626
17	36	6.021	22	-.00773
19	40	11.402	35	.03210
19	46	0.	49	.07761
19	53	0.	37	-.12542
19	60	5.701	64	.01714
16	62	3.504	74	-.02324
16	65	0.	46	.02509
16	67	1.118	71	.00442
15	67	0.	134	-.01031
14	67	4.031	195	.07105
11	61	0.	202	.06613
9	57	3.579	176	.04736
6	57	4.473	80	-.00592
4	64	3.837	67	-.06936
3	63	2.236	205	-.01205
3	61	0.	218	-.10584
3	60	0.	226	.03193
3	59	0.	221	-.05215
3	58	0.	223	-.01980
3	57	0.	226	.02594
3	56	6.519	210	-.00289
2	53	2.236	221	-.05675
3	52	5.000	228	-.07485
3	46	0.	226	.02311
3	41	0.	224	.00037
3	36	0.	218	-.12003

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.02034
11	18	11.402	28	-.09787
11	24	8.310	30	-.02901
13	27	0.	5	-.10394
15	30	2.549	90	-.00818
16	30	0.	312	-.03965
17	30	.707	5	.09778
17	31	0.	43	-.02477
17	32	0.	49	.08677
17	33	0.	43	-.03458
17	34	0.	40	-.07270
17	35	0.	41	-.06409
17	36	6.021	20	-.04124
19	40	11.402	34	.00564
19	46	0.	47	.05192
19	53	0.	46	.02189
19	60	5.701	59	-.07498
16	62	3.504	73	-.03812
16	65	0.	50	.08977
16	67	1.118	69	-.02726
15	67	0.	131	-.05315
14	67	4.031	190	-.00670
11	61	0.	192	-.09634
9	57	3.579	173	-.00056
6	57	4.473	75	-.09493
4	64	3.837	67	-.07448
3	63	2.236	208	.02959
3	61	0.	231	.11487
3	60	0.	227	.03775
3	59	0.	228	.06243
3	58	0.	223	-.03231
3	57	0.	221	-.05386
3	56	6.519	211	.00307
2	53	2.236	217	-.13245
3	52	5.000	233	.00529
3	46	0.	228	.05619
3	41	0.	227	.03942
3	36	0.	225	.00944

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	305	-.15623
11	18	11.402	33	-.00345
11	24	8.310	31	-.01282
13	27	0.	11	.00673
15	30	2.549	95	-.09929
16	30	0.	315	.01751
17	30	.707	90	-.01218
17	31	0.	39	-.08946
17	32	0.	42	-.03546
17	33	0.	45	.00455
17	34	0.	51	.10810
17	35	0.	43	-.02082
17	36	6.021	18	-.08615
19	40	11.402	36	.04795
19	46	0.	43	-.03391
19	53	0.	47	.05136
19	60	5.701	60	-.05098
16	62	3.504	77	.02194
16	65	0.	47	.04413
16	67	1.118	71	-.00956
15	67	0.	132	-.03864
14	67	4.031	201	.18145
11	61	0.	196	-.03038
9	57	3.579	172	-.02786
6	57	4.473	83	.04952
4	64	3.837	71	.00283
3	63	2.236	213	.12309
3	61	0.	224	-.01493
3	60	0.	225	.00576
3	59	0.	225	.00266
3	58	0.	224	-.00319
3	57	0.	228	.05886
3	56	6.519	207	-.05978
2	53	2.236	224	-.00617
3	52	5.000	232	-.01708
3	46	0.	226	.02463
3	41	0.	227	.04389
3	36	0.	223	-.02235

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	321	.11388
11	18	11.402	36	.04084
11	24	8.310	35	.04824
13	27	0.	10	-.01968
15	30	2.549	4	.08174
16	30	0.	314	-.00305
17	30	.707	90	-.00323
17	31	0.	45	.01493
17	32	0.	42	-.04566
17	33	0.	42	-.04830
17	34	0.	40	-.07985
17	35	0.	45	.00083
17	36	6.021	20	-.05364
19	40	11.402	30	-.06140
19	46	0.	40	-.07101
19	53	0.	43	-.02994
19	60	5.701	66	.04602
16	62	3.504	77	.02904
16	65	0.	44	-.01049
16	67	1.118	75	.06069
15	67	0.	132	-.03496
14	67	4.031	187	-.06959
11	61	0.	200	.02824
9	57	3.579	169	-.06386
6	57	4.473	81	.01985
4	64	3.837	70	-.01182
3	63	2.236	207	.02015
3	61	0.	223	-.03104
3	60	0.	218	-.11180
3	59	0.	223	-.02353
3	58	0.	221	-.05452
3	57	0.	223	-.01923
3	56	6.519	211	.01886
2	53	2.236	222	-.03822
3	52	5.000	237	.08162
3	46	0.	228	.05712
3	41	0.	223	-.02393
3	36	0.	223	-.02258

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	309	-.09041
11	18	11.402	31	-.04232
11	24	8.310	35	.04913
13	27	0.	10	-.01093
15	30	2.549	90	-.01335
16	30	0.	307	-.12580
17	30	.707	1	.02050
17	31	0.	45	.00666
17	32	0.	43	-.02850
17	33	0.	42	-.03879
17	34	0.	39	-.09953
17	35	0.	44	-.00777
17	36	6.021	23	-.00264
19	40	11.402	34	.02202
19	46	0.	44	-.00744
19	53	0.	42	-.04346
19	60	5.701	58	-.08106
16	62	3.504	78	.05239
16	65	0.	49	.08420
16	67	1.118	73	.03803
15	67	0.	134	-.00093
14	67	4.031	185	-.10498
11	61	0.	198	.00065
9	57	3.579	173	-.00135
6	57	4.473	81	.01914
4	64	3.837	71	.00478
3	63	2.236	201	-.08805
3	61	0.	228	.06179
3	60	0.	230	.08874
3	59	0.	228	.05845
3	58	0.	225	.01180
3	57	0.	229	.07945
3	56	6.519	210	-.00379
2	53	2.236	228	.06376
3	52	5.000	238	.10151
3	46	0.	222	-.04719
3	41	0.	227	.04719
3	36	0.	223	-.02548

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	312	-.04892
11	18	11.402	33	-.00224
11	24	8.310	32	-.00246
13	27	0.	9	-.03204
15	30	2.549	91	-.02617
16	30	0.	308	-.10561
17	30	.707	93	-.05784
17	31	0.	46	.01884
17	32	0.	46	.01955
17	33	0.	36	-.14184
17	34	0.	44	-.01487
17	35	0.	40	-.08579
17	36	6.021	21	-.03490
19	40	11.402	34	.01733
19	46	0.	45	.00020
19	53	0.	47	.04952
19	60	5.701	62	-.00882
16	62	3.504	75	-.00255
16	65	0.	44	-.01631
16	67	1.118	64	-.12767
15	67	0.	134	-.01105
14	67	4.031	195	.07673
11	61	0.	197	-.01009
9	57	3.579	170	-.05847
6	57	4.473	78	-.02722
4	64	3.837	77	.09727
3	63	2.236	209	.04700
3	61	0.	220	-.07076
3	60	0.	226	.03267
3	59	0.	222	-.04422
3	58	0.	226	.03186
3	57	0.	221	-.06680
3	56	6.519	215	.07861
2	53	2.236	226	.03540
3	52	5.000	233	.00979
3	46	0.	222	-.03574
3	41	0.	226	.02779
3	36	0.	226	.02413

CARDS= 20 SCALE= 50 SPEED=290 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.05774
11	18	11.402	38	.08785
11	24	8.310	31	-.02251
13	27	0.	7	-.06808
15	30	2.549	4	.08283
16	30	0.	315	.01112
17	30	.707	91	-.02028
17	31	0.	43	-.02579
17	32	0.	49	.08173
17	33	0.	45	.01507
17	34	0.	41	-.06274
17	35	0.	45	.01320
17	36	6.021	20	-.03925
19	40	11.402	31	-.04654
19	46	0.	46	.03315
19	53	0.	44	-.00277
19	60	5.701	66	.04711
16	62	3.504	69	-.11741
16	65	0.	43	-.02566
16	67	1.118	74	.05023
15	67	0.	136	.03164
14	67	4.031	194	.06287
11	61	0.	200	.04290
9	57	3.579	175	.02718
6	57	4.473	80	-.00043
4	64	3.837	70	-.02355
3	63	2.236	207	.02487
3	61	0.	223	-.01797
3	60	0.	226	.03313
3	59	0.	223	-.02611
3	58	0.	221	-.05155
3	57	0.	233	.14479
3	56	6.519	205	-.08699
2	53	2.236	224	-.01581
3	52	5.000	238	.10030
3	46	0.	224	-.00045
3	41	0.	229	.07889
3	36	0.	231	.12086

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.00978
11	18	11.402	34	.00927
11	24	8.310	32	.00480
13	27	0.	15	.06529
15	30	2.549	2	.04221
16	30	0.	319	.08048
17	30	.707	92	-.03705
17	31	0.	49	.08185
17	32	0.	46	.03256
17	33	0.	49	.08183
17	34	0.	47	.04008
17	35	0.	43	-.01838
17	36	6.021	19	-.05784
19	40	11.402	35	.03051
19	46	0.	45	.00075
19	53	0.	39	-.09109
19	60	5.701	68	.08116
16	62	3.504	71	-.06890
16	65	0.	49	.07472
16	67	1.118	70	-.02124
15	67	0.	135	.00941
14	67	4.031	191	.00758
11	61	0.	200	.02887
9	57	3.579	168	-.09576
6	57	4.473	78	-.03671
4	64	3.837	72	.01494
3	63	2.236	203	-.04503
3	61	0.	225	.00433
3	60	0.	225	.00411
3	59	0.	226	.02432
3	58	0.	228	.06606
3	57	0.	222	-.03516
3	56	6.519	212	.02375
2	53	2.236	223	-.02400
3	52	5.000	231	-.02322
3	46	0.	219	-.09821
3	41	0.	223	-.03025
3	36	0.	228	.06230

