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Final Report

CR-128945

OBJECTIVE TECHNIQUES FOR PSYCHOLOGICAL ASSESSMENT

73-9045
March 14, 1973

(NASA-CR-128945) OBJECTIVE TECHNIQUES FOR PSYCHOLOGICAL ASSESSMENT Final Report (AiResearch Mfg. Co., Los Angeles, Calif.) 111 p HC $7.75 CSCL 05E

N73-24136

Unclas
G3/05 05006

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Manned Spacecraft Center
Houston, Texas

NAS 9-12771

GARRETT

AIRESEARCH MANUFACTURING COMPANY
Los Angeles, California

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CONTENTS

SECTION I

INTRODUCTION

GENERAL

This document, prepared from work done under contract NAS 9-12771 and monitored by Dr. W. E. Fedderson, presents the results of a research program to develop objective methods for psychological assessment of crew members prior to and during long-duration space flights.

The ultimate goal of the research program described in this report is the development of an objective method of psychologically assessing both potential space flight crew candidates and their individual and group behavior during long-duration space flight. The long-term aim of the program is to discover and use psychological, performance, and psychophysiological variables that can be monitored in the course of routine mission-oriented behavior and that have indicative and predictive values for psychosocial well-being.

Thus, the long-range research objectives are to develop and evaluate assessment methodology; to test and demonstrate this methodology in situations as closely resembling manned space flight conditions as possible; to modify, update, and validate the methodology under situations of confinement and stress; and ultimately to evolve the assessment techniques and hardware into a system fully compatible with both spacecraft hardware and the anticipated life style of crew members on long-duration missions. The latter is important because crew acceptance is vital for the ultimate utility of the proposed methodology.

The selected research paradigm investigates attentional flexibility as a means of psychological assessment (i.e. the ability to adapt rapidly those functional states of attention that are appropriate for any personal, social, or mission change in orientation, process, or task). Thus, the near-term objective of the program is to devise tasks requiring high attentional states and to determine the assessment power of various associate performance and psychophysiological variables for evaluating these states of attention.

Attentional behavior was selected as an appropriate psychological process upon which to focus because alterations in attention can occur at several levels of functioning, are detectable, and can be indicative of a wide variety of factors relevant to the well-being of individuals and groups. Psychological assessment methodology was developed using established relationships between various performance and psychophysiological variables and between those aspects of attention necessary to engage successfully in a broad category of functions.

WORK ACCOMPLISHED

The orientation taken during this phase of work was to develop and demonstrate a hardware instrumentation system and an experimental paradigm that could be used to collect data in manned isolation chamber experiments. These isolation chamber experiments had been planned for the near future, and the initial aim was to collect the demonstrative data during those test conditions.

The principal work conducted under this contract and described in the body of this report is as follows:

(a) A substantive review of pertinent literature

(b) Selection of appropriate methods of objective psychological evaluation

(c) Development of techniques for psychological evaluation

(d) Development of apparatus, instrumentation, computer programs, and procedures to test the methods selected under items (b) and (c) above

(e) Pilot study experimentation

(f) Evaluation and report on the pilot study results

(g) Recommendations for future research and development

SECTION II

BACKGROUND

REVIEW OF RECENT LITERATURE

Reviews of the broad and varied subject of attentional behavior can be found in Koster (1969) (Reference 1), Sanders (1970) (Reference 2), and Mackworth (1970) (Reference 3); in addition, Moray (1969) (Reference 4) proposed six different meanings of attention as used in psychological research. Posner and Boies (1971) (Reference 5), however, provide three general concepts or categories under which most research (as well as Moray's meanings) can be categorized. These are listed below.

> Alertness, or Arousal--A varying state of readiness to detect stimuli in repetitive, boring, or low-stimulus frequency tasks (such as vigilance tasks). The term also relates to level of sensitivity to stimuli during periods of preparation for receiving stimulation. Both performance measures (e.g., Mackworth, 1970) (Reference 3) and physiological measures (e.g., Näätänen, 1970) (Reference 6) of alertness provide rationale for including alertness as a component of attention.
>
> Selective Attention--The ability to select one kind of information from another or to select one source of information from other sources. Studies of selective attention may involve sensory modalities, location of signals, selection of responses, content of the information in the stimulus array, or internal templates, models, and memories of past events.
>
> Limited Central Processing Capability--The difficulty in handling two tasks simultaneously; the delay of signals that arrive during reaction time.

For the purpose of this review, emphasis will be placed on the first two topics above and an additional category, Psychophysiological Factors, will be added. This latter section is presented separately because the nature of certain dependent variables, and their utilization as indicative of major modes of responding on an organismic level, has received great emphasis and aroused considerable controversy.

Alertness, Isolation, and Clinical Factors

Fedderson and Kanas (1971) (Reference 7) reviewed the stresses of long-duration space flight and argued for improved personnel selection techniques and better understanding of these stresses so that intervention strategies might be developed. Memford (1970) (Reference 8) argued for utilization of responses to stress as indexes for selection of personnel and presented data from psychological, physiological, and chemical tests.

Zubek (1970), (Reference 9) reporting on behavioral and electroencephalographic changes in individuals and groups of men during 14 days in isolation, emphasized the changes in perceptual processes.

Another recent study on isolation by Serafetinides (1971) (Reference 10) also found an ever-present progressive reduction of cortical activity in cases of sensory deprivation. It appears that this perennially consistent alteration in the EEG could be accepted as prima facie evidence of sensory deprivation.

Evidence that the effects of varied levels of sensory input represent a two-edged sword was obtained by Zuckerman et al. (1970) (Reference 11). Utilizing subjects in confinement, they produced environments designed to provide high, normal, and low levels of arousal by manipulation of sensory variety in the environment. They found that anxiety and adrenocortical responses were elevated in both the high arousal and low arousal situations as compared with the control situation. Of the two extreme conditions, subjects preferred the high arousal situation to the low arousal one, which was associated with depression. From this and other work (such as that of Frankenhauser et al.) (Reference 12), some approximation of the optimum level of arousal that should be the design objective for space stations and other long-duration manned systems can be obtained.

Shapiro et al. (1970) (Reference 13) observed the effects of sensory reduction in organs and systems not usually monitored in this type of research. They found that reduction of auditory and vestibular inputs resulted in a marked inhibition of gastric secretion.

In trying to understand the relationship of monotony to psychophysiological responses, Coffman and Kimmel (1971) (Reference 14) studied a situation in which the occurrence of a brief light flash in the dark would be contingent upon the occurrence of a galvanic skin response (GSR). They found that there was instrumental conditioning of the GSR under these conditions. Consequently, they argued that the occurrence of an orienting response may have a reinforcing effect. Orienting responses are discussed subsequently.

Bohlin (1971) (Reference 15), studied the effect of monotonous stimulation on the rate of sleep onset and habituation of the orienting response. He found that monotonous stimulation put his subjects to sleep more quickly than no stimulation. He also found that the rate of habituation of the orienting response tracked the rate of sleep onset. For a comparison between boring stimulation and boring responses London, H., et al. (1972) (Reference 16) studied change in autonomic arousal during performance of boring tasks. They found higher heart rates with very boring tasks and suggested a curvilinear relationship between information rate and autonomic arousal. It is their suggestion that both boring, highly redundant information and low redundancy, rapidly changing situations will result in higher heart rates than will moderate levels of information processing.

Frankenhauser, et al. (1971) (Reference 12), in studying psychophysiological reactions to understimulation and overstimulation, found that these two conditions increased the rate of adrenaline and nonadrenaline production as compared with controls at moderate levels of stimulation. They also found that subjects who produced more adrenaline performed better in the under-stimulation condition, while subjects with less adrenaline production performed better in the overstimulation condition. The same observation was made with heart rate as the dependent variable. They interpret their data as supporting a curvilinear relationship between level of arousal and performance, with performance being optimal at moderate levels of arousal. Averill, J. R. et al. (1972) (Reference 17), in a study on complex emotional study, observed that when subjects were shown an isolated accident scene out of context they invariably responded with slowing heart rates; however, if the accident scene were shown within the context of an action film, the opposite response, heart rate acceleration, was observed.

Rathbart and Mellinger (1972) (Reference 18) studied attention and responsivity to remote dangers and found substantial individual differences in their population, which they characterized as fear repressors and sensitizers.

In a study along similar lines, Rice and Greenfield (1969) (Reference 19), studying the psychophysiological correlates of "LaBelle Indifference" found that patients who remained calm in the face of frightening and disabling impairment showed greater physiological arousal than did control subjects. They concluded that psychological defense does not prevent arousal of covert physiological correlates of emotion.

Schmolling and Lopidus (1972) (Reference 20), studying performance in schizophrenics, found that schizophrenics have an elevated base level of physiological parameters. Consequently, under stressful stimulation (in accord with the law of initial values) little increase is seen above baseline values for physiological measure. They characterize these subjects as being hyper-vigilant, impaired in attending, and showing difficulty in shifting the response set.

Little recent research has been conducted on shifts of attention or perception. Mackintosh and Little (1969) (Reference 21), using pigeons, have shown that strengthening of attention to a single relevant dimension increases the rate of response reversal. Schell (1971) (Reference 22) in experiments with children strongly resembling "learning set" experiments, also has shown that learning to attend to one stimulus dimension at a time improves the shift of attention from one stimulus dimension to another.

The rate of reversal of the Necker cube illusion was investigated by Roland (1970) (Reference 23). He found that stress, in the forms of cold pressor stimulation, increased the rate of reversal of the illusion. Heart rate also was correlated with the rate of reversal of the illusion.

Selective Attention and Performance

Typical studies within this category on sensing modality have been made on visual and auditory signals processing by Mackintosh and Little (1969) (Reference 21) using pigeons, and by Webster and Haslerud (1964) (Reference 24) using humans. Wachtel (1967) (Reference 25) presented a survey of evidence suggesting that attention is like a beam of light focused more or less sharply on particular sources of incoming data. He suggested that a distinction can be drawn between the narrowness of focusing at any time and the extent to which the beam ranges over the field of attentional opportunities. He proposed that characteristic tendencies in these two respects can be regarded as facets of personality varying between types of individuals. For example, highly anxious people can be thought of as tending to have a narrow beam that roams widely over the field so that their attention skips rapidly from item to item, but is intensely directed to any item on which it is actually resting. Welford (1970) (Reference 26) commented that . . ."selection seems commonly to be made in terms of attitudes and hypotheses brought to a present situation from past experience--we perceive what we expect to occur or along the lines of what is familiar. It seems clear, therefore, that selection must often be a high-grade process, concerned with data which have already been processed to a substantial extent by the mechanisms of perception. This may well be true even when selection appears to be made in terms of simple sensory quantities."

Classic data in support of this last statement by Welford was reported by Cabanac (1971) (Reference 27) in a study of alliesthesia. In this study Cabanac demonstrated the effect of changing physiological states on the qualities of incoming stimuli. In his studies temperatures and gustatory and olfactory stimuli judged as pleasant under one set of physiological conditions were judged as unpleasant under another. For example, a pleasant tasting liquid became too sweet for hours following ingestion of glucose.

A wide variety of experimental studies has shown that perceptual selection is a task involving some mental activity by the observer, and the more precise that selection must be, the longer it takes or the higher the risk of error.

Baddeley (1972) (Reference 28) suggests that it is plausible to assume that an increase in arousal will focus the subject's attention more and more narrowly on that aspect of the situation that is of greatest immediate importance to him. If this happens to be the task he is required to perform, then his efficiency will be increased; if not, his performance will deteriorate until he abandons the task.

Fortunately, however, response to a dangerous environment may be much more adaptive than this. Work by Epstein and Fenz (1965) (Reference 29) suggests that the experienced parachutist learns to inhibit anxiety since it tends to disrupt performance. They suggest that both the fear and the inhibition focus on the jump but generalize temporally both to prior and later aspects of the jumping situation, and to other stimuli associated more or less closely with jumping. If one assumes the generalization gradient associated with the inhibition of fear to be steeper than that associated with fear itself, then the point of maximum emotional response will tend to be displaced away from the danger stimulus; the greater the degree of inhibition, the farther away will be the displacement.

It seems then that subjects who are repeatedly exposed to a dangerous situation can in some way learn to inhibit their anxiety and displace it away from the point of maximum danger.

Considerable literature already exists on the effects of physiological arousal on performance, much of which suggests that they are related by a function resembling an inverted U; that is, as arousal increases, performance improves up to a maximum beyond which further increments in level of arousal lead to poorer and poorer performance (Hebb, 1955 (Reference 30); Malmo, 1959, (Reference 31)). A good deal of experimental data can be accounted for in terms of the inverted-U function. One weakness is its ability to account for almost any result so long as the exact location on the inverted U of the task in question is not specified in advance. The situation is further complicated, however, by the fact that the peak of the inverted U occurs at quite different levels of arousal for different tasks (Corcoran, 1965) (Reference 32). This is intuitively reasonable; however, unless an objective means of assessing a task in advance is available, prediction of performance under stress becomes even more difficult. It seems unlikely that such an assessment can be made until the cause of the inverted-U relationship is known.

One possible explanation of the relationship lies in the suggestion made by a number of workers that an increase in arousal produces a narrowing of attention, with the subject concentrating more and more on the central features of the task and paying less and less attention to more peripheral ones (Easterbrook 1959, (Reference 33); Teichner 1968, (Reference 34)). Perhaps the strongest experimental evidence for such a view comes from recent work by Hockey (1970 a,b) (References 35 and 36) on the effects of loud noise on performance. In one of his experiments, Hockey (1970a) (Reference 35) required his subjects to perform a centrally located tracking task, while at the same time monitoring a series of six small lights distributed on either side of the central task at varying distances from the center. Occasionally one of these lights would be illuminated briefly; if the subject detected this he pressed an appropriate response button. Subjects were tested both in continuous loud noise and in quieter conditions. Overall tracking performance was significantly higher in the noise condition than in the control condition, which showed a decrement during the session. Detection scores on the peripheral task tended to deteriorate with increasing distance from the center. Noise exaggerated this bias by improving performance on the central lights at the expense of peripheral lights. When no central task was required, noise improved detection performance; thus it appears that noise does not simply impair peripheral vision.

In a subsequent experiment, Hockey (1970b) (Reference 36) showed that subjects missed more peripheral signals in noise because they regarded them as less probable than central signals, not simply because of their peripheral location. A comparable result was recently reported by Cornsweet (1969) (Reference 37) who used threat of electric shock to increase level of arousal.

Although experimental results show a clear effect on breadth of attention of stresses that may reasonably be assumed to influence the subject's level of arousal, so far there is no direct evidence that danger will have such an effect. Evidence that this is the case comes from a study by Weltman and Egstrom (1967) (Reference 38) in which novice divers were required to perform a central task while monitoring a faint peripheral light. While the central task did not affect peripheral vigilance on the surface, during diving a distinct subgroup of the subjects emerged who showed much slower response to the peripheral lights, while showing no impairment on the central task. These subjects appeared to be more anxious than the other subgroup, which showed no deterioration under water, but unfortunately no objective measure of anxiety was available. This defect was remedied in a subsequent study (Weltman et al., 1971) (Reference 39) in which a similar dual task was performed by naive subjects during a simulated 60-ft dive in a pressure chamber. After an explanation of the potential dangers and emergency procedures, the door of the pressure chamber was bolted and a rise in pressure simulated, although actual pressure did not change. Experimental subjects showed a clear anxiety response in terms of both increased heart rate and subjective ratings. They also showed a clear decrement in detection of peripheral light signals but no drop in performance on the central task, relative to an unstressed control group.

Wachtel (1967) (Reference 25) and Moray (1969) (Reference 4) provide general reviews of performance research in selective attention, while the review of this area by Howarth and Bloomfield (1971) (Reference 40) concentrates on experiments involving attentional phenomena in search performance tasks. One specialized method of evaluating attention is shadowing performance tasks in auditory research. This topical area is thoroughly reviewed by Underwood and Moray (1971) (Reference 41).

Larkin and Greenberg (1970) (Reference 42), in studying the effect of uncertainty in presentation of auditory signals, conclude that selective attention may be a recognition phenomenon and not a detection phenomenon. They suggest that no amount of training should alter the detectability of a signal, but that differential experience, by practice, may enable a listener to recognize one tone more efficiently than another.

Typical studies involving the number of stimuli presented are represented by the studies of Chuprikova (1969) (Reference 43), Teichner (1971)(Reference 44), and Rabbit (1964) (Reference 45). Chuprikova found that increasing the number of signals possible in a representation had a continuously limiting effect on the preparedness of subjects to react. Teichner's thorough study on the effects of the number of possible signals on reaction time and probability of detection found that reaction time increased as a function of the number of possible signals and also that the probability of detection decreased as a function of increasing number of possible signals. Rabbit, using a sorting performance technique, found that scanning visual displays to find certain stimuli involved the process of ignoring other stimuli. Specifically, he found that the number of irrelevant stimuli in a display affected both the speed and the accuracy of the sorting task.

Warm (1971) (Reference 46) investigated partial reinforcement concepts utilizing a vigilance task. With a reaction time measure as a dependent variable and knowledge of results as one of the independent variables, he found that withdrawal of knowledge of results increased reaction time, and the effect of withdrawing the knowledge of results was greater in continuous than in partial reinforcement conditions.

Germana (1969) (Reference 47) manipulated interstimulus intervals and found that when the interstimulus intervals were increased greater than 240 msec, no habituation was found. Germana feels that this may be due to the establishment of the stimulus arrival rate. He also observed that recall was unaffected up to interstimulus intervals of 240 msec.

Limited Central Processing Capacity

The principal recent development in this area of attention is the study by Allport et al. (1972) (Reference 48) disproving the "single channel hypothesis" of human information processing. Their alternative hypothesis is that attention operates as if there were a number of independent special processes operating in panel. Each process is limited in capacity per unit time and most processors may be turned to a single specific problem under conditions related to signal importance.

PSYCHOPHYSIOLOGICAL FACTORS

Psychophysiological concomitants of attention can be classified into two major categories of research: (1) those studies utilizing the electroencephalograph as the principal dependent variable, and (2) investigations into phenomena associated with the orienting reaction. Studies concentrating on the first category are discussed first; however, the bulk of the discussion will focus on the latter category.

Electroencephalographic Studies--Glaser (1963) (Reference 49) has summarized the correlations between EEG findings and behavior. Electroencephalographic studies have been primarily centered around observations on the contingent negative variation or evoked potential; however, some cogent observations are being made in situations involving operant conditioning or training of EEG components.

Since 1960 there has been growing evidence to support the theory that selective attention and selective perception have their neurophysiological basis in blocking irrelevant sensory impulses. Thus, sensory pathways of unattended modalities lose some degree of their capacity to transmit signals, while the attended modality may be facilitated simultaneously. Näätänen (1971) (Reference 6) produced experimental results that show nonspecific anticipatory cortical activation preceding relevant stimuli. This, he argues, is the real reason for the greater amplitudes of potentials evoked by relevant stimuli. Hillgard et al. (1971) (Reference 50) studied those evoked potentials during auditory signal detection and found that the detected signals evoked potentials several times the magnitude of unevoked potentials. He also found that detection threshold performance was identical with concurrent electrophysiological measures of threshold.

Donald and Goff (1971) (Reference 51) reported that they have found EEG components of attention related to increases in cortical responsivity and dissociated from the contingent negative variations. Gale et al. (1971) (Reference 52) utilized subjective estimates of alertness in a vigilance type task while manipulating signal expectancy. They found EEG changes correlated with changes in expectancy in the task.

Subjective reports of subjects in the Garrett/AiResearch laboratory (Wortz, 1971) (Reference 53), corroborated by personal communication with other researchers (L. Fehmi, 1970 (Reference 54); Kamiya, 1970 (Reference 55)) in the field concerning their findings, lend support to the hypothesis that readily monitored brain wave parameters are correlated with awareness and attentional abilities. Fehmi (1970) (Reference 54), for example, reports that the amplitude of brain wave potentials is observed to be correlated with the way in which visual stimuli are viewed. When artists were instructed to view and critically apprehend their field of vision, a low-voltage, fast-electroencephalographic activity was recorded from five brain loci: midline occipital, parietal and frontal lobes, and the right and left temporal lobes. When the opposite instruction was given to view the visual field with a gestalt orientation or in the attitude that would be assumed while actively engaged in painting, the electroencephalographic activity was characterized by high-voltage, slow waves in the alpha wave region of the frequency spectrum. A grasped, stationary, and critically viewed attentional field was associated with low-voltage activity while a flowing, integrative, gestalt-like approach to the attentional field was associated with high voltage activity.

Gale et al. (1972) (Reference 52), in a study that failed in its main purpose, which was to replicate correlation between EEG, extroversion, time of day, and performance, did find incidentally that higher voltage EEG correlates with better signal detection. Consequently this vigilance task correlates with the contention of Wortz and Fehmi above.

Barry and Beh (1972) (Reference 56) found that duration of the desynchronization of the alpha rhythm of the EEG co-varied with the stimulus intensity, whereas the magnitude of the desynchronization did not.

Invgar (1971) (Reference 57) in a study of cerebral blood flow, arousal, and cerebral metabolism suggests that the EEG correlates of arousal and desynchronization are correlated with an increase in cerebral blood flow. He even indicates that regional changes in cerebral blood flow are dependent on the type of cortical activity at each region.

<u>Orientation Reaction (OR) Studies</u>--Psychophysiological studies of attention also have proceeded from the direction stemming from the work of Sokolov, which is summarized in "Perception and the Conditioned Reflex," (1963) (Reference 58) and reviewed by Lynn (1966) (Reference 59).

This perspective of attention is in terms of what the Russian investigations denoted as the orientation--or what it is--reaction (OR). Essentially, the orientation reaction or reflex involves (behaviorally) the turning of the organism toward the source of a novel stimulus. In addition, however, there are a number of concomitant physiological components of this turning toward a stimulus. The physiological changes include pupillary dilation; reduction of threshold in all sensory modalities; increased electromyographic activity; faster, lower-amplitude EEG; peripheral vasoconstriction; cephalic vasodilation; GSR; delayed respiration followed by increased amplitude and lowered frequency; and slowed heart rate. These physiological changes occur regardless of bodily movement, and their occurrence is used to define the occurrence of an orienting reaction (OR).

Essentially, stimuli that can initiate an OR are those that have signal significance, i.e., are either novel, intense, complex, or incongruous; are surprising; or produce tendencies for competing or conflicting reactions.

In addition to the OR, there are two other basic physiologic reactions of the same class that can occur in response to stimuli and must be distinguished from the OR. These are adaptive reactions and defensive reactions. Adaptive reactions refer to responses that have homeostatic or negative feedback reactions, e.g., vasodilation in response to thermal stress or pupillary dilation in response to decreases in illumination. The defensive reaction (DR), on the other hand, occurs in response to very intense or threatening stimuli and is essentially the startle reaction, which includes eye blink, cephalic vasoconstriction (instead of the cephalic vasodilation seen in the OR), and heart rate acceleration.

The other components of the OR occur in the DR without variance from the OR pattern. In addition to cephalic vasoconstriction and heart rate acceleration, another important difference between the OR and DR is that stimuli that will produce an OR will eventually habituate, and the OR will disappear. This is apparently not the case with the DR; it does not habituate. Although Wortz (1967, 1968, and 1969) (References 60, 61, and 62) has found evidence that upon repeated stimulation this response can develop from a DR into an OR, it is suggested by Wortz (1968) (Reference 61) that high-stimulus intensities just below the DR threshold may at times evoke the DR if the general health or coping mechanisms of the organisms deteriorate.

The classic representation of the relationship of the OR and DR in terms of numbers of stimulus presentations and the intensity of the stimulation is reproduced from Sokolov (1963) (Reference 58) and shown in Figure 2-1. This representation, showing that a constant intensity and tendency is to move from an OR to a DR with increasing number of stimulations, is contrary to the observations of Wortz who observed habituation of the DR evolving into an OR with cutaneous shock. The source of this discrepancy may be due to the type of stimuli employed or to levels of arousal. Sokolov observed the DR as a simple reflex and employed repetitions of a simple stimulus of fixed intensity, while Wortz observed a conditioned reflex response to a repetition of stimulus of fixed intensity.

It is apparent, however, that certain factors may vary the OR/DR threshold for a given stimulus intensity. It is suggested that psychophysiological consequences of presentation of stimuli near this threshold, for a given person and in terms of whether an OR or DR is elicited, may be indicative of fundamental aspects of the perceptual coping mechanisms of that person.

A recent study by Gogan (1970) (Reference 63) measuring psychophysiological response to forces of different intensity provide data that tend to correlate with the previously described studies. One of Gogan's principal observations is a correlation between EMG components of the DR and EEG characteristics at the time of presentation of the signal stimulus (Figure 2-2). His data show that at slower EEG frequencies, the magnitude of the elicited startle response is lower. It can be argued from this data and that of Pilsbury and Meyerowitz (Reference 64) that for stimuli of moderately high intensities, field-dependent individuals are more likely to produce a DR than field-independent subjects. Consequently, if disease does operate to alter the distribution of attention for exteroception, it can be hypothesized that this shift will be reflected in the mechanisms of the orienting and defensive reactions.

B

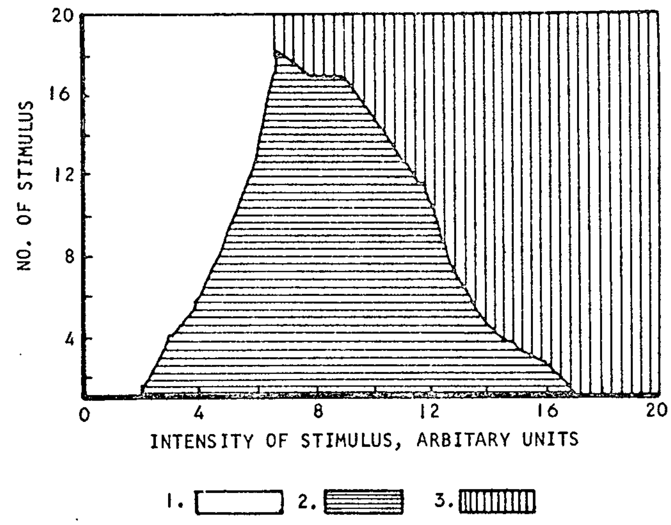

Figure 2-1. Relationship between Orienting Reflexes and Defensive Reflexes Produced by Electrodermal Stimuli of Various Strengths

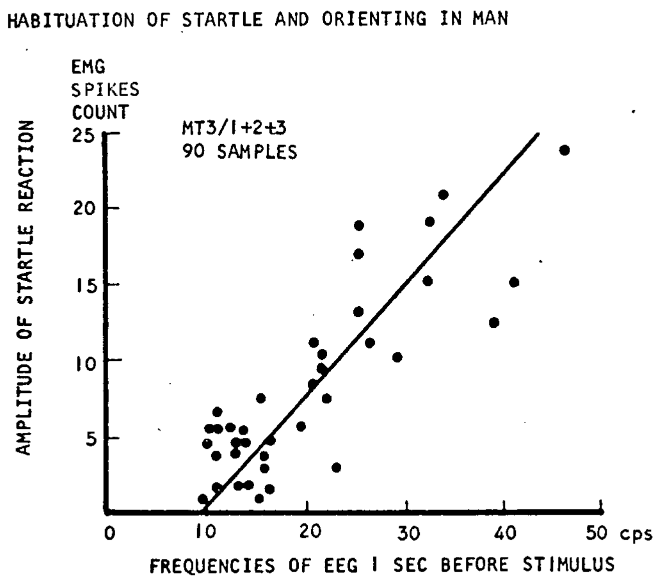

Figure 2-2. Amplitude of the Startle Reaction Plotted Against Frequency of EEG Measured One Second Before Each Stimulus

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Specifically, it is [illegible] that the most fruitful phenomena to investigate in this regard are the [illegible] in the threshold region between the OR and DR. Thus it is hypothesized that the OR/DR threshold will vary with attentional load, decreasing as attentional load is increased.

Raskin et al. (1969) (Reference 65) studied cephalic vasomotor and heart rate measures of the OR utilizing 80- and 120-db white noise signals. They always found cephalic vasoconstriction (as measured by forehead blood content or forehead pulse amplitude) to the stimulus, whereas heart rate differentiated between the two intensities. Heart rate deceleration occurred in conjunction with the 80-db stimulus while heart rate acceleration occurred with the 120-db signal.

Keefe (1970) (Reference 66) utilized a 1000-Hz tone at 70 db, and observed a biphasic forehead pulse response that he interpreted as vasodilation followed by vasoconstriction. The magnitude of vasomotor response was found to be related to the prestimulus level, which corresponds to the law of initial values. He also observed that heart rate acceleration was associated with head pulse constriction.

Fantalova (1970) (Reference 67) used a 1000-Hz tone stimulus and rheography for pulse volume measurements in an attempt to measure organ volumes as a consequence of the OR. He concluded that rheography could be used to detect the time of pulse arrival, but not organ volume.

In a study of procedural aspects of research on the OR, Gliner et al. (1971) (Reference 68) found that alterations in order of stimulus presentation can produce orienting reactions.

Just as important as the occurrence of the OR, if not more so, is the rate of habituation of this response. Gabriel and Ball (1970) (Reference 69), utilizing tactile stimuli, found that the OR magnitude would increase as the novelty of a stimulus increased. They also found a spread of OR habituation effect from a principal finger (which was stimulated) to adjacent fingers. Beideman and Sterm (1971) (Reference 70) found that the occurrence of the orienting response observed at the start of a signal and the terminal orienting response (TOR) observed at the cessation of a signal are related to the content and duration of the stimulus. Essentially, they observed that the OR and TOR habituate in the same manner. The idea is that each successive stimulus provides less information; therefore, the novelty diminishes and consequently both OR and TOR diminish. They observed that the TOR habituates at a faster rate than the OR, presumably because after the onset of a signal its termination is more predictable than the stimulus onset. This determinability of the timing between signals also was studied by Germana (1969) (Reference 47), who manipulated the interstimulus interval. He found that as the interstimulus interval increased, the rate of habituation decreased.

Maltzman et al. (1971) (Reference 71) found that stress slowed the rate of habituation of the OR. In a unique set of experiments they found that undergraduates in a first experimental stress situation habituated more slowly than in a second situation, while graduate students habituated more rapidly in a first experimental situation than they did in a second situation just prior to taking a stressful examination. This second paradigm (with the stress in a separate area of the subject's life and affecting the rate of OR habituation) is relevant to the proposed research.

Coles et al. (1971) (Reference 72) investigated personality factors and the OR, and suggested that neuroticism is positively resulted to the magnitude of the OR.

Lacey and Lacey (1964) (Reference 73) reported on cardiac deceleration in a simple visual reaction time experiment. They found cardiac deceleration to a warning stimulus and cardiac acceleration to the reaction time signal stimulus. These observations were confirmed by Graham and Clifton (1966) (Reference 74), who, in addition to the heart rate deceleration to the warning stimulus, observed acceleration both before and after the response.

While studying vigilance tasks, Kibler (1967) (Reference 75) found a correlation between the signal detection efficiency and the magnitude of the cardiac deceleration.

The relationship between heart rate and signal stimuli was further explored by Coles et al. (1972) (Reference 76). They also found that a warning signal produced heart rate deceleration and that the signal stimulus produced heart rate acceleration. When they instructed their subjects not to respond to the signal stimulus, the heart rate still accelerated, but at a lower rate than when a response was required. They suggested classifying stimuli as imperative or warning, based on the direction of the change in heart rate.

In linking the cardiac components of the orienting and defensive reflexes to vascular components, Hare (1972) (Reference 77) found that heart rate deceleration was accompanied by cephalic vasodilation while heart rate acceleration was accompanied by cephalic vasoconstriction. Thus, although he replicated the Sokolov model, he made his observation by separating his subjects into types based on their heart rate responses to anxiety-arousing accident scenes. He suggested that the classic patterns of cardiovascular activity occur in only some subjects and only under some conditions and that they may be obscured by undifferentiated group data.

Hare defined his optimal grouping of subjects as accelerators, decelerators, and medium decelerators.

In an earlier report Hare et al. (1971) (Reference 78) reported on autonomic responses to effective visual stimulation consisting of female figures, homicides, and ordinary objects. They found the largest heart rate deceleration in women shown slides of nude females and the largest vasomotor response in women shown slides of homicides. The converse was true for male subjects.

Carrol (1971) (Reference 79), using effective visual stimuli to study forehead vasomotor responses, found an initial decrease in forehead pulse amplitude to all stimuli, followed by an elevation in amplitude above the baseline level across a period of 15 seconds.

Wilkinson et al. (1972) (Reference 80) added confusion to this area of study by finding that different psychological measures differ in reflecting apparent arousal. In studying performance and arousal as a function of incentive, information load, and task novelty, he found that pulse volume responded to changes in task difficulty while pulse rate responded to incentive.

Zeiner and Schell (1971) (Reference 81), using skin resistance as a parameter, found faster learning and higher orienting responses to innocuous stimuli than to noxious stimuli. They suggested that the response to these two classes of stimuli may involve different physiological processes.

COGNITIVE PROCESSES

In an important paper, Kreitler and Kreitler (1972) (Reference 82) relate the orienting response to cognitive process, i.e., processes involved in the production of meaning. Their contention is that cognitive processes allow a better understanding and more precise prediction of human behavior than other variables. They introduce the concept of cognitive orientation to suggest the cognitive nature of the orienting process. Their primary assumptions are that (a) attempt to achieve cognitive orientation (C.O.) is a primary tendency, (b) human behavior is altered by cognitive orientation, and (c) information about C.O. allows the prediction of the course of ensuing behavior.

A few definitions are required in order to prepare for a brief description of this model and its relationship both to the work previously cited and to the work evolving under this contractual program. These definitions are fairly well evolved in the paper by Kreitler and Kreitler and their derivations will not be reiterated here.

First is the idea of meaning dimensions (13 lexical and 10 symbolic dimensions are evolved on the basis of experimental data), which are the rules for the categorizing process that is applied to input stimuli. These rules function as an "address" to direct scanning and matching to neuronal models. Denotive meaning is then the result of a match between input stimulus and the neuronal model. The term "meaning action" is applied to this selection, retrieval, and matching process. The role of meaning action then is to establish meaning values of a kind that enables a defensive reaction (DR), a conditioned response (CR), and an unconditioned response (UR) or an adaptive response (AR) to be elicited. If meaning action fails, i.e. none of the above is obtained, an orienting response (OR) is released. Sufficiency of a denotive meaning then is the habituation of the OR and the elicitation of an AR, CR, DR or UR (UR other than the OR).

When the elicited response is insufficient, the molar behavior is mobilized. This occurs when:

(a) In spite of the OR, no new information about the stimulus object is achieved and the information available is inadequate for a denotative meaning.

(b) Denotative meaning was established and a CR was produced, but that method of coping was inadequate.

(c) The pattern of denotative meaning includes a value that expresses the requirement for molar behavior.

The meaning dimensions most likely involved in determination of denotative meaning are the lexical dimensions of sensory qualities, contextual allocation, similarity and contrast, and potentialities for action. Evidence that the application of these meaning dimensions for stimulus recognition are simultaneous are provided by Allport et al. (1972) (Reference 48) and Neisser (1967) (Reference 83).

Although the theoretical paper by the Kreitlers is developed toward the idea of being able to predict behavior from beliefs and belief clusters, (and some evidence is provided for this contention), the relevant point for this project is the interrelationship of OR's and cognitive processes.