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.01817
11	18	11.402	33	.00032
11	24	8.310	33	.01270
13	27	0.	10	-.01285
15	30	2.549	0	.00125
16	30	0.	312	-.04165
17	30	.707	93	-.06894
17	31	0.	49	.08364
17	32	0.	45	.01648
17	33	0.	39	-.08824
17	34	0.	46	.02477
17	35	0.	49	.07048
17	36	6.021	22	-.01828
19	40	11.402	30	-.06173
19	46	0.	43	-.02932
19	53	0.	50	.09897
19	60	5.701	68	.08179
16	62	3.504	76	.00521
16	65	0.	43	-.02387
16	67	1.118	71	-.00583
15	67	0.	133	-.02691
14	67	4.031	192	.02880
11	61	0.	198	.00358
9	57	3.579	175	.02884
6	57	4.473	76	-.06623
4	64	3.837	73	.03730
3	63	2.236	207	.00922
3	61	0.	226	.02681
3	60	0.	221	-.05903
3	59	0.	223	-.01812
3	58	0.	219	-.10169
3	57	0.	226	.03397
3	56	6.519	204	-.11028
2	53	2.236	222	-.04096
3	52	5.000	237	.07643
3	46	0.	223	-.02222
3	41	0.	227	.04139
3	36	0.	221	-.06247

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.00648
11	18	11.402	31	-.03152
11	24	8.310	29	-.05227
13	27	0.	16	.08991
15	30	2.549	91	-.02147
16	30	0.	316	.02835
17	30	.707	2	.04480
17	31	0.	50	.09372
17	32	0.	45	.00218
17	33	0.	47	.04408
17	34	0.	43	-.02678
17	35	0.	46	.02982
17	36	6.021	24	.03018
19	40	11.402	29	-.07832
19	46	0.	43	-.02121
19	53	0.	44	-.00214
19	60	5.701	63	.00608
16	62	3.504	75	-.00344
16	65	0.	45	.01090
16	67	1.118	69	-.04356
15	67	0.	134	-.00062
14	67	4.031	194	.06070
11	61	0.	197	-.01321
9	57	3.579	172	-.02174
6	57	4.473	74	-.10765
4	64	3.837	75	.06141
3	63	2.236	209	.04813
3	61	0.	219	-.09057
3	60	0.	222	-.03855
3	59	0.	223	-.02386
3	58	0.	224	-.00089
3	57	0.	222	-.04407
3	56	6.519	210	-.01173
2	53	2.236	224	-.00827
3	52	5.000	233	.00078
3	46	0.	224	.00055
3	41	0.	218	-.11717
3	36	0.	223	-.02238

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	320	.09858
11	18	11.402	41	.12871
11	24	8.310	30	-.03562
13	27	0.	16	.09015
15	30	2.549	95	-.09910
16	30	0.	315	.00388
17	30	.707	90	-.01208
17	31	0.	46	.01840
17	32	0.	45	.00414
17	33	0.	43	-.02184
17	34	0.	48	.06910
17	35	0.	43	-.03373
17	36	6.021	25	.04303
19	40	11.402	30	-.05819
19	46	0.	43	-.02379
19	53	0.	42	-.03999
19	60	5.701	62	-.00813
16	62	3.504	73	-.04980
16	65	0.	43	-.03190
16	67	1.118	66	-.08370
15	67	0.	134	-.00236
14	67	4.031	192	.02887
11	61	0.	199	.02123
9	57	3.579	170	-.05554
6	57	4.473	78	-.03448
4	64	3.837	72	.01608
3	63	2.236	206	.00117
3	61	0.	220	-.07186
3	60	0.	226	.03552
3	59	0.	226	.02611
3	58	0.	224	-.01183
3	57	0.	225	.01519
3	56	6.519	211	.00481
2	53	2.236	220	-.07751
3	52	5.000	229	-.06221
3	46	0.	220	-.07156
3	41	0.	222	-.04982
3	36	0.	230	.09243

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.04459
11	18	11.402	31	-.03469
11	24	8.310	37	.08184
13	27	0.	10	-.01574
15	30	2.549	92	-.03745
16	30	0.	311	-.06085
17	30	.707	91	-.03190
17	31	0.	42	-.04451
17	32	0.	44	-.00641
17	33	0.	47	.04449
17	34	0.	43	-.03335
17	35	0.	42	-.03666
17	36	6.021	27	.07621
19	40	11.402	37	.06264
19	46	0.	41	-.06350
19	53	0.	45	.01705
19	60	5.701	62	-.01463
16	62	3.504	76	.01804
16	65	0.	48	.05975
16	67	1.118	68	-.04812
15	67	0.	138	.06190
14	67	4.031	191	.00198
11	61	0.	200	.03435
9	57	3.579	173	-.00204
6	57	4.473	77	-.04728
4	64	3.837	67	-.06503
3	63	2.236	202	-.07112
3	61	0.	225	.01039
3	60	0.	225	.01493
3	59	0.	227	.03731
3	58	0.	223	-.03175
3	57	0.	224	-.00567
3	56	6.519	207	-.06429
2	53	2.236	221	-.05211
3	52	5.000	238	.09900
3	46	0.	225	.01616
3	41	0.	227	.04433
3	36	0.	223	-.02746

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.03266
11	18	11.402	35	.03685
11	24	8.310	33	.00952
13	27	0.	12	.01473
15	30	2.549	90	-.01281
16	30	0.	314	-.00020
17	30	.707	91	-.03000
17	31	0.	43	-.02607
17	32	0.	39	-.09162
17	33	0.	44	-.01264
17	34	0.	45	.01544
17	35	0.	45	.00462
17	36	6.021	23	.00520
19	40	11.402	29	-.07557
19	46	0.	41	-.06300
19	53	0.	45	.00844
19	60	5.701	60	-.05261
16	62	3.504	77	.03044
16	65	0.	48	.05602
16	67	1.118	72	.00937
15	67	0.	136	.02086
14	67	4.031	194	.05597
11	61	0.	204	.10447
9	57	3.579	176	.04735
6	57	4.473	82	.03976
4	64	3.837	68	-.04793
3	63	2.236	209	.05591
3	61	0.	224	-.00117
3	60	0.	223	-.01908
3	59	0.	225	.00927
3	58	0.	224	-.01136
3	57	0.	224	-.00857
3	56	6.519	211	.00671
2	53	2.236	225	.00593
3	52	5.000	235	.04226
3	46	0.	224	-.00089
3	41	0.	227	.04973
3	36	0.	229	.07393

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.04924
11	18	11.402	39	.10609
11	24	8.310	37	.08927
13	27	0.	8	-.04265
15	30	2.549	7	.13773
16	30	0.	316	.01949
17	30	.707	91	-.03152
17	31	0.	51	.10492
17	32	0.	39	-.09341
17	33	0.	48	.06112
17	34	0.	41	-.06894
17	35	0.	38	-.11666
17	36	6.021	26	.06303
19	40	11.402	30	-.05425
19	46	0.	44	-.01118
19	53	0.	42	-.03609
19	60	5.701	62	-.02282
16	62	3.504	70	-.08722
16	65	0.	48	.05684
16	67	1.118	78	.11288
15	67	0.	137	.04219
14	67	4.031	192	.02013
11	61	0.	196	-.02843
9	57	3.579	172	-.01334
6	57	4.473	79	-.01713
4	64	3.837	72	.01938
3	63	2.236	208	.03453
3	61	0.	225	.00794
3	60	0.	226	.03427
3	59	0.	228	.06496
3	58	0.	223	-.01713
3	57	0.	222	-.03926
3	56	6.519	211	.01352
2	53	2.236	223	-.01929
3	52	5.000	228	-.07499
3	46	0.	221	-.05295
3	41	0.	221	-.05276
3	36	0.	224	-.00145

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	319	.08532
11	18	11.402	32	-.02631
11	24	8.310	37	.07982
13	27	0.	9	-.03923
15	30	2.549	0	.01578
16	30	0.	311	-.06564
17	30	.707	0	.00666
17	31	0.	42	-.04829
17	32	0.	44	-.00532
17	33	0.	43	-.02431
17	34	0.	42	-.03765
17	35	0.	40	-.07151
17	36	6.021	20	-.04851
19	40	11.402	38	.09121
19	46	0.	45	.00939
19	53	0.	44	-.00287
19	60	5.701	63	-.00712
16	62	3.504	74	-.02622
16	65	0.	45	.00351
16	67	1.118	69	-.03541
15	67	0.	135	.00146
14	67	4.031	192	.02404
11	61	0.	198	.00197
9	57	3.579	175	.03574
6	57	4.473	80	-.00217
4	64	3.837	77	.09537
3	63	2.236	207	.01122
3	61	0.	228	.05386
3	60	0.	227	.04508
3	59	0.	225	.01725
3	58	0.	223	-.03005
3	57	0.	226	.02238
3	56	6.519	210	-.00867
2	53	2.236	228	.05879
3	52	5.000	235	.04263
3	46	0.	227	.05290
3	41	0.	225	.01089
3	36	0.	222	-.04380