SECTION III

METHOD

EXPERIMENTAL PARADIGM

The independent variables selected for this experiment were (1) task and (2) auditory stimulus probe variables. The task variables built into the apparatus are (1) type of signal detection task (task difficulty), (2) time allowed to complete the task, (3) the inclusion of a reaction time task along with the signal detection task, and (4) the reaction time task alone. The auditory stimulus probe variable was the intensity of the auditory signal (variable in 2 db increments from 60 to 120 db).

The independent variables actually used in the pilot testing were task difficulty, inclusion or exclusion of the auditory probe reaction time task, and the intensity of the auditory stimulus. Ten middle-aged male professional engineers were selected as subjects for the pilot study.

The physiological-dependent variables were direction and magnitude of heart rate changes, finger pulse volume changes, ear pulse volume changes, and rheoencephalograph pulse changes. The performance-dependent variables were task completion, number of errors, and reaction times.

The subjects were instrumented and seated in front of a video console and keyboard (Figures 3-1 and 3-2). The subjects were informed that a 40- by 40-character alphanumeric matrix would be displayed periodically on the video screen, together with instructions for the task. The alternative sets of instructions were to (1) count the occurrence of a given character, e.g. the letter r, (2) count the number of vowels; and (3) count the occurrence of an inclusive set, e.g. h through l. The subject was informed of the time allowed for the task at hand, e.g. 99 seconds, also displayed on the video screen. The subject was instructed to strive for speed as well as accuracy and was advised he would be scored in terms of both errors and time to complete the task. In addition the subject was informed that periodically a tone would be initiated in his earphones and when this occurred, he should respond as quickly as possible to eliminate the tone signal by pushing the "interrupt" button on his keyboard.

The different tasks are presented to the subject consecutively with a 120-second rest period between each task. The probe stimulus problem is presented randomly and at random db levels at the discretion of the experimenter.

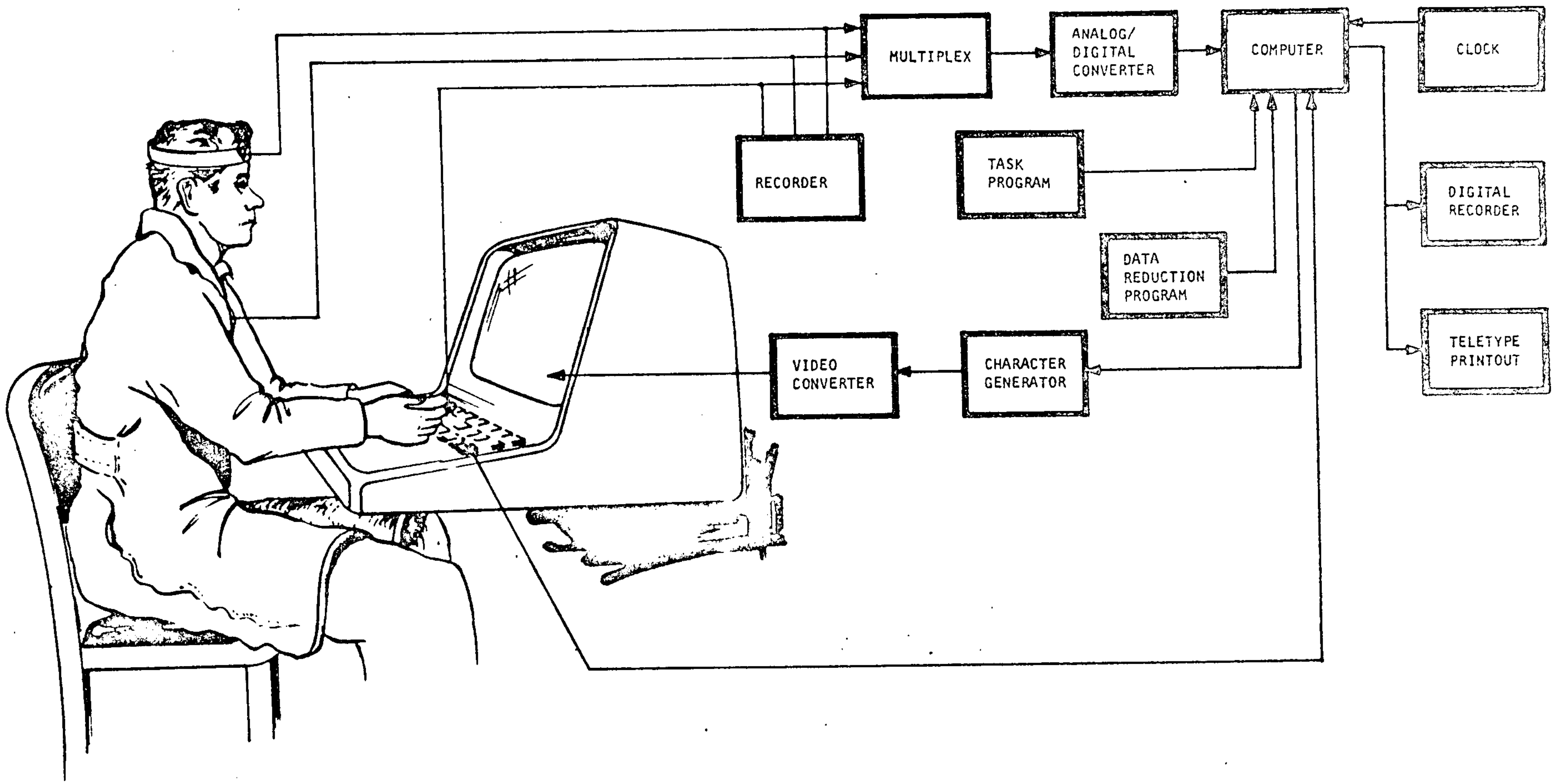

Figure 3-1. Experimental Apparatus Block Diagram

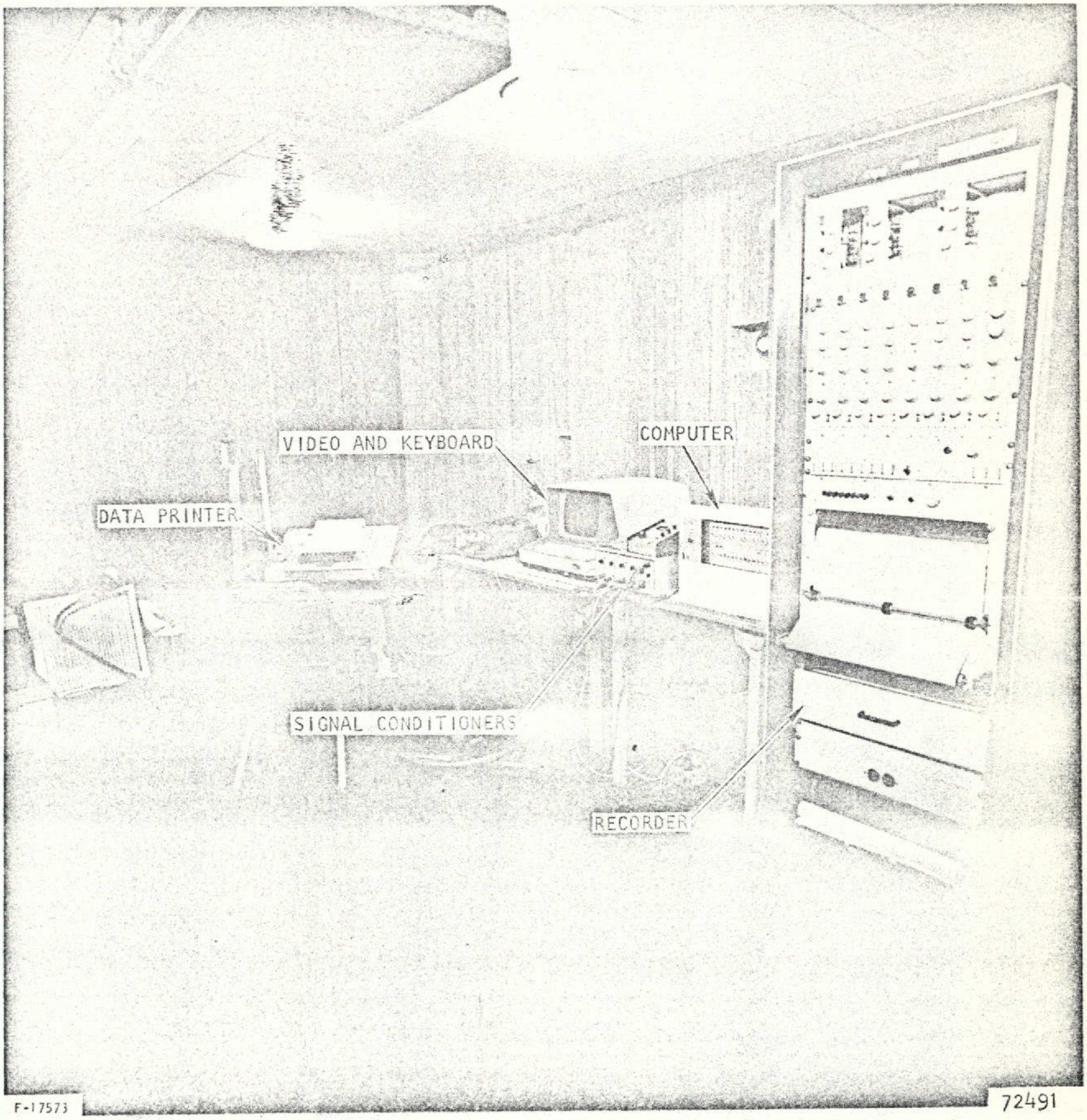

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Figure 3-2. Video Console and Keyboard

INSTRUMENTATION

Discussion of System Design

The psychological assessment (PA) signal conditioner provides interfacing between a test subject and a digital computer. The PA signal conditioner accepts input signals from biosensors located on the test subject's body, amplifies these signals, provides level shifting and level detecting functions, and then conditions the signals for output to a digital computer. The parameters conditioned in this manner are: electrocardiogram (ECG), rheoencephalogram (REG), finger plethysmogram (PG), and ear lobe plethysmogram (EPG). Also included in the PA signal conditioner is an audio response stimulator circuit, used to determine the subject's reaction time and to discriminate between orienting and defensive reactions. The subject's physiological reactions are picked up via sensors, conditioned by the signal conditioner unit, then recorded and analyzed by the digital computer to determine the subject's psychological condition. A block diagram of the signal conditioning system is shown in Figure 3-3. Because of the complexity of the system, the design discussion will be handled separately for each subsystem. The subsystems to be discussed are

Electrocardiograph (ECG)

Rheoencephalograph (REG)

Plethysmograph (PG and EPG)

Audio response stimulator

Electrocardiogram (ECG)--The electrocardiogram (ECG) sensors, when placed on the subject's sternum in a trans-thoracic manner, pick up the electrical activity of the heart. This electrical activity indicates heart rate, blood pressure, and heart volume changes. This program is interested only in the heart rate signal. In a typical heart rate signal waveform (ECG) the peak volume at the "R" point has a level of one to two millivolts, depending on the type of sensors used and their placement on the subject. The period between "R" peaks can vary from 1-1/2 sec to 1/2 sec, which corresponds to a heart rate variation of 40 beats/min to 120 beats/min.

The sensors used are silver/silver "floating" biodes, which are held in place with double-sided tape, and make electrical contact to the skin through a liquid medium (biogel) produced especially for this purpose.

The differential voltage level at the output of the ECG sensors ranges from 0.1 to 2 mv peak, while the common mode voltages range from 10 to 100 mv peak. For this reason a differential amplifier with high common-mode rejection (CMR) is required for this subsystem. Drawing LSK 36170 in Appendix C shows that the ECG amplifier consists of three operational amplifier units. The input stage consists of two operational amplifiers (op amps) connected in a high CMR common-feedback configuration. This circuit uses the op amps as noninverting stages. In this mode the input impedance at the positive input terminal

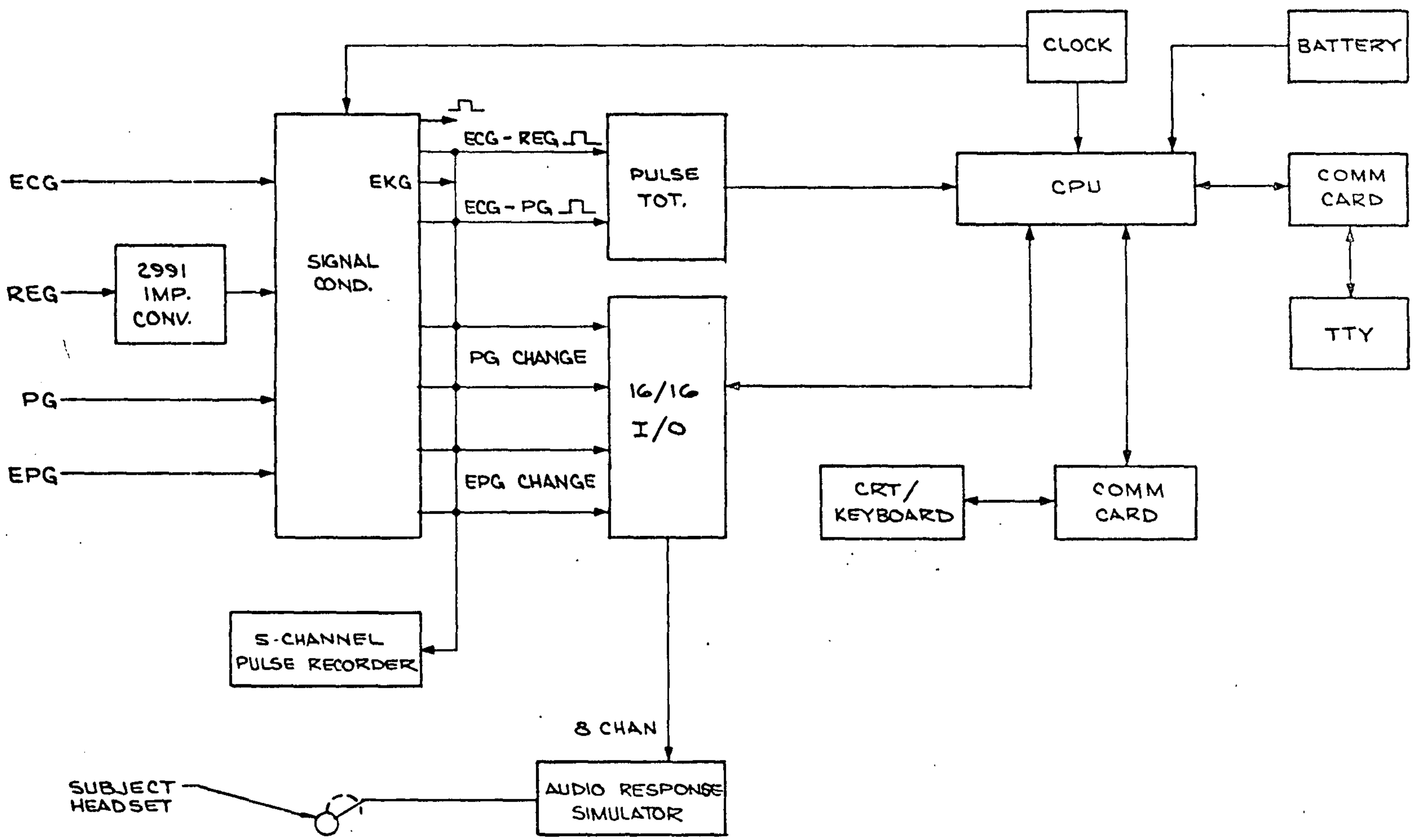

Figure 3-3. Block Diagram of Signal Conditioning System

is greater than 10 meg. The feedback for this first stage uses a common resistor (R3) to determine the stage gain, and provides maximum CMR by matching the gains of the two input op amps. The third op amp is used both as a differential to a single-ended converter stage and as a gain stage. This stage is capacitor-coupled to the first stage to help eliminate baseline (zero) shift due to poor sensor/subject connections. The output of this amplifier is routed to an analog output terminal, and to the PG-ECG-REG level comparator board. This comparator board accepts the ECG analog signal, compares it to an adjustable level, and then uses the square wave obtained from the level comparator to trigger an integrated flip-flop. This flip-flop opens a gate allowing clock pulses coming from the digital computer to flow into a pulse totalizer unit. This flip-flop is reset by a signal generated by the REG/PG amplifiers, thus stopping the flow of clock pulses. The number of pulses that have been accumulated within the pulse totalizer unit is proportional to the time difference between an ECG pulse and a REG/PG pulse. This time difference data is used by the digital computer to help determine the physiological state of the subject.

Rheoencephalograph (REG)--The reheoencephalogram (REG) is a measure of the fluctuation in cerebral tissue impedance due to blood flow pulsations. The sensors used are the same as for the ECG measurement ("floating" biodes). In use, the patient constitutes the unknown arm of a balanced wheatstone bridge, which is excited by a 10- to 50-KHz sine-wave signal. The ac output of the bridge is detected and amplified to yield a 0- to 2-volt peak output signal for a 0- to 5-percent change in cerebral impedance. The REG signal has the waveform shown in Figure 3-4a. The period of this signal ranges from 1/2 to 1/3 sec.

The REG signal is preconditioned by a commercial signal conditioning unit, a biocom impedance converter (BK). The output of this unit is a 0- to ±2-v signal. The signal is routed from the BK to the REG amplifier card (Drawing LSK 36175 in Appendix C).

In this circuit, the first stage (Z1) is connected as a unity gain differential amplifier. This is done to avoid ground loops that may occur between the PA signal conditioner and BK unit. The output of this first stage is applied to a level comparator stage (Z2). This stage compares the REG signal to an adjustable dc level; the square wave thus produced is routed to the REG-ECG-PG comparator card, where it is used to trigger an integrated flip-flop. This flip-flop, which is set by the ECG pulse and reset by the REG pulse, gates a clock signal that is used to calculate the time difference between the ECG and REG pulses.

Finger Plethysmograph (PG) and Ear Lobe Plethysmograph (EPG)--The plethysmograph sensors (PG and EPG) are used to measure blood volume change at a specific point on the body. A finger sensor and an ear lobe sensor are employed for this test. Both of these sensors operate by measuring the amount of a specific wavelength of light (7350A) that is abosrbed by the organ being monitored. The light is generated by a small light source and is conducted by the skin of the subject to a nearby photocell. The photocell produces a resistance change proportional to the amount of light falling on it. The photocell is connected into a bridge circuit that translates the resistance

Figure 3-4a. REG Waveform

Figure 3-4b. PG Waveform

Figure 3-4. Rheoencephalograph (REG) and Finger Plethysmograph (PG) Waveforms change into a voltage signal (see Drawing LSK 36174 in Appendix C for more details on this bridge circuit; see Figure 3-4b for details on the PG signal waveform). The voltage signals are then routed to the PG and EPG amplifier cards (Drawings LSK 36172 and 36173 in Appendix C). These cards consist of a differential input stage with a gain of 20, a second ac-coupled stage with a variable gain of 1/2 to 6, and a comparator stage that compares the analog signal level with an adjustable dc level. The square wave produced by this comparator stage is used to gate a flip-flop, thus allowing a series of clock pulses to pass into a pulse totalizer unit. The total number of pulses counted at the end of a cycle is proportional to the time between an ECG pulse and a PG pulse. This time difference is used by the digital computer to help determine the subject's psychological state.

Audio Response Simulator (Drawing LSK 36179 in Appendix C)--The audio response simulator generates a variable level tone that is used to test the subject's concentration and reaction time. The audio level is programmed by the digital computer using seven binary bits of information. These bits are applied to the input of a digital-to-analog converter (D/A). The output of this D/A converter is a 0- to 10-vdc level. This signal is applied to the second stage, which performs level shifting and scaling on the D/A signal. The output of the second stage is then applied to the X input of a multiplier. The Y input of the multiplier is fed from a sine wave oscillator located on a PC card (Drawing LSK 36180 in Appendix C). The multiplier is used here as a linear amplitude modulator and provides an output level proportional to the digital binary number input to the D/A converter.

The controlled level output from the multiplier is then applied to the audio drive card (Drawing LSK 36180) where it is amplified sufficiently to drive a set of stereo headphones. The final output sound level is program controllable from 60 to 110 db by the digital computer system. The frequency of the tone also is manually variable using a control on the front panel of the PA signal conditioner package. The frequency range is 1 to 8 KHz. During testing this control is set for maximum subject annoyance.

Additional system schematics are shown in Appendix C (Drawings LSK 36170, 36171, 36176, 36168, 36169, and 36211.

Method of Operation

The method of operation for the PA signal conditioner is broken down into the following step-by-step procedure:

STEP 1

Plug the PA signal conditioner unit into a 115-v, 60-Hz power outlet. Connect the cable from the PA unit to the digital computer. Connect the ECT, PG, EPG, and BK cables to the PA unit inputs. Connect the REG sensors to the inputs of the BK unit.

STEP 2

Turn on the signal conditioner and allow the unit to warm up while proceeding to Step 3.

STEP 3

Connect the ECG, REG, PG, and EPG sensors to the subject under test. Procedures for each sensor follow:

1. ECG Sensors--There are three silver/silver biodes used for the ECG input. The + and - biodes and the reference biode are applied to the sternum (see Figure 3-5a). The procedure for applying each biode follows:

   (a) Using alcohol, clean the subject's skin in the area to which the biode will be applied. A slight abrasion of the skin using biobrade pads will remove the dry outer layer and thus lower the skin resistance.

   (b) Remove the double-sided adhesive washer (biocom 1080B) from the wax paper backing, leaving the top wax paper washer in place.

   (c) Center the hole in the adhesive washer over the cavity in the biode and press the adhesive washer to the biode face.

   (d) Fill the biode cavity with biogel. Be sure that no voids or air bubbles are left in the gel during this process. The cavity should be slightly over-filled. The excess can then be removed using a stiff, straight edge (heavy paper, knife edge, etc.).

   (e) Remove the wax paper washer and gently press the biode and washer in place.

   NOTE: Be sure to clean the silver/silver biodes with alcohol after each usage.

2. REG Sensors--The REG sensors consist of two biodes, and are attached using the same procedure as described for the ECG sensors. The placement on the subject is shown in Figures 3-5a and b and 3-6.

3. PG Sensors--The finger PG sensor is simply slipped over the subject's finger, with the ball of the forefinger resting over the photocell cutout. The spring-and-cork assembly is then put in place to help hold the finger over the photocel and light source cutouts. See Figure 3-7a and 3-8 for details.

STEP 4

Place stereo headphones on subject, ensuring that the level controls located on each headphone are full on. See Figures 3-7b and 3-8 for details.

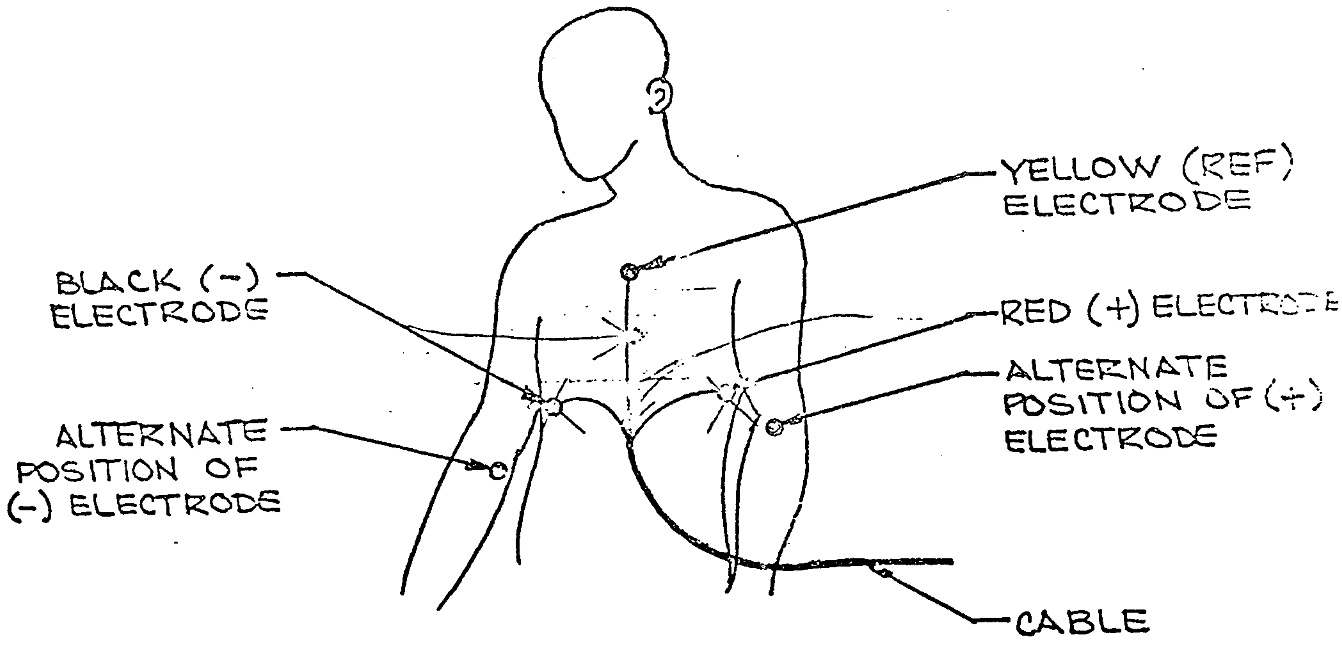

Figure 3-5a. ECG Sensor Placement

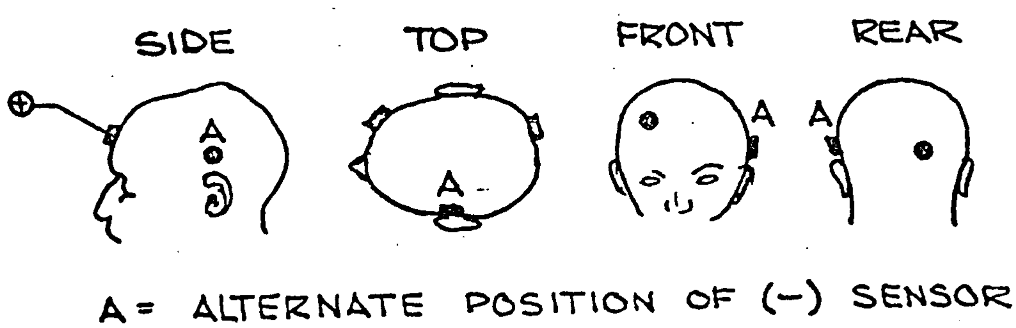

Figure 3-5b. REG Sensor Placement

Figure 3-5. ECG and REG Sensor Placement

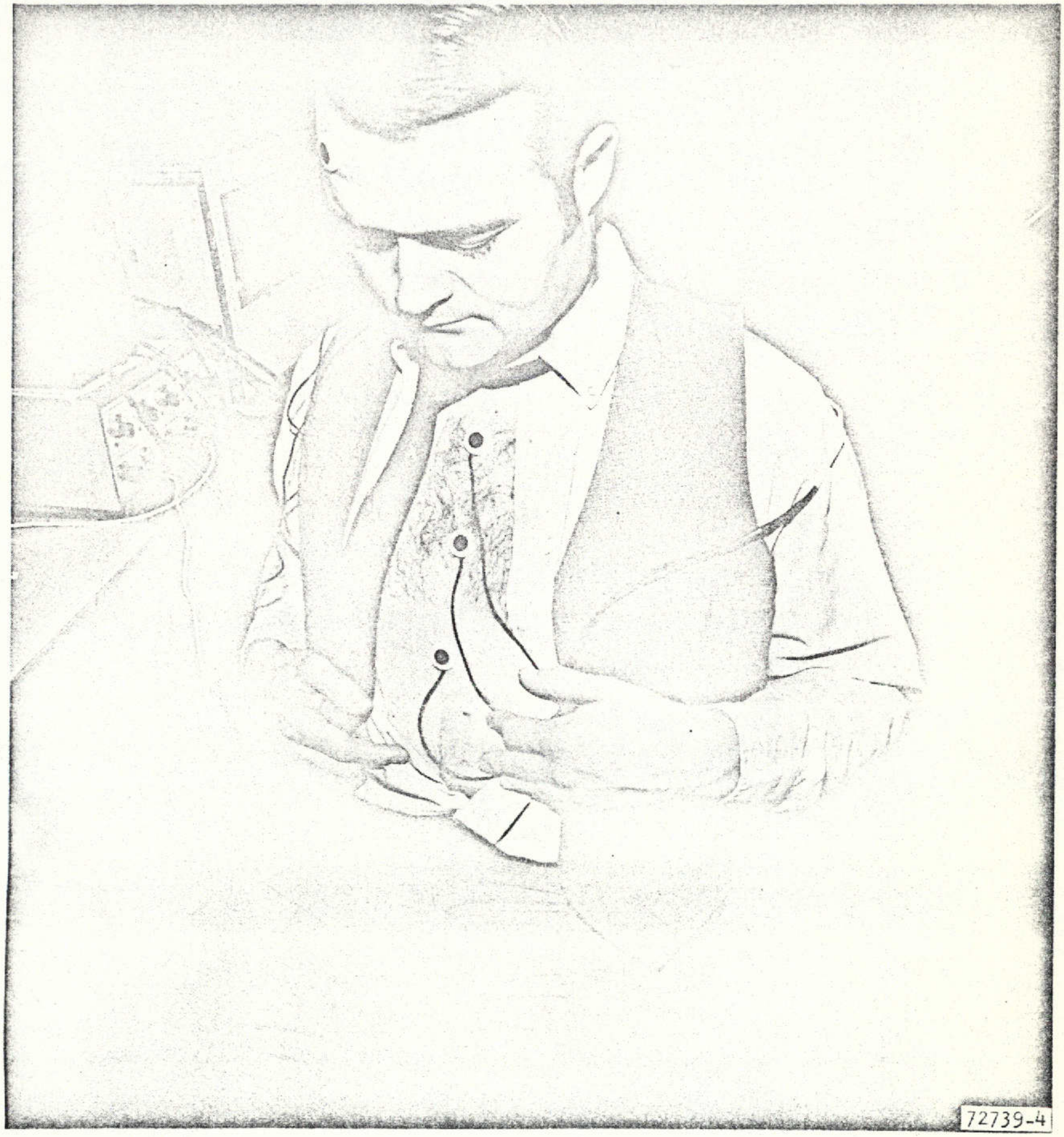

Figure 3-6. ECG and REG Sensor Placement

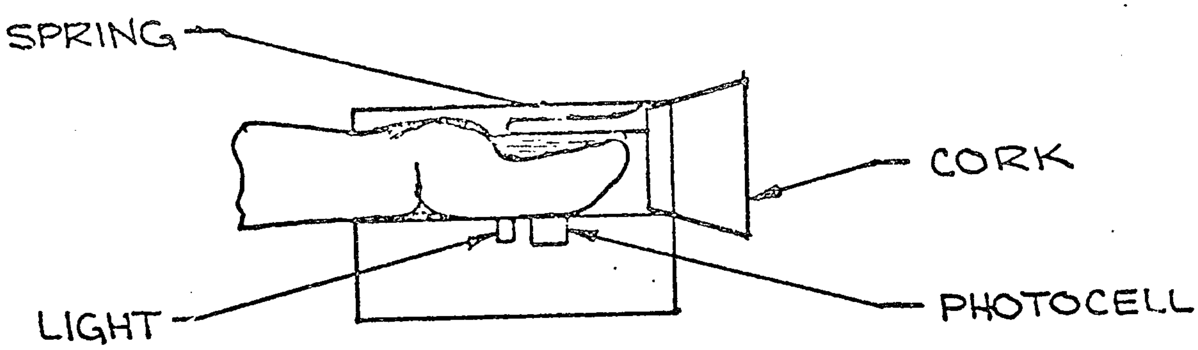

Figure 3-7a. PG Sensor Placement

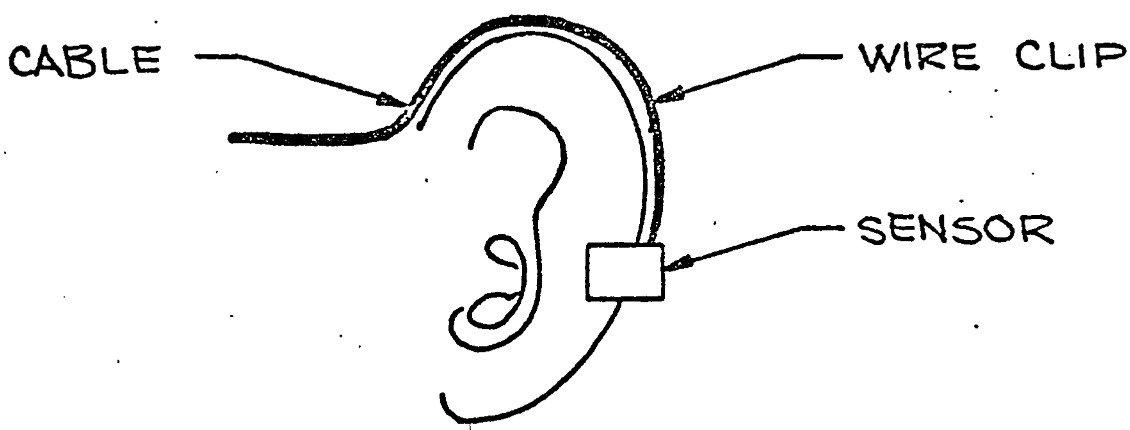

Figure 3-7b. EPG Sensor Placement

Figure 3-7. PG and EPG Sensor Placement

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Figure 3-8. PG and EPG Sensor Placement

STEP 5

Turn on the BK and balance the unit using the procedure outlined below:

1. Turn master switch to "BATT. TEST" position. Note that the meter reads in the green area.

2. Turn the master switch to "AC SHORT" position.

3. Turn "BALANCE" control until meter reads in the green area of the scale.

4. Turn "GAIN" control fully clockwise.

STEP 6

Set the trigger level controls located on the front of the PA conditioner unit so that the (LED) indicators are located under each level control flash at a constant rate. A constant flashing rate indicates that the trigger circuit is set to the proper level for consistent data output.

Turning the level control clockwise from mid-travel gives an increasing positive trigger level; counterclockwise from mid-travel gives an increasing negative level.

STEP 7

Set the audio simulator frequency control, located on the right side of the PA conditioner's front panel, to the desired frequency. The PA signal conditioning system is now ready for use.

Method of Calibration

The PA signal conditioner has only one circuit that requires calibration. This is the audio response simulator. For this circuit the audio sound level should be calibrated for a range of 60 to 110 db. To aid in this calibration a B&D "Artificial Ear", model 4153, was acquired.

To calibrate the sound response system the following equipment is needed:

Dc power supply (+5V at 100 ma)

Artificial ear (B&K model 4153)

Headphones (part of PA unit)

1/2-in. microphone cartridge (B&K model 4134)

Cathode follower (B&K model 2615)

Sound level meter (B&K model 2203)

Octave filter set (B&K model 1613)

The method of calibrating the audio response system is broken down into the following step-by-step procedure:

STEP 1

1. Plug PA signal conditioner into 115-v 60-Hz power line
2. Turn on power and allow a 5-min warmup period
3. Plug stereo headphones into PA signal conditioner audio output jack (located on front panel)
4. Make sure both level controls on headphones are full on
5. Set up the B&K equipment per instruction manual BB4153

STEP 2

Short together pins F, P, C, D, R, V, U, and K on the computer input connector (connector located on lower right of PA front panel).

STEP 3

Apply 5 vdc on pins F (neg) and J (pos).

STEP 4

Adjust TRIM pot R8 located on the rear edge of Card 9 (green ejector code), so that a level of +40 db is indicated on the B&K sound level meter. The frequency control should be set at mid-travel for this step.

STEP 5

Short together pins P, C, D, R, V, U, and K on the computer input connector and then connect this bus to the 5-vdc positive supply line.

STEP 6

The sound should now be adjusted to +100 db using TRIM pot R8 on Card 9. This sets the full-scale sound level. The lower limit can now be checked using Step 2 to determine the total range of the audio response simulator, which should be about 45 db.

The unit is now calibrated for use.

ECG Amplifier
System Specification Sheet

INPUT

Range - Amplitude	0.01 mv to 20.0 mv
- Frequency response	0.1 Hz to 100 Hz
- Sensitivity	Fixed
Impedance	
Differential	10 megohm Single ended N/A
Common mode	1 megohm
Common mode rejection - dc	70 db
- ac	60 db to 1 KHz
Max. common mode input	±10 vdc or 20 vac pk-pk
Waveform any	
Crest factor	N/A
Form factor	N/A

OUTPUT

Range - Amplitude	0 to ±10 vdc
- Frequency response	0.1 Hz to 100 Hz
- System gain	X 500
Impedance	
Differential	N/A Single-ended 50 ohm
Common mode	N/A
Waveform	
Crest factor	N/A
Form factor	N/A

READOUT--None

System errors - Linearity	Precision
Threshold	Resolution
Hysteresis	
Drift - with time	
- with temperature	
- with supply	
Noise - ripple	
Power requirements	±15 vdc at 20 ma
Environmental specifications	
Temperature	70°C max
Humidity	90 percent max
Acceleration	Normal handling shock
Mechanical specifications	
Configuration	PC card
Size	3-3/4 by 6-1/2 by 1 in.
Volume	24.4 cu in.
Weight	6 oz

REG Amplifier
System Specification Sheet

INPUT

Range - Amplitude	0 to 10 vdc or vac pk
- Frequency response	Dc to 1 kHz
- Sensitivity	
Impedance	
Differential	20K ohm Single-ended 20K ohm
Common Mode	10K ohm
Common mode rejection - dc	60 db
- ac	60 db to 1 kHz
Max common mode input	±10 vdc or vac pk
Waveform any	
Crest factor	N/A
Form factor	N/A

OUTPUT

Range - Amplitude	0 to ±10 vdc or 20 vac pk-pk
- Frequency response	Dc to 1 kHz
- System gain	Unity (x1)
Impedance	
Differential	N/A Single-ended less than 10 ohm
Common mode	N/A

REG Amplifier
System Specification Sheet (Cont'd)

Waveform--Any	
Crest factor	N/A
Form factor	N/A
READOUT--None	
System errors - Linearity	Precision
Threshold	Resolution
Hysteresis	
Drift - with time	
with temperature	
with supply	
Noise - ripple	
Power requirements	±15 vdc at 30 ma
Environmental specifications	
Temperature	$70^{\circ}C$ max
Humidity	90 ± max
Acceleration	Shock normal handling
Mechanical specifications	
Configuration	PC card
Size	3-3/4 by 6-1/2 by 1/2 in.
Volume	12 cu in.
Weight	6 oz

PG and EPG Amplifier
System Specification Sheet

INPUT

Range - Amplitude	0 to ±150 mv dc or pk ac
- Frequency response	Dc to 100 Hz at -3 db
- Sensitivity	
Impedance	
Differential	100K ohm Single-ended 50K ohm
Common mode	50K ohm
Common mode rejection - dc	60 db
- ac	60 db to 1 kHz
Max common mode input	±10 vdc or 20 vac pk-pk
Waveform any	
Crest factor	N/A
Form factor	N/A

OUTPUT

Range - Amplitude	Zero to ±10 vdc or 20 vac pk-pk
- Frequency response	Dc to 100 Hz
- System gain	X 10 to X 60
Impedance	
Differential	N/A Single-ended 10 ohm
Common mode	N/A
Waveform any	
Crest factor	N/A
Form factor	N/A

PG and EPG Amplifier
System Specification Sheet (Cont'd)

READOUT None

System errors -	Linearity	Precision
	Threshold	Resolution
	Hysteresis	
	Drift - with time	
	with temperature	
	with supply	
	Noise - ripple	
Power requirements		±15 vdc at 40 ma
Environmental specifications		
	Temperature	70°C max
	Humidity	90 percent max
	Acceleration	Shock normal handling
Mechanical specifications		
	Configuration	PC card
	Size	3-3/4 by 6-1/2 by 1/2 in.
	Volume	12 cu in.
	Weight	6 oz

Audio Stimulator
System Specification Sheet

INPUT

Range - Amplitude	7 binary bit percent (2^7 = 128.1 range)
- Frequency response	1 kHz max. program rate
- Sensitivity	
Impedance	
Differential	N/A Single-ended TTL compatible
Common mode	N/A
Common mode rejection - dc	N/A
- ac	N/A
Max common mode input	N/A
Waveform square	
Crest factor	N/A
Form factor	TTL compatible

OUTPUT

Range - Amplitude	60 to 110 db sound level
- Frequency response	1 to 10 kHz tone
- System gain	Variable output level from 40 to 70 db
Impedance	
Differential	N/A Single-ended 10 ohm
Common mode	N/A
Waveform--sine	
Crest factor	N/A
Form factor	N/A

READOUT--None

System errors -	Linearity	Precision
	Threshold	Resolution
	Hysteresis	
	Drift - with time	
	with temperature	
	with supply	
	Noise - ripple	
Power requirements		±15 vdc at 80 ma
Environmental specifications		
	Temperature	70°C max
	Humidity	90 percent max
	Acceleration	Shock normal handling
Mechanical specifications		
	Configuration	2 ea - PC cards
	Size	3-3/4 by 6-1/2 by 1 in. each card
	Volume	48 cu in.
	Weight	14 oz total

COMPUTER PROGRAM

The computer consists of a Texas Instrument (T.I.) 960 control computer with 8000 16-bit words of core memory and several standard input/output interface cards, including one that interfaces to a teletypewriter ASR 33 (TTY) typewriter with paper tape reader and punch, and one that interfaces with a Lear Siegler 7700 interactive display terminal. The TTY is the primary input/output device to all T.I. 960 software and the display terminal is attached specifically for this particular use of the computer.

Other interface cards consist of an interval timer with 1 msec resolution, a pulse accumulator, and a digital input and digital output card that allows 16 binary bits of information to communicate to the computer in each direction. Seven bits of the digital output interface are attached to an AiResearch-manufactured audio generator and two other bits are used as test information recorded on a strip chart recorder. The interval timer measures reaction times of the test subject and determines the duration of each test section. The pulse accumulator is not used at present; however, it is designed to be used to calculate parameters based on measurements made on the test subject. The intended use of this device would require additional storage or a high-speed output device.

The present purpose of the Texas Instrument computer is two-fold. The main objective is to display a game on the cathode ray tube (CRT) of the Lear Siegler 7700. This game is to be played by the subject while under test. The second objective is to apply a stressing audio signal to the test subject and measure his response time to the signal.

At present, three types of games may be played to count the occurrence of (1) a character; (2) characters between limits, either numbers between two other numbers with a maximum spread of 5, or letters between two other letters with a maximum spread of 4; (3) vowels. In each game the test subject counts the occurrence of a character or characters within a 20-by-20 matrix of characters displayed on the CRT screen. The rules of the game along with the time limit allowed also are displayed on the screen. The computer calculates the correct result, the test subject enters his result through the keyboard of the CRT, and these two results are printed on the TTY. These games are displayed for a fixed period of time (1-999 sec) that is determined before the start of the game. If at the end of this time the test subject has not responded with his answer, the computer designates his answer to be zero, erases the CRT screen, and prints the results. Provision has been made to enter a different period of time for display of the matrix and the rules but the present computer program does not utilize these times.

Throughout the duration of these games the secondary objective of the computer is attained. A background audio signal is applied to the test subject through earphones attached to the audio generator. At random intervals throughout the game (from 2 to 32 sec), a stressing tone of variable volume is applied to the subject. This tone is terminated when the test subject depresses the interrupt key on the CRT keyboard. The length of time taken by the test subject to terminate the tone is logged by the computer. These times, in hundredths of a second, are displayed on the TTY at the end of each game. The background tone volume may be set at the beginning of a game or series of games through the TTY keyboard. This audio level is then transmitted to the digital output card as a seven-bit binary number (0-127).

The computer program is written to allow the test conductor to enter various test options, such as game duration, the volume of the background audio signal, the 20-by-20 character matrix, the type and number of games to be played, and the start of these games. These options are entered by depressing one of several keys on the TTY keyboard. The format of the options and the particular key that initiates the option are described in Appendix A. When the computer program is initially loaded into the computer there is a default condition for the duration of the game and the audio signal. The matrix of characters and the game type must be entered before execution of a game.

The computer program, Appendix B, is so written that other options and other games may be added easily to the existing code. The program is written entirely in SAL/960 code, the assembler language of the TI 960, and operates on a stand-alone basis. The program is loaded into the computer under supervision of the programming supervisor monitor (PSM); however, when execution of the program is initiated, the addresses of the internal and communications register unit interrupt servicing routines are modified.

SECTION IV

RESULTS

Eleven subjects were tested in the formal pilot study portion of this program. Each subject was presented with three performance tasks in the following test order, in 3 sets of 12 tests with a 2-minute rest break between each task set.

Test No.	Task No.
1	1
2	1
3	2
4	1
5	2
6	3
7	2
8	2
9	2
10	1
11	2
12	3

Seven of the subjects were presented with a fourth task set that was identical in order of presentation; however, for this fourth task set, the probe stimulus was not utilized.

Every presentation of the alphanumeric matrix was randomized, as was the temporal interval between occurrences of the probe stimulus. The probe stimulus was presented in four intensities: 90, 100, 110, and 120 db. The amplitude setting of each probe stimulus also was determined randomly.

Data were collected on the reaction time and character count on the performance tasks for all the subjects. These two figures, together with the correct character count, were printed out on the teletype.

Table 4-1 presents the mean reaction time data for each subject by the type of task and the [illegible] of 12 tests (note there is no reaction time data for Test Set 4).

Table 4-2 presents the ratio of each subject's character count to the actual character count on the signal detection task by the type of task and the test set.

The following parameters were recorded in analog fashion as a strip chart:

Channel 1--Time, seconds

Channel 2--ECG, beat to beat

Channel 3--REG, beat to beat and pulse amplitude

Channel 4--FPG, beat to beat and pulse amplitude

Channel 5--EPG, beat to beat and pulse amplitude

Channel 6--Probe stimulus, amplitude (arbitrary scale)

Channel 7--Probe stimulus, occurrence; event

Channel 8--Test time, start and stop events

Channel 9--Heart rate, analog calibrated

A typical example of the analog record is shown in Figure 4-1.

Inspection of this figure reveals that, for example, changes in heart rate are most pronounced in the intervals between tests, when the set of instructions is presented for the next test.

Individual pulses and changes in pulse amplitude can be seen in the REG, FDG, and EPG traces. In addition, differences in timing are discernible among each of them and between the ECG.

Performance became asymptotic after the first series of twelve tests, as shown by the plot of correct responses and reaction time (Figure 4-2). Performance stabilized at an average of approximately 75 percent correct and reaction time stabilized around 450 milliseconds. The effect of the reaction time/probe stimulus task on performance is evident in the fourth test set point, where the average percentage correct performance moves up to 85 percent when the probe stimulus is eliminated.

Figure 4-3 shows the average reaction time for all subjects as a function of the number of trials. This curve is slightly smoothed by employing a running average of three tests per point. It is apparent that reaction time became asymptotic at about the end of the first test set of 12 tests.

TABLE 4-1

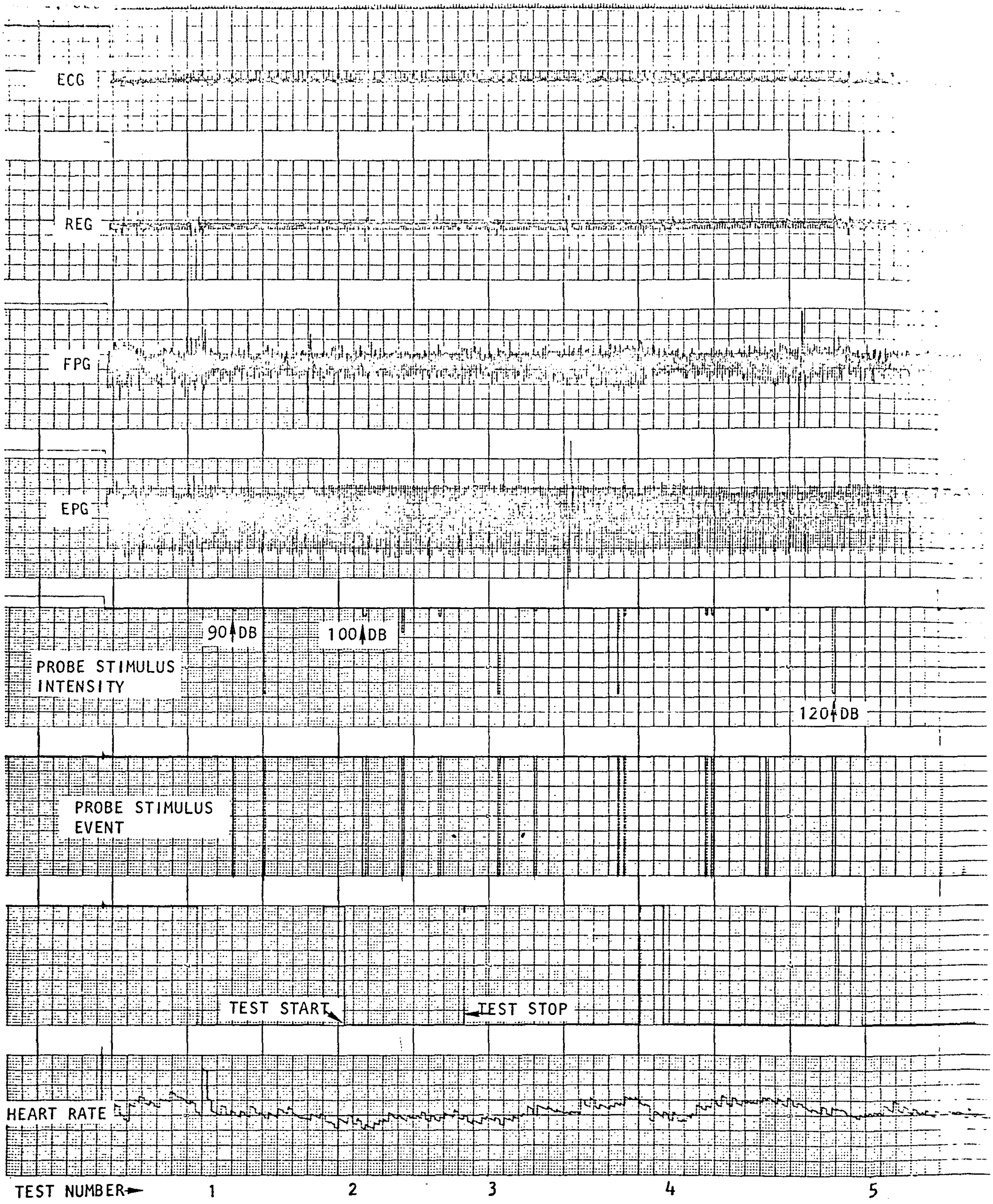
REACTION TIME, SEC

Task	Test Set No.	Subject										
		1	2	3	4	5	6	7	8	9	10	11
1	1	1.20	0.48	0.86	0.57	1.19	0.57	1.16	0.74	0.57	0.82	1.23
	2	0.68	0.59	0.44	0.43	0.58	0.36	0.62	0.43	0.34	0.31	1.10
	3	0.50	0.63	0.37	0.46	0.40	0.33	0.49	0.46	0.31	0.33	1.04
	4											
2	1	1.02	0.52	0.48	0.53	1.56	0.43	0.73	0.47	0.48	0.59	0.97
	2	0.84	0.47	0.44	0.40	0.45	0.36	0.52	0.41	0.44	0.41	0.96
	3	0.83	0.46	0.41	0.46	0.48	0.40	0.53	0.43	0.42	0.36	0.96
	4											
3	1	0.92	0.46	0.54	0.40	0.96	0.40	0.67	0.40	0.51	0.33	0.97
	2	0.76	0.47	0.39	0.34	0.49	0.40	0.53	0.37	0.37	0.36	0.89
	3	0.49	0.46	0.36	0.36	0.37	0.45	0.62	0.41	0.34	0.32	0.80
	4											

TABLE 4-2

PERCENT CORRECT

Task	Test Set No.	Subject 1	2	3	4	5	6	7	8	9	10	11
1	1	80	74	77	92	92	96	79	82	77	80	67
	2	86	84	85	90	90	99	82	82	83	87	57
	3	97	74	78	95	96	99	90	71	89	100	53
	4					81	98	90	66	84	97	67
2	1	39	63	60	57	47	69	42	78	51	25	20
	2	0	53	67	80	76	78	43	76	61	78	46
	3	41	55	74	79	79	89	37	59	60	73	42
	4					83	96	37	80	69	86	57
3	1	0	45	67	70	70	86	71	0	0	65	45
	2	0	50	84	67	67	93	90	0	55	73	48
	3	0	53	96	0	0	95	77	0	61	68	54
	4					85	97	90	0	64	75	0



FOLDOUT FRAME

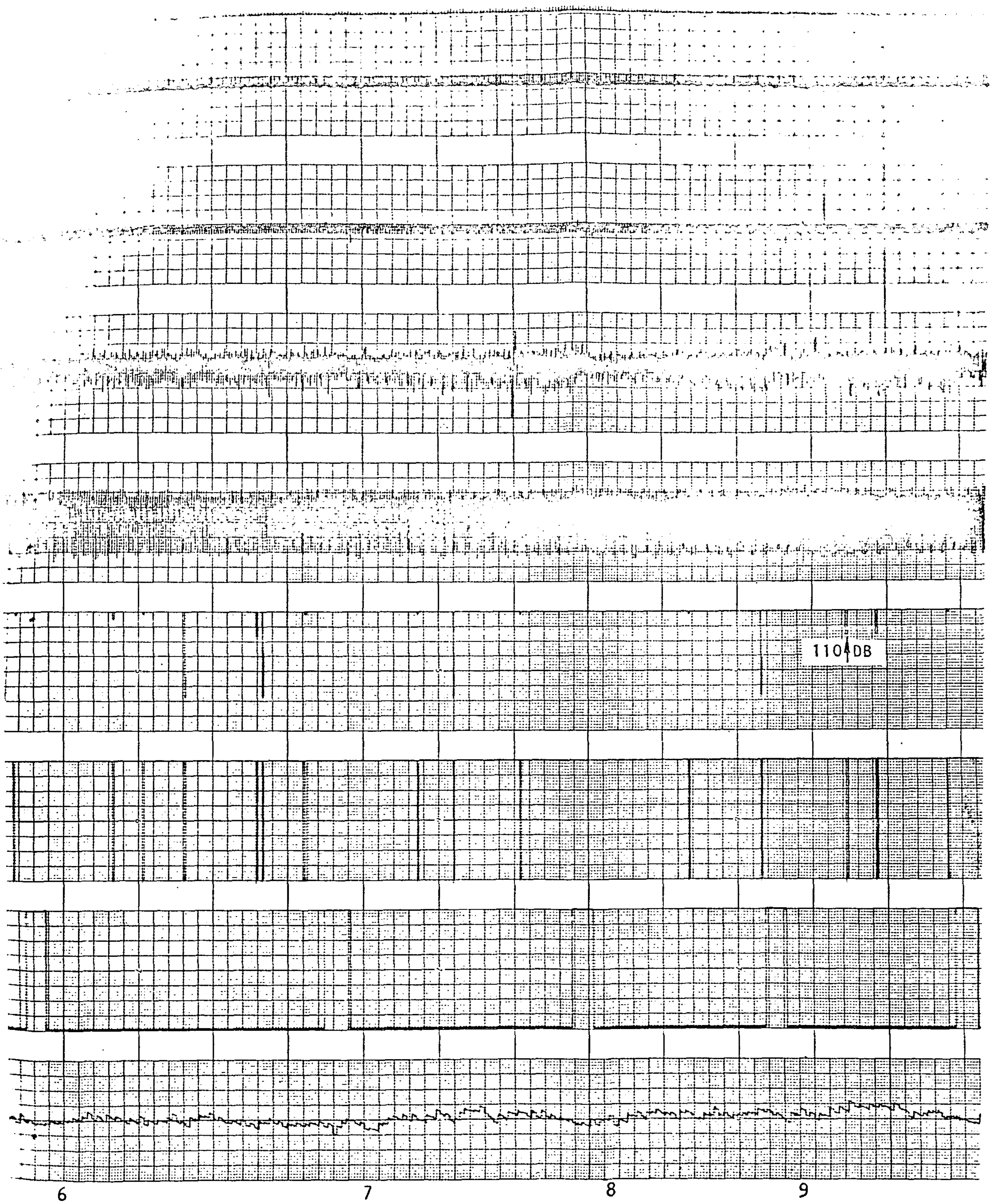


Figure 4-1. Analog Record, Subject No. 7
Second Test Set, Tests 1 to 9

FOLDOUT FRAME 2

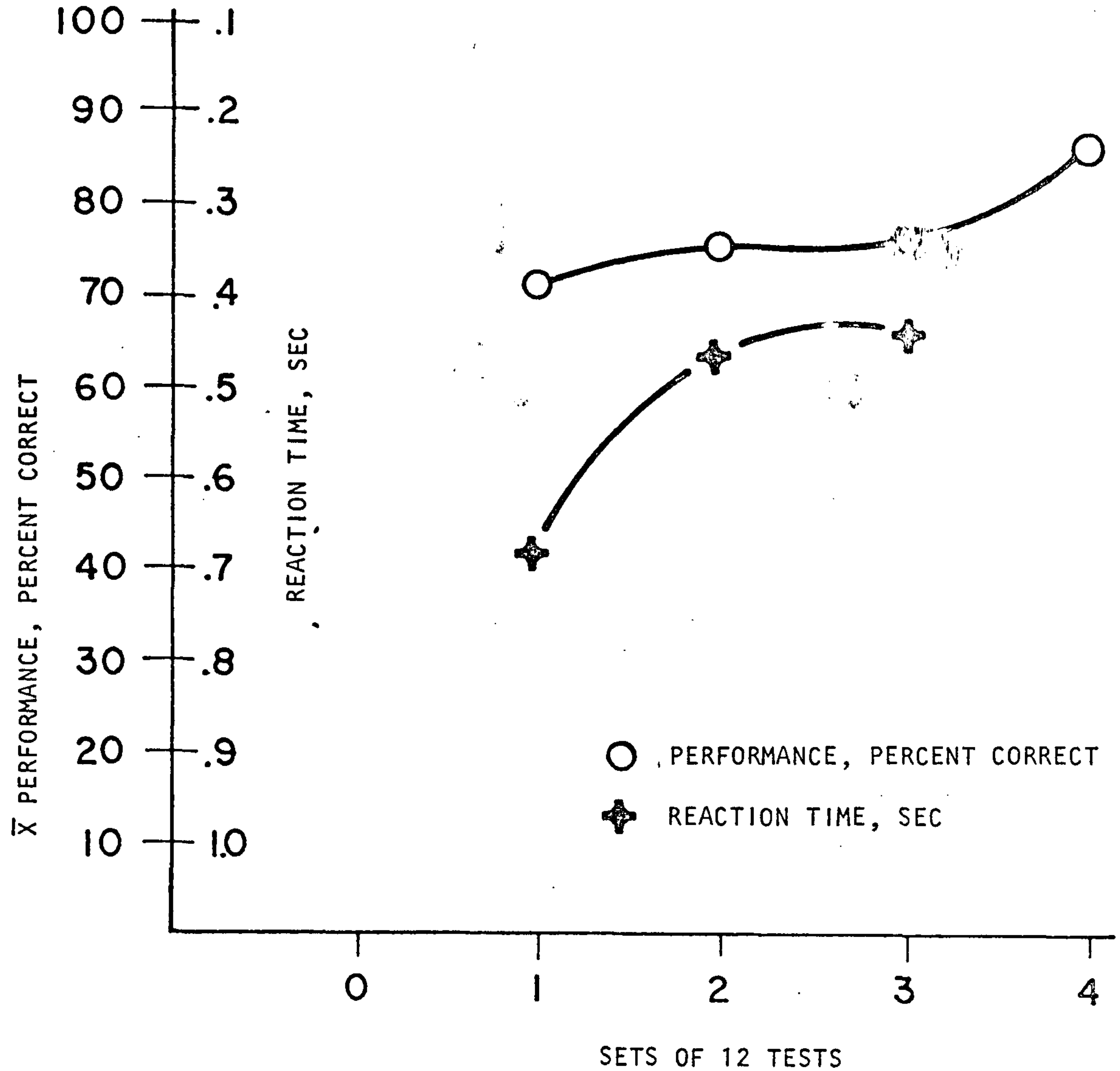


Figure 4-2. Average Performance and Reaction Time as a Function of Test Set

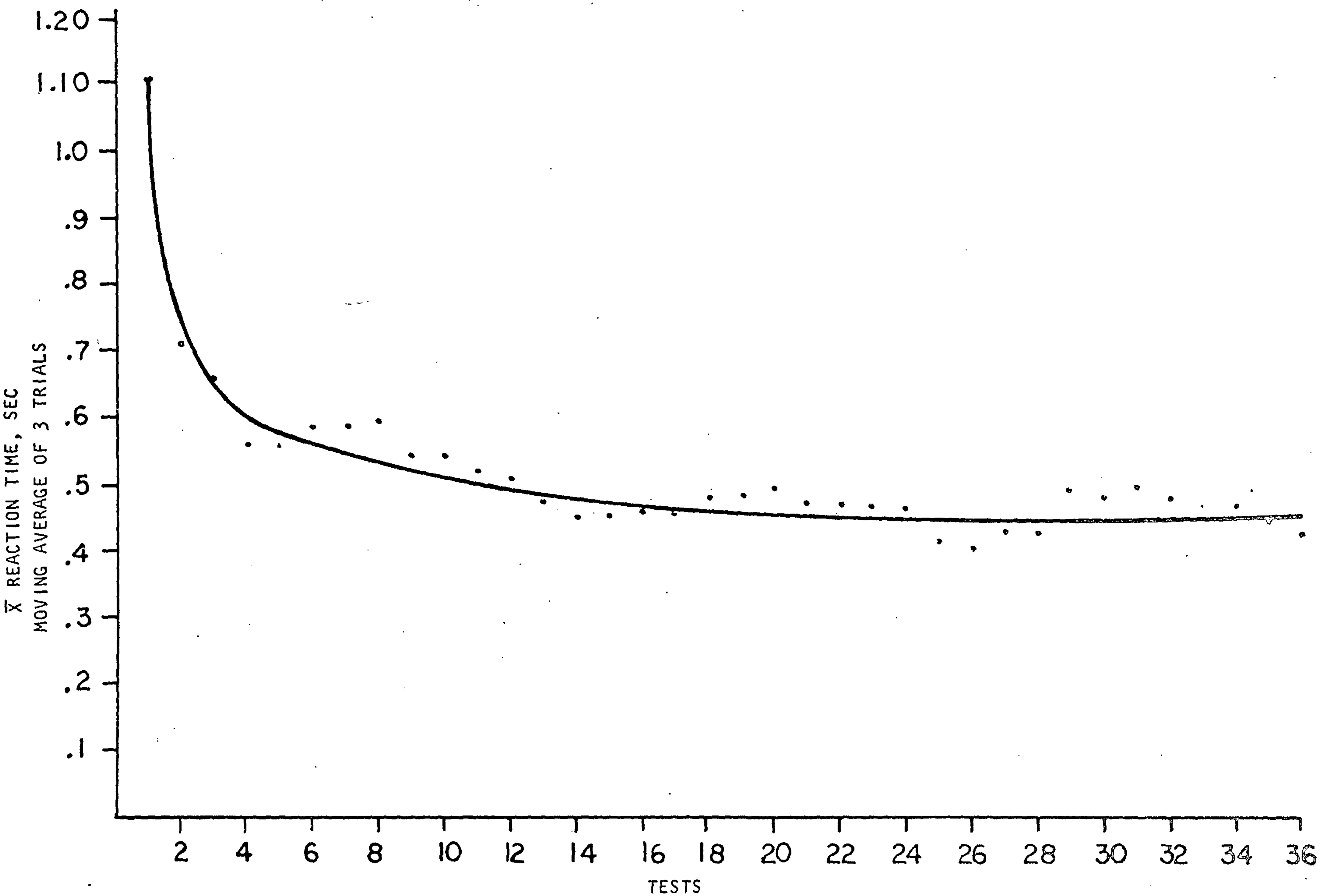


Figure 4-3. Average Reaction Time for All Subjects by Trial

In Figure 4-4, the effects of the different performance tasks are separated out by task, with the data averaged for each of the four sets. It is apparent that better performance, in terms of correct responses, is achieved under Task I conditions than for Tasks II and III. The difference between Task I and the other two tasks is considerably lessened when the probe stimulus/reaction time task requirement is removed from the test situation.

Figure 4-5, which presents a plot of the average time required to complete the tasks, shows that task time for a given task remains relatively constant across the four sets of 12 tests. The tasks separate in terms of apparent difficulty in the same way as in the previous figure, with Task I clearly taking less time.

The relationship between performance on the signal detection and reaction time tasks is plotted in Figure 4-6. Most noteworthy is the fact that signal detection and reaction time performance improve together. The separation of task effects on the joint plot of these two variables is also pronounced. When reaction time is related to task time (Figure 4-7), there appears to be little or no interaction between them.

Figure 4-8 relates performance to task duration by each of the task types. Little change is seen in this relationship as a consequence of experience in the test situation. The removal of the probe stimulus task, however, significantly alters the relationship between these two variables, which suggests that this relationship may be sensitive to further alterations in the subject/task situation.

Table 4-3 presents a matrix of the average heart rate throughout each test for the various test conditions. Generally the average heart rate decreased with experience; however, the average rate increased with the fourth test set for each of the tasks. This may be due in part to the novelty of the fourth test set (no probe stimulus).

Table 4-4 presents a matrix of the average end-of-test (last 5 seconds) heart rate by task type. The relationship among the end-of-test average values for heart rate is similar to that observed for the average heart rates.

The plots of heart rate variability are shown in terms of changes in heart rate greater than 2 beats/minute in any five-second period plotted in terms of (1) sets of 12 tests (Figure 4-9); (2) performance (Figure 4-10); and (3) reaction time (Figure 4-11). Generally it appears that heart rate variability is reduced for difficult tasks and increased for an easy task as a function of experience with the task. It is, however, apparent that heart rate variability is inversely related to task difficulty. When this dependent variable is considered together with correct responding (Figure 4-10), little if any relationship is suggested. There does, however, seem to be an inverse relationship between heart rate change and reaction time (Figure 4-11). This relationship is confounded with the task variable, as might be expected from Figure 4-9.