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.03013
11	18	11.402	35	.03504
11	24	8.310	33	.01684
13	27	0.	8	-.04210
15	30	2.549	93	-.05470
16	30	0.	317	.03673
17	30	.707	89	-.00025
17	31	0.	46	.02188
17	32	0.	44	-.00912
17	33	0.	40	-.08608
17	34	0.	44	-.01497
17	35	0.	45	.01687
17	36	6.021	26	.05120
19	40	11.402	34	.01381
19	46	0.	43	-.01998
19	53	0.	49	.07401
19	60	5.701	62	-.02136
16	62	3.504	79	.06630
16	65	0.	41	-.06160
16	67	1.118	76	.08486
15	67	0.	136	.01869
14	67	4.031	188	-.04548
11	61	0.	199	.01351
9	57	3.579	173	-.00066
6	57	4.473	78	-.03055
4	64	3.837	72	.01501
3	63	2.236	208	.04295
3	61	0.	225	.00803
3	60	0.	223	-.02249
3	59	0.	226	.01961
3	58	0.	225	.01720
3	57	0.	226	.03051
3	56	6.519	212	.03187
2	53	2.236	226	.02121
3	52	5.000	235	.04908
3	46	0.	223	-.01734
3	41	0.	220	-.07709
3	36	0.	223	-.01803

CARDS= 20 SCALE= 50 SPEED=360 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	306	-.15242
11	18	11.402	32	-.02936
11	24	8.310	33	.01761
13	27	0.	12	.02390
15	30	2.549	91	-.03145
16	30	0.	316	.03066
17	30	.707	91	-.02427
17	31	0.	46	.03248
17	32	0.	46	.02057
17	33	0.	44	-.01635
17	34	0.	46	.01990
17	35	0.	45	.01289
17	36	6.021	19	-.06039
19	40	11.402	29	-.08073
19	46	0.	40	-.07991
19	53	0.	38	-.11625
19	60	5.701	63	.00538
16	62	3.504	79	.06623
16	65	0.	51	.11144
16	67	1.118	69	-.03520
15	67	0.	134	-.01098
14	67	4.031	193	.03958
11	61	0.	199	.02170
9	57	3.579	168	-.08969
6	57	4.473	81	.02283
4	64	3.837	66	-.08147
3	63	2.236	205	-.02580
3	61	0.	224	-.00940
3	60	0.	222	-.03946
3	59	0.	226	.03379
3	58	0.	227	.05212
3	57	0.	224	-.00528
3	56	6.519	206	-.07051
2	53	2.236	223	-.01949
3	52	5.000	230	-.05063
3	46	0.	225	.00449
3	41	0.	223	-.02233
3	36	0.	225	.01311

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.00373
11	18	11.402	32	-.02500
11	24	8.310	32	.00755
13	27	0.	9	-.02440
15	30	2.549	2	.05169
16	30	0.	313	-.02500
17	30	.707	92	-.04742
17	31	0.	44	-.01125
17	32	0.	43	-.02620
17	33	0.	49	.08148
17	34	0.	44	-.00758
17	35	0.	47	.03992
17	36	6.021	19	-.06014
19	40	11.402	35	.03990
19	46	0.	44	-.00699
19	53	0.	45	.01713
19	60	5.701	65	.03726
16	62	3.504	71	-.07870
16	65	0.	47	.03648
16	67	1.118	68	-.05421
15	67	0.	136	.01831
14	67	4.031	195	.07271
11	61	0.	197	-.02314
9	57	3.579	169	-.07785
6	57	4.473	80	-.00385
4	64	3.837	70	-.02031
3	63	2.236	205	-.02319
3	61	0.	224	-.00812
3	60	0.	225	.00119
3	59	0.	222	-.04211
3	58	0.	225	.00713
3	57	0.	222	-.04735
3	56	6.519	211	.01850
2	53	2.236	226	.02414
3	52	5.000	234	.03171
3	46	0.	223	-.02938
3	41	0.	224	-.00493
3	36	0.	226	.02103

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.04983
11	18	11.402	34	.02102
11	24	8.310	27	-.08103
13	27	0.	12	.02887
15	30	2.549	92	-.04109
16	30	0.	322	.14025
17	30	.707	3	.06350
17	31	0.	42	-.03840
17	32	0.	46	.02844
17	33	0.	45	.00248
17	34	0.	47	.04038
17	35	0.	39	-.09634
17	36	6.021	25	.03774
19	40	11.402	31	-.03804
19	46	0.	48	.06571
19	53	0.	44	-.00028
19	60	5.701	57	-.09536
16	62	3.504	79	.06424
16	65	0.	46	.02445
16	67	1.118	65	-.10604
15	67	0.	137	.03623
14	67	4.031	191	.00244
11	61	0.	202	.07595
9	57	3.579	167	-.10216
6	57	4.473	78	-.03239
4	64	3.837	74	.04376
3	63	2.236	206	.00197
3	61	0.	226	.02278
3	60	0.	224	-.01418
3	59	0.	223	-.01739
3	58	0.	221	-.05623
3	57	0.	226	.02486
3	56	6.519	216	.09065
2	53	2.236	226	.02906
3	52	5.000	232	-.01742
3	46	0.	226	.03188
3	41	0.	223	-.02309
3	36	0.	226	.02421

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	312	-.04843
11	18	11.402	33	-.00795
11	24	8.310	35	.06145
13	27	0.	8	-.04902
15	30	2.549	90	-.00137
16	30	0.	309	-.08842
17	30	.707	94	-.07826
17	31	0.	47	.04316
17	32	0.	43	-.01978
17	33	0.	45	.01092
17	34	0.	43	-.02746
17	35	0.	44	-.00285
17	36	6.021	25	.04727
19	40	11.402	33	-.00658
19	46	0.	45	.01001
19	53	0.	44	-.01076
19	60	5.701	65	.04421
16	62	3.504	73	-.04486
16	65	0.	40	-.08545
16	67	1.118	71	-.00879
15	67	0.	135	.00877
14	67	4.031	187	-.07137
11	61	0.	196	-.02837
9	57	3.579	171	-.03530
6	57	4.473	75	-.09192
4	64	3.837	71	.00358
3	63	2.236	207	.02280
3	61	0.	226	.03057
3	60	0.	229	.08298
3	59	0.	227	.04183
3	58	0.	224	-.01164
3	57	0.	220	-.08039
3	56	6.519	208	-.03459
2	53	2.236	223	-.03058
3	52	5.000	236	.06109
3	46	0.	223	-.02716
3	41	0.	224	-.01290
3	36	0.	225	.00752

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	319	.08526
11	18	11.402	35	.02444
11	24	8.310	34	.03931
13	27	0.	12	.02486
15	30	2.549	94	-.07375
16	30	0.	315	.00330
17	30	.707	1	.02808
17	31	0.	42	-.04707
17	32	0.	48	.05682
17	33	0.	46	.02426
17	34	0.	47	.05105
17	35	0.	45	.00251
17	36	6.021	23	-.00160
19	40	11.402	34	.01343
19	46	0.	46	.02170
19	53	0.	37	-.12478
19	60	5.701	65	.03337
16	62	3.504	74	-.01941
16	65	0.	49	.07592
16	67	1.118	68	-.05396
15	67	0.	131	-.05714
14	67	4.031	190	-.01157
11	61	0.	200	.02862
9	57	3.579	174	.01853
6	57	4.473	80	-.00488
4	64	3.837	72	.01207
3	63	2.236	208	.03606
3	61	0.	227	.04542
3	60	0.	224	-.00799
3	59	0.	226	.01970
3	58	0.	226	.02049
3	57	0.	226	.01846
3	56	6.519	210	-.01317
2	53	2.236	222	-.03706
3	52	5.000	228	-.08634
3	46	0.	224	-.00500
3	41	0.	229	.08343
3	36	0.	225	.00628

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	312	-.04895
11	18	11.402	31	-.03127
11	24	8.310	31	-.02303
13	27	0.	14	.04962
15	30	2.549	3	.05731
16	30	0.	312	-.03949
17	30	.707	4	.07167
17	31	0.	45	.01722
17	32	0.	44	-.00058
17	33	0.	46	.03285
17	34	0.	47	.04445
17	35	0.	45	.01090
17	36	6.021	17	-.09243
19	40	11.402	36	.05122
19	46	0.	45	.00764
19	53	0.	41	-.06425
19	60	5.701	65	.04035
16	62	3.504	75	-.01506
16	65	0.	46	.02661
16	67	1.118	69	-.03489
15	67	0.	139	.08149
14	67	4.031	191	.00763
11	61	0.	193	-.08438
9	57	3.579	174	.01872
6	57	4.473	80	-.00375
4	64	3.837	72	.01378
3	63	2.236	210	.06272
3	61	0.	224	-.01056
3	60	0.	226	.03491
3	59	0.	223	-.02544
3	58	0.	223	-.02637
3	57	0.	225	.00906
3	56	6.519	211	.00757
2	53	2.236	222	-.03905
3	52	5.000	232	-.00479
3	46	0.	225	.01763
3	41	0.	223	-.02857
3	36	0.	222	-.04880

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.07001
11	18	11.402	31	-.03039
11	24	8.310	33	.02662
13	27	0.	8	-.04608
15	30	2.549	1	.02668
16	30	0.	316	.02414
17	30	.707	91	-.03429
17	31	0.	47	.04820
17	32	0.	46	.02410
17	33	0.	44	-.01380
17	34	0.	43	-.02472
17	35	0.	44	-.00758
17	36	6.021	24	.01566
19	40	11.402	34	.01659
19	46	0.	46	.01788
19	53	0.	45	.01465
19	60	5.701	65	.03677
16	62	3.504	70	-.08658
16	65	0.	44	-.00288
16	67	1.118	74	.04425
15	67	0.	134	-.00098
14	67	4.031	193	.04132
11	61	0.	196	-.02734
9	57	3.579	172	-.02094
6	57	4.473	79	-.01198
4	64	3.837	72	.00908
3	63	2.236	205	-.01276
3	61	0.	221	-.05498
3	60	0.	227	.04727
3	59	0.	222	-.04199
3	58	0.	221	-.06241
3	57	0.	227	.04283
3	56	6.519	208	-.04042
2	53	2.236	225	.00932
3	52	5.000	233	.00364
3	46	0.	224	-.00115
3	41	0.	224	.00080
3	36	0.	224	.00077