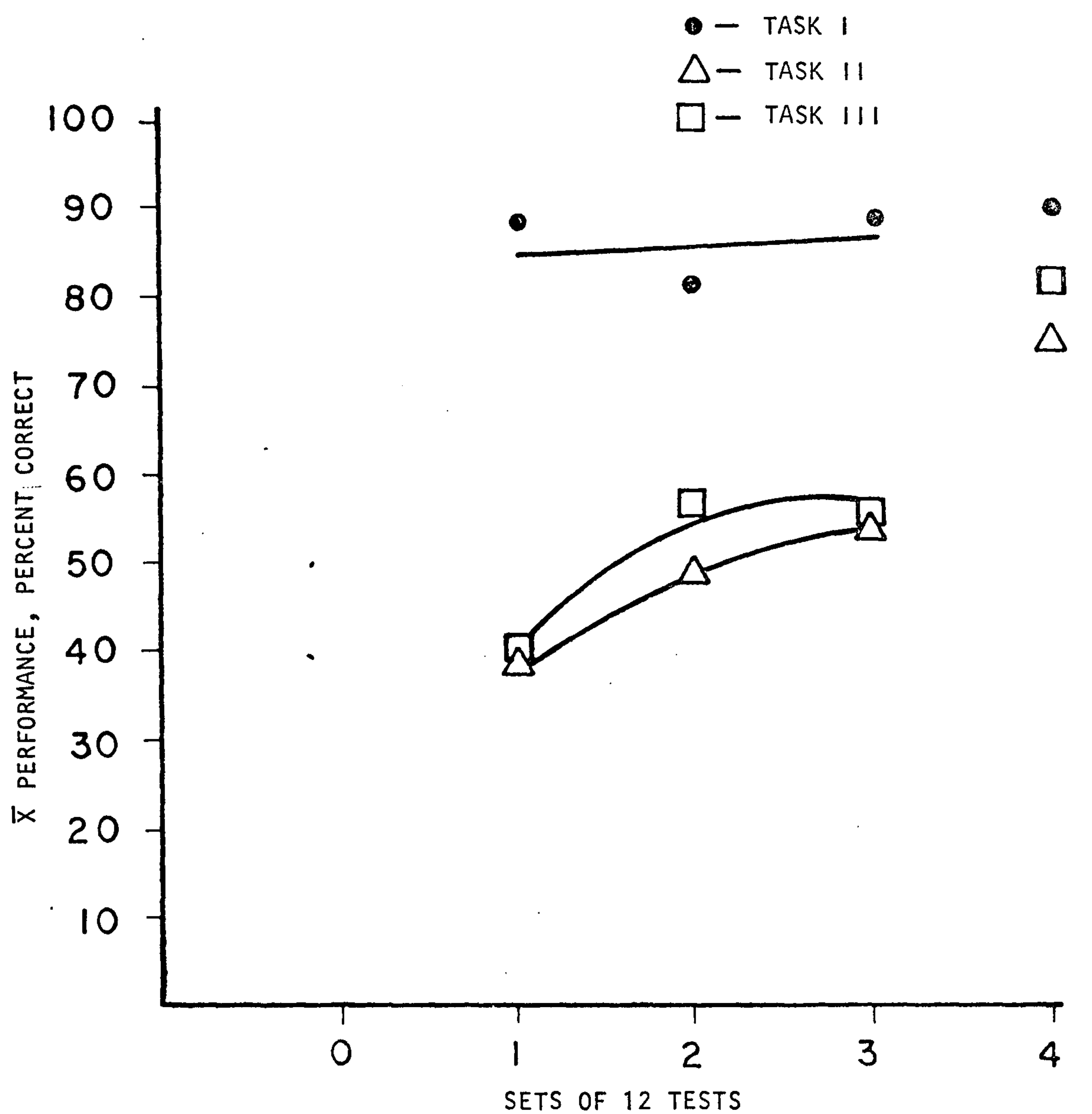


Figure 4-4. Performance as a Function of Test Sets by Task Type

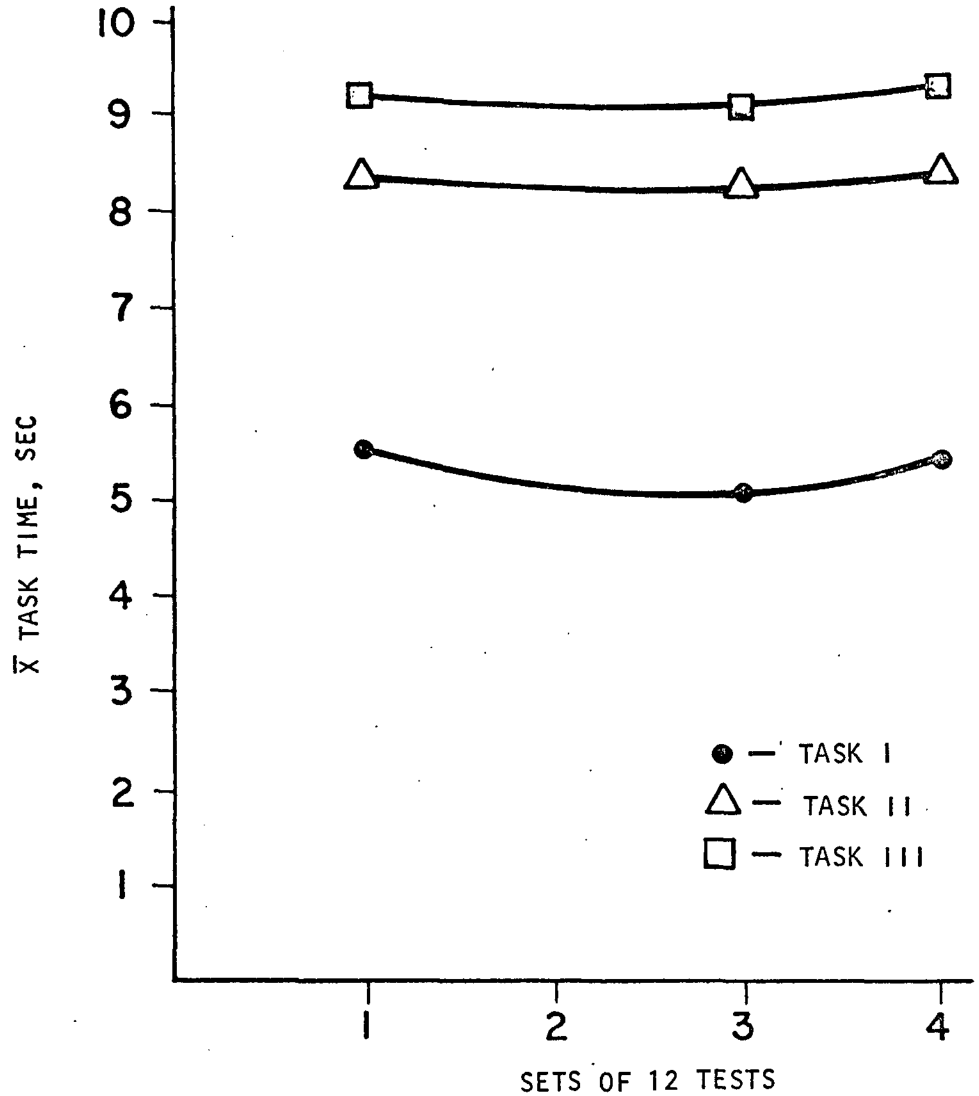


Figure 4-5. Task Duration

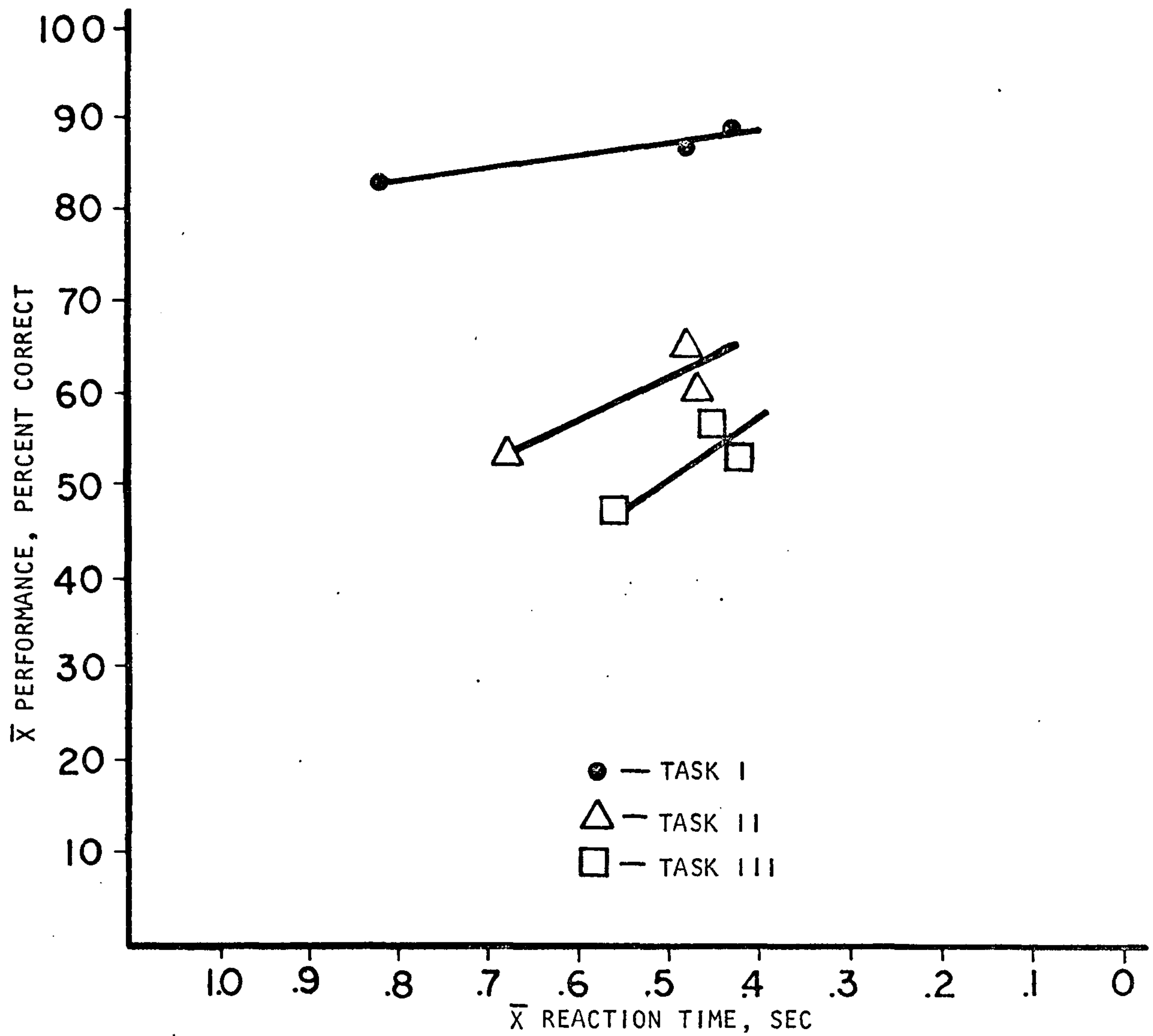


Figure 4-6. Signal Detection Performance as a Function of Reaction Time

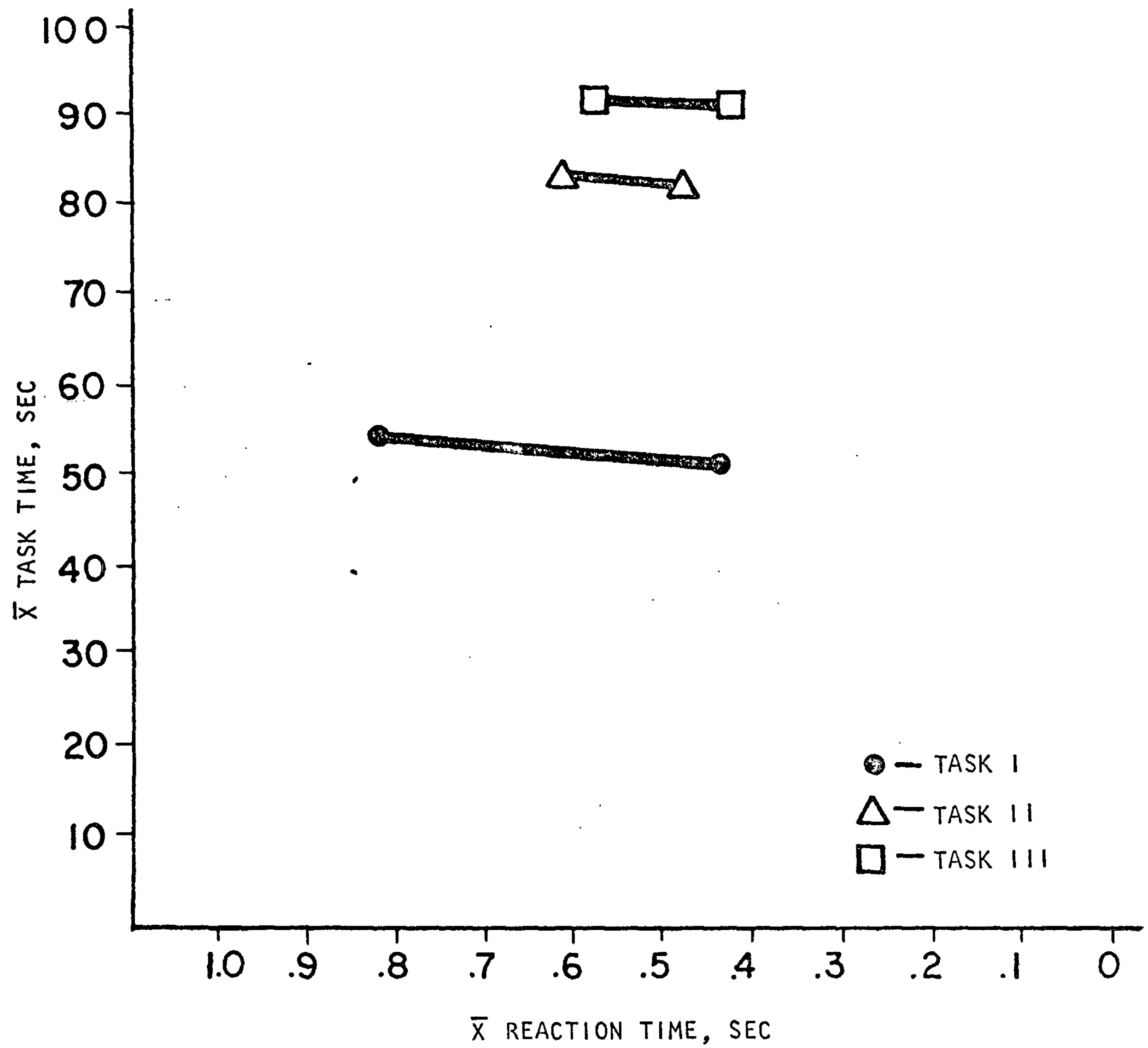


Figure 4-7. Interdependence of Task Time and Reaction Time

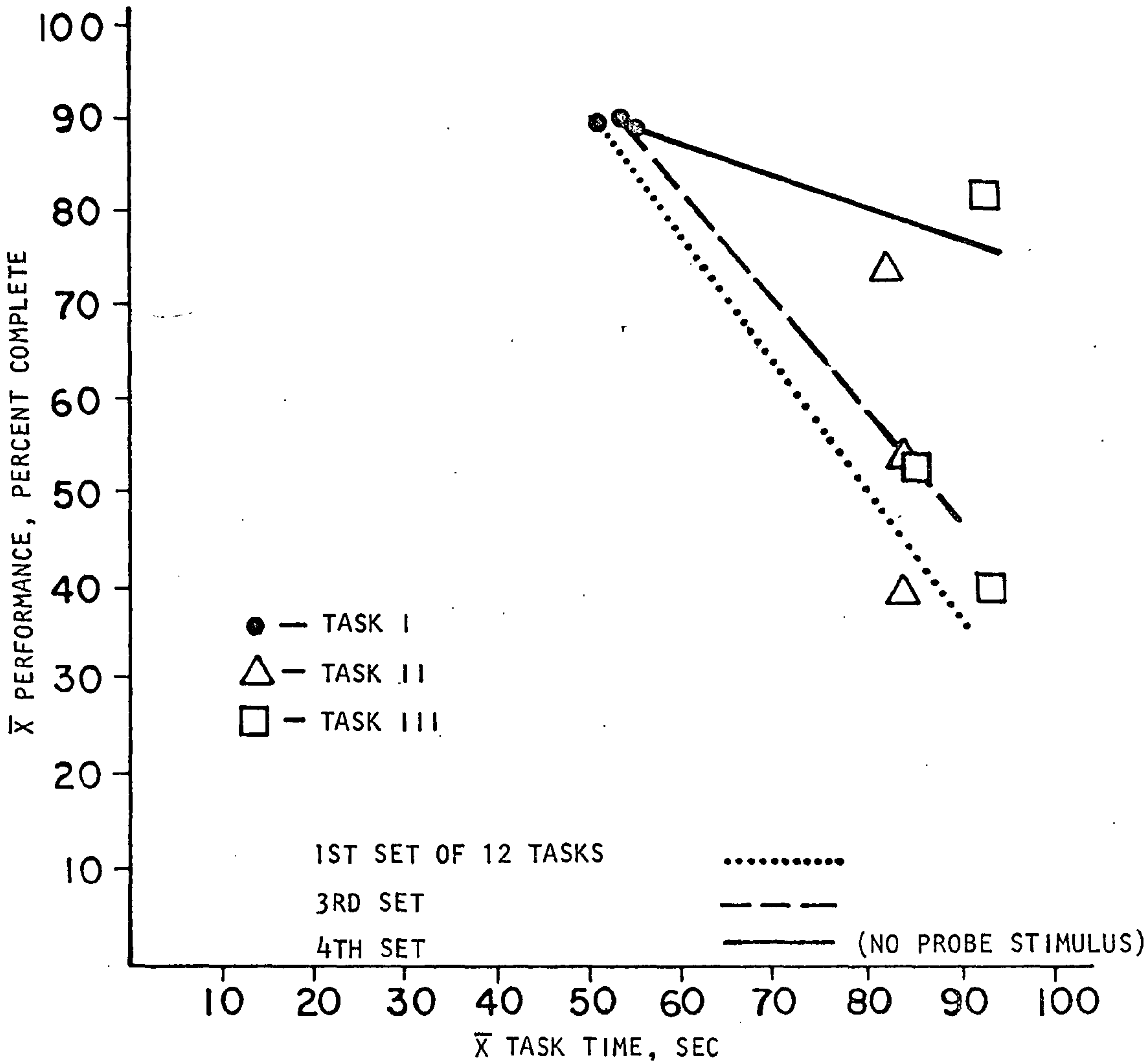


Figure 4-8. Performance as a Function of Task Duration, Comparing Tests With and Without the Probe Stimulus

TABLE 4-3

AVERAGE HEART RATE

Set of 12 Tests	Task Type				
		Task 1	Task 2	Task 3	$\overline{X}$
	1	81.1	81.1	74.6	78.9
	3	76.0	77.6	77.6	77.1
	4	78.7	78.9	81.6	79.7
	$\overline{X}$	78.6	79.2	77.9	

TABLE 4-4

END-OF-TEST (LAST 5 SEC)
AVERAGE HEART RATE

Set of 12 Tests	Task Type				
		Task 1	Task 2	Task 3	$\overline{X}$
	1	80.8	79.6	75.5	78.6
	3	68.0	79.1	79.1	75.4
	4	77.6	80.6	81.2	79.8
	$\overline{X}$	75.5	79.8	78.6	

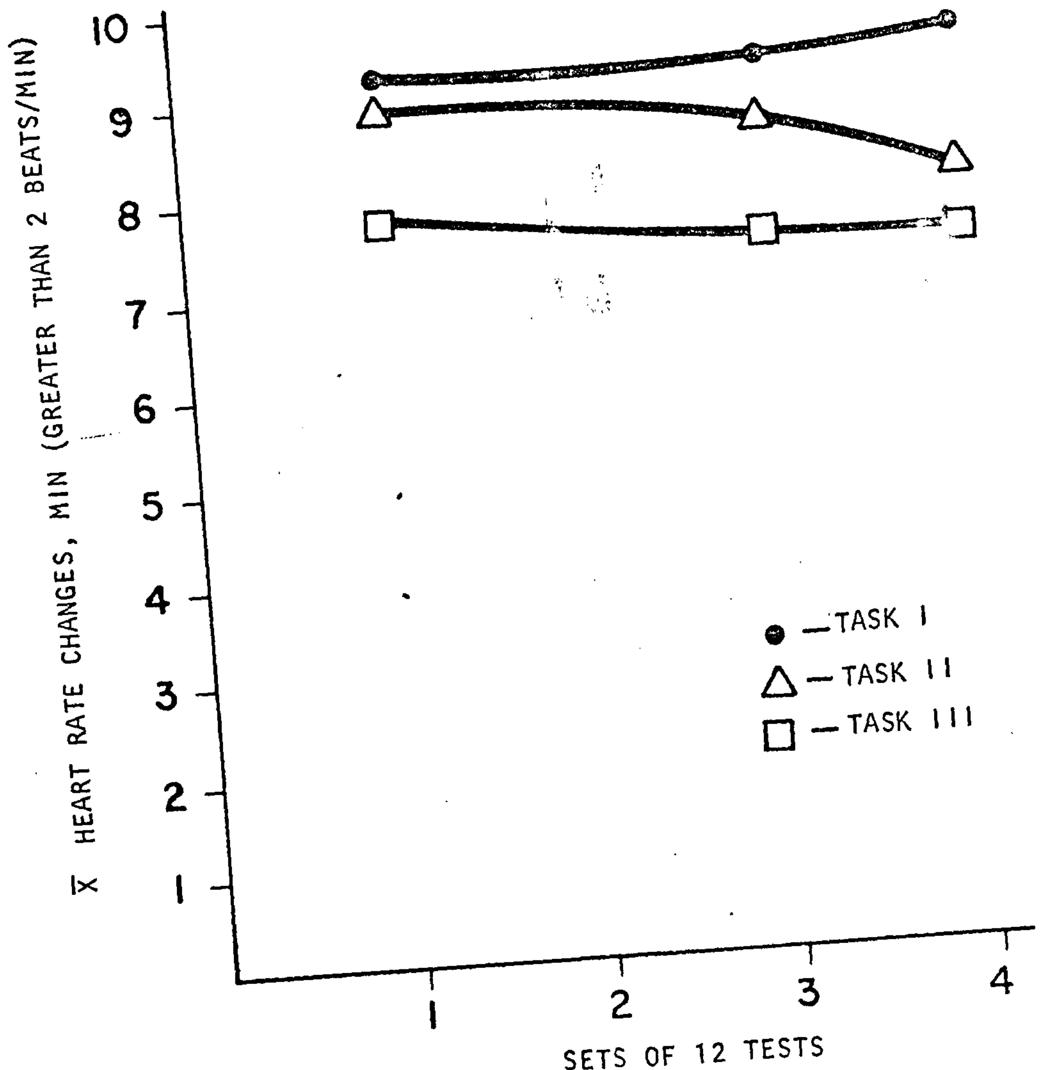


Figure 4-9. Heart Rate Variability by Sets of 12 Tests

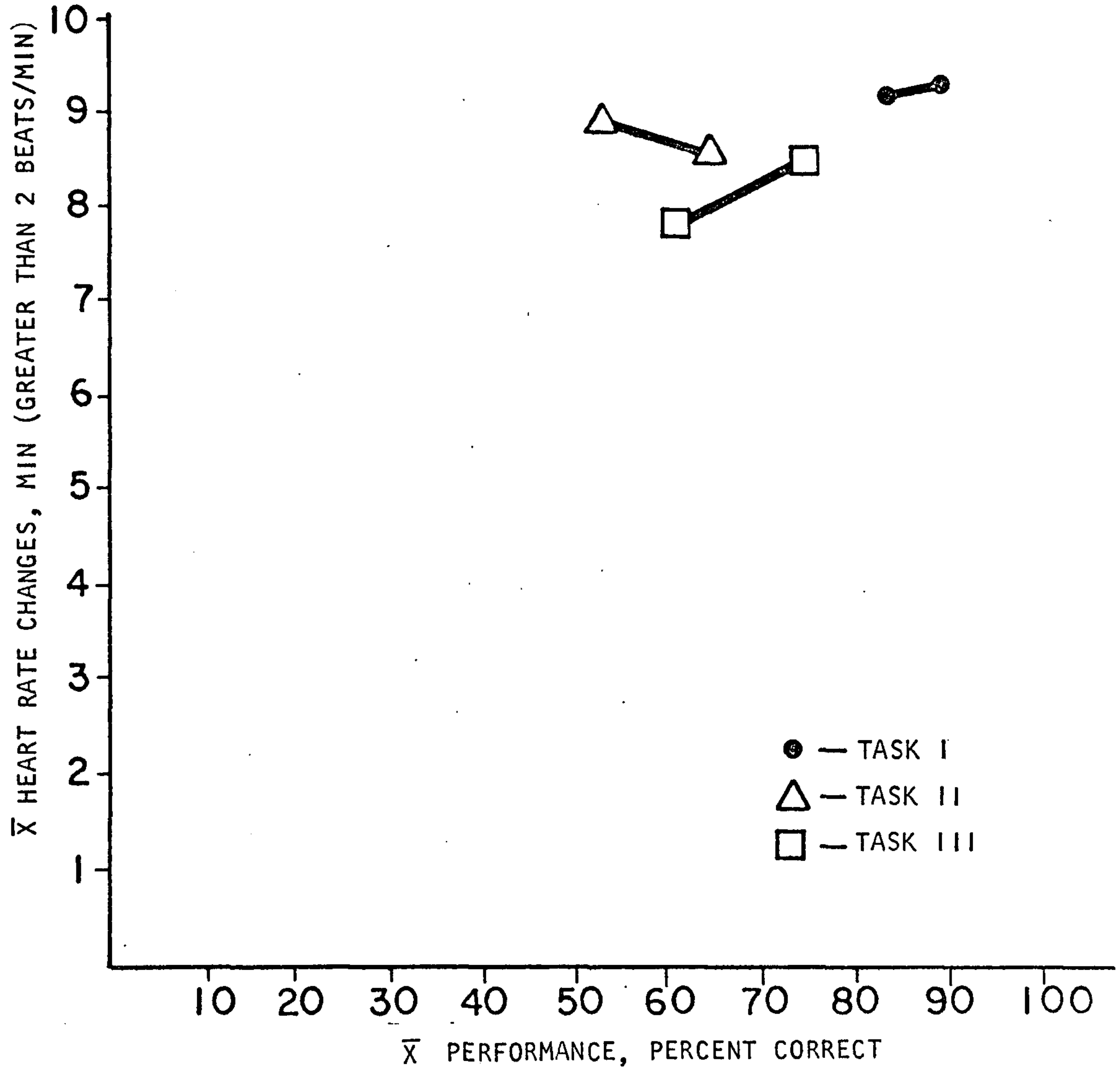


Figure 4-10. Heart Rate Variability and Performance

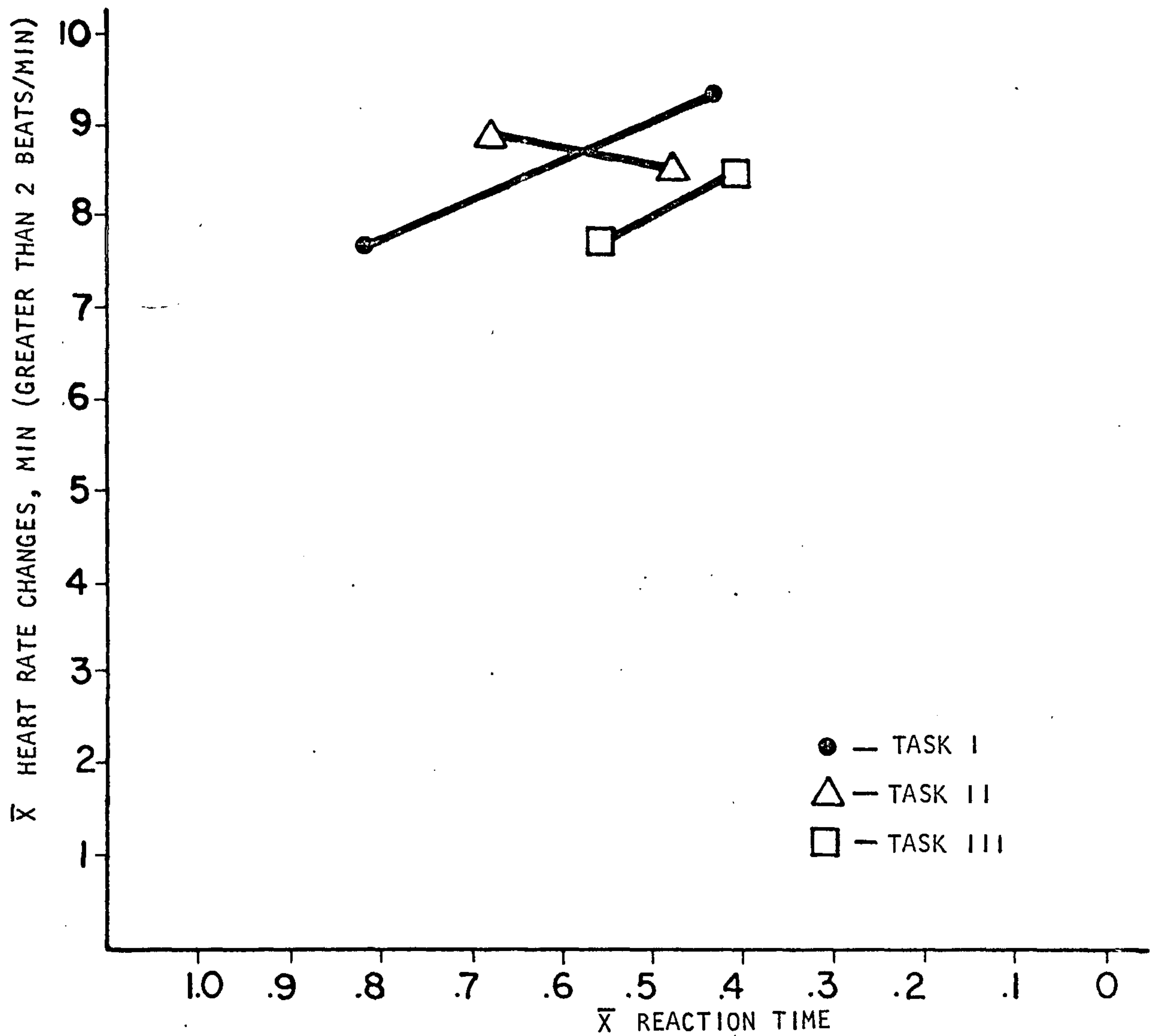


Figure 4-11. Heart Rate Variability and Reaction Time

The heart rate at the end of the test period (last five seconds) appears to be related to both performance (Figure 4-12) and reaction time (Figure 4-13). Generally, end-of-test heart rate is lower with both improved performance and improved reaction time.

Figure 4-14 shows the percentages of the probe stimulus events that were followed by a change in heart rate greater than 2 beats/minute within 5 seconds following the probe stimulus. Clear separation of the data by tasks is shown in this figure. It appears that the probability of the probe stimulus causing a change in heart rate decreases as the difficulty of the task increases. The amount of experience in the situation seems to have little effect.

Figure 4-15 illustrates this same parameter separated by direction of the change in heart rate. With the easy task (Task I), the heart rate acceleration and deceleration appear equally probable. As both task difficulty and experience increase, the apparent probability of heart rate acceleration increases over that of heart rate deceleration.

Figure 4-16 shows these same dependent variables as a function of the intensity of the probe stimulus. Again, for the easy task, the probability of heart rate acceleration and deceleration are quite similar; however, as both task difficulty and probe stimulus intensity increase, the probability of heart rate acceleration increases over the probability of heart rate deceleration.

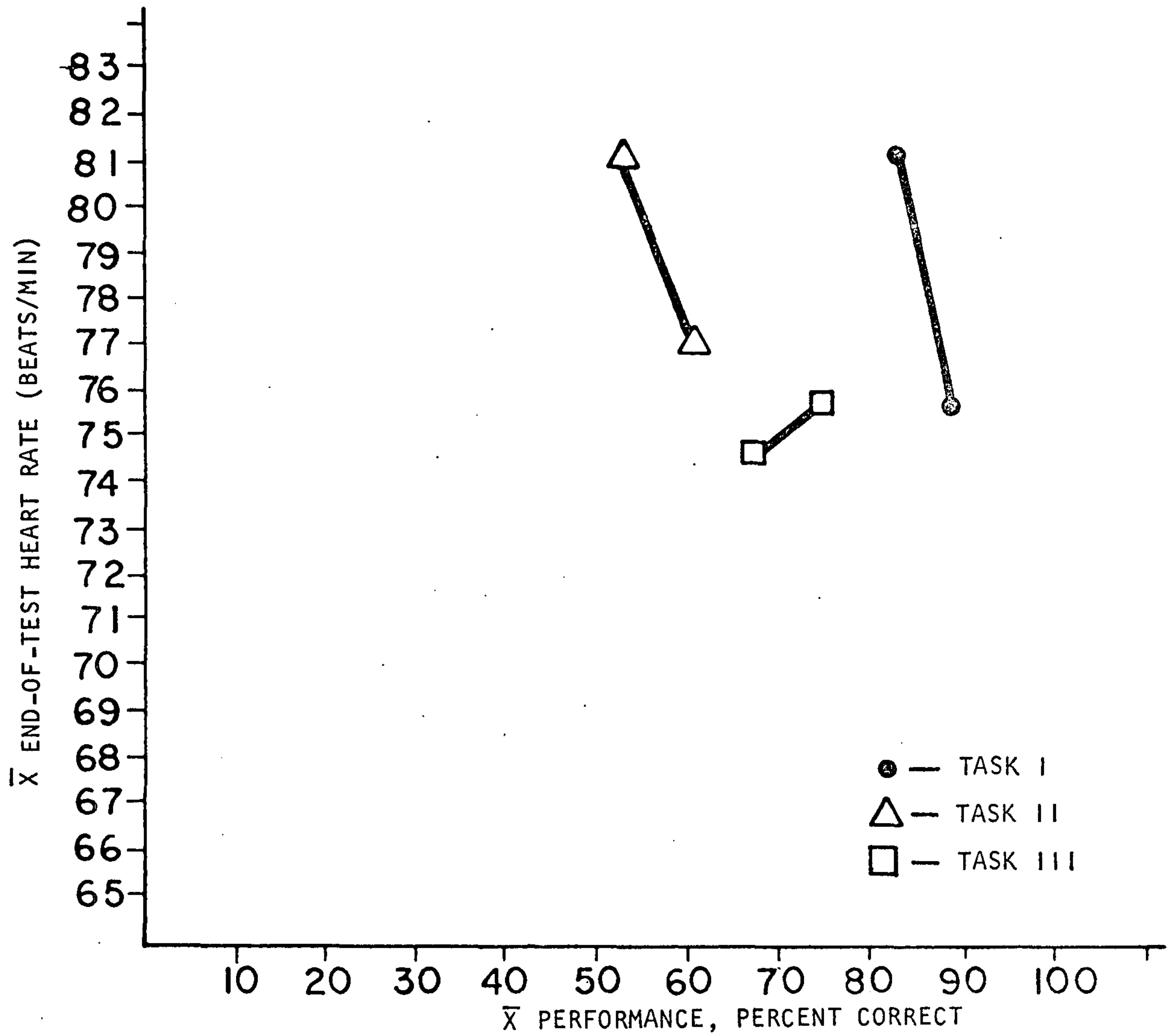


Figure 4-12. Effects of Performance on End-of-Test Heart Rate

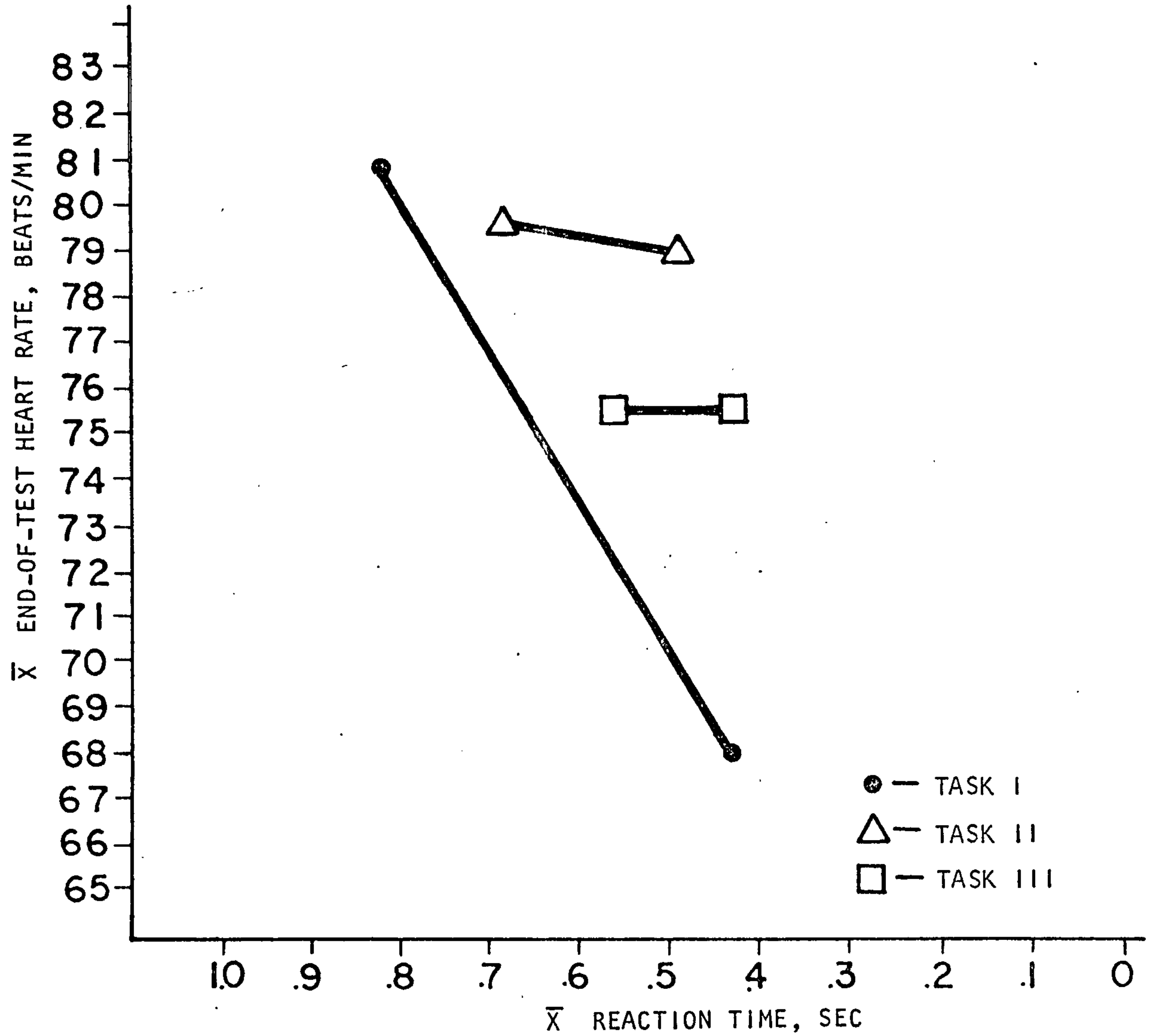


Figure 4-13. Interaction of Reaction Time and End-of-Test Heart Rate

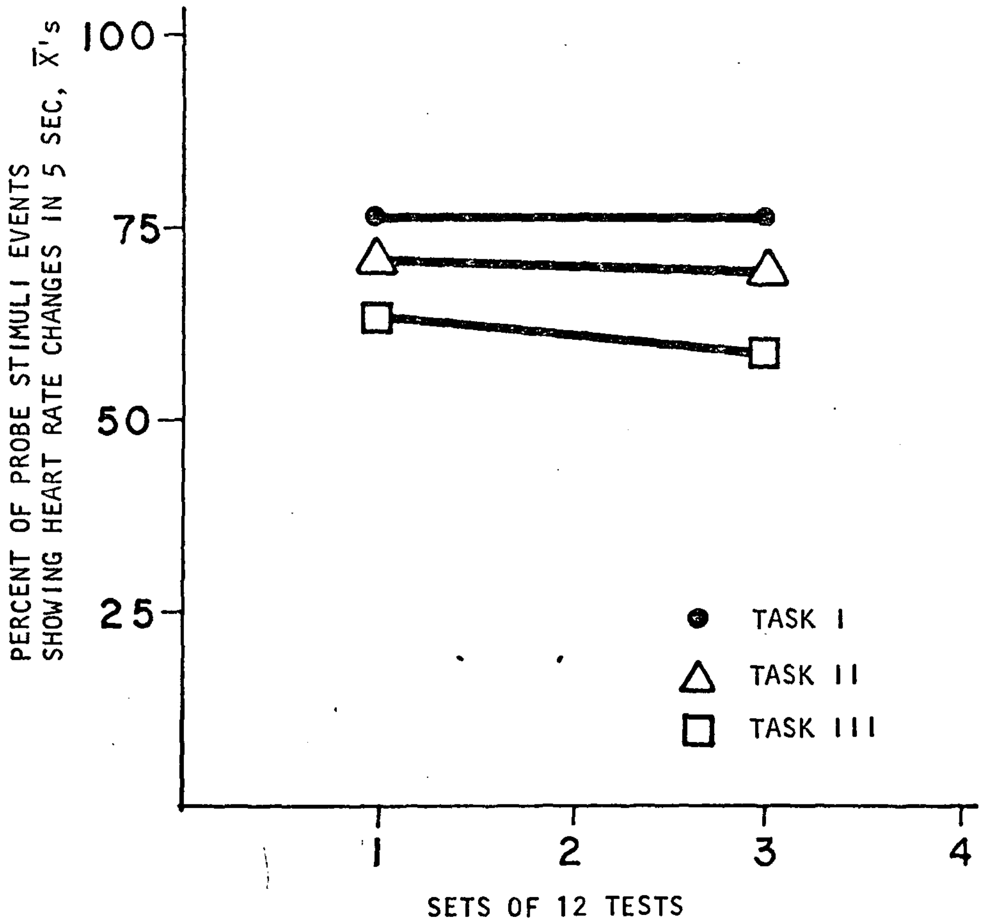


Figure 4-14. Probe Stimulus-Related Changes in Heart Rate

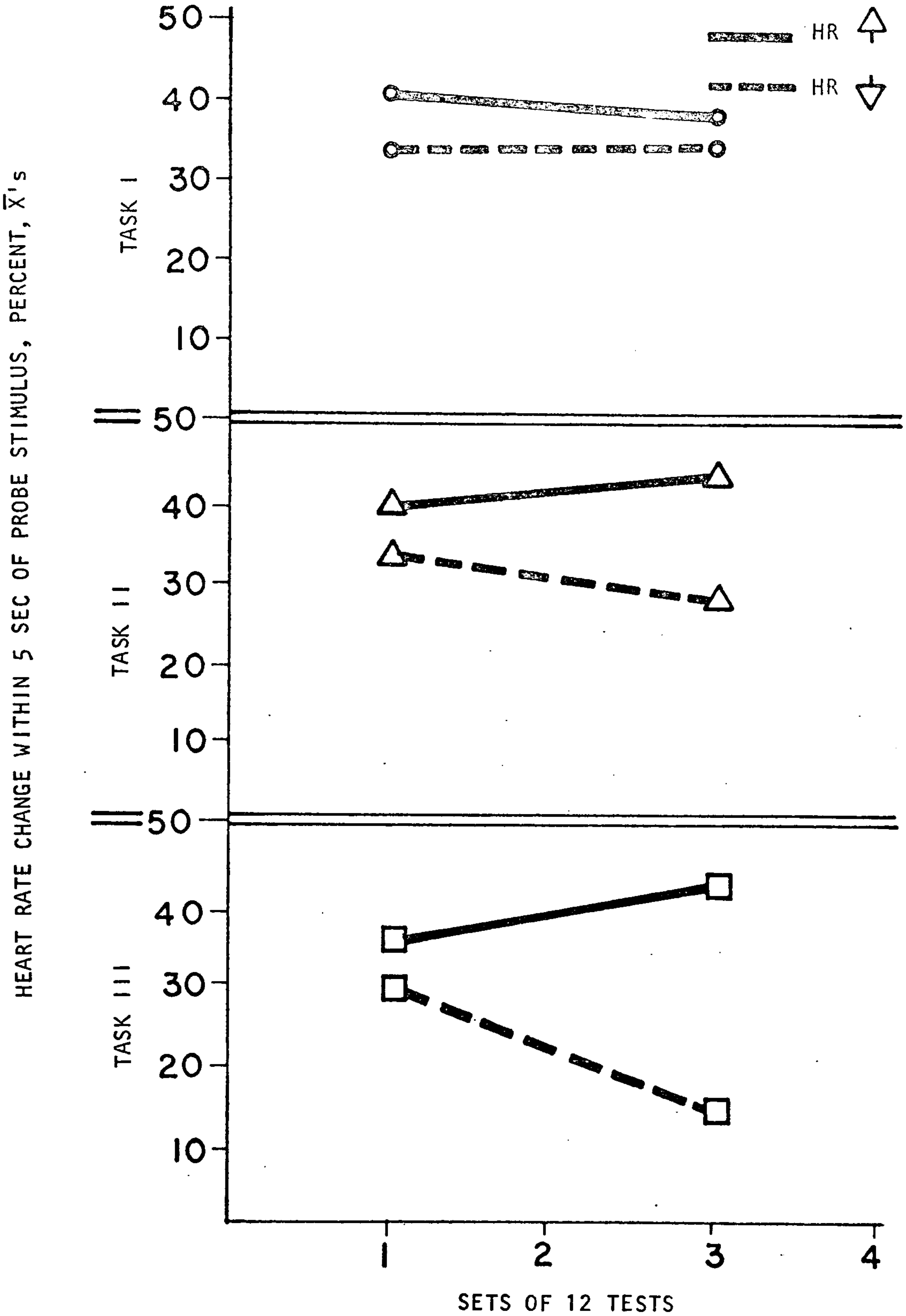


Figure 4-15. Heart Rate Acceleration and Deceleration by Task and Test Sets

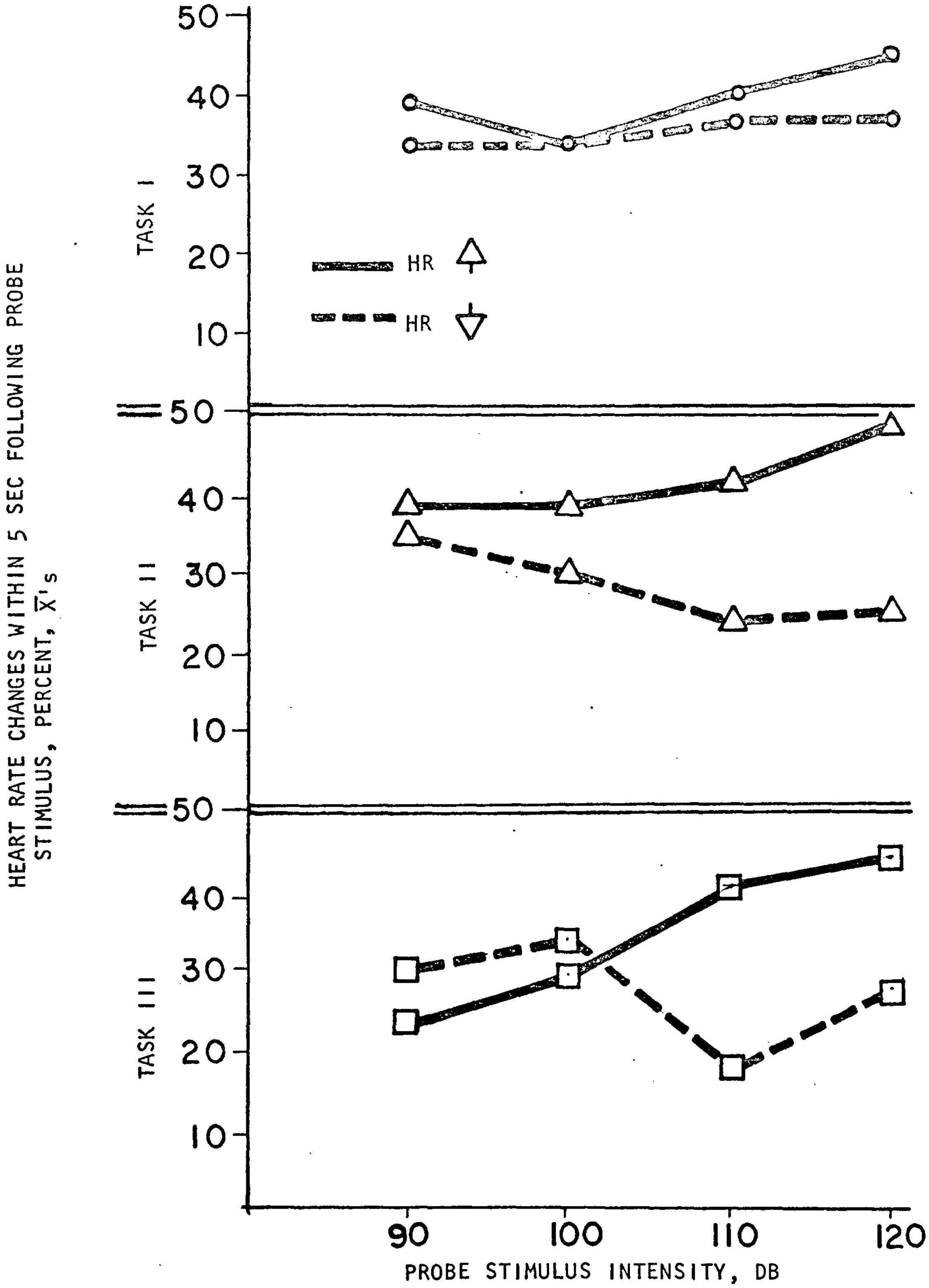


Figure 4-16. Heart Rate Acceleration and Deceleration by Task and Probe Stimulus Intensity

SECTION V

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The specific goal of the program described in this report was to initiate by literature review and pilot study, a program that eventually would result in a psychological assessment technique for assessing objectively the major aspects of the psychological state of an astronaut. This objective assessment must meet the following criteria:

(a) The method used in the assessment technique must elucidate appropriate methods of medical intervention when necessary.

(b) The method must be fully compatible with currently accepted space flight practices, values, and procedures.

(c) The method must be applicable to the assessment of potential space flight crew members.

(d) The assessment must be on a total organismic level.

(e) The method must be applicable to the assessment of both individuals and groups.

In general, this phase achieved direction for the program and evaluated the general trend of the recommended approach. Major specific accomplishments were:

(a) Substantive review of the relevant research.

(b) Selection of appropriate methods and techniques for application.

(c) The method selected simultaneously observed the effects of situational variables on performance, physiology, and psychophysiological dependent variables.

(d) Selection of an experimental paradigm to evaluate the proposed methods (visual and auditory signal detection in the face of visual and auditory noise, under time pressure, competition pressure, and with periodic distracting probe stimuli).

(e) Selection of simultaneously observed physiological, task performance, threshold, and psychophysiological dependent variables.

(f) Development of apparatus, instrumentation, computer programs, test procedures, and data reduction techniques to evaluate the recommended approach.

(g) Performance of pilot studies.

The more important observations made during the pilot study were:

(a) The performance tasks selected differed in difficulty in terms of correct performance, reaction time, end-of-test heart rate, task time, and heart rate changes following the probe stimulus. The rank order of task difficulty (I, II, and III) was consistent for all dependent measures.

(b) The removal of the probe stimulus/reaction time task substantially improved task performance, slightly increased the time to complete the task, decreased heart rate variability on the difficult tasks, and increased heart rate variability on the easy tasks.

(c) Heart rate variability increased as task difficulty decreased and also appeared to increase with decreasing reaction time.

(d) The probability of a heart rate change within 5 seconds of the probe stimulus decreased with increasing task difficulty.

(e) The probability that a heart rate change within 5 seconds of the probe stimulus would be an acceleration in rate increased with both task difficulty and probe stimulus intensity.

(f) It also was observed that there were individually unique ways of responding (e.g., vasoconstriction to low levels of the probe stimulus, maintenance of vasoconstriction for extended periods, biphasic vasoconstriction/dilation, difference in temporal intervals between ECG, FPG, and REG pulse signals, etc.).

It is probable that these characteristic types of physiological response will prove predictive of eventual disease states, personality variables, etc.

Due to the pilot nature of this test program and the exigencies of cost and schedule, systematic data reduction was not attempted on REG, EPG, and FPG parameters. Inspection of the data on these dependent variables led to the comments in (f) above.

On the basis of the study and the pilot testing, it is recommended that (1) the line of investigation reported be continued with fully designed experiments; (2) the range of observation and computations be extended to include temporal relationships between the dependent variables; and (3) sufficient data be collected to clarify the effects of the independent variables and the relations between dependent variables, to classify the individually unique ways of responding, and to make a sufficient number of observations to be indicative of normative data.

If the data continue to support the fundamental contention in a fully designed experiment, then the basic approach must be extended to experimentation in multiperson situations and in conjunction with other environmental stressors such as isolation.

F

APPENDIX A

FORMAT OF OPTIONS

APPENDIX A

FORMAT OF OPTIONS

Certain keys on the teletype keyboard control certain options within the computer. These keys and the options they control are listed below. In each case the computer acknowledges the character by printing a space and ringing the bell of the teletype. Further action by the operator is noted below and any required input must be in the exact format as stated.

Teletype Key	Optional Input	Option
V	DDD	The three-digit number (DDD) (less than 128) volume level of the background audio signal (0 represents the quietest, 127 represents the lowest)
M		Reads 400 alphanumeric characters from the paper tape reader as the input matrix. The computer automatically starts the reader.
T	D XXX	Where XXX is a three-digit number representing the time limit in seconds. The digit D represents which of the three time limits is to be modified. D=1, the time limit for the entire game D=2, the time limit the matrix is to be displayed D=3, the time limit the rules of the game are to be displayed (D=2, D=3 are not presently used)
G	D	D is a one-digit number specifying which of three games is to be displayed. D=1, count the occurrence of an alphanumeric character D=2, count the occurrence of characters between limits D=3, count the occurrence of vowels

Teletype Key	Optional Input	Option
P		Read a paper tape specifying several games to be played in succession, punched in the following format where NN is a two-digit number specifying the number of games to be read in. GG-----are NN, one-digit numbers specifying which of the three games is to be played. Starts execution of the game or games specified by a preceding G or P parameter.

APPENDIX B

COMPUTER PROGRAM

APPENDIX B

COMPUTER PROGRAM

```
SEQER LC    OBJECT                                      SOURCE

  1   0000              PHSYC PSEG
  2   0000 029C               DATA  START,X'1C0'
      0001 01C0
  3   0002 0000               DATA  0,0,0,0,0,0,0
      0003 0000
      0004 0000
      0005 0000
      0006 0000
      0007 0000
      0008 0000
  4   0009 0000               DATA  0,0,0,0,0,0,0
      000A 0000
      000B 0000
      000C 0000
      000D 0000
      000E 0000
      000F 0000
  5   0010 007F         MSK1  DATA  X'7F'
  6   0011 000F         MSK2  DATA  X'000F'
  7   0012 FFBF         MSK3  DATA  X'FFBF'
  8   0013 8000         MSK4  DATA  X'8000'
  9   0014 000A         LFCR  DATA  X'0A',X'8D'
      0015 008D
 10   0016 0020         SPBEL DATA  X'20',X'07'
      0017 0007
 11   0018 0011         RDON  DATA  X'11'
 12   0019 0013         RDOFF DATA  X'13'
 13   001A 0F00         CRU   DATA  X'F00'      TTY
 14   001B 0F10               DATA  X'F10'      CRT
 15   001C 0F20               DATA  X'F20'      TIMER
 16   001D 0F30               DATA  X'F30'      PULSE
 17   001E 0F40               DATA  X'F40'      IODEV
 18   001F 0000         C0    DATA  0
 19   0020 0001         C1    DATA  1
 20   0021 0002         C2    DATA  2
 21   0022 0003         C3    DATA  3
 22   0023 0004         C4    DATA  4
 23   0024 0006         C6    DATA  6
 24   0025 0010         C16   DATA  16
 25   0026 0014         C20   DATA  20
 26   0027 0018         C24   DATA  24
 27   0028 003C         C60   DATA  60
 28   0029 0190         C400  DATA  400
 29   002A 0320         C800  DATA  800
 30   002B 0001         CMULT DATA  1
 31   002C 000A               DATA  10
 32   002D 0064               DATA  100
 33   002E 03E8               DATA  1000
 34   002F 2710               DATA  10000
```

```
0030 0003      MLINE DATA  3
0031 000A      MCOL  DATA  10
0032 0081      CRTFN DATA  X'81'      CRT FUNCTION
0033 0003            DATA  X'03'      LOAD CURSOR
0034 0087            DATA  X'87'      BEEP
0035 0099            DATA  X'99'      CLEAR SCREEN
0036 0000            DATA  0          SPARE
0037 0005            DATA  X'0005'    INTERRUPT
0038 FFA0            DATA  X'FFA0'    SPACE
0039 0087            DATA  X'87'      DISABLE KEYBOARD
003A 0006            DATA  X'06'      ENABLE KEYBOARD
003B 0000      TTYCH DATA  0
003C 0000      CRTCH DATA  0
003D 0030      NUMS  DATA  X'30',X'39'
003E 0039
003F 0041      VOWLS DATA  X'41',X'45',X'49'
0040 0045
0041 0049
0042 004F            DATA  X'4F',X'55'
0043 0055
0044 0000      DUM   DATA  $-$,$-$
0045 0000
0046 0000            DATA  $-$,$-$
0047 0000
0048 0032      TIMES DATA  50         GAME
0049 01F4            DATA  500        DISPLAY
004A 01F4            DATA  500        RULES
004B 0000      WRKST DATA  $-$        GAME TIME                   0
004C 0000            DATA  $-$        DISPLAY                     1
004D 0000            DATA  $-$        RULES                       2
004E FFFF            DATA  -1         GAME IN PROGRESS            3
004F 0000            DATA  $-$        CALC ANSWER                 4
0050 0000            DATA  $-$        INPUT ANSWER                5
0051 0000            DATA  $-$        SOUND LEVEL                 6
0052 0000            DATA  $-$        SOUND INTERVAL              7
0053 00BF            DATA  X'BF'      BEEP LEVEL                  8
0054 0000            DATA  $-$        GAME NUMBER                 9
0055 0000            DATA  $-$        NO OF GAMES                10
0056 0000            DATA  $-$        NO OF SOUND RESPONSES      11
0057 0000            DATA  $-$        SPARE                      12
0058 0054      CHINP DATA  X'54'    T SET A TIME
0059 004D            DATA  X'4D'    M READ MATRIX
005A 0047            DATA  X'47'    G READ 1 GAME
005B 0050            DATA  X'50'    P READ SEVERAL GAMES
005C 0056            DATA  X'56'    V SET VOLUME
005D 0058            DATA  X'58'    X EXECUTE
005E 02C8            DATA  NEXTI    DUMMY
005F 038C      CHROT DATA  SETTM
0060 031C            DATA  RDMAT
0061 030E            DATA  RDGME
0062 0354            DATA  RDGMS
```

```
80   0063 0302               DATA  SVLEV
81   0064 03A8               DATA  XCUTE
82   0065 0081        ROOL1  DATA  X'81',X'03',15,0
     0066 0003
     0067 000F
     0068 0000
83   0069 2043204F           DATA  C' C O U N T   T H E  '
     006B 2055204E
     006D 20542020
     006F 20542048
     0071 20452020
84   0073 204F2043           DATA  C' O C C U R R E N C E  '
     0075 20432055
     0077 20522052
     0079 2045204E
     007B 20432045
     007D 2020
85   007E 204F2046           DATA  C' O F   *'
     0080 2020202A
86   0082             ROOL2  EQU   $+10
87   0082 0000               DATA  $-$,$-$
     0083 0000
88   0084 204E2055           DATA  C' N U M B L E T T'
     0086 204D2042
     0088 204C2045
     008A 20542054
89   008C 0081               DATA  X'81',X'03',7,0
     008D 0003
     008E 0007
     008F 0000
90   0090 2043204F           DATA  C' C O U N T   T H E  '
     0092 2055204E
     0094 20542020
     0096 20542048
     0098 20452020
91   009A 202A202A           DATA  C' * * * * E R S   B E T W'
     009C 202A202A
     009E 20452052
     00A0 20532020
     00A2 20422045
     00A4 20542057
92   00A6 20452045           DATA  C' E E N   *   A N D   *'
     00A8 204E2020
     00AA 202A2020
     00AC 2041204E
     00AE 20442020
     00B0 202A
93   00B1 0081        ROOL3  DATA  X'81',X'03',24,0
     00B2 0003
     00B3 0018
     00B4 0000
```

```
00B5 2043204F        DATA  C' C O U N T   T H E'
00B7 2055204E
00B9 20542020
00BB 20542048
00BD 2045
00BE 20202056        DATA  C'   V O W E L S'
00C0 204F2057
00C2 2045204C
00C4 2053
00C5 043E      RULES DATA  RULE1
00C6 0478            DATA  RULE2
00C7 04FC            DATA  RULE3
00C8 0592      ANSI  DATA  ANSI1
00C9 0592            DATA  ANSI2
00CA 0592            DATA  ANSI3
00CB 008D            DATA  X'8D',X'0A'
00CC 000A
00CD 20542059 MESG1 DATA  C' T Y P E   1 - G R A D E'
00CF 20502045
00D1 20202031
00D3 202D2047
00D5 20522041
00D7 20442045
00D9 20202020        DATA  C'           /             '
00DB 20202020
00DD 202F2020
00DF 20202020
00E1 20202020
00E3 20202020
00E5 20522045        DATA  C' R E A C T I O N S       '
00E7 20412043
00E9 20542049
00EB 204F204E
00ED 20532020
00EF 20202020
00F1 20202020        DATA  C'                         '
00F3 20202020
00F5 20202020
00F7 20202020
00F9 20202020
00FB 20202020
00FD 20202020        DATA  C'                         '
00FF 20202020
0101 20202020
0103 20202020
0105 20202020
0107 20202020
0109 20202020        DATA  C'                         '
010B 20202020
010D 20202020
010F 20202020
```

```
       0111 20202020
       0113 20202020
109    0115 20202020          DATA  C'                                    '
       0117 20202020
       0119 20202020
       011B 20202020
       011D 20202020
       011F 20202020
110    0121 20202020          DATA  C'                                    '
       0123 20202020
       0125 20202020
       0127 20202020
       0129 20202020
       012B 20202020
111    012D 20202020          DATA  C'                                    '
       012F 20202020
       0131 20202020
       0133 20202020
       0135 20202020
       0137 20202020
112    0139 20202020          DATA  C'                                    '
       013B 20202020
       013D 20202020
       013F 20202020
       0141 20202020
       0143 20202020
113    0145 0081              DATA  X'81',X'03',22,1
       0146 0003
       0147 0016
       0148 0001
114    0149 20472041 DPTMS DATA  C' G A M E   T I M E '
       014B 204D2045
       014D 20202054
       014F 2049204D
       0151 20452020
115    0153 202A202A          DATA  C' * * *   S E C S   '
       0155 202A2020
       0157 20532045
       0159 20432053
       015B 20202020
116    015D 02C8              DATA NEXTI,0
       015E 0000
117    015F 0000     STATS DATA  0,0,INTSV
       0160 0000
       0161 016B
118    0162 0000              DATA  0,0,INTSV+2
       0163 0000
       0164 016D
119    0165 0000              DATA  0,0
       0166 0000
120    0167 7881015F          SXBW  STATS
```

```
0169 78810162        SXBW  STATS+3
                *
                *          INTERNAL INTERRUPT SERVICE
016B           INTSV EQU   $
016B 7082016B        B     $
                *          CRU INTERRUPT SERVICE
016D 44840000        LA    4,PHSYC
016F 44850000        LA    5,PHSYC
0171 44860000        LA    6,PHSYC
0173 4407001A        L     7,CRU
0175 300F0991        BBNE  15,1,$+28
0177 340B0000        SETB  11,0
0179 340C0000        SETB  12,0
017B 340D0000        SETB  13,0
017D 1420B43B        MOV   C1,TTYCH
017F 44010019        L     1,RDOFF
0181 E08A0191        BC    10,$+16
0183 58010010        N     1,MSK1
0185 48810019        ST    1,RDOFF
0187 08008019        LDCR  (0,8),RDOFF
0189 300F0989        BBNE  15,1,$
018B 340B0000        SETB  11,0
018D 340C0000        SETB  12,0
018F 340D0000        SETB  13,0
0191 4407001B        L     7,CRU+1
0193 300F099D        BBNE  15,1,$+10
0195 340B0000        SETB  11,0
0197 340C0000        SETB  12,0
0199 340D0000        SETB  13,0
019B 1420B43C        MOV   C1,CRTCH
019D 4407001D        L     7,CRU+3
019F 0800001F        LDCR  (0,0),C0
01A1 4407001C        L     7,CRU+2
01A3 30000A09        BBNE  0,1,INTRT
01A5 340F0000        SETB  15,0
01A7 34000000        SETB  0,0
01A9 4401004E        L     1,WRKST+3
01AB E08C0209        BC    12,INTRT
01AD 0801E02E        LDCR  (1,14),CMULT+3
01AF 340F0800        SETB  15,1
01B1 204BBFFF        AMI   WRKST,-1
01B3 204CBFFF        AMI   WRKST+1,-1
01B5 204DBFFF        AMI   WRKST+2,-1
01B7 2052BFFF        AMI   WRKST+7,-1
01B9 4401004B        L     1,WRKST
01BB E08A01E9        BC    10,$+46
01BD 4407001C        L     7,CRU+2
01BF 340F0000        SETB  15,0
01C1 4407001B        L     7,CRU+1
01C3 08008032        LDCR  (0,8),CRTFN
01C5 300B09C5        BBNE  11,1,$
```

```
01C7 340B0000          SETB   11,0
01C9 08008039          LDCR   (0,8),CRTFN+7
01CB 300B09CB          BBNE   11,1,$
01CD 340B0000          SETB   11,0
01CF 08008035          LDCR   (0,8),CRTFN+3
01D1 300B09D1          BBNE   11,1,$
01D3 340B0000          SETB   11,0
01D5 340D0000          SETB   13,0
01D7 141FB450          MOV    C0,WRKST+5
01D9 44010054          L      1,WRKST+9
01DB 4613069A          L      3,GAMES,1
01DD 46320211          L      2,WKDUM,3
01DF 48820165          ST     2,STATS+6
01E1 5002008A          S      2,X'8A'
01E3 48820166          ST     2,STATS+7
01E5 708001E7          XSB    $+2
01E7 7C000165          LDS    STATS+6
                *
01E9 4401004C          L      1,WRKST+1
01EB E08A01EF          BC     10,$+4
01ED 70070000          NOP
01EF 4401004D          L      1,WRKST+2
01F1 E08A01F5          BC     10,$+4
01F3 70070000          NOP
01F5 44010052          L      1,WRKST+7
01F7 E08A0209          BC     10,INTRT
01F9 4407001E          L      7,CRU+4
01FB 08007053          LDCR   (0,7),WRKST+8
01FD 34080000          SETB   8,0
01FF 08092022          LDCR   (9,2),C3
0201 44010056          L      1,WRKST+11
0203 461206AE          L      2,RESPT,1
0205 4C02002E          A      2,CMULT+3
0207 4A9206AE          ST     2,RESPT,1
0209            INTRT  EQU    $
0209 44010163          L      1,STATS+4
020B 58010012          N      1,MSK3
020D 48810163          ST     1,STATS+4
020F 7C000162          LDS    STATS+3
0211 0000       WKDUM  DATA   $-$
0212 059A              DATA   ANSI1+8
0213 059A              DATA   ANSI1+8,ANSI1+8
0214 059A
                *
                *             EAI INTERFACE I/O
0215 0000       EAIDT  DATA   $-$           I/O CHARACTER          0
0216 0000              DATA   $-$           XR2 SAVE               1
0217 0020              DATA   X'20',X'5F'                          2,3
0218 005F
0219 0000              DATA   $-$
021A            EAIIO  EQU    $
```

```
021A 48820216          ST    2,EAIDT+1
021C 48830219          ST    3,EAIDT+4
021E 50810001          SA    1,1
0220 C402001F          CRL   2,C0
0222 E08B0250          BC    11,EAIRD
0224 14001615          MOV   (0,0),EAIDT
0226 54020215          LOT   2,EAIDT
0228 60070082          MLA   7,X'82'
022A 5C020215          OR    2,EAIDT
022C 48820215          ST    2,EAIDT
022E 340A0800          SETB  10,1
0230 08008215          LDCR  (0,8),EAIDT
0232 44020087          L     2,X'87'
0234 5002001A          S     2,CRU
0236 E08A0242          BC    10,$+12
0238 4403003B          L     3,TTYCH
023A E08B0238          BC    11,$-2
023C 50030083          S     3,X'83'
023E 4883003B          ST    3,TTYCH
0240 7082024A          B     $+10
0242 4403003C          L     3,CRTCH
0244 E08B0242          BC    11,$-2
0246 50030083          S     3,X'83'
0248 4883003C          ST    3,CRTCH
024A 4C800001          AA    0,1
024C 0C1F0224          ARB   -1,$-40,1
024E 70820296          B     EAIRT
                 *
0250             EAIRD EQU   $
0250 44020087          L     2,X'87'
0252 5002001A          S     2,CRU
0254 E08A026C          BC    10,$+24
0256 4403003B          L     3,TTYCH
0258 E08B0256          BC    11,$-2
025A 50030083          S     3,X'83'
025C 4883003B          ST    3,TTYCH
025E 2C008215          STCR  (0,8),EAIDT
0260 08008215          LDCR  (0,8),EAIDT
0262 4403003B          L     3,TTYCH
0264 E08B0262          BC    11,$-2
0266 50030083          S     3,X'83'
0268 4883003B          ST    3,TTYCH
026A 70820280          B     $+22
026C 4403003C          L     3,CRTCH
026E E08B026C          BC    11,$-2
0270 50030083          S     3,X'83'
0272 4883003C          ST    3,CRTCH
0274 2C008215          STCR  (0,8),EAIDT
0276 08008215          LDCR  (0,8),EAIDT
0278 4403003C          L     3,CRTCH
027A E08B0278          BC    11,$-2
```

```
027C 50030083         S     3,X'83'
027E 4883003C         ST    3,CRTCH
0280 44020215         L     2,EAIDT
0282 58020010         N     2,MSK1
0284 48820215         ST    2,EAIDT
0286 50020015         S     2,LFCR+1
0288 E08B0296         BC    11,EAIRT
028A 1A15B617         CML   EAIDT,EAIDT+2
028C 70820250         B     EAIRD
028E 70820250         B     EAIRD
0290 1615A000         MOV   EAIDT,(0,0)
0292 4C800001         AA    0,1
0294 0C1F0250         ARB   -1,EAIRD,1
0296            EAIRT EQU   $
0296 44020216         L     2,EAIDT+1
0298 44030219         L     3,EAIDT+4
029A 72B20002         B     2,3
                *
029C            START EQU   $
029C 44840000         LA    4,PHSYC
029E 44850000         LA    5,PHSYC
02A0 44860000         LA    6,PHSYC
02A2 44810090         LA    1,X'90'
02A4 1567A400         MOV   STATS+8,(0,1)
02A6 1568A401         MOV   STATS+9,(1,1)
02A8 1569A404         MOV   STATS+10,(4,1)
02AA 156AA405         MOV   STATS+11,(5,1)
02AC 4407001A         L     7,CRU
02AE 0800001F         LDCR  (0,0),C0
02B0 4407001B         L     7,CRU+1
02B2 0800001F         LDCR  (0,0),C0
02B4 4407001C         L     7,CRU+2
02B6 0800001F         LDCR  (0,0),C0
02B8 4407001D         L     7,CRU+3
02BA 0800001F         LDCR  (0,0),C0
02BC 4407001E         L     7,CRU+4
02BE 34080800         SETB  8,1    TURNSOUND OFF
02C0 0809201F         LDCR  (9,2),C0
02C2 141FB43B         MOV   C0,TTYCH
02C4 141FB43C         MOV   C0,CRTCH
02C6 7C00015D         LDS   STATS-2
                *
                *           WAIT FOR NEXT INPUT
02C8            NEXTI EQU   $
02C8 4401003B         L     1,TTYCH
02CA E08A02D2         BC    10,$+8
02CC 4401003C         L     1,CRTCH
02CE E08A0538         BC    10,ANSER
02D0 708202C8         B     NEXTI
02D2 4407001A         L     7,CRU
02D4 50010081         S     1,X'81'
```

```
0206 4881003B        ST     1,TTYCH
02D8 2C008044        STCR   (0,8),DUM
02DA 08008044        LDCR   (0,8),DUM
02DC 4401003B        L      1,TTYCH
02DE E08B02DC        BC     11,$-2
02E0 50010081        S      1,X'81'
02E2 4881003B        ST     1,TTYCH
02E4 44010044        L      1,DUM
02E6 58010010        N      1,MSK1
02E8 48810044        ST     1,DUM
02EA 44020024        L      2,C6
02EC C621005B        CRL    1,CHINP,2
02EE E08B02F4        BC     11,$+6
02F0 0C2F02EC        ARB    -1,$-4,2
02F2 708202C8        B      NEXTI
02F4 44800016        LA     0,SPBEL
02F6 44010021        L      1,C2
02F8 48820046        ST     2,DUM+2
02FA 44020020        L      2,C1
02FC 7483021A        BL     3,EAIIO
02FE 44020046        L      2,DUM+2
0300 7222005F        *B     CHROUT,2
                *
                *              READ SOUND VOLUME LEVEL
0302            SVLEV EQU    $
0302 44010022        L      1,C3
0304 4407001A        L      7,CRU
0306 7483066A        BL     3,REDNO
0308 408100FF        XORA   1,X'FF'
030A 48810051        ST     1,WRKST+6
030C 708202C8        B      NEXTI
                *
                *              READ GAME NUMBER
030E            RDGME EQU    $
030E 44010020        L      1,C1
0310 4407001A        L      7,CRU
0312 7483066A        BL     3,REDNO
0314 4881069A        ST     1,GAMES
0316 14208455        MOV    C1,WRKST+10
0318 14208454        MOV    C1,WRKST+9
031A 708202C8        B      NEXTI
                *
                *              READ IN THE MATRIX
031C            RDMAT EQU    $
031C 14298444        MOV    C400,DUM
031E 44800018        LA     0,RDON
0320 44010020        L      1,C1
0322 44020020        L      2,C1
0324 4407001A        L      7,CRU
0326 7483021A        BL     3,EAIIO
0328 44800702        LA     0,MATRX
```

```
0328 44010028          L     1,C60
032C 4402001F          L     2,C0
032E 7483021A          BL    3,EAIIO
0330 C4800892          CRLA  0,MATRX+400
0332 E08C032A          BC    12,$-8
0334 44010019          L     1,RDOFF
0336 5C010013          OR    1,MSK4
0338 48810019          ST    1,RDOFF
033A 44800019          LA    0,RDOFF
033C 44010020          L     1,C1
033E 44020020          L     2,C1
0340 7483021A          BL    3,EAIIO
0342 44000029          L     0,C400
0344 44810702          LA    1,MATRX
0346 44820892          LA    2,MATRX+400
0348 14002800          MOV   (0,1),(0,2)
034A 4C010020          A     1,C1
034C 4C020020          A     2,C1
034E 50000020          S     0,C1
0350 E08A0348          BC    10,$-8
0352 708202C8          B     NEXTI
                 *           READ SEVERAL GAMES
0354             RDGMS EQU   $
0354 44800018          LA    0,RDON
0356 44010020          L     1,C1
0358 44020020          L     2,C1
035A 4407001A          L     7,CRU
035C 7483021A          BL    3,EAIIO
035E 44010021          L     1,C2
0360 7483066A          BL    3,REDNO
0362 48810055          ST    1,WRKST+10
0364 48810046          ST    1,DUM+2
0366 48810054          ST    1,WRKST+9
0368 4480069A          LA    0,GAMES
036A 48800047          ST    0,DUM+3
036C 44010020          L     1,C1
036E 7483066A          BL    3,REDNO
0370 44000047          L     0,DUM+3
0372 4A810000          ST    1,0,0
0374 4C000020          A     0,C1
0376 48800047          ST    0,DUM+3
0378 20468FFF          AMI   DUM+2,-1
037A E08A036C          BC    10,$-14
037C 44010019          L     1,RDOFF
037E 5C010013          OR    1,MSK4
0380 48810019          ST    1,RDOFF
0382 44800019          LA    0,RDOFF
0384 44010020          L     1,C1
0386 44020020          L     2,C1
0388 7483021A          BL    3,EAIIO
038A 708202C8          B     NEXTI
```

```
                         *
                         *           SET TIMES
038C                     SETTM EQU   $
038C 44010020                  L     1,C1
038E 4407001A                  L     7,CRU
0390 7483066A                  BL    3,REDNO
0392 50010020                  S     1,C1
0394 48810046                  ST    1,DUM+2
0396 44800016                  LA    0,SPBEL
0398 44010022                  L     1,C3
039A 44020020                  L     2,C1
039C 7483021A                  BL    3,EAIIO
039E 44010021                  L     1,C2
03A0 7483066A                  BL    3,REDNO
03A2 44000046                  L     0,DUM+2
03A4 4A810048                  ST    1,TIMES,0
03A6 708202C8                  B     NEXTI
                         *
03A8                     XCUTE EQU   $
03A8 1448B44B                  MOV   TIMES,WRKST          INITIALISE TIMES
03AA 1449B44C                  MOV   TIMES+1,WRKST+1
03AC 144AB44D                  MOV   TIMES+2,WRKST+2
03AE 44010054                  L     1,WRKST+9
03B0 E08A03B4                  BC    10,$+4
03B2 708202C8                  B     NEXTI
03B4 4407001B                  L     7,CRU+1
03B6 08008035                  LDCR  (0,8),CRTFN+3
03B8 4401003C                  L     1,CRTCH
03BA E08B03B8                  BC    11,$-2
03BC 50010081                  S     1,X'81'
03BE 4881003C                  ST    1,CRTCH
03C0 1426B446                  MOV   C20,DUM+2            DISPLAY MATRIX
03C2 448106D6                  LA    1,BUF
03C4 1432A400                  MOV   CRTFN,(0,1)
03C6 1433A401                  MOV   CRTFN+1,(1,1)
03C8 1431A402                  MOV   MCOL,(2,1)
03CA 1430A403                  MOV   MLINE,(3,1)
03CC 44800702                  LA    0,MATRX
03CE 448106DA                  LA    1,BUF+4
03D0 4402001F                  L     2,C0
03D2 50020026                  S     2,C20
03D4 14000400                  MOV   (0,0),(0,1)
03D6 4C000020                  A     0,C1
03D8 4C010020                  A     1,C1
03DA 0C2103D4                  ARB   1,$-6,2
03DC 48800047                  ST    0,DUM+3
03DE 448006D6                  LA    0,BUF
03E0 44010027                  L     1,C24
03E2 44020020                  L     2,C1
03E4 4407001B                  L     7,CRU+1
03E6 7483021A                  BL    3,EAIIO
```

```
03E8 448106D6          LA    1,BUF
03EA 20032001          AMI   (3,1),1
03EC 44000047          L     0,DUM+3
03EE 2046BFFF          AMI   DUM+2,-1
03F0 E08A03CE          BC    10,$-34
03F2 44000048          L     0,TIMES
03F4 448106D6          LA    1,BUF
03F6 748[illegible]34      BL    3,BINAS
03F8 448[illegible]D6      LA    1,BUF
03FA 140[illegible]553     MOV   (3,1),DPTMS+10
03FC 14043554          MOV   (4,1),DPTMS+11
03FE 14053555          MOV   (5,1),DPTMS+12
0400 44800145          LA    0,DPTMS-4
0402 44010027          L     1,C24
0404 44020020          L     2,C1
0406 4407001B          L     7,CRU+1
0408 7483021A          BL    3,EAIIO
040A 4407001E          L     7,CRU+4            SET SOUND LEVEL
040C 08007051          LDCR  (0,7),WRKST+6
040E 34080000          SETB  8,0
0410 4401001F          L     1,C0
0412 488106AE          ST    1,RESPT
0414 141FB456          MOV   C0,WRKST+11
0416 4401004B          L     1,WRKST            FIND SOUND
0418 58010011          N     1,MSK2             INTERVAL
041A 4612070C          L     2,MATRX+10,1
041C 58020011          N     2,MSK2
041E 4C020021          A     2,C2
0420 48820052          ST    2,WRKST+7
0422 60010052          MLA   1,WRKST+7
0424 448006D6          LA    0,BUF
0426 1432A000          MOV   CRTFN,(0,0)
0428 143AA001          MOV   CRTFN+8,(1,0)
042A 44010021          L     1,C2
042C 44020020          L     2,C1
042E 4407001B          L     7,CRU+1
0430 7483021A          BL    3,EAIIO
0432 44010054          L     1,WRKST+9
0434 50010020          S     1,C1
0436 48810054          ST    1,WRKST+9
0438 4612069A          L     2,GAMES,1
043A 50020020          S     2,C1
043C 722200C5          *B    RULES,2            GAME TYPE
                *
043E            RULE1  EQU   $
043E 44810031          LA    1,X'31'
0440 468100D2          ST    1,MESG1+5
0442 440[illegible]          L     1,MATRX+178
0444 488[illegible]1         ST    1,ROOL1+28
0446 44800065          LA    0,ROOL1
0448 4481001D          LA    1,29
```

```
044A 44020020          L     2,C1
044C 4407001B          L     7,CRU+1
044E 7483021A          BL    3,EAIIO
0450 4407001C          L     7,CRU+2
0452 0801E02E          LDCR  (1,14),CMULT+3
0454 34000000          SETB  0,0
0456 340F0800          SETB  15,1
0458 4407001E          L     7,CRU+4
045A 08092020          LDCR  (9,2),C1
045C 1420B44E          MOV   C1,WRKST+3
                *            END OF INITIALISATION
                *            CALCULATE ANSWER
045E 44000081          L     0,ROOL1+28
0460 58000010          N     0,MSK1
0462 44810702          LA    1,MATRX
0464 4402001F          L     2,C0
0466 C2100000          CR    0,0,1
0468 E08B046C          BC    11,$+4
046A 7082046E          B     $+4
046C 4C020020          A     2,C1
046E 4C010020          A     1,C1
0470 C4810892          CRLA  1,MATRX+400
0472 E08C0466          BC    12,$-12
0474 4882004F          ST    2,WRKST+4
0476 708202C8          B     NEXTI
                *
0478            RULE2 EQU    $
0478 44810032          LA    1,X'32'
047A 488100D2          ST    1,MESG1+5
047C 440107B3          L     1,MATRX+177
047E 50010021          S     1,C2
0480 48810082          ST    1,ROOL2-10
0482 4C010023          A     1,C4
0484 48810083          ST    1,ROOL2-9
0486 440107B3          L     1,MATRX+177
0488 50810040          SA    1,X'40'
048A E08A04AA          BC    10,$+32
                *            NUMBERS
048C 44010082          L     1,ROOL2-10
048E 50810030          SA    1,X'30'
0490 E08A0496          BC    10,$+6
0492 44810030          LA    1,X'30'
0494 48810082          ST    1,ROOL2-10
0496 44010083          L     1,ROOL2-9
0498 50810039          SA    1,X'39'
049A E08C04A0          BC    12,$+6
049C 44810039          LA    1,X'39'
049E 48810083          ST    1,ROOL2-9
04A0 1484B49A          MOV   ROOL2-8,ROOL2+14
04A2 1485B49B          MOV   ROOL2-7,ROOL2+15
04A4 1486B49C          MOV   ROOL2-6,ROOL2+16
```

```
04A6 1487B49D        MOV   ROOL2-5,ROOL2+17
04A8 708204CA        B     $+34
                *          LETTERS
04AA 44010082        L     1,ROOL2-10
04AC 4C010020        A     1,C1
04AE 48810082        ST    1,ROOL2-10
04B0 50810041        SA    1,X'41'
04B2 E08A04B8        BC    10,$+6
04B4 44810041        LA    1,X'41'
04B6 48810082        ST    1,ROOL2-10
04B8 44010083        L     1,ROOL2-9
04BA 5081005A        SA    1,X'5A'
04BC E08C04C2        BC    12,$+6
04BE 4481005A        LA    1,X'5A'
04C0 48810083        ST    1,ROOL2-9
04C2 1488B49A        MOV   ROOL2-4,ROOL2+14
04C4 1489B49B        MOV   ROOL2-3,ROOL2+15
04C6 148AB49C        MOV   ROOL2-2,ROOL2+16
04C8 148BB49D        MOV   ROOL2-1,ROOL2+17
                *
04CA 1482B4AA        MOV   ROOL2-10,ROOL2+30
04CC 1483B4B0        MOV   ROOL2-9,ROOL2+36
04CE 4480008C        LA    0,ROOL2
04D0 44810025        LA    1,37
04D2 44020020        L     2,C1
04D4 4407001B        L     7,CRU+1
04D6 7483021A        BL    3,EAIIO
04D8 4407001C        L     7,CRU+2
04DA 0801E02E        LDCR  (1,14),CMULT+3
04DC 34000000        SETB  0,0
04DE 340F0800        SETB  15,1
04E0 4407001E        L     7,CRU+4
04E2 08092020        LDCR  (9,2),C1
04E4 1420B44E        MOV   C1,WRKST+3
                *          CALCULATE THE ANSWER
04E6 44810702        LA    1,MATRX
04E8 4402001F        L     2,C0
04EA 18003482        CML   (0,1),ROOL2-10
04EC 708204F2        B     $+6
04EE 708204F2        B     $+4
04F0 4C020020        A     2,C1
04F2 4C010020        A     1,C1
04F4 C4810892        CRLA  1,MATRX+400
04F6 E08C04EA        BC    12,$-12
04F8 4882004F        ST    2,WRKST+4
04FA 708202C8        B     NEXTI
                *
04FC            RULE3 EQU   $
04FC 44810033        LA    1,X'33'
04FE 488100D2        ST    1,MESG1+5
0500 44800081        LA    0,ROOL3
```

```
0502 44810014        LA     1,20
0504 44020020        L      2,C1
0506 4407001B        L      7,CRU+1
0508 7483021A        BL     3,EAIIO
050A 4407001C        L      7,CRU+2
050C 0801E02E        LDCR   (1,14),CMULT+3
050E 34000000        SETB   0,0
0510 340F0800        SETB   15,1
0512 4407001E        L      7,CRU+4
0514 08092020        LDCR   (9,2),C1
0516 1420B44E        MOV    C1,WRKST+3
               *            CALCULATE THE ANSWER
0518 44810702        LA     1,MATRX
051A 4402001F        L      2,C0
051C 4483003F        LA     3,VOWLS
051E 10002C00        CM     (0,1),(0,3)
0520 70820528        B      $+8
0522 70820528        B      $+6
0524 4C020020        A      2,C1
0526 7082052E        B      $+8
0528 4C030020        A      3,C1
052A C4830044        CRLA   3,VOWLS+5
052C E08C051E        BC     12,$-14
052E 4C010020        A      1,C1
0530 C4810892        CRLA   1,MATRX+400
0532 E08C051C        BC     12,$-22
0534 4882004F        ST     2,WRKST+4
0536 708202C8        B      NEXTI
               *
               *            INPUT ON CRT
0538           ANSER EQU    $
0538 4407001B        L      7,CRU+1
053A 2C008044        STCR   (0,8),DUM
053C 50010081        S      1,X'81'
053E 4881003C        ST     1,CRTCH
0540 44010044        L      1,DUM
0542 58010010        N      1,MSK1
0544 48810044        ST     1,DUM
0546 50010037        S      1,CRTFN+5
0548 E08B0552        BC     11,$+10
054A 1844B43D        CML    DUM,NUMS
054C 708202C8        B      NEXTI
054E 708202C8        B      NEXTI
0550 70820588        B      $+56
0552 44010052        L      1,WRKST+7
0554 E08A02C8        BC     10,NEXTI
0556 4407001C        L      7,CRU+2
0558 2C01E044        STCR   (1,14),DUM
055A 44020056        L      2,WRKST+11
055C 4401002E        L      1,CMULT+3
055E 50010044        S      1,DUM
```

```
0560 4E2106AE         A      1,RESPT,2
0562 4AA106AE         ST     1,RESPT,2
0564 44010056         L      1,WRKST+11
0566 4C010020         A      1,C1
0568 48810056         ST     1,WRKST+11
056A 50010025         S      1,C16
056C E08C0570         BC     12,$+4
056E 1425B456         MOV    C16,WRKST+11
0570 4407001E         L      7,CRU+4
0572 08007051         LDCR   (0,7),WRKST+6
0574 34080000         SETB   8,0
0576 08092020         LDCR   (9,2),C1
0578 44010044         L      1,DUM
057A 58010011         N      1,MSK2
057C 48810052         ST     1,WRKST+7
057E 60010052         MLA    1,WRKST+7
0580 44010056         L      1,WRKST+11
0582 4402001F         L      2,C0
0584 4A9206AE         ST     2,RESPT,1
0586 708202C8         B      NEXTI
0588 1420B43C         MOV    C1,CRTCH
058A 44010054         L      1,WRKST+9
058C 4612069A         L      2,GAMES,1
058E 50020020         S      2,C1
0590 722200C8         *B     ANSI,2
0592            ANSI3 EQU    $
0592            ANSI2 EQU    $
0592            ANSI1 EQU    $
0592 44010021         L      1,C2
0594 44070018         L      7,CRU+1
0596 7483066A         BL     3,REDNO
0598 48810050         ST     1,WRKST+5
059A 204EBFFE         AMI    WRKST+3,-2
059C 4407001E         L      7,CRU+4
059E 0809201F         LDCR   (9,2),C0
05A0 34080800         SETB   8,1
05A2 44000050         L      0,WRKST+5
05A4 448106D6         LA     1,BUF
05A6 74830634         BL     3,BINAS
05A8 448206D6         LA     2,BUF
05AA 140554DC         MOV    (5,2),MESG1+15
05AC 140454DB         MOV    (4,2),MESG1+14
05AE 4400004F         L      0,WRKST+4
05B0 448106D6         LA     1,BUF
05B2 74830634         BL     3,BINAS
05B4 448206D6         LA     2,BUF
05B6 140554E0         MOV    (5,2),MESG1+19
05B8 140454DF         MOV    (4,2),MESG1+18
05BA 141FB444         MOV    C0,DUM
05BC 448200F1         LA     2,MESG1+36
05BE 44010044         L      1,DUM
```