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.00776
11	18	11.402	32	-.01410
11	24	8.310	33	.02310
13	27	0.	12	.02132
15	30	2.549	2	.04741
16	30	0.	318	.06603
17	30	.707	0	.00435
17	31	0.	42	-.04242
17	32	0.	44	-.00753
17	33	0.	43	-.03317
17	34	0.	44	-.01304
17	35	0.	45	.01403
17	36	6.021	23	.01223
19	40	11.402	32	-.02857
19	46	0.	44	-.00018
19	53	0.	43	-.02485
19	60	5.701	64	.01822
16	62	3.504	77	.03089
16	65	0.	46	.02703
16	67	1.118	70	-.02078
15	67	0.	134	-.00633
14	67	4.031	193	.04180
11	61	0.	198	.00791
9	57	3.579	174	.02290
6	57	4.473	79	-.02428
4	64	3.837	71	.00398
3	63	2.236	205	-.02032
3	61	0.	224	-.00919
3	60	0.	225	.01684
3	59	0.	222	-.03907
3	58	0.	224	-.00928
3	57	0.	224	-.01359
3	56	6.519	212	.03232
2	53	2.236	224	-.01237
3	52	5.000	237	.08192
3	46	0.	226	.03469
3	41	0.	225	.00299
3	36	0.	225	.00107

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.05522
11	18	11.402	35	.02348
11	24	8.310	33	.01183
13	27	0.	14	.06240
15	30	2.549	1	.01804
16	30	0.	311	-.06148
17	30	.707	4	.08425
17	31	0.	42	-.04716
17	32	0.	42	-.04871
17	33	0.	46	.03216
17	34	0.	44	-.01716
17	35	0.	49	.07038
17	36	6.021	21	-.02508
19	40	11.402	33	-.00469
19	46	0.	45	.01631
19	53	0.	47	.04193
19	60	5.701	63	.00505
16	62	3.504	77	.02152
16	65	0.	45	.00540
16	67	1.118	67	-.06263
15	67	0.	139	.07301
14	67	4.031	192	.01488
11	61	0.	200	.04392
9	57	3.579	174	.01665
6	57	4.473	80	-.00312
4	64	3.837	70	-.01329
3	63	2.236	206	-.00411
3	61	0.	225	.00476
3	60	0.	227	.04687
3	59	0.	226	.02226
3	58	0.	224	-.01548
3	57	0.	223	-.01755
3	56	6.519	210	-.00142
2	53	2.236	226	.03145
3	52	5.000	232	-.01370
3	46	0.	228	.06627
3	41	0.	226	.02184
3	36	0.	221	-.05875

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.01315
11	18	11.402	37	.06121
11	24	8.310	30	-.02787
13	27	0.	7	-.07196
15	30	2.549	0	.00773
16	30	0.	313	-.01753
17	30	.707	1	.02838
17	31	0.	41	-.05681
17	32	0.	45	.00701
17	33	0.	42	-.03518
17	34	0.	44	-.00835
17	35	0.	48	.06821
17	36	6.021	22	-.01199
19	40	11.402	30	-.04826
19	46	0.	41	-.06750
19	53	0.	43	-.02077
19	60	5.701	62	-.02079
16	62	3.504	79	.06080
16	65	0.	42	-.03739
16	67	1.118	71	.00070
15	67	0.	137	.03580
14	67	4.031	194	.05248
11	61	0.	196	-.02716
9	57	3.579	170	-.05491
6	57	4.473	78	-.03983
4	64	3.837	71	-.00500
3	63	2.236	209	.04346
3	61	0.	224	-.01204
3	60	0.	221	-.06749
3	59	0.	223	-.03196
3	58	0.	225	.01050
3	57	0.	229	.07369
3	56	6.519	213	.04735
2	53	2.236	225	.00642
3	52	5.000	238	.09947
3	46	0.	223	-.03057
3	41	0.	224	-.00718
3	36	0.	224	-.00690

CARDS= 20 SCALE= 50 SPEED=430 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.01942
11	18	11.402	32	-.01490
11	24	8.310	34	.03378
13	27	0.	12	.02810
15	30	2.549	91	-.01881
16	30	0.	316	.03188
17	30	.707	2	.05033
17	31	0.	43	-.02624
17	32	0.	43	-.02721
17	33	0.	45	.01330
17	34	0.	47	.04292
17	35	0.	39	-.09856
17	36	6.021	22	-.01933
19	40	11.402	35	.03649
19	46	0.	45	.00383
19	53	0.	42	-.03823
19	60	5.701	64	.01780
16	62	3.504	77	.02789
16	65	0.	43	-.01740
16	67	1.118	75	.07283
15	67	0.	135	.00057
14	67	4.031	193	.04444
11	61	0.	196	-.03864
9	57	3.579	173	-.00496
6	57	4.473	80	.00586
4	64	3.837	70	-.01294
3	63	2.236	210	.06275
3	61	0.	227	.03713
3	60	0.	224	-.01392
3	59	0.	228	.05703
3	58	0.	224	-.00164
3	57	0.	227	.04175
3	56	6.519	212	.01930
2	53	2.236	227	.03950
3	52	5.000	234	.03325
3	46	0.	227	.03996
3	41	0.	224	-.00396
3	36	0.	224	-.00832

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.01844
11	18	11.402	35	.03988
11	24	8.310	35	.05449
13	27	0.	9	-.02399
15	30	2.549	0	.00062
16	30	0.	315	.00962
17	30	.707	0	.00324
17	31	0.	50	.09348
17	32	0.	48	.05960
17	33	0.	44	-.01183
17	34	0.	42	-.04296
17	35	0.	40	-.08687
17	36	6.021	21	-.02542
19	40	11.402	31	-.04607
19	46	0.	41	-.06071
19	53	0.	45	.01021
19	60	5.701	66	.05976
16	62	3.504	74	-.01715
16	65	0.	44	-.00936
16	67	1.118	72	.01166
15	67	0.	132	-.04841
14	67	4.031	193	.03792
11	61	0.	193	-.07864
9	57	3.579	175	.03461
6	57	4.473	83	.04345
4	64	3.837	69	-.03605
3	63	2.236	205	-.02410
3	61	0.	226	.02128
3	60	0.	225	.01742
3	59	0.	223	-.02173
3	58	0.	223	-.01865
3	57	0.	224	.00079
3	56	6.519	209	-.03206
2	53	2.236	228	.05394
3	52	5.000	230	-.04021
3	46	0.	226	.02884
3	41	0.	224	-.00587
3	36	0.	225	.01562

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.05937
11	18	11.402	34	.00600
11	24	8.310	32	.00002
13	27	0.	11	.00890
15	30	2.549	90	-.00736
16	30	0.	314	-.01407
17	30	.707	2	.03704
17	31	0.	46	.02291
17	32	0.	44	-.00333
17	33	0.	45	.00985
17	34	0.	45	.00761
17	35	0.	44	-.00043
17	36	6.021	22	-.02066
19	40	11.402	33	-.00972
19	46	0.	45	.00350
19	53	0.	43	-.01784
19	60	5.701	63	-.00315
16	62	3.504	74	-.01964
16	65	0.	40	-.08112
16	67	1.118	68	-.04879
15	67	0.	137	.04668
14	67	4.031	193	.03370
11	61	0.	199	.01930
9	57	3.579	176	.04861
6	57	4.473	81	.02471
4	64	3.837	72	.00941
3	63	2.236	207	.01340
3	61	0.	223	-.02139
3	60	0.	224	-.01585
3	59	0.	225	.01372
3	58	0.	224	-.00790
3	57	0.	222	-.04653
3	56	6.519	211	.01160
2	53	2.236	222	-.04788
3	52	5.000	233	.01102
3	46	0.	228	.06228
3	41	0.	225	.01232
3	36	0.	221	-.05317

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	314	-.01536
11	18	11.402	33	-.00949
11	24	8.310	29	-.04566
13	27	0.	9	-.03580
15	30	2.549	1	.03201
16	30	0.	317	.04890
17	30	.707	91	-.02980
17	31	0.	42	-.04659
17	32	0.	48	.06189
17	33	0.	44	-.00014
17	34	0.	45	.01484
17	35	0.	46	.03058
17	36	6.021	20	-.04207
19	40	11.402	37	.05930
19	46	0.	42	-.03820
19	53	0.	43	-.02356
19	60	5.701	64	.02050
16	62	3.504	76	.00379
16	65	0.	41	-.05237
16	67	1.118	71	.00304
15	67	0.	137	.03704
14	67	4.031	194	.05643
11	61	0.	196	-.03859
9	57	3.579	173	.00542
6	57	4.473	77	-.05205
4	64	3.837	68	-.05304
3	63	2.236	207	.02518
3	61	0.	222	-.03666
3	60	0.	223	-.02489
3	59	0.	224	-.00310
3	58	0.	225	.00752
3	57	0.	224	.00047
3	56	6.519	209	-.02823
2	53	2.236	224	-.00612
3	52	5.000	233	.01223
3	46	0.	227	.03824
3	41	0.	225	.00510
3	36	0.	225	.01574

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.02358
11	18	11.402	35	.03043
11	24	8.310	32	.00386
13	27	0.	13	.04235
15	30	2.549	1	.02132
16	30	0.	312	-.03567
17	30	.707	0	.00886
17	31	0.	47	.03996
17	32	0.	46	.02519
17	33	0.	41	-.06460
17	34	0.	42	-.03535
17	35	0.	47	.04857
17	36	6.021	26	.05036
19	40	11.402	34	.02032
19	46	0.	42	-.03664
19	53	0.	40	-.08317
19	60	5.701	66	.05113
16	62	3.504	75	-.00971
16	65	0.	46	.02409
16	67	1.118	71	.00303
15	67	0.	135	.00781
14	67	4.031	191	-.00157
11	61	0.	197	-.02126
9	57	3.579	172	-.01163
6	57	4.473	81	.02173
4	64	3.837	74	.06002
3	63	2.236	205	-.01352
3	61	0.	224	-.01121
3	60	0.	222	-.04220
3	59	0.	225	.01336
3	58	0.	225	.00609
3	57	0.	230	.10000
3	56	6.519	210	.00055
2	53	2.236	223	-.03034
3	52	5.000	234	.02480
3	46	0.	223	-.03375
3	41	0.	225	.00387
3	36	0.	225	.01778

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	312	-.03954
11	18	11.402	33	-.00581
11	24	8.310	33	.02166
13	27	0.	9	-.02440
15	30	2.549	1	.02797
16	30	0.	313	-.02550
17	30	.707	90	-.00320
17	31	0.	45	.00726
17	32	0.	45	.00540
17	33	0.	43	-.02827
17	34	0.	44	-.00633
17	35	0.	44	-.00346
17	36	6.021	21	-.03725
19	40	11.402	35	.03393
19	46	0.	47	.04441
19	53	0.	45	.00254
19	60	5.701	63	.00161
16	62	3.504	73	-.03887
16	65	0.	44	-.01681
16	67	1.118	70	-.02075
15	67	0.	135	.00967
14	67	4.031	189	-.02779
11	61	0.	195	-.05806
9	57	3.579	175	.03284
6	57	4.473	80	.00478
4	64	3.837	73	.02967
3	63	2.236	207	.01004
3	61	0.	227	.03859
3	60	0.	224	-.01455
3	59	0.	226	.03023
3	58	0.	226	.03237
3	57	0.	224	-.00549
3	56	6.519	210	.00108
2	53	2.236	227	.04424
3	52	5.000	234	.02496
3	46	0.	223	-.03362
3	41	0.	225	.00322
3	36	0.	226	.02888

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.00809
11	18	11.402	35	.02392
11	24	8.310	30	-.02789
13	27	0.	8	-.04114
15	30	2.549	91	-.02260
16	30	0.	313	-.02633
17	30	.707	92	-.04691
17	31	0.	41	-.06325
17	32	0.	46	.02309
17	33	0.	45	.01068
17	34	0.	46	.02166
17	35	0.	44	-.00484
17	36	6.021	25	.03796
19	40	11.402	34	.01113
19	46	0.	44	-.00512
19	53	0.	45	.00748
19	60	5.701	62	-.01966
16	62	3.504	74	-.01910
16	65	0.	48	.06417
16	67	1.118	70	-.01488
15	67	0.	134	.00050
14	67	4.031	186	-.07886
11	61	0.	199	.01971
9	57	3.579	171	-.03297
6	57	4.473	84	.06186
4	64	3.837	70	-.02432
3	63	2.236	206	.00451
3	61	0.	227	.04588
3	60	0.	224	-.00498
3	59	0.	224	-.00049
3	58	0.	229	.08562
3	57	0.	227	.04254
3	56	6.519	209	-.02414
2	53	2.236	225	.01311
3	52	5.000	231	-.02622
3	46	0.	224	-.00377
3	41	0.	226	.02763
3	36	0.	227	.04011

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.03040
11	18	11.402	36	.04302
11	24	8.310	31	-.01686
13	27	0.	12	.01304
15	30	2.549	91	-.03104
16	30	0.	315	.00477
17	30	.707	92	-.03937
17	31	0.	45	.01638
17	32	0.	41	-.05581
17	33	0.	45	.00952
17	34	0.	42	-.04582
17	35	0.	46	.02142
17	36	6.021	24	.03050
19	40	11.402	32	-.01470
19	46	0.	46	.02722
19	53	0.	45	.00299
19	60	5.701	61	-.03008
16	62	3.504	76	.00668
16	65	0.	42	-.04275
16	67	1.118	70	-.01540
15	67	0.	134	-.00150
14	67	4.031	190	-.01573
11	61	0.	195	-.05119
9	57	3.579	174	.01421
6	57	4.473	81	.02351
4	64	3.837	70	-.01867
3	63	2.236	205	-.02202
3	61	0.	226	.03464
3	60	0.	220	-.07314
3	59	0.	224	-.01413
3	58	0.	224	-.00529
3	57	0.	222	-.05107
3	56	6.519	209	-.02138
2	53	2.236	224	-.01252
3	52	5.000	234	.02857
3	46	0.	224	-.00951
3	41	0.	224	-.01397
3	36	0.	226	.02056

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.00872
11	18	11.402	30	-.04829
11	24	8.310	30	-.03745
13	27	0.	9	-.02302
15	30	2.549	91	-.02388
16	30	0.	316	.02333
17	30	.707	1	.02564
17	31	0.	45	.00686
17	32	0.	45	.01657
17	33	0.	46	.02038
17	34	0.	45	.01030
17	35	0.	46	.03503
17	36	6.021	21	-.03651
19	40	11.402	30	-.05887
19	46	0.	44	-.01169
19	53	0.	46	.02183
19	60	5.701	63	.00544
16	62	3.504	76	.00790
16	65	0.	45	.01250
16	67	1.118	74	.04626
15	67	0.	134	-.00997
14	67	4.031	189	-.02343
11	61	0.	200	.03703
9	57	3.579	177	.07417
6	57	4.473	80	-.00272
4	64	3.837	73	.02571
3	63	2.236	203	-.04959
3	61	0.	225	.01796
3	60	0.	225	.01125
3	59	0.	223	-.02713
3	58	0.	226	.02116
3	57	0.	223	-.02591
3	56	6.519	209	-.02773
2	53	2.236	222	-.04195
3	52	5.000	231	-.02761
3	46	0.	223	-.03148
3	41	0.	225	.01547
3	36	0.	229	.07140

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	317	.04933
11	18	11.402	38	.08425
11	24	8.310	33	.02430
13	27	0.	15	.06543
15	30	2.549	90	-.01210
16	30	0.	315	.01283
17	30	.707	1	.03112
17	31	0.	42	-.04753
17	32	0.	46	.02762
17	33	0.	41	-.06259
17	34	0.	45	.01223
17	35	0.	47	.04049
17	36	6.021	21	-.02586
19	40	11.402	33	-.00295
19	46	0.	45	.01161
19	53	0.	40	-.07283
19	60	5.701	64	.01415
16	62	3.504	73	-.04534
16	65	0.	47	.03968
16	67	1.118	68	-.05813
15	67	0.	134	-.01275
14	67	4.031	190	-.01005
11	61	0.	199	.01430
9	57	3.579	175	.03347
6	57	4.473	81	.01387
4	64	3.837	73	.03978
3	63	2.236	209	.04434
3	61	0.	229	.07652
3	60	0.	229	.07254
3	59	0.	224	-.00852
3	58	0.	223	-.01836
3	57	0.	226	.03097
3	56	6.519	210	-.00619
2	53	2.236	227	.03666
3	52	5.000	232	-.00260
3	46	0.	227	.03843
3	41	0.	227	.04279
3	36	0.	224	-.00007

CARDS= 20 SCALE= 50 SPEED=500 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	318	.06941
11	18	11.402	35	.03517
11	24	8.310	31	-.00945
13	27	0.	13	.03262
15	30	2.549	90	-.00208
16	30	0.	313	-.02866
17	30	.707	92	-.04531
17	31	0.	49	.08551
17	32	0.	45	.00589
17	33	0.	44	-.00785
17	34	0.	43	-.02422
17	35	0.	46	.02567
17	36	6.021	21	-.03042
19	40	11.402	34	.01536
19	46	0.	46	.02052
19	53	0.	44	-.00255
19	60	5.701	60	-.05369
16	62	3.504	75	-.00006
16	65	0.	44	-.00541
16	67	1.118	73	.03117
15	67	0.	132	-.03825
14	67	4.031	190	-.01364
11	61	0.	199	.01402
9	57	3.579	175	.03099
6	57	4.473	82	.04157
4	64	3.837	70	-.02224
3	63	2.236	205	-.01824
3	61	0.	223	-.03345
3	60	0.	229	.08134
3	59	0.	222	-.03430
3	58	0.	224	-.00492
3	57	0.	223	-.01985
3	56	6.519	212	.03287
2	53	2.236	225	.00239
3	52	5.000	231	-.02399
3	46	0.	223	-.02461
3	41	0.	225	.01628
3	36	0.	224	-.01143

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 1

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.00763
11	18	11.402	36	.04232
11	24	8.310	34	.03703
13	27	0.	9	-.03135
15	30	2.549	1	.02183
16	30	0.	317	.04449
17	30	.707	0	.00690
17	31	0.	44	-.01633
17	32	0.	45	.01511
17	33	0.	41	-.05494
17	34	0.	47	.04960
17	35	0.	43	-.02723
17	36	6.021	21	-.03382
19	40	11.402	33	.00529
19	46	0.	46	.01895
19	53	0.	46	.02262
19	60	5.701	66	.04525
16	62	3.504	76	.00646
16	65	0.	43	-.02139
16	67	1.118	70	-.02541
15	67	0.	135	.00257
14	67	4.031	189	-.02767
11	61	0.	198	-.00677
9	57	3.579	170	-.05509
6	57	4.473	77	-.05854
4	64	3.837	74	.05429
3	63	2.236	209	.04588
3	61	0.	223	-.02604
3	60	0.	222	-.04224
3	59	0.	225	.00385
3	58	0.	225	.00187
3	57	0.	225	.00459
3	56	6.519	213	.04165
2	53	2.236	223	-.03143
3	52	5.000	235	.04862
3	46	0.	226	.02117
3	41	0.	224	-.00842
3	36	0.	226	.02153