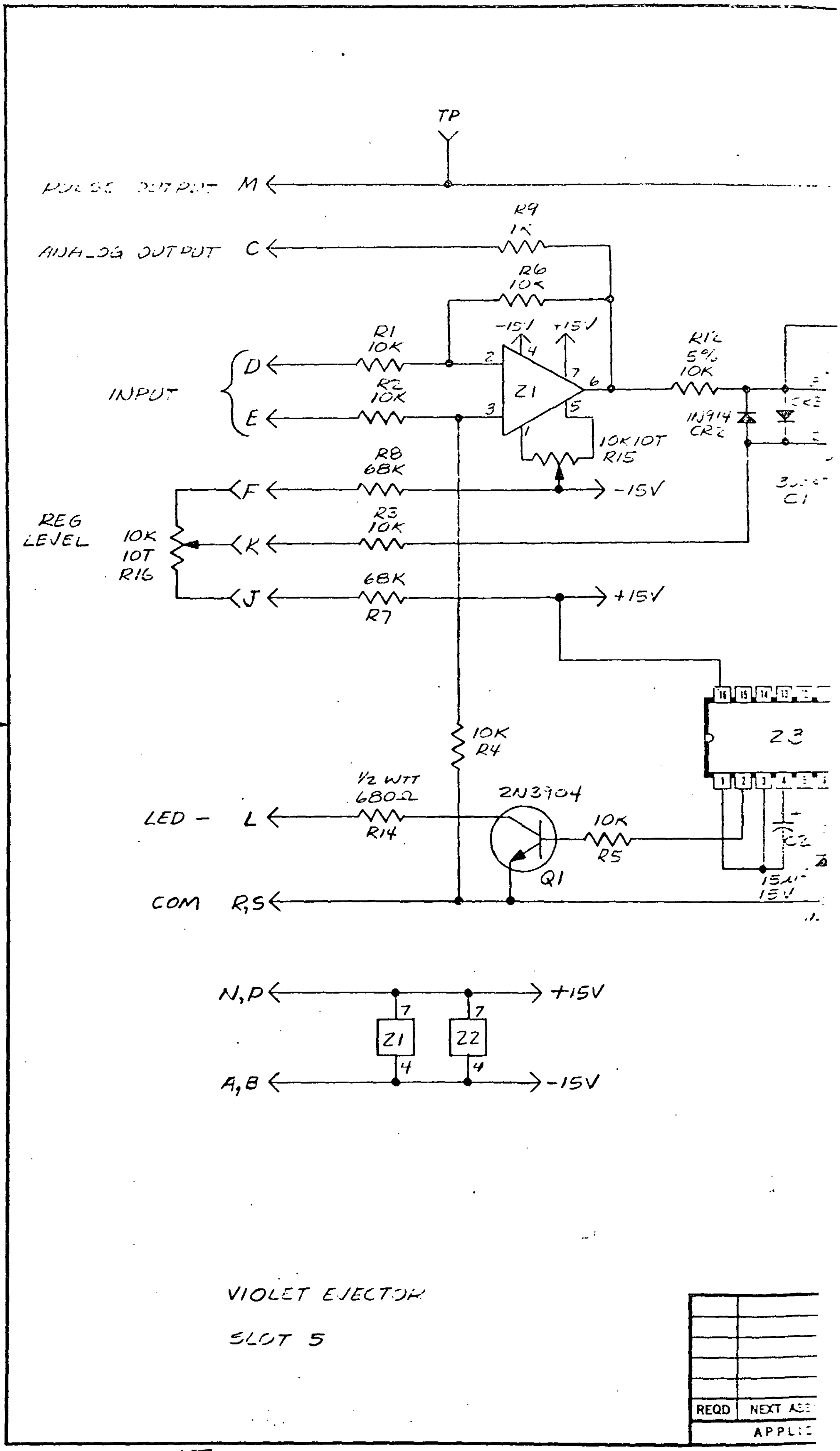
```
05C0 1044B456          CM    DUM,WRKST+11
05C2 708205C8          B     $+6
05C4 708205E2          B     $+30
05C6 708205E2          B     $+28
05C8 461006AE          L     0,RESPT,1
05CA 5000002E          S     0,CMULT+3
05CC 448106D6          LA    1,BUF
05CE 48820045          ST    2,DUM+1
05D0 74830634          BL    3,BINAS
05D2 44020045          L     2,DUM+1
05D4 448306D6          LA    3,BUF
05D6 14026800          MOV   (2,3),(0,2)
05D8 14036801          MOV   (3,3),(1,2)
05DA 14046802          MOV   (4,3),(2,2)
05DC 4C820004          AA    2,4
05DE 2044A001          AMI   DUM,1
05E0 708205BE          B     $-34
05E2 508200CD          SA    2,MESG1
05E4 4C020021          A     2,C2
05E6 48820081          ST    2,X'81'
05E8 448000CB          LA    0,MESG1-2
05EA 44020020          L     2,C1
05EC 4407001A          L     7,CRU
05EE 7483021A          BL    3,EAIIO
05F0 748305F8          BL    3,SCRMB
05F2 44000054          L     0,WRKST+9
05F4 E08A03A8          BC    10,XCUTE
05F6 708202C8          B     NEXTI
                 *
                 *           SCRAMBLE MATRIX
05F8             SCRMB EQU   $
05F8 48830045          ST    3,DUM+1
05FA 44000702          L     0,MATRX
05FC 58000010          N     0,MSK1
05FE 44010703          L     1,MATRX+1
0600 58010010          N     1,MSK1
0602 46020702          L     2,MATRX,0
0604 46130702          L     3,MATRX,1
0606 4A920702          ST    2,MATRX,1
0608 4A830702          ST    3,MATRX,0
060A 142AB444          MOV   C800,DUM
060C 4480070C          LA    0,MATRX+10
060E 44810731          LA    1,MATRX+47
0610             SCRM1 EQU   $
0610 46020000          L     2,0,0
0612 46130000          L     3,0,1
0614 4A920000          ST    2,0,1
0616 4A830000          ST    3,0,0
0618 4C800011          AA    0,17
061A 4C81000B          AA    1,11
061C C4800A21          CRLA  0,MATRX+799
```

```
061E E08B0624            BC     11,$+6
0620 E08C0624            BC     12,$+4
0622 5000002A            S      0,C800
0624 C4810A21            CRLA   1,MATRX+799
0626 E08B062C            BC     11,$+6
0628 E08C062C            BC     12,$+4
062A 5001002A            S      1,C800
062C 2044BFFF            AMI    DUM,-1
062E E08A0610            BC     10,SCRM1
0630 44030045            L      3,DUM+1
0632 72B20002            B      2,3
                   *
                   *            BINARY TO ASCII
0634               BINAS EQU    $
0634 44820030            LA     2,X'30'
0636 4A920001            ST     2,1,1
0638 4A920002            ST     2,2,1
063A 4A920003            ST     2,3,1
063C 4A920004            ST     2,4,1
063E 4A920005            ST     2,5,1
0640 4482002B            LA     2,X'2B'
0642 4A900000            ST     0,0,1
0644 E08A064E            BC     10,$+10
0646 E08B064E            BC     11,$+8
0648 50000020            S      0,C1
064A 4080FFFF            XORA   0,X'FFFF'
064C 4C020021            A      2,C2
064E 4A920000            ST     2,0,1
0650 4C010020            A      1,C1
0652 4482002F            LA     2,CMULT+4
0654 C6200000            CRL    0,0,2
0656 E08C065E            BC     12,$+8
0658 20002001            AMI    (0,1),1
065A 52200000            S      0,0,2
065C 70820654            B      $-8
065E 50020020            S      2,C1
0660 4C010020            A      1,C1
0662 C482002B            CRLA   2,CMULT
0664 E08C0668            BC     12,$+4
0666 70820654            B      $-18
0668 72B20002            B      2,3
                   *
                   *
066A               REDNO EQU    $               READ NUMBER IN
066A 48830045            ST     3,DUM+1
066C 448006D6            LA     0,BUF
066E 488106DF            ST     1,BUF+9
0670 4402001F            L      2,C0
0672 7483021A            BL     3,EAIIO         READ NO IN
0674 48810044            ST     1,DUM
0676 440306DF            L      3,BUF+9
```

```
0678 50030044           S     3,DUM
067A 50030021           S     3,C2      CHAR COUNT-1
067C 463106D6           L     1,BUF,3
067E 50810030           SA    1,X'30'
0680 0C3F0684           ARB   -1,$+4,3
0682 70820696           B     REDRT
0684 4480002C           LA    0,CMULT+1
0686 463206D6           L     2,BUF,3
0688 50820030           SA    2,X'30'
068A 0C2F068E           ARB   -1,$+4,2
068C 70820692           B     $+6
068E 4E010000           A     1,0,0
0690 0C2F068E           ARB   -1,$-2,2
0692 4C000020           A     0,C1
0694 0C3F0686           ARB   -1,$-14,3
0696             REDRT  EQU   $
0696 44030045           L     3,DUM+1
0698 72B20002           B     2,3
069A             GAMES  RES   20
06AE             RESPT  RES   40
06D6             BUF    RES   44
0702             MATRX  RES   800
0A22 007D        ENDLB  DATA  X'7D',0
0A23 0000
0A24                    END   ENDLB
```

APPENDIX C

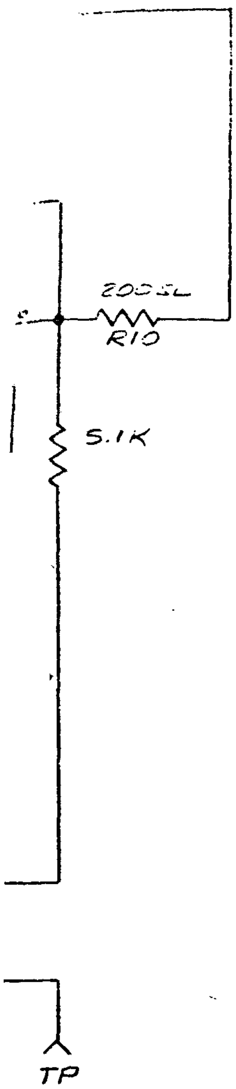
SYSTEM SCHEMATICS



FOLDOUT FRAME 1

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			Z3	LOGIC TELEDYNE DUAL O/S - 342AN	
			Z2	IC OP AMP FAIRCHILD 709	
			Z1	IC OP AMP FAIRCHILD 741	
			CR1-CR3	DIODE 1N914	
			C2	CAPACITOR 15 μf 15V	
			C1	CAPACITOR 300 pf	
			Q1	TRANSISTOR 2N3904	
			R15-R16	POT BOURNS 10K 10T	
			R14	RESISTOR 680Ω 1/2 WATT 2%	
			R13	22M 1/4 WATT 5%	
			R12	10K 5%	
			R11	1.5K 2%	
			R10	200Ω	
			R9	1K	
			R7-R8	68K	
			R1-R6	RESISTOR 10K 1/4 WATT 2%	

← ASSY — PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
MACHINE FILLET RADII .015 — .030
SURFACE ROUGHNESS PER MIL-STD-10
BURR CONTROL PER SC653
DIMENSION LIMITS HELD AFTER PLATING
IDENT MARKING PER MC16
DIMENSIONING AND TOL PER MIL-STD-8

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC

CONTRACT NO.

DFT	[illegible]	10-25-72
CHK		
VALUE ENGR		
MATL		
STRESS		
APPD	[illegible]	[illegible]
APPD		
AIRESEARCH APPD		
OTHER ACTIVITY APPD		

GARRETT — AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

REG. PREAMPLIFIER, PSYCHOLOGICAL ASSESSMENT

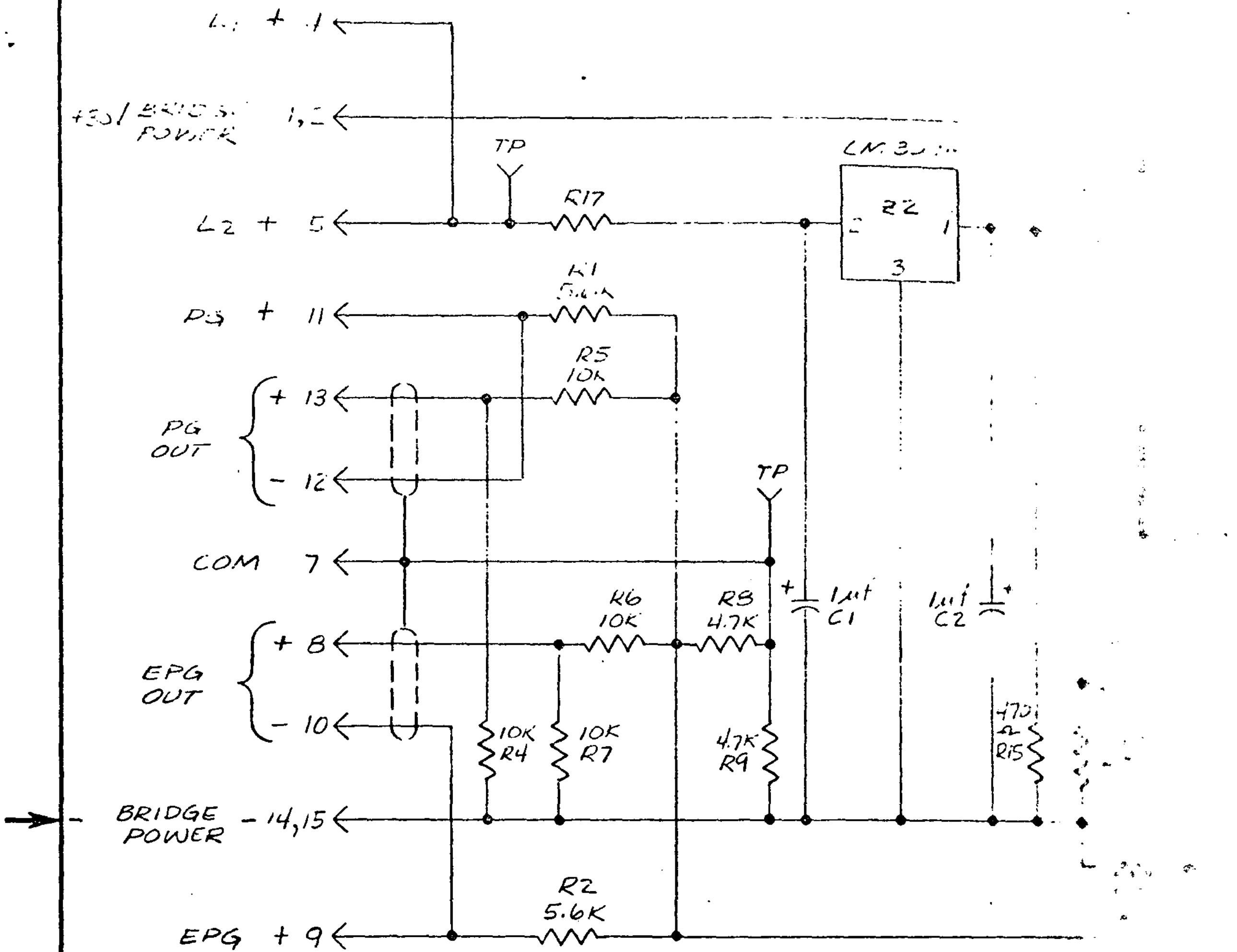
SIZE	CODE IDENT NO.	DWG NO.
C	70210	LSK 36175

SCALE ~ | SHEET 1 OF 1

REV LETTER — DWG NO. LSK 36175

C-1

FOLDOUT FRAME 2

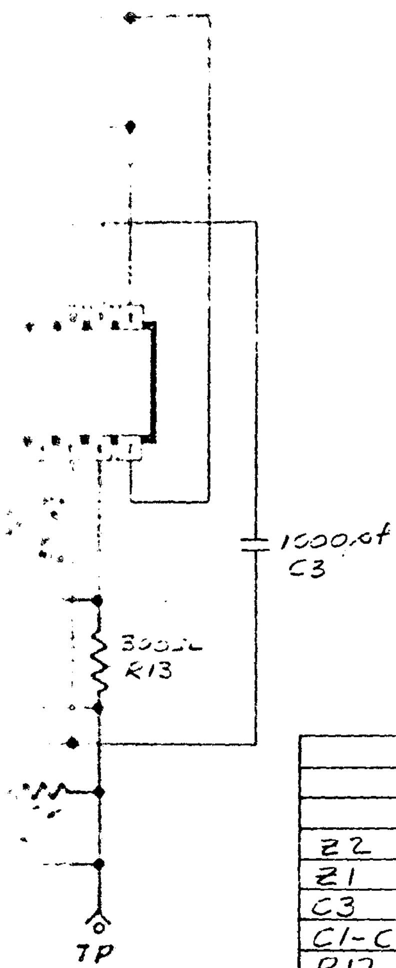


YELLOW EJECTOR
SLOT 4

REQD	NEXT A
	APP

C2 FOLDOUT FRAME 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			Z2	REGULATOR NATIONAL LM309H	
			Z1	REGULATOR FAIRCHILD μA723	
			C3	CAPACITOR 1000pf	
			C1-C2	CAPACITOR 1μf 35VDC	
			R17	RESISTOR SELECTED 3 WATT	
			R16	400Ω 3 WATT 2%	
			R15	470Ω 3 WATT 2%	
			R14	6.2K 1/4 WATT	
			R13	300Ω	
			R12	2.7K	
			R11	15K	
			R10	8.2K	
			R8-R9	4.7K	
			R4-R7	10K	
			R1-R3	RESISTOR 5.6KΩ 1/4 WATT 2%	

← ASSY

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
MACHINE FILLET RADII .015 — .030
SURFACE ROUGHNESS PER MIL-STD-10
... CONTROL PER SC653
... LIMITS HELD AFTER PLATING
... MARKING PER MC16
... DIMENSIONING AND TOL PER MIL-STD-8

HEAT TREATMENT — HARDNESS AND SPEC

PROCESS — NAME AND SPEC

CONTRACT NO.