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 2

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.01911
11	18	11.402	35	.02696
11	24	8.310	32	-.00694
13	27	0.	14	.06184
15	30	2.549	1	.02130
16	30	0.	313	-.01976
17	30	.707	90	-.01713
17	31	0.	44	-.00722
17	32	0.	44	-.00315
17	33	0.	44	-.01411
17	34	0.	44	-.01477
17	35	0.	45	.01744
17	36	6.021	21	-.03771
19	40	11.402	31	-.03997
19	46	0.	44	.00008
19	53	0.	46	.01951
19	60	5.701	67	.06306
16	62	3.504	75	-.00066
16	65	0.	47	.04118
16	67	1.118	69	-.03682
15	67	0.	135	.01149
14	67	4.031	193	.04466
11	61	0.	198	-.00110
9	57	3.579	175	.02893
6	57	4.473	78	-.04163
4	64	3.837	72	.01371
3	63	2.236	207	.02460
3	61	0.	222	-.03690
3	60	0.	223	-.02007
3	59	0.	222	-.03540
3	58	0.	223	-.03234
3	57	0.	224	-.00340
3	56	6.519	210	-.01068
2	53	2.236	222	-.03742
3	52	5.000	231	-.02033
3	46	0.	223	-.02531
3	41	0.	223	-.03145
3	36	0.	225	.01356

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 3

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	316	.02563
11	18	11.402	36	.05248
11	24	8.310	32	-.00022
13	27	0.	9	-.02559
15	30	2.549	91	-.03176
16	30	0.	313	-.02273
17	30	.707	91	-.02135
17	31	0.	42	-.04207
17	32	0.	47	.03713
17	33	0.	46	.02249
17	34	0.	45	.00791
17	35	0.	44	-.01015
17	36	6.021	24	.01741
19	40	11.402	33	-.01093
19	46	0.	42	-.03684
19	53	0.	46	.03215
19	60	5.701	64	.01489
16	62	3.504	77	.03503
16	65	0.	43	-.01820
16	67	1.118	70	-.01852
15	67	0.	135	.01754
14	67	4.031	189	-.02932
11	61	0.	198	-.00250
9	57	3.579	174	.02182
6	57	4.473	80	-.00186
4	64	3.837	71	-.00570
3	63	2.236	205	-.02522
3	61	0.	224	-.00131
3	60	0.	227	.05250
3	59	0.	224	-.01299
3	58	0.	224	-.01646
3	57	0.	227	.03702
3	56	6.519	212	.01914
2	53	2.236	225	.00551
3	52	5.000	235	.03899
3	46	0.	223	-.03367
3	41	0.	224	-.01264
3	36	0.	226	.03250

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 4

OX	OY	RADIUS	DEGREES	GAMMA (RADIANS)
9	14	2.500	313	-.02125
11	18	11.402	32	-.01985
11	24	8.310	35	.05205
13	27	0.	12	.01314
15	30	2.549	91	-.02973
16	30	0.	313	-.01709
17	30	.707	90	-.00933
17	31	0.	46	.02327
17	32	0.	45	.00636
17	33	0.	45	.00650
17	34	0.	45	.01638
17	35	0.	47	.03711
17	36	6.021	24	.02966
19	40	11.402	36	.04610
19	46	0.	45	.01221
19	53	0.	44	-.00382
19	60	5.701	65	.03825
16	62	3.504	75	-.01117
16	65	0.	45	.00566
16	67	1.118	69	-.03067
15	67	0.	131	-.06288
14	67	4.031	191	.00026
11	61	0.	200	.03242
9	57	3.579	171	-.03666
6	57	4.473	77	-.04552
4	64	3.837	69	-.03255
3	63	2.236	206	-.00085
3	61	0.	224	-.01039
3	60	0.	224	-.01319
3	59	0.	223	-.02283
3	58	0.	227	.05214
3	57	0.	224	-.01375
3	56	6.519	212	.02185
2	53	2.236	227	.04435
3	52	5.000	234	.01936
3	46	0.	224	-.00562
3	41	0.	222	-.04592
3	36	0.	220	-.08256

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 5

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.01836
11	18	11.402	33	.00541
11	24	8.310	31	-.02512
13	27	0.	10	-.02017
15	30	2.549	91	-.02553
16	30	0.	316	.03149
17	30	.707	91	-.02625
17	31	0.	46	.02008
17	32	0.	44	-.01483
17	33	0.	45	.01352
17	34	0.	45	.00742
17	35	0.	43	-.02181
17	36	6.021	24	.02932
19	40	11.402	35	.03812
19	46	0.	42	-.04595
19	53	0.	42	-.04242
19	60	5.701	63	-.00406
16	62	3.504	76	.00504
16	65	0.	46	.03290
16	67	1.118	71	.00241
15	67	0.	133	-.01940
14	67	4.031	190	-.01382
11	61	0.	199	.02618
9	57	3.579	172	-.01844
6	57	4.473	82	.03701
4	64	3.837	70	-.01795
3	63	2.236	206	-.00154
3	61	0.	225	.01793
3	60	0.	224	-.00114
3	59	0.	225	.01819
3	58	0.	224	-.01036
3	57	0.	225	.01439
3	56	6.519	210	.00110
2	53	2.236	223	-.02349
3	52	5.000	233	.01193
3	46	0.	224	-.00258
3	41	0.	225	.00866
3	36	0.	223	-.02907

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 6

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.03310
11	18	11.402	31	-.03760
11	24	8.310	34	.03463
13	27	0.	10	-.01187
15	30	2.549	0	.00490
16	30	0.	314	-.01100
17	30	.707	90	-.01319
17	31	0.	44	-.01436
17	32	0.	45	.01267
17	33	0.	43	-.03077
17	34	0.	42	-.05100
17	35	0.	44	-.00595
17	36	6.021	22	-.01253
19	40	11.402	32	-.01837
19	46	0.	45	.00678
19	53	0.	44	-.00866
19	60	5.701	60	-.05028
16	62	3.504	75	-.01438
16	65	0.	42	-.03881
16	67	1.118	72	.02074
15	67	0.	132	-.05165
14	67	4.031	193	.04075
11	61	0.	197	-.02291
9	57	3.579	173	-.00973
6	57	4.473	79	-.01117
4	64	3.837	73	.03036
3	63	2.236	203	-.05463
3	61	0.	226	.01887
3	60	0.	225	.01331
3	59	0.	223	-.01792
3	58	0.	223	-.02058
3	57	0.	223	-.01825
3	56	6.519	210	-.01068
2	53	2.236	225	.00265
3	52	5.000	235	.03474
3	46	0.	227	.04459
3	41	0.	224	-.00070
3	36	0.	224	-.00037

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 7

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	313	-.02566
11	18	11.402	32	-.02472
11	24	8.310	32	-.00540
13	27	0.	9	-.02410
15	30	2.549	91	-.01832
16	30	0.	316	.02018
17	30	.707	91	-.03361
17	31	0.	47	.04577
17	32	0.	48	.06384
17	33	0.	47	.04685
17	34	0.	46	.02215
17	35	0.	44	-.00658
17	36	6.021	25	.03982
19	40	11.402	31	-.04430
19	46	0.	41	-.06712
19	53	0.	48	.05657
19	60	5.701	59	-.06546
16	62	3.504	75	-.01410
16	65	0.	47	.04590
16	67	1.118	72	.01887
15	67	0.	133	-.02355
14	67	4.031	189	-.03214
11	61	0.	198	.00469
9	57	3.579	171	-.04381
6	57	4.473	79	-.02603
4	64	3.837	71	-.00938
3	63	2.236	206	-.00219
3	61	0.	223	-.02584
3	60	0.	225	.00878
3	59	0.	224	-.00859
3	58	0.	222	-.04583
3	57	0.	224	-.00469
3	56	6.519	210	-.00442
2	53	2.236	226	.03230
3	52	5.000	233	.00630
3	46	0.	225	.01297
3	41	0.	222	-.03620
3	36	0.	226	.02291

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 8

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.01655
11	18	11.402	33	-.00519
11	24	8.310	35	.05231
13	27	0.	10	-.01240
15	30	2.549	90	-.00316
16	30	0.	314	-.01019
17	30	.707	90	-.01760
17	31	0.	45	.01586
17	32	0.	45	.01299
17	33	0.	43	-.01751
17	34	0.	46	.02432
17	35	0.	45	.00105
17	36	6.021	23	.00866
19	40	11.402	35	.02663
19	46	0.	42	-.05122
19	53	0.	44	-.00710
19	60	5.701	67	.06403
16	62	3.504	76	.01351
16	65	0.	44	-.00702
16	67	1.118	70	-.02220
15	67	0.	133	-.02717
14	67	4.031	190	-.02108
11	61	0.	199	.01078
9	57	3.579	174	.01050
6	57	4.473	75	-.08876
4	64	3.837	69	-.03264
3	63	2.236	206	-.00408
3	61	0.	227	.04029
3	60	0.	224	-.00898
3	59	0.	226	.01971
3	58	0.	226	.02844
3	57	0.	221	-.05814
3	56	6.519	208	-.03820
2	53	2.236	225	.01003
3	52	5.000	231	-.02913
3	46	0.	226	.02465
3	41	0.	226	.02622
3	36	0.	227	.04587