DFT [signature] 20-29-72
CHK
VALUE ENGR
MATL
STRESS
APPD [signature]
APPD
AIRESEARCH APPD
OTHER ACTIVITY APPD

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A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

PG POWER SUPPLY & BRIDGE, PSYCHOLOGICAL ASSESSMENT

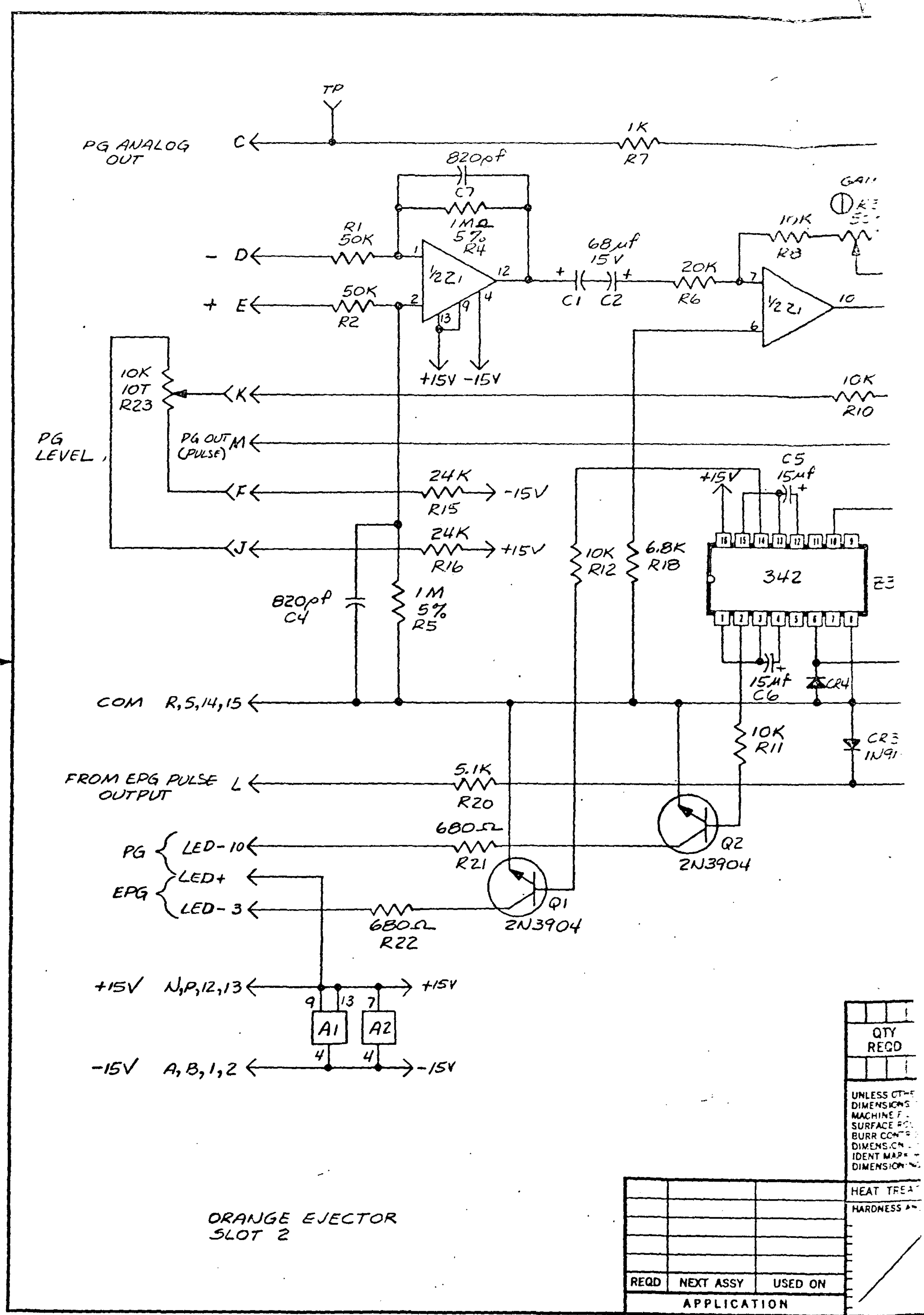
SIZE C | CODE IDENT NO. 70210 | DWG NO. LSK 36174

SCALE ~ | SHEET 1 OF 1

REV LETTER — DWG NO. LSK 36174

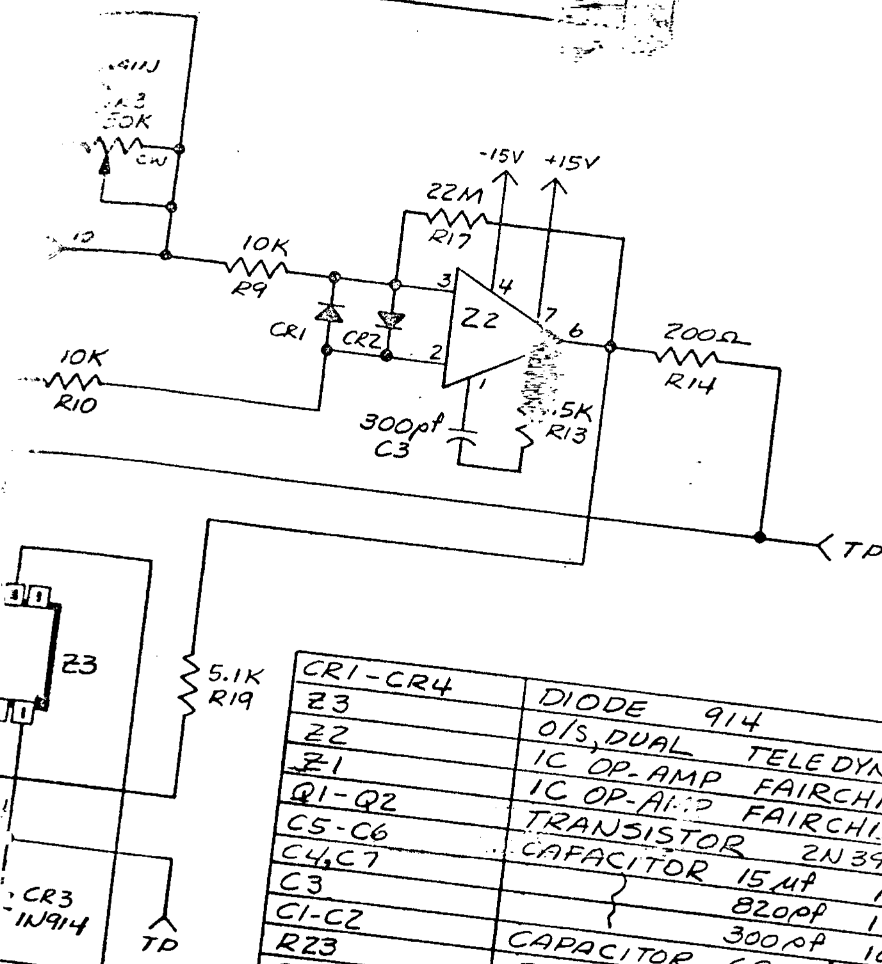
C-2

2



FOLDOUT FRAME 1

LTR	REVISIONS DESCRIPTION	DATE	APPROVED



ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
		CR1-CR4	DIODE 914
		Z3	O/S, DUAL TELEDYNE 342CJ
		Z2	IC OP-AMP FAIRCHILD UA7709312
		Z1	IC OP-AMP FAIRCHILD U7A7747312
		Q1-Q2	TRANSISTOR 2N3904
		C5-C6	CAPACITOR 15 µf 100V
		C4,C7	820pf 100V
		C3	300pf 100V
		C1-C2	CAPACITOR 68 µf 15V
		R23	POT BOURNS 10T-10K 35005-2-103
		R21-R22	RESISTOR 680Ω 1/2W 5%
		R19-R20	5.1K 1/4W 2%
		R18	6.8K
		R17	22M
		R15-R16	24K
		R14	200Ω
		R13	1.5K
		R8-R12	10K
		R7	1K
		R6	20K 2%
		R4-R5	RESISTOR 1M 1/4W 5%
		R3	TRIM POT BOURNS 50K
		R1-R2	RESISTOR 50K 1/4W 2%

← ASSY

PARTS LIST — SYM

[...] OTHERWISE SPECIFIED:
[...]NS ARE IN INCHES.
[...] ILLET RADII .015 — .030
[...]ROUGHNESS PER MIL-STD-10
[...]TROL PER SC653
[...] LIMITS HELD AFTER PLATING
[...]KING PER MC16
[...]ING AND TOL PER MIL-STD-8

[...]ATMENT [...]ND SPEC	PROCESS NAME AND SPEC
/	/

CONTRACT NO.

DFT Dan Lee 19 SEPT 72
CHK
VALUE ENGR
MATL
STRESS
APPD
APPD [signature] 9/20/72
AIRESEARCH APPD
OTHER ACTIVITY APPD

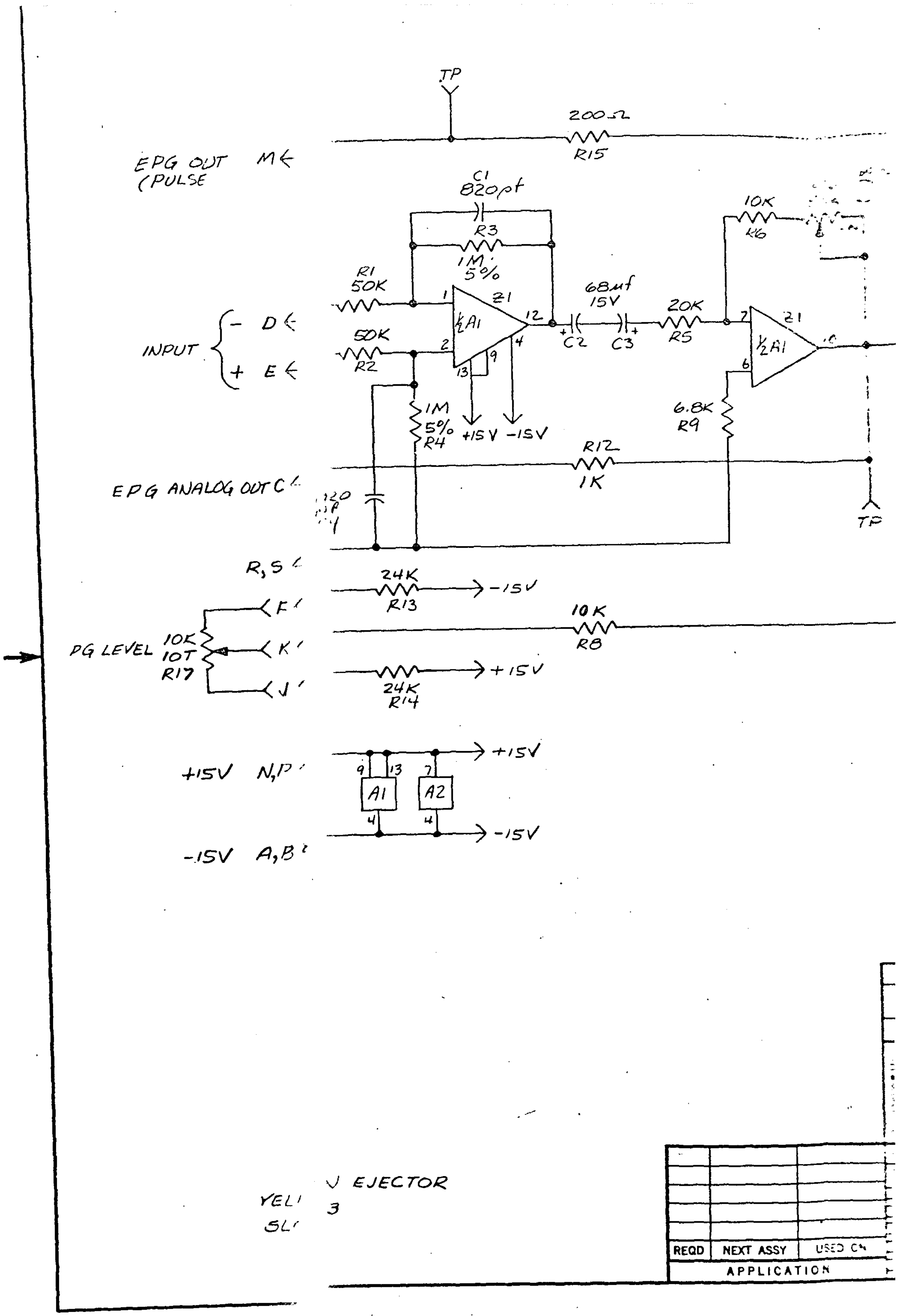
GARRETT AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

PLETHYSMOGRAPH AMPLIFIER, PSYCHOLOGICAL ASSESSMENT

SIZE	CODE IDENT NO.	DWG NO.
C	70210	LSK 36172

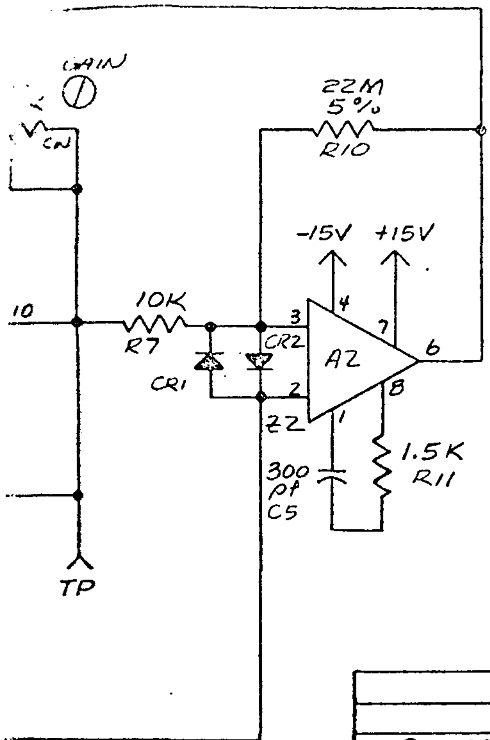
SCALE ~ — SHEET 1 OF 1

REV LETTER — DWG NO. LSK36172



FOLDOUT FRAME

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			CR1-CR2	DIODE 1N914	
			C5	CAPACITOR 300pf	
			C2-C3	} 68 uf - 15V	
			C1, C4	CAPACITOR 820pf	
			Z2	IC OP AMP FAIRCHILD UA709	
			Z1	IC OP AMP FAIRCHILD U7A7747312	
			R17	POT BOURNS 10K 10T 3500S-2-103	
			R16	TRIM POT BOURNS 50K	
			R15	RESISTOR 200Ω 1/4 WATT 5%	
			R13-R14	24K 2%	
			R12	1K 2%	
			R11	1.5K 2%	
			R10	22M 5%	
			R9	6.8K 2%	
			R6-R8	10K }	
			R5	20K 2%	
			R3-R4	1M 5%	
			R1-R2	RESISTOR 50K 1/4 WATT 2%	

← ASSY

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
MACHINE FILLET RADII .015 — .030
SURFACE ROUGHNESS PER MIL-STD-10
BURR CONTROL PER SC653
DIMENSION LIMITS HELD AFTER PLATING
IDENT MARKING PER MC16
DIMENSIONING AND TOL PER MIL-STD-8

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC

CONTRACT NO.

DFT Dan Lee 20 Sep 72
CHK
VALUE ENGR
MATL
STRESS
APPD [signature] 9/24/72
APPD
AIRESEARCH APPD
OTHER ACTIVITY APPD

GARRETT AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

PLETHYSMOGRAPH AMPLIFIER, PSYCHOLOGICAL ASSESSMENT

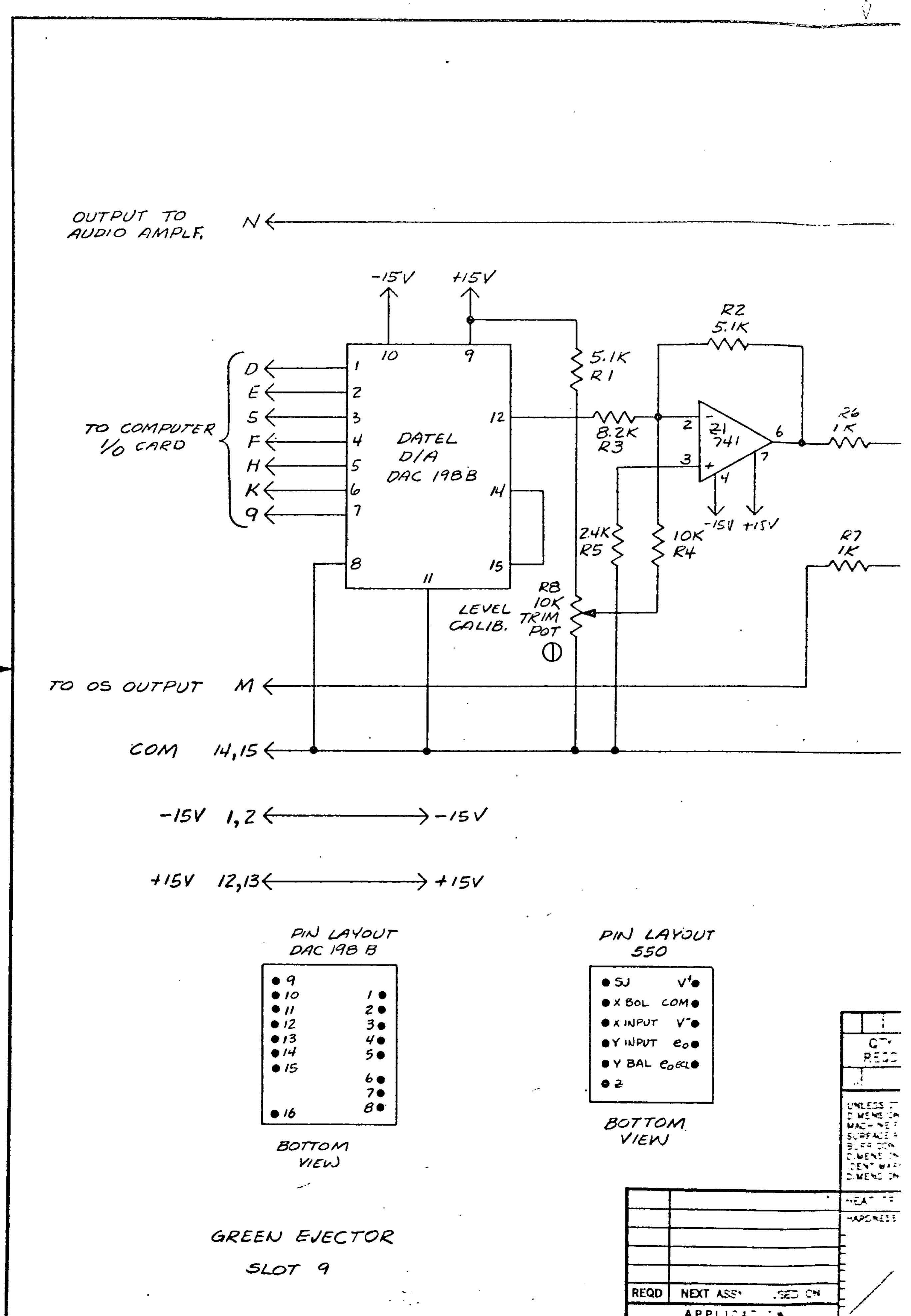
SIZE	CODE IDENT NO.	DWG NO.
C	70210	LSK 36173

SCALE ~ SHEET 1 OF 1

REV LETTER
DWG NO. LSK 36173

C-4

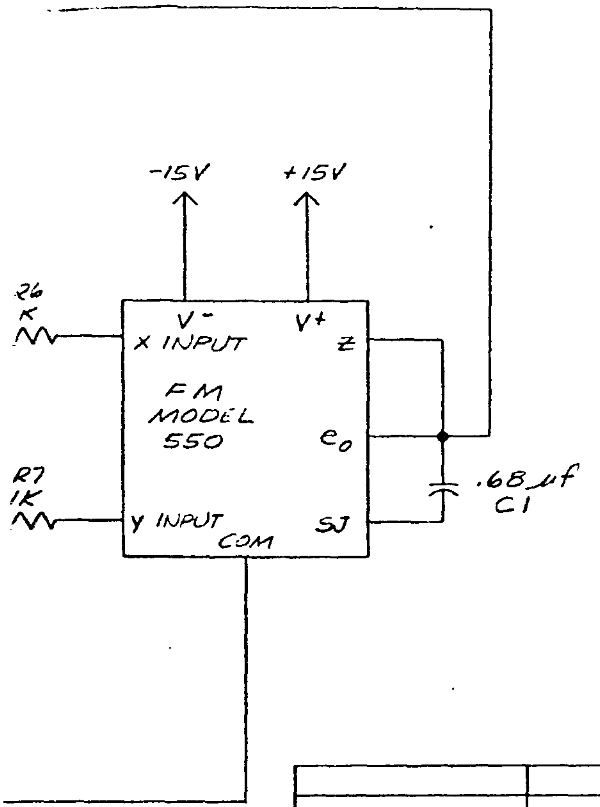
FOLDOUT FRAME 2



FOLDOUT FRAME 1

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



REV LETTER

DWG NO. LSK 36179

QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			Z1	OP-AMP µA741	
			C1	CAPACITOR .68µf	
			R8	TRIM POT BOURNS 10K	
			R6-R7	RESISTOR 1K 1/4 WATT 2%	
			R5	〃 2.4K 〃 〃	
			R4	〃 10K 〃 〃	
			R3	〃 8.2K 〃 〃	
			R1-R2	RESISTOR 5.1K 1/4 WATT 2%	

← ASSY

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
MACHINE FILLET RADII .015 — .030
SURFACE ROUGHNESS PER MIL-STD-10
BURR CONTROL PER SC653
DIMENSION LIMITS HELD AFTER PLATING
IDENT MARKING PER MC16
DIMENSIONING AND TOL PER MIL-STD-8

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC

CONTRACT NO.

DFT	Dian Li	22 SEPT 72
CHK		
VALUE ENGR		
MATL		
STRESS		
APPD	[signature]	9/26/72
APPD		
AIRESEARCH APPD		
OTHER ACTIVITY APPD		

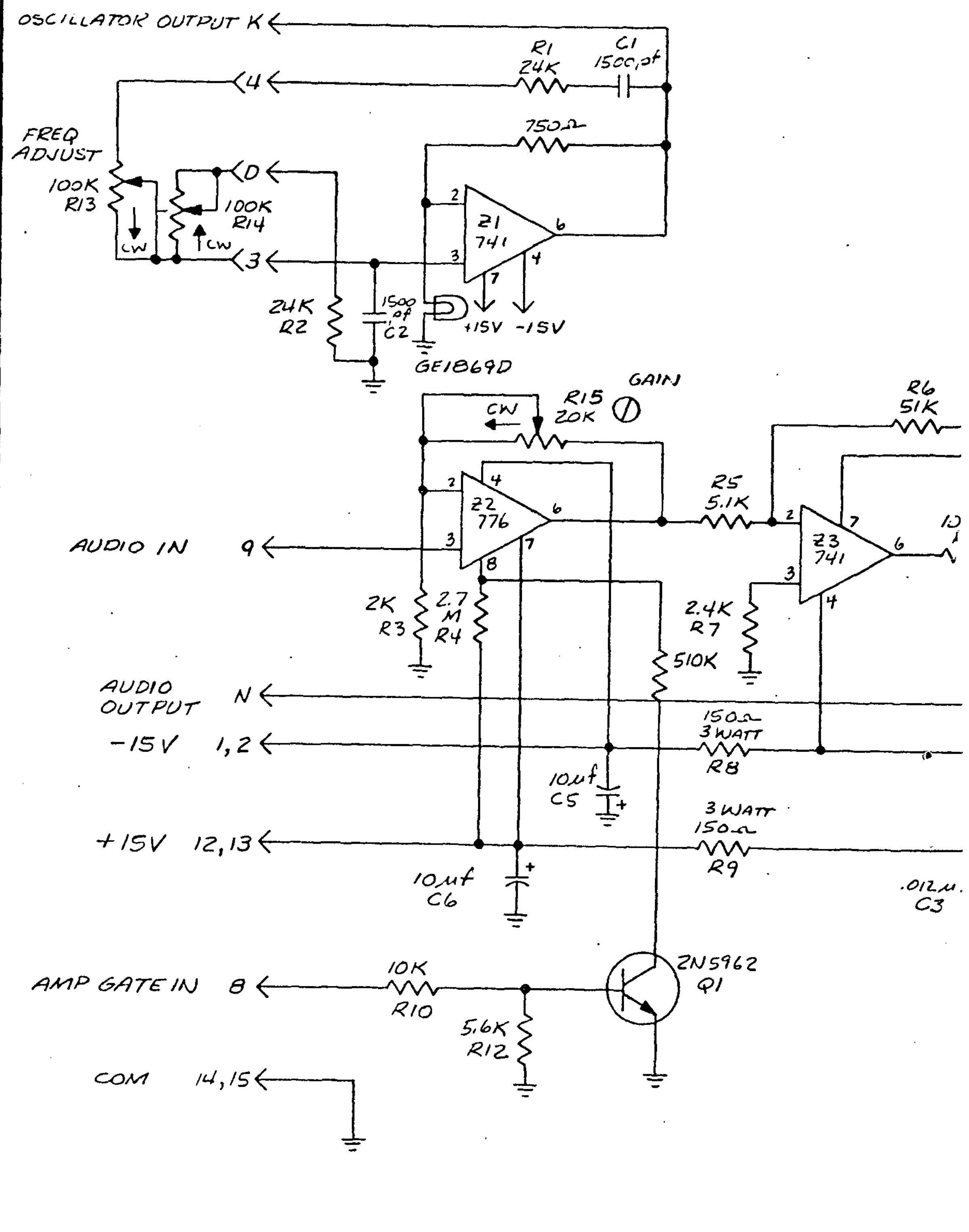
GARRETT AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

AUDIO RESPONSE SIMULATOR PSYCHOLOGICAL ASSESSMENT

SIZE	CODE IDENT NO.	DWG NO.
C	70210	LSK 36179

SCALE ~ | SHEET 1 OF 1

FOLDOUT FRAME 2



GREEN EJECTOR

SLOT 10

REQD	NEXT ASSY	
	APPLICATION	

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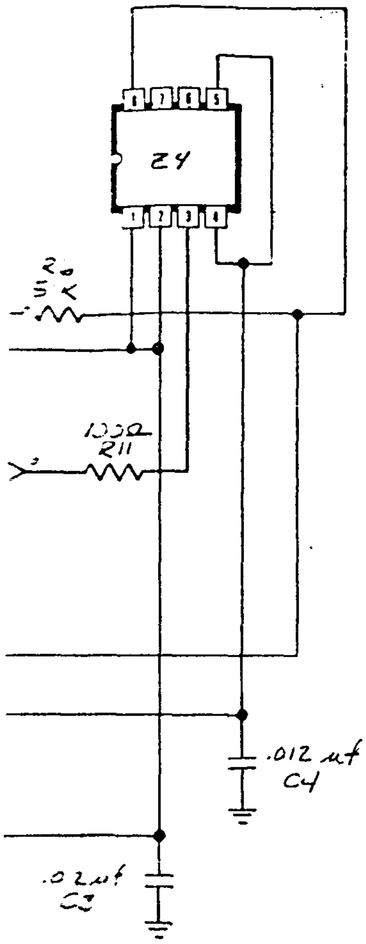
REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			Z4	NATIONAL BOOSTER N.4000ZC	
			Z3	OP-AMP FAIRCHILD 741	
			Z2	OP-AMP FAIRCHILD 776	
			Z1	OP-AMP FAIRCHILD 741	
			Q1	TRANSISTOR 2N5962	
			C5-C6	CAPACITOR 10uf - 35V	
			C3-C4	CAPACITOR .012uf - 100V	
			C1-C2	CAPACITOR 1500pf - 100V	
			R15	TRIM POT BOURNS 20K	
			R13-R14	POT AB-DUAL 100K	
			R12	RESISTOR 5.6K 1/4 WATT	
			R11	100Ω 1/4 WATT	
			R10	10K 1/4 WATT	
			R8-R9	150Ω 3 WATT	
			R7	2.4K 1/4 WATT 2%	
			R6	51K	
			R5	5.1K	
			R4	2.7M	
			R3	2K	
			R1-R2	RESISTOR 24K 1/4 WATT 2%	

← ASSY

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
MACHINE FILLET RADII .015 — .030
SURFACE ROUGHNESS PER MIL-STD-10
BURR CONTROL PER SC653
DIMENSION LIMITS HELD AFTER PLATING
IDENT MARKING PER MC16
DIMENSIONING AND TOL PER MIL-STD-8

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC

CONTRACT NO.

DFT Dan Lee 22 SEPT 72
CHK
VALUE ENGR
MATL
STRESS
APPD [illegible] 9/25/72
APPD
AIRESEARCH APPD
OTHER ACTIVITY APPD

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

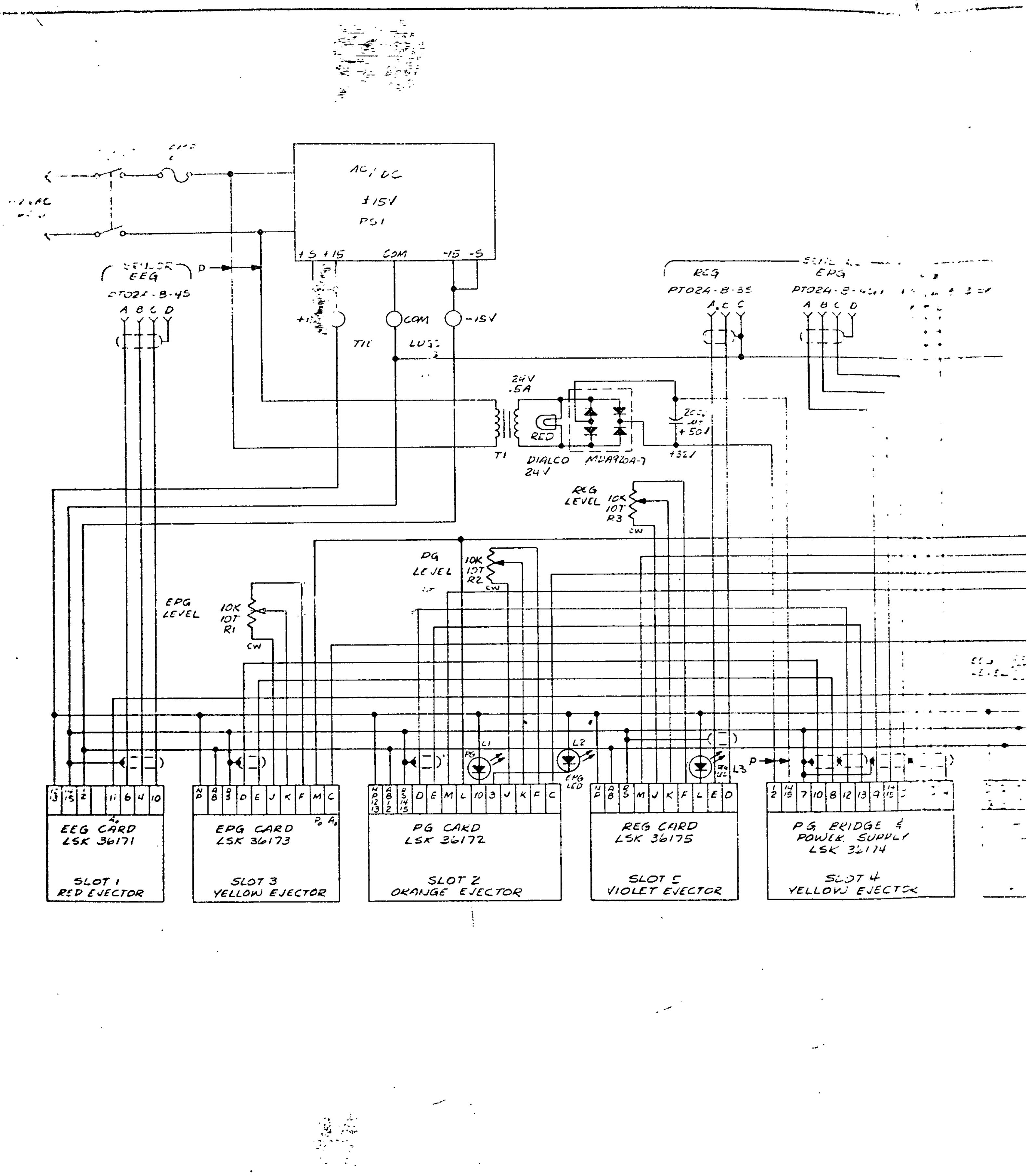
DRIVER AUDIO PSYCHOLOGICAL ASSESSMENT

SIZE C | CODE IDENT NO. 70210 | DWG NO. LSK 36180

SCALE ~ | SHEET 1 OF 1

REV LETTER

DWG NO. LSK 36180



FOLDOUT FRAME 1

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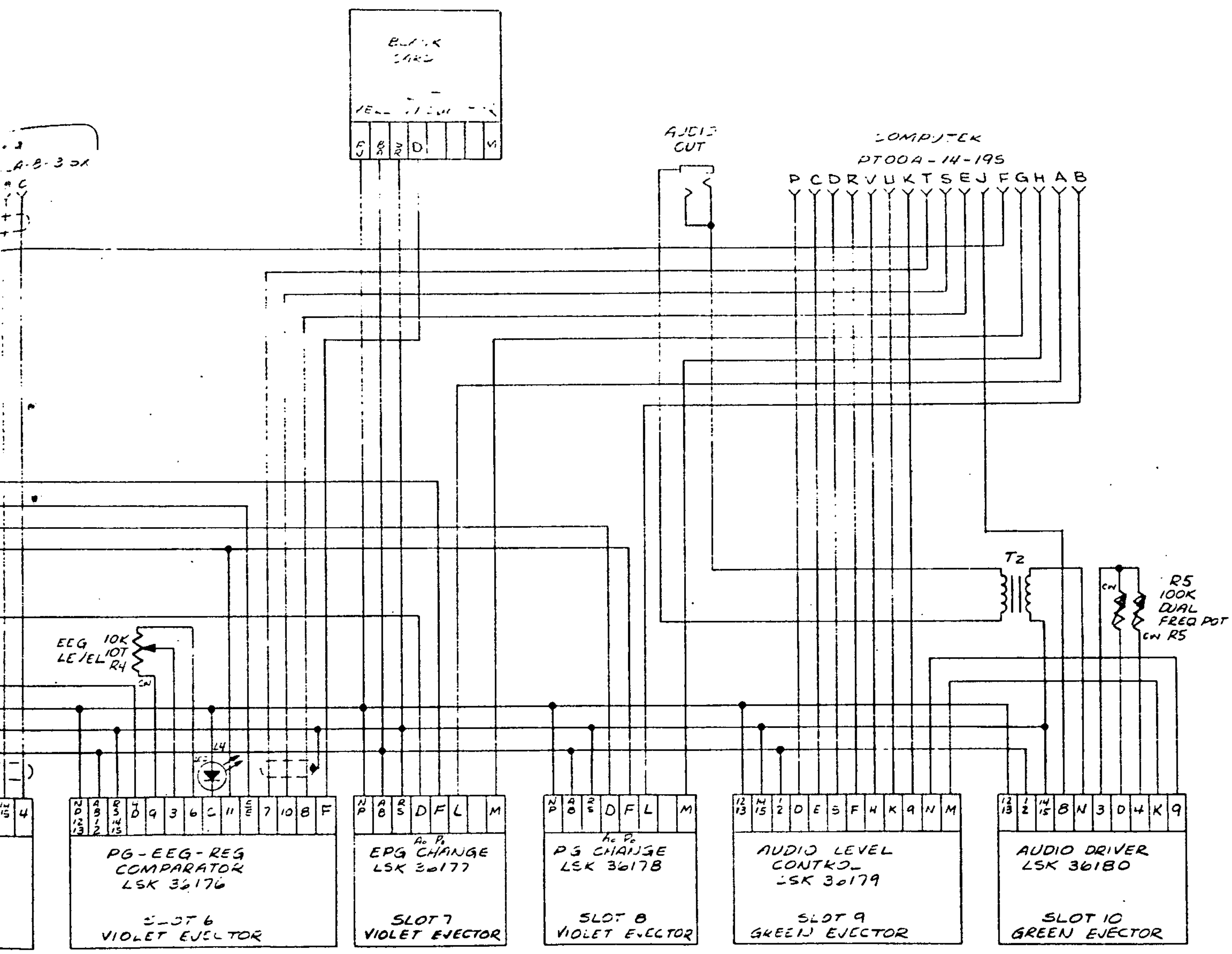
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			R5	POT DUAL AB TYPE CCU-104	
			R1-R4	LISTED ON LSK 36172, LSK 36173, LSK 36175, LSK 36176	
			L1-L4	LED DIALCO 521-9165	
			PS1	ACIDC MODEL GA15D1.1-1	
			T2	AUDIO TRANS - STANCOR TA-42	
			T1	24V @ 1.0A - TRORASON 21F101	
			← ASSY	PARTS LIST	