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 9

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.01046
11	18	11.402	34	.00808
11	24	8.310	32	.00209
13	27	0.	12	.01978
15	30	2.549	90	-.01762
16	30	0.	315	.00470
17	30	.707	0	.00203
17	31	0.	45	.00106
17	32	0.	41	-.06364
17	33	0.	45	.01435
17	34	0.	43	-.01757
17	35	0.	42	-.04820
17	36	6.021	20	-.04119
19	40	11.402	31	-.03373
19	46	0.	46	.03010
19	53	0.	44	-.00447
19	60	5.701	61	-.03518
16	62	3.504	78	.03830
16	65	0.	47	.04818
16	67	1.118	71	-.00136
15	67	0.	133	-.01720
14	67	4.031	195	.07002
11	61	0.	201	.05681
9	57	3.579	171	-.02931
6	57	4.473	79	-.02089
4	64	3.837	69	-.03757
3	63	2.236	210	.07050
3	61	0.	227	.04459
3	60	0.	223	-.02905
3	59	0.	224	-.00184
3	58	0.	225	.00393
3	57	0.	229	.07461
3	56	6.519	211	.01307
2	53	2.236	225	.00714
3	52	5.000	232	-.00677
3	46	0.	225	.00972
3	41	0.	226	.01865
3	36	0.	224	-.00796

CARDS= 20 SCALE= 50 SPEED=570 THRESH= 20.0 TIME= 10

OX	OY	RADIUS	DEGREES	GAMMA(RADIANS)
9	14	2.500	315	.00287
11	18	11.402	33	.00270
11	24	8.310	30	-.03297
13	27	0.	14	.06216
15	30	2.549	91	-.02026
16	30	0.	313	-.03192
17	30	.707	1	.02304
17	31	0.	42	-.03831
17	32	0.	46	.01787
17	33	0.	43	-.03300
17	34	0.	45	.00424
17	35	0.	44	-.00803
17	36	6.021	23	.00370
19	40	11.402	34	.02036
19	46	0.	44	-.00414
19	53	0.	45	.00525
19	60	5.701	63	-.00379
16	62	3.504	76	.00968
16	65	0.	41	-.05369
16	67	1.118	70	-.02046
15	67	0.	132	-.04649
14	67	4.031	193	.04059
11	61	0.	200	.03577
9	57	3.579	172	-.02469
6	57	4.473	83	.04756
4	64	3.837	72	.01300
3	63	2.236	208	.03404
3	61	0.	226	.03515
3	60	0.	224	-.00747
3	59	0.	224	-.00743
3	58	0.	227	.04649
3	57	0.	224	-.00702
3	56	6.519	208	-.04017
2	53	2.236	225	.01154
3	52	5.000	233	.00050
3	46	0.	228	.06312
3	41	0.	224	.00023
3	36	0.	226	.02474

```
*M4977-4526,FMS,DEBUG,5,5,8000,4000    NEGROPONTE FINAL TEST1 REPEAT
*      XEQ
*             MAD
              INTEGER CARDS,SCALE,SPEED,FIELD,X,Y,NX,NY,OX,OY,PX,PY,TEST,ST
             1ARTX,ENDX,STARTY,ENDY,AR,K1,K2,K3,DR,ER,FR,H,I,J,M,N,A,B,DGRS
             2,PLUS,STOP,TIME,TIMES,SPCR,SPCRT,THRCR,THRCRT
              DIMENSION FIELD (1400,AD)
              VECTOR VALUES AD = 2,1,70
              READ FORMAT IN,CARDS, SCALE, SPEED, THRESH, EMP1, EMP2
              VECTOR VALUES IN = $3I10, 3F10.5*$
              READ FORMAT CONT,TIMES,SPCR,SPCRT,THRCR,THRCRT
              VECTOR VALUES CONT = $ 5I10*$
              SPCALE = SCALE/(SPEED*.682)
              READ FORMAT INPUT, FIELD (1,1)...FIELD(CARDS,70)
              VECTOR VALUES INPUT = $70C1*$
              WRITE BINARY TAPE 5, FIELD (1,1)...FIELD(CARDS,70)
              B = SETU.(45678901)
              SPCRTT = 0
              THRTT = 0
              TIME = 1
              TRANSFER TO SKIPRD
NBEGIN        TIME = 1
RBEGIN        READ BINARY TAPE 5, FIELD(1,1)...FIELD(CARDS,70)
SKIPRD        REWIND TAPE 5
              PRINT RESULTS CARDS,SCALE,SPEED,THRESH
              PRINT RESULTS EMP1,EMP2,SPCALE,TIME
              PUNCH FORMAT KNOW,CARDS,SCALE,SPEED,THRESH,TIME
              VECTOR VALUES KNOW = $ 6HCARDS=,I4,8H  SCALE=,I3,8H  SPEED=,I
             13,8H THRESH=,F5.1,8H   TIME=,I3*$
              OX = 0
              START = RANNO.(XX)
              STOP= 50 * START
              THROUGH BEGIN,  FOR CHECK = 1, 1, CHECK .G.STOP
BEGIN         RECT1 = RANNO.(XX)
              RECT2 = RANNO. (XX)
              R1 = ((-2*(LOG.(RECT1 ))).P.0.5)*(COS.(2.0*3.1416*RECT2 ))
              GAMMA = (EMP1/SPEED)*R1
              PRINT RESULTS GAMMA
              THROUGH LOOK, FOR X=1,1,X.G.CARDS
              THROUGH LOOK, FOR Y=1,1,Y.G.70
LOOK          WHENEVER FIELD (X,Y) .E. $A$, TRANSFER TO NEXT
NEXT          NY = Y
              NX = X
              TEST = $1$
              FIELD (X,Y) = $.$
NOP           TEST = TEST + 1000000000K
              STARTX = X-5
              STARTY = Y-7
              WHENEVER STARTY .L.0, STARTY = 0
              WHENEVER STARTX .L.0, STARTX = 0
              ENDX = X+5
              ENDY = Y+7
              WHENEVER ENDX .G. CARDS, ENDX = CARDS
              WHENEVER ENDY .G. 70, ENDY = 70
              THROUGH FIND, FOR X = STARTX, 1,X.G.ENDX
```

```
          THROUGH FIND, FOR Y = STARTY,1,Y.G.ENDY
          WHENEVER OX.E.0, TRANSFER TO SKIP
          WHENEVER TEST .E. 1260606060 60K, TRANSFER TO SKIP2
          WHENEVER  FIELD(X,Y) .E. TEST, TRANSFER TO CC
          TRANSFER TO DUMMY
SKIP      WHENEVER FIELD (X,Y) .E. TEST, TRANSFER TO BB
          TRANSFER TO DUMMY
SKIP2     TEST = $0$
          WHENEVER FIELD (X,Y) .E. $0$, TRANSFER TO CC
DUMMY     CONTINUE
FIND      CONTINUE
          TRANSFER TO END
BB        OX = X
          OY = Y
          FIELD (X,Y) = $.$
          TRANSFER TO NOP
CC        PX = X
          PY = Y
          PLUS=(((((NX-OX).P.2.0)+((NY-OY).P.2.0)).P.0.5)+((((OX-PX).P.
         12.0)+((OY-PY).P.2.0)).P.0.5))/2.0
          OMEGA = 0.
          FIELD (X,Y) = $.$
          AR=  (NX*OY)+(OX*PY)+(PX*NY)-(PX*OY)-(OX*NY)-(NX*PY)
          RADIUS = 0.
          WHENEVER AR .E. 0, TRANSFER TO BOUND
          K1 = (NX*NX)+(NY*NY)
          K2 = (OX*OX)+(OY*OY)
          K3 = (PX*PX)+(PY*PY)
          DR= -((K1*OY)+(K2*PY)+(K3*NY)-(K3*OY)-(K2*NY)-(K1*PY))
          ER= -((NX*K2)+(OX*K3)+(PX*K1)-(PX*K2)-(OX*K1)-(NX*K3))
          FR= -((NX*OY*K3)+(OX*PY*K1)+(PX*NY*K2)-(PX*OY*K1)-(OX*NY*K3)-
         1(NX*PY*K2))
          DETER = ((DR.P.2.0)+(ER.P.2.0)-(4*AR*FR))/(4*(AR.P.2.0))
          WHENEVER DETER .GE. 0.
           RADIUS = (DETER).P.0.5
          OTHERWISE
           TRANSFER TO ERROR4
          END OF CONDITIONAL
          OMEGA=(SPEED*.682)/(RADIUS*SCALE)
BOUND     WHENEVER PY-NY.G..ABS.(NX-PX).OR.PX.E.NX+PY-NY
           BETA = 0.
           H = 1
           TRANSFER TO QUAD(H)
          OR WHENEVER NX-PX.G..ABS.(NY-PY).OR.PY.E.NY+NX-PX
           BETA = 1.5708
           H = 2
           TRANSFER TO QUAD(H)
          OR WHENEVER NY-PY.G..ABS.(NX-PX).OR.PX.E.NX-NY+PY
           BETA = 3.1416
           H = 3
           TRANSFER TO QUAD(H)
          OR WHENEVER PX-NX .G..ABS.(NY-PY).OR.PY.E.NY-PX+NX
           BETA = 4.7124
           H = 4
           TRANSFER TO QUAD(H)
```

```
            OTHERWISE
             TRANSFER TO ERROR2
            END OF CONDITIONAL
QUAD(1)     WHENEVER NX.G.PX
             THETA = (ATAN.((NX-PX)/(PY-NY+0.0)))+.7854
            OR WHENEVER  NX.LE.PX
             THETA = .7854 -(ATAN.((PX-NX)/(PY-NY+0.0)))
            END OF CONDITIONAL
            TRANSFER TO RANDOM
CHNG(1)     I=OY
            J=70
            TRANSFER TO BBODY
SECT(1)     M=OX-((Y-OY)*(TAN.(THETA)))
            N=OX+((Y-OY)/(TAN.(THETA)))
            TRANSFER TO CBODY
QUAD(2)     WHENEVER PY.G.NY
             THETA=(ATAN.((NX-PX)/(PY-NY+0.0)))-.7854
            OR WHENEVER PY .LE.NY
             THETA=.7854+(ATAN.((NY-PY)/(NX-PX+0.0)))
            END OF CONDITIONAL
            TRANSFER TO RANDOM
CHNG(2)     M=1
            N=OX
            TRANSFER TO ABODY
SECT(2)     I=OY-((OX-X)*(TAN.(THETA)))
            J=OY+((OX-X)/(TAN.(THETA)))
            TRANSFER TO BBODY
QUAD(3)     WHENEVER NX.G.PX
             THETA=(ATAN.((NY-PY)/(NX-PX+0.0)))-.7854
            OR WHENEVER NX.LE.PX
             THETA=.7854+(ATAN.((PX-NX)/(NY-PY+0.0)))
            END OF CONDITIONAL
            TRANSFER TO RANDOM
CHNG(3)     I=1
            J=OY
            TRANSFER TO BBODY
SECT(3)     M=OX-((OY-Y)/(TAN.(THETA)))
            N=OX+((OY-Y)*(TAN.(THETA)))
            TRANSFER TO CBODY
QUAD(4)     WHENEVER NY.G.PY
             THETA=(ATAN.((PX-NX)/(NY-PY+0.0)))-.7854
            OR WHENEVER NY.LE.PY
             THETA=.7854+(ATAN.((PY-NY)/(PX-NX+0.0)))
            END OF CONDITIONAL
            TRANSFER TO RANDOM
CHNG(4)     M=OX
            N=CARDS
            TRANSFER TO ABODY
SECT(4)     I=OY-((X-OX)/(TAN.(THETA)))
            J=OY+((X-OX)*(TAN.(THETA)))
            TRANSFER TO BBODY
RANDOM      RECT1 = RANNO.(XX)
            RECT2 = RANNO.(XX)
            R1 = ((-2*(LOG.(RECT1 ))).P.0.5)*(COS.(2.0*3.1416*RECT2 ))
            GAMMA =(((EMP1/SPEED)*R1)+(GAMMA/EMP2))/57.283
```

```
           PRINT RESULTS GAMMA,BETA,THETA,H
           THETA = THETA + GAMMA
           WHENEVER THETA .L. 1.5708 .AND.THETA .GE. 0.0
            TRANSFER TO CHNG(H)
           OR WHENEVER THETA .GE. 1.5708 .AND. H.NE. 4
            THETA = THETA - 1.5708
            H = H + 1
            TRANSFER TO CHNG(H)
           OR WHENEVER THETA .GE. 1.5708
            THETA = THETA - 1.5708
            H = 1
            TRANSFER TO CHNG(H)
           OR WHENEVER THETA .L. 0.0 .AND. H .NE. 1
            THETA = 1.5708 - THETA
            H = H - 1
            TRANSFER TO CHNG(H)
           OTHERWISE
            THETA = 1.5708 - THETA
            H = 1
            TRANSFER TO CHNG(H)
           END OF CONDITIONAL
ABODY      THROUGH LOOP,FOR X = M, 1, X.G.N
           TRANSFER TO SECT(H)
BBODY      WHENEVER I.L.0, I=0
           WHENEVER J.G.70, J=70
           THROUGH LOOP, FOR Y = I, 1, Y.G.J
           WHENEVER H.E.2 .OR. H.E.4 , TRANSFER TO DBODY
           TRANSFER TO SECT(H)
CBODY      WHENEVER M.L.0, M=0
           WHENEVER N.G.CARDS, N=CARDS
           THROUGH LOOP, FOR X = M, 1, X.G.N
DBODY      WHENEVER FIELD (X,Y).NE. $X$, TRANSFER TO LOOP
           A=.ABS.(SCALE*(Y-OY))
           B=.ABS.(SCALE*(X-OX))
           WHENEVER A .E. 0  , TRANSFER TO LOOP
           ANGVEL =(((57.283 *A)/(A.P.2 + B.P.2))*(.682)*(SPEED))+OMEGA
           WHENEVER ANGVEL .LE. THRESH, TRANSFER TO LOOP
           WHENEVER FIELD (X,Y) .E. $X$
           FIELD (X,Y) = PLUS
           OTHERWISE
            FIELD (X,Y) = FIELD (X,Y) + PLUS
           END OF CONDITIONAL
LOOP       CONTINUE
           DGRS = 57.283 *(THETA+BETA)
           PRINT RESULTS OX,OY,RADIUS, DGRS
           PUNCH FORMAT PGRMC,OX,OY,RADIUS,DGRS,GAMMA
           VECTOR VALUES PGRMC = $ S17, 2I10, F10.3, I10, F10.5 *$
           NX=OX
           NY=OY
           OX=PX
           OY=PY
           X = OX
           Y = OY
           TRANSFER TO NOP
END        THROUGH POSIE, FOR X = STARTX, 1, X.G.ENDX
```

```
          THROUGH POSIE, FOR Y = STARTY, 1, Y.G.ENDY
POSIE     WHENEVER FIELD (X,Y) .E. $Z$, TRANSFER TO OUT
          PRINT COMMENT $1ERROR HAS OCCURRED AS THE NEXT PLACE HAS NOT
         1BEEN FOUND. IS NEXT MARK WITHIN THE 10X14 SEARCHING RECTANGL$
          PRINT COMMENT $ OR ELSE YOU HAVE FORGOTTEN TO PLACE A Z AT TH
         1E END OF THE DESCRIBED ROUTE$
          PRINT FORMAT ERR1,OX,OY,PX,PY
          VECTOR VALUES ERR1= $52H THE LAST TWO RECOGNIZED POSITIONS WE
         1RE AT LOCATION(,2I5,16H) AND LOCATION (, 2I5,2H) *$
          TRANSFER TO OUT
ERROR2    PRINT COMMENT $ ERROR HAS OCCURED IN THE LOCATION OF QUADRANT
         1S$
          PRINT COMMENT $ THETA                   NX     NY     OX     OY     PX
         1   PY     RADIUS   $
          PRINT FORMAT ERR2,THETA,NX,NY,OX,OY,PX,PY,RADIUS
          VECTOR VALUES ERR2 =$F6.2,S10(6I10,F12.2*$
          TRANSFER TO OUT
ERROR4    PRINT COMMENT $ ERROR HAS OCCURRED RADIUS VECTOR IS NEGATIVE$
          PRINT COMMENT $    NX       NY       OX       OY       PX       P
         1Y       K1       K2       K3       DR       ER       FR    DETER$
          PRINT FORMAT ERR4,NX,NY,OX,OY,PX,PY, K1,K2,K3,DR,ER,FR,DETER
          VECTOR VALUES ERR4 = $1H , 12I8,F12.4*$
OUT       THROUGH RPLC, FOR X = 1, 1, X.G.CARDS
          THROUGH RPLC, FOR Y = 1, 1, Y.G.70
          WHENEVER FIELD (X,Y) .E. $.$ .OR. FIELD (X,Y) .E. $X$.OR. FIE
         1LD (X,Y) .E. $ $ .OR. FIELD (X,Y) .E. $Z$, TRANSFER TO RPLC
          FIELD (X,Y) = FIELD (X,Y) / SPCALE
          WHENEVER FIELD (X,Y) .G. 9
           FIELD (X,Y) = $0$
          OR WHENEVER FIELD (X,Y) .L. 1
           FIELD (X,Y) = $X$
          OTHERWISE
          FIELD (X,Y) = FIELD (X,Y) .LS. 30
          END OF CONDITIONAL
RPLC      CONTINUE
          PRINT RESULTS SPCALE
          PRINT COMMENT $1
         1    0X0       1X0       2X0       3X0       4X0       5X0
         2   6X0$
          PRINT COMMENT $
         1 1234567890123456789012345678901234567890123456789012345678901234567890
         21234567890$
          PRINT FORMAT FINITO, FIELD (1,1)...FIELD(CARDS,70)
          VECTOR VALUES FINITO = $ S47, 70C1*$
          PRINT COMMENT $
         1 1234567890123456789012345678901234567890123456789012345678901234567890
         21234567890$
          PRINT COMMENT $
         1    0X0       1X0       2X0       3X0       4X0       5X0
         2   6X0$
          PUNCH FORMAT HAVE, FIELD (1,1)...FIELD(CARDS,70)
          VECTOR VALUES HAVE = $70C1*$
          WHENEVER TIME .GE. TIMES, TRANSFER TO SPC
          TIME = TIME + 1
          TRANSFER TO RBEGIN
```

```
SPC          WHENEVER SPCR .E.0 .OR. SPCRTT .GE.SPCRT
              TRANSFER TO THR
             OTHERWISE
              SPCRTT = SPCRTT + 1
              SPEED = SPEED + SPCR
              TRANSFER TO NBEGIN
             END OF CONDITIONAL
THR          WHENEVER THRCR .E.0 .OR. THRTT .GE. THRCRT
              TRANSFER TO ATLAST
             OTHERWISE
              THRTT = THRTT + 1
              THRESH = THRESH + THRCR
              TRANSFER TO RBEGIN
             END OF CONDITONAL
ATLAST       END OF PROGRAM
*     DATA
```