UNLESS OTHERWISE SPECIFIED:
BURR CONTROL PER SC653
IDENTIFICATION MARKING PER MC16
STD INTERPRETATIONS PER P1B5

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC

CONTRACT NO.
DFT · CHK · VALUE ENGR · MATL · STRESS · APPD · APPD · AIRESEARCH APPD · OTHER ACTIVITY APPD

REQD	NEXT ASSY	USED ON
APPLICATION		

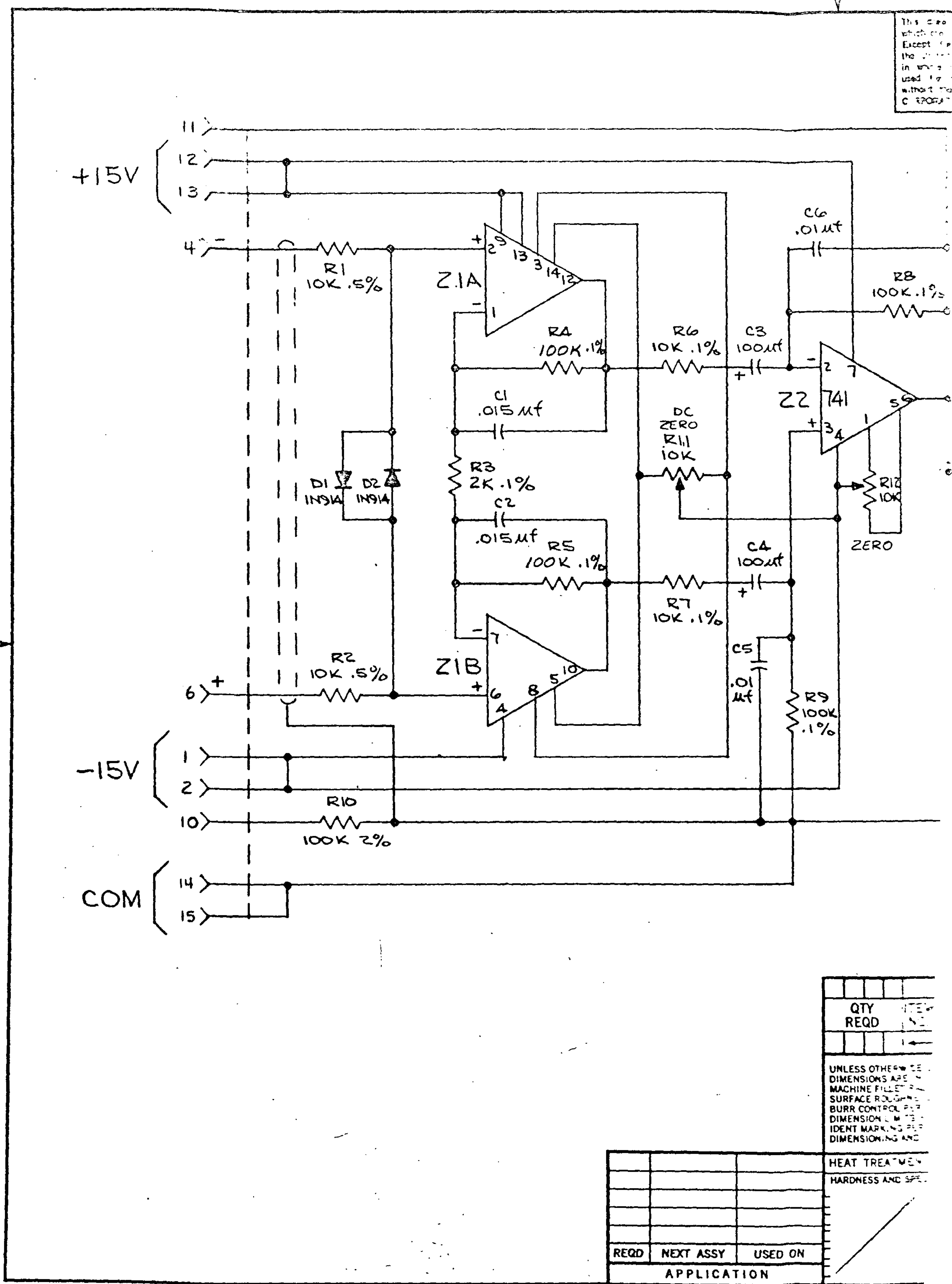
AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

S.C. SYSTEM WIRING, PSYCHOLOGICAL ASSESSMENT

SIZE D | CODE IDENT NO. 70210 | DWG NO. LSK 36170

SCALE ~ | SHEET 1 OF 1

FOLDOUT FRAME 7



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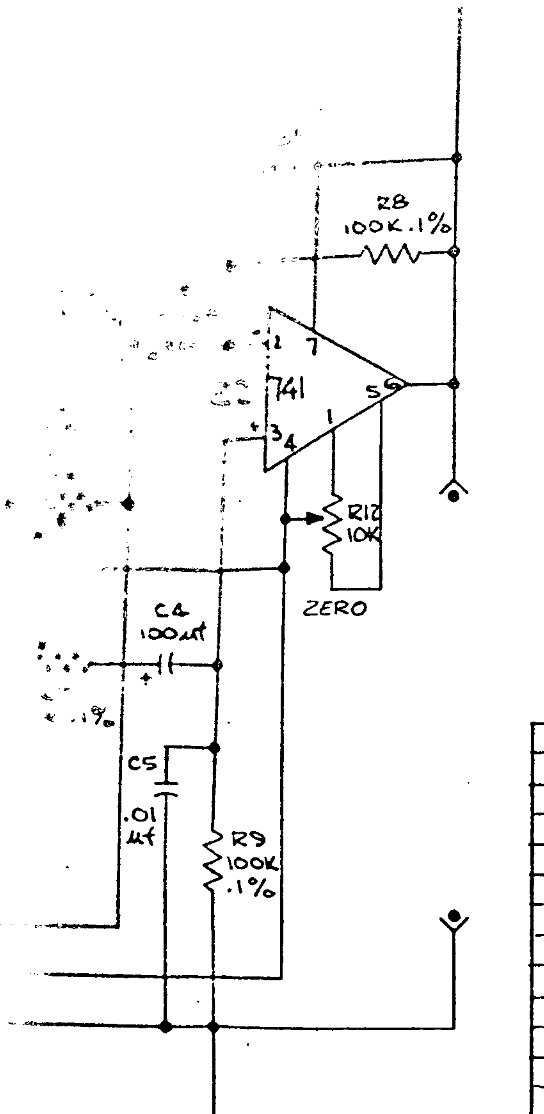


QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			Z2	OP. AMP. UA741	
			Z1	OP. AMP. U7A7747312	
			D1, D2	DIODE IN914	
			C5, C6	CAPACITOR .01 µf	
			C3, C4	CAPACITOR 100 µf - 6VDC	
			C1, C2	CAPACITOR .015 µf	
			R11, R12	POTENTIOMETER 10K	
			R10	RESISTOR 100K 2%	
			R8, R9	100K .1%	
			R6, R7	10K .1%	
			R4, R5	100K .1%	
			R3	2K .1%	
			R1, R2	RESISTOR 10K .5%	

← ASSY

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
MACHINE FILLET RADII .015 — .030
SURFACE ROUGHNESS PER MIL-STD-10
BURR CONTROL PER SC653
DIMENSION LIMITS HELD AFTER PLATING
IDENT MARKING PER MC16
DIMENSIONING AND TOL PER MIL-STD-8

HEAT TREATMENT — HARDNESS AND SPEC

PROCESS — NAME AND SPEC

CONTRACT NO.

DFT [signature] 19SEPT72
CHK
VALUE ENGR
MATL
STRESS
APPD [signature] 9/20/72
APPD
AIRESEARCH APPD
OTHER ACTIVITY APPD

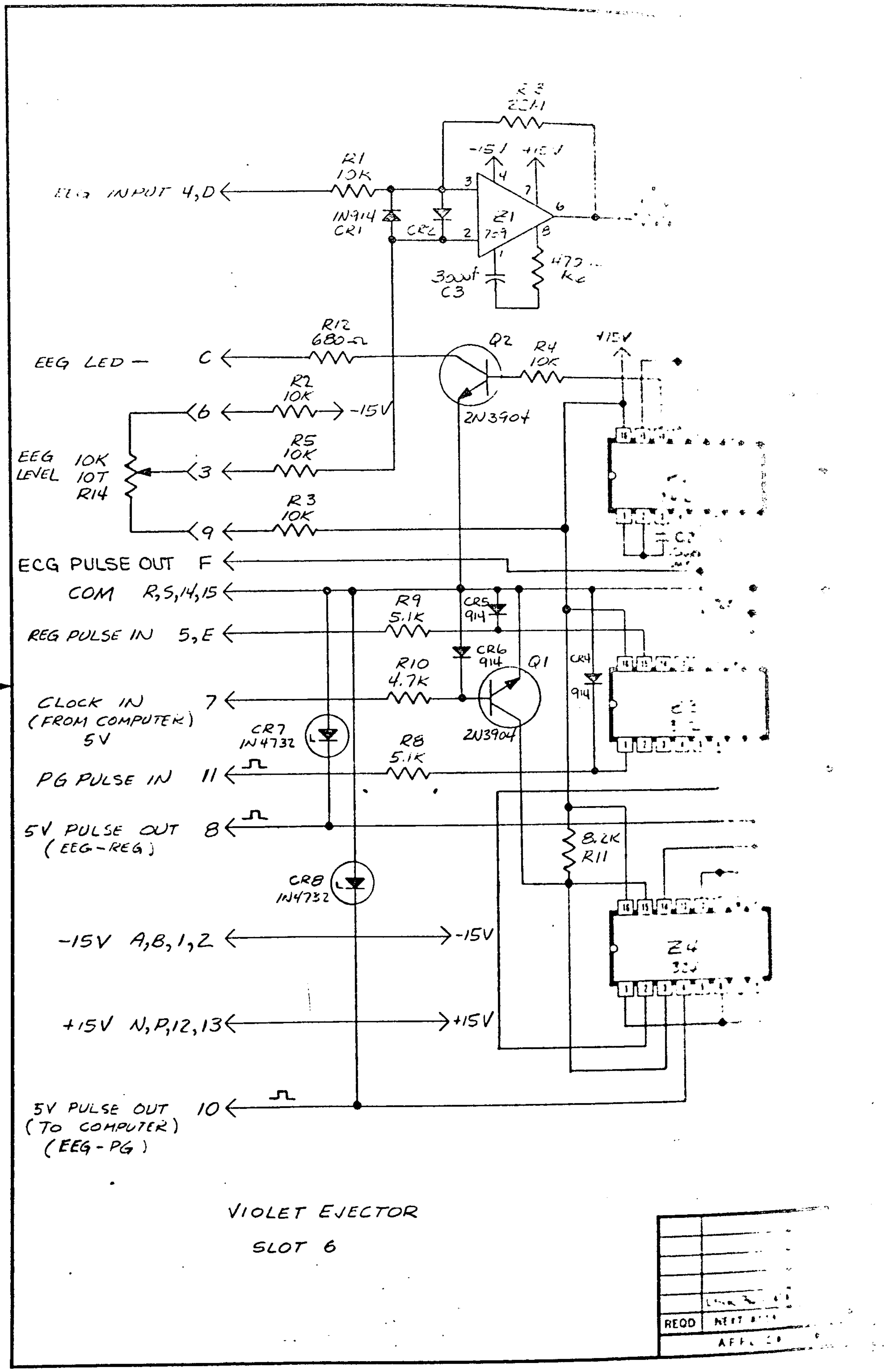
AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

SCHEMATIC, ECG AMPLIFIER - PSYCHOLOGICAL ASSESSMENT

SIZE C | CODE IDENT NO. 70210 | DWG NO. LSK36171

SCALE NONE | SHEET 1 OF 1

USED ON | APPLICATION



VIOLET EJECTOR

SLOT 6

FOLDOUT FRAME

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	ADDED ECG PULSE OUT F...	[illegible]	[illegible]

914
3

PARTS LIST

QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			Z4	QUAD 2 INPUT N AND GATE - TELEDYNE 324AJ	
			Z3	DUAL FLIP-FLOP TELEDYNE 312AJ	
			Z2	DUAL O/S - TELEDYNE 342AJ	
			Z1	I/C OP AMP FAIRCHILD 709	
			Q1-Q2	TRANSISTOR 2N3904	
			CR7-CR8	DIODE 1N4732	
			CR1-CR6	DIODE 1N914	
			C3	CAPACITOR 300pf	
			C2	.068µf	
			C1	CAPACITOR 15µf 15V	
			R14	POT BOURNS 10K 10T	
			R13	RESISTOR 22M 5%	
			R12	680Ω 1/2 WATT	
			R11	8.2K 1/4 WATT	
			R10	4.7K	
			R7-R9	5.1K	
			R6	470Ω	
			R1-R5	RESISTOR 10K 1/4 WATT 2%	

← ASSY

REV A LETTER

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
MACHINE FILLET RADII .015 — .030
SURFACE ROUGHNESS PER MIL-STD-10
BURR CONTROL PER SC653
DIMENSION LIMITS HELD AFTER PLATING
IDENT MARKING PER MC16
DIMENSIONING AND TOL PER MIL-STD-8

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC

CONTRACT NO.
DFT Dan Lee 20 SEP 72
CHK
VALUE ENGR
MATL
STRESS
APPD [illegible] 9/26/72
APPD
AIRESEARCH APPD
OTHER ACTIVITY APPD

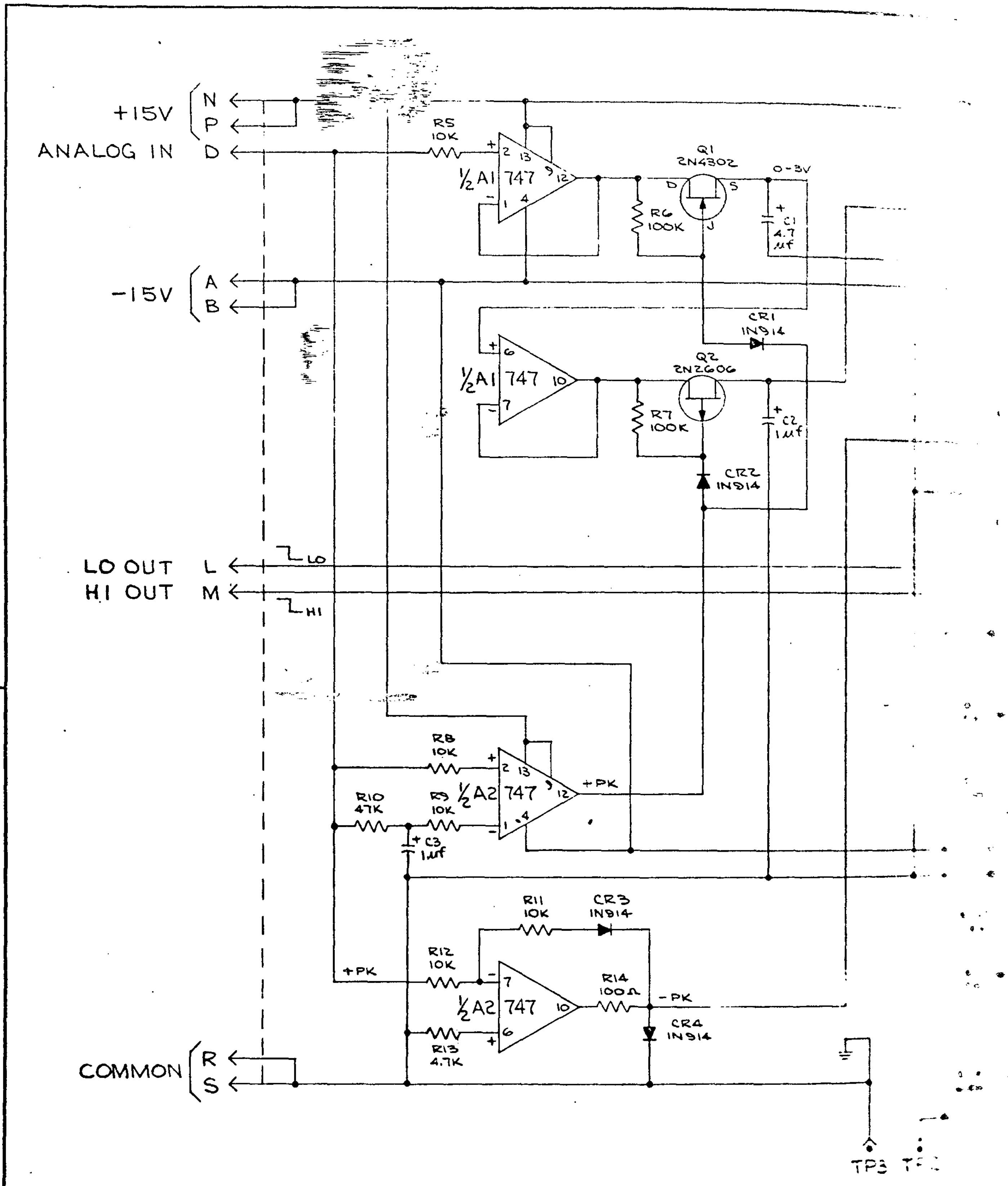
AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

PG-EEG-REG LEVEL COMPARATOR, PSYCHOLOGICAL ASSESSMENT

SIZE	CODE IDENT NO.	DWG NO.
C	70210	LSK 36176

SCALE ~ SHEET 1 OF 1

DWG NO. LSK 36176

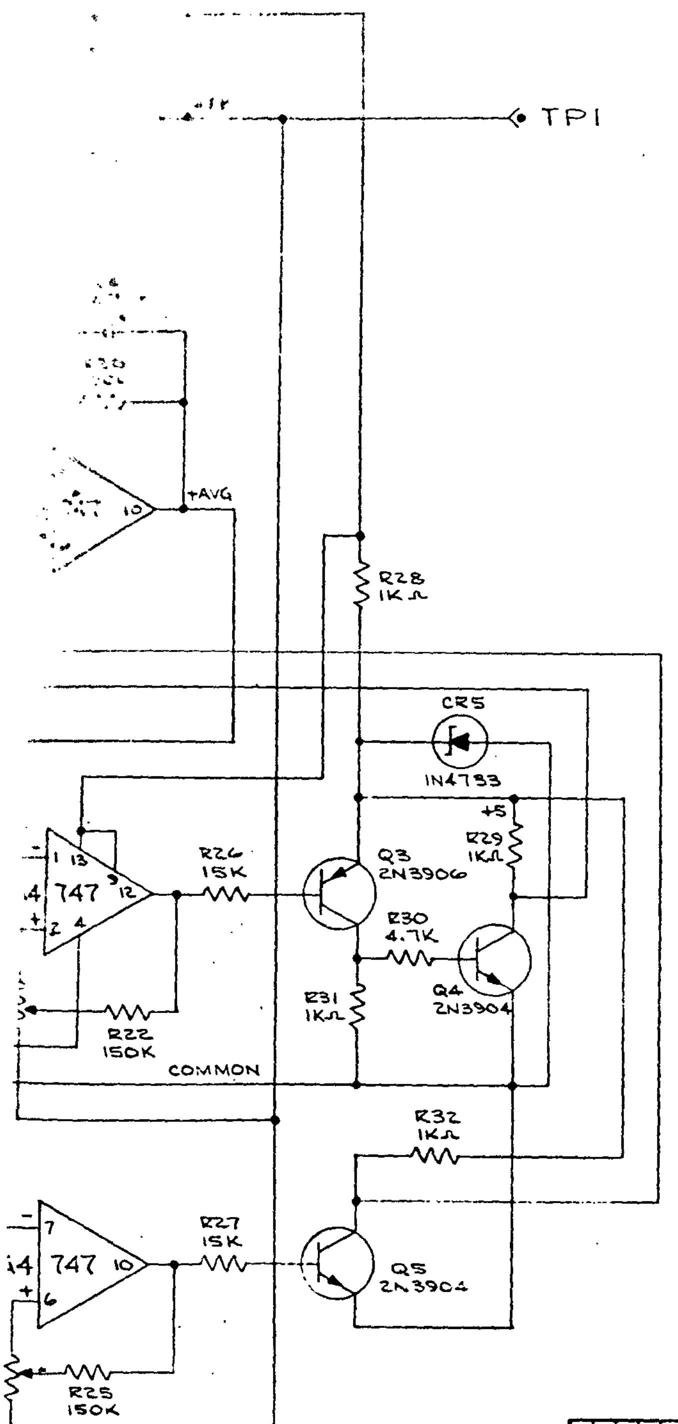


ONE OF TWO SHOWN

LOCATION: SLOT 7 & 8
VIOLET EJECTOR

FOLDOUT FRAME 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
			A1 - A4	INTEGRATED CIRCUIT µA747	
			Q4, Q5	TRANSISTOR 2N3904	
			Q3	↕ ↕ 2N3906	
			Q2	2N2606, P-FET	
			Q1	TRANSISTOR 2N4302, N-FET	
			CR5	DIODE, ZENER 1N4733	
			CR1 - CR4	DIODE 1N914	
			C2, C3	CAPACITOR 1.0µf	
			C1, C4	CAPACITOR 4.7µf	
			R28, R29, R31, R32	RESISTOR 1K 1/4 WATT METAL FILM	
			R26, R27	15K	
			R24	6.8K	
			R22, R25	150K	
			R21, R23	7.5K	
			R14	100Ω	
			R13, R30	4.7K	
			R10, R19	47K	
			R6, R7, R18, R20	100K	
			R5, R8, R9, R11, R12, R15,	RESISTOR 10K 1/4 WATT METAL FILM	
			R3, R4	POTENTIOMETER 4TURN BOURNS 3339P	
			R1, R2	POTENTIOMETER 20TURN BOURNS	

← ASSY

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
BURR CONTROL PER SC663
IDENTIFICATION MARKING PER MC16
STD INTERPRETATIONS PER PIB5

HEAT TREATMENT — HARDNESS AND SPEC
PROCESS — NAME AND SPEC

CONTRACT NO.
DFT / CHK / VALUE ENGR / MATL / STRESS / APPD / APPD / AIRESEARCH APPD / OTHER ACTIVITY APPD

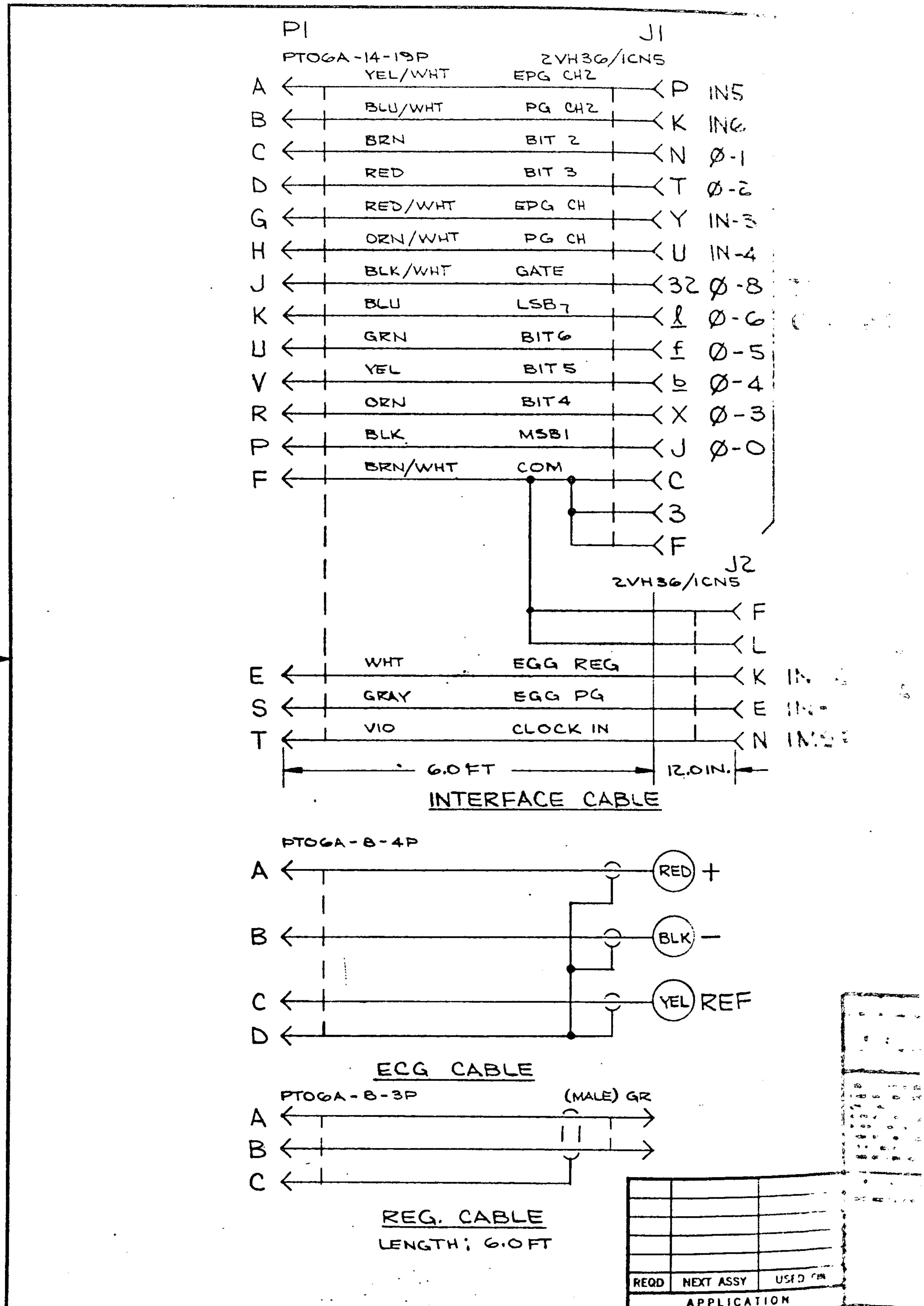
AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

SCHEMATIC, EPG/PG CHANGE CARD - PSYCHOLOGICAL ASSESSMENT

SIZE D | CODE IDENT NO. 70210 | DWG NO. LSK36168

SHEET 1 OF 1

LSK36168



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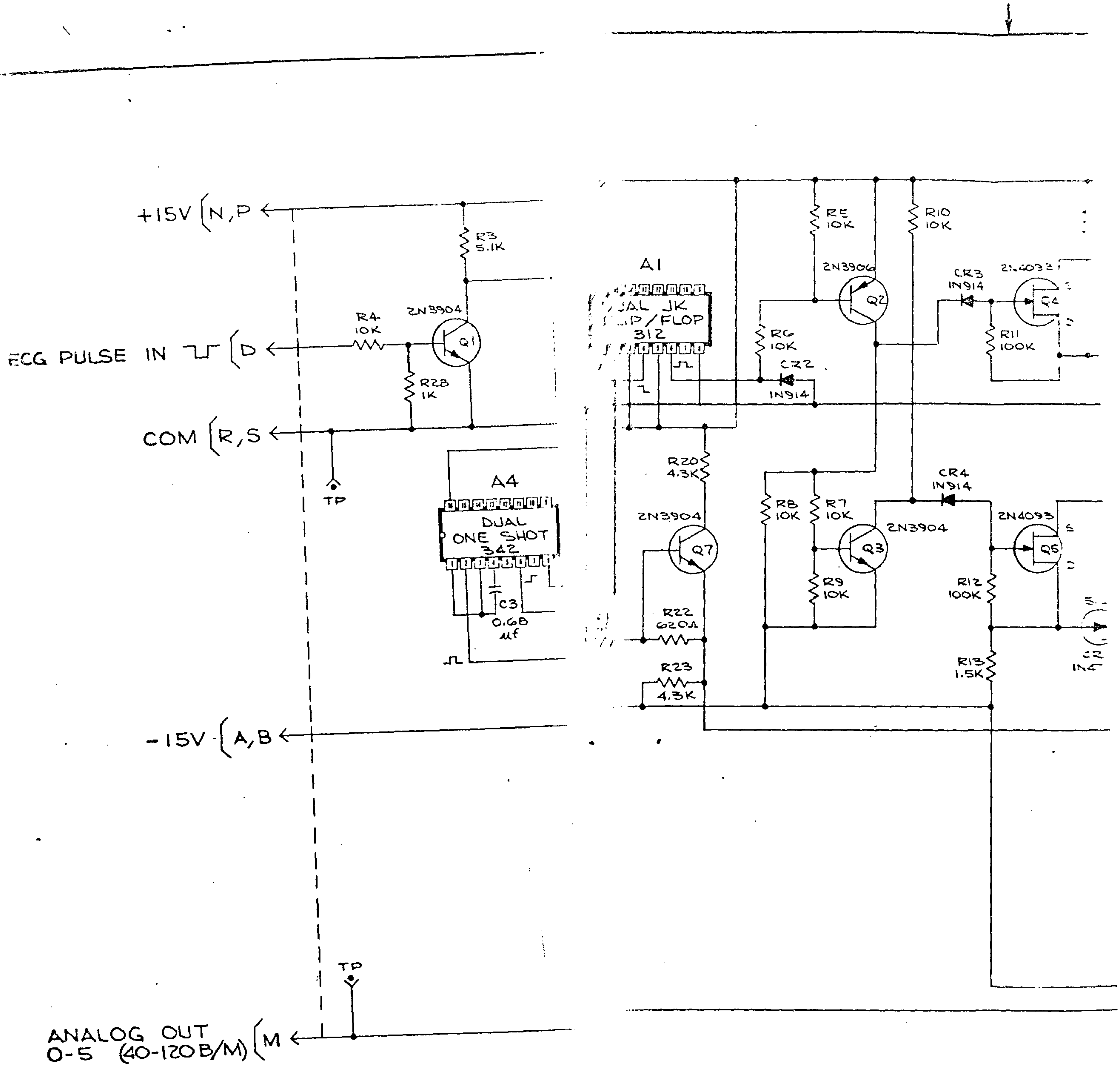
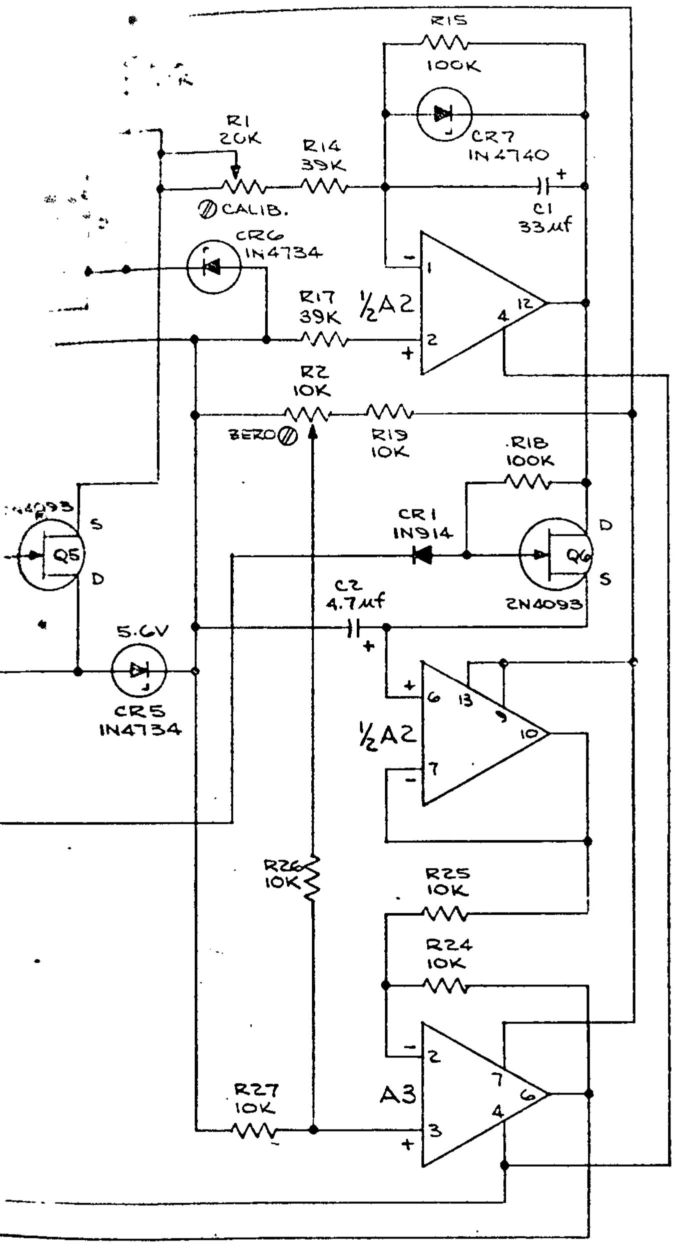


SLOT 11 - YELLOW EJECTOR

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
A4	DUAL ONE SHOT AJ342 TELEDYNE
A3	OP AMP FUSB7741393
A2	OP AMP U7A7747312
A1	DUAL JK FLIP/FLOP AJ312 TELEDYNE
CR7	DIODE, ZENER IN4740
CR5, CR6	DIODE, ZENER IN4734
CR1-CR4	DIODE IN914
C3	CAPACITOR 0.68 µf
C2	CAPACITOR 4.7 µf
C1	CAPACITOR 33 µf
Q4, Q5, Q6	TRANSISTOR 2N4093
Q2	TRANSISTOR 2N3906
Q1, Q3, Q7	TRANSISTOR 2N3904
R28	RESISTOR 1K ¼W 2% METAL FILM
R22	620Ω
R20, R23	4.3K
R14, R17	39K
R13, R16	1.5K
R11, R12, R15, R18	100K
R4-R10, R19, R21, R24-R27	10K
R3	RESISTOR 5.1K ¼W 2% METAL FILM
R2	POT. EDGE MOUNT 10K 3282H-1-103 BOURNS
R1	POT. EDGE MOUNT 20K 3282H-1-203 BOURNS

QTY REQD	ITEM NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	SYM
	← ASSY			PARTS LIST	

UNLESS OTHERWISE SPECIFIED:
BURR CONTROL PER SC653
IDENTIFICATION MARKING PER MC16
STD INTERPRETATIONS PER P185

HEAT TREATMENT	PROCESS
HARDNESS AND SPEC	NAME AND SPEC

CONTRACT NO.
DFT 12 JAN 73
CHK
VALUE ENGR
MATL
STRESS
APPD
APPD
AIRESEARCH APPD
OTHER ACTIVITY APPD

REQD	NEXT ASSY	USED ON
APPLICATION		

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
LOS ANGELES, CALIFORNIA

SCHEMATIC, CARDIOTACH - PSYCHOLOGICAL ASSESSMENT

SIZE	CODE IDENT NO.	DWG NO.
D	70210	LSK36211

SCALE NONE SHEET 1 OF 1

LSK36211

APPENDIX D

REFERENCES AND BIBLIOGRAPHY

APPENDIX D

REFERENCES AND BIBLIOGRAPHY

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