A STUDY OF FACTORS IN MARKSMANSHIP

by

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Abstract

This study is an attempt to describe as accurately as possible what occurs in terms of patterns of respiration, stock pressure, and aiming time when a group of poor marksmen and a group of good marksmen fire a Service rifle with a No. 1 tube from a prone position on an indoor miniature range. In addition, some data on the possible influence of the firer's position, vision and shooting experience are also discussed.

The basic argument of the research runs as follows. If the principal factors under consideration here are important in marksmanship, then it should be possible to demonstrate their importance by one or all of the following procedures:

(a) By comparing good marksmen with poor marksmen in terms of the factors studied.

(b) By comparing the patterns of breathing, stock pressure and aiming time which obtain for the dead-on-the-bull and in-the-bullseye shots fired by the Good Marksman Group with: shots falling in the same areas fired by the Poor Marksman Group; and shots which fall outside the bull in various designated areas of the target fired by both the Good Marksman Group and the Poor Marksman Group.

(c) By comparing one with the other, the patterns of breathing, stock pressure and aiming time which obtain for shots fired by the Good Marksman Group and the Poor Marksman Group falling in areas other than the bullseye.

All the subjects used in the study were volunteers from two groups of university students. Group I consisted of 44 members of the C.O.T.C., U.N.T.D. and R.C.A.F. Flight at the University of British Columbia. Group II consisted of 64 university students not belonging to the above mentioned groups. Complete and detailed analyses were made of 19 subjects in Group I and 21 subjects in Group II. The manner in which these subjects were chosen for detailed study is discussed in the text of the report.

The main equipment used in this study consisted of:

(a) A Lee Enfield rifle with a No. 1 tube, so equipped as to permit the measurement of stock pressure and aiming time.

(b) A "General Radio" recording camera which permitted a continuous record of the changes in respiratory, pressure and aiming time patterns as the subject fired.

(c) A pneumograph and a sphygmomanometer to measure the respiratory changes.

Some of the principal results of this study may be summarized as follows:

1. The respiratory trends associated with the bullseye shots fired by the Good Marksmen Group are distinct from any other group, especially with regard to the "follow through" after firing.

2. Those shots falling high on the target fired by either group appear to be associated with a characteristic respiratory trend, especially immediately after the firepoint.

3. The low shots in the major target areas by the Poor Marksmen resemble each other in respiratory trends.

4. Exhaling before firing; breathing immediately after firing; and the shortest aiming time of all shots, seem to be the characteristic trends associated with off-target shots.

5. The low shots fired by the Good Marksmen are associated with breathing after the firepoint and an aiming time which is longer than the bullseye shots for the same group.

6. The "vice-like" grip recommended by the training manuals is not observed when firing a Service rifle with a .22 bore.

7. Neither shots fired by the Good Marksmen, nor shots fired by the Poor Marksmen, whether they be good or poor, can be accounted for in terms of either the amount of pressure exerted at the firepoint or to any changes in the amount of pressure exerted immediately before or after firing.

8. Whether a shot falls in the bullseye, off the target, or in any of the other specified areas of the target, would not appear to be significantly dependent upon whether or not stock pressure is associated with it.

9. There is some indication that for most individuals, the recommended firing position is the most stable one and as such, is an aid in good shooting.

The concluding sections of the report are concerned with a summary description of the trends associated with shots falling in the bullseye area and shots falling off the target in terms of all the factors studied. In this section there is also included a discussion of the values and limitations of the miniature range as a technique for training marksmen. In this connection, it is noted that this study is in agreement with an earlier study carried out by the Army Operational Research Group. A discussion of the possible values and some limitations of the study together with suggestions for further research, complete the report.

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CHAPTER I

INTRODUCTION

Origin of the Study

In 1949, the Army Operational Research Group carried out an investigation into the teaching of weapons training (19). It was this report that served as a point of departure for the present study. Therefore, the principal findings of this original report that have relevance for the present research will be discussed in some detail in the following pages.

The research reported here was begun by Dr. T.W. Cook at the University of Saskatchewan in 1949. However, in August of the same year, the rifle and other equipment used in this study were transferred to the University of British Columbia where modifications were made both in the equipment and the original experimental design, and where the research was completed under the supervision of Professor E.S.W. Belyea of the Department of Philosophy

and Psychology at the University of British Columbia.

The Purpose of the Study

This study is an attempt to describe as accurately as possible what occurs in terms of patterns of respiration, stock pressure, and aiming time when a group of poor marksmen and a group of good marksmen fire a service rifle (with a no. 1 tube) from a prone position on an indoor miniature range. In addition, some data on the possible influences of the firer's position, vision and shooting experience are also discussed.

As will be seen shortly, some studies of marksmanship have been concerned with the problem of whether or not the skills required are innate or acquired. This study makes no attempt to answer this problem. In a sense then, this study is primarily descriptive rather than explanatory since neither the materials used nor the data obtained justify an attempt to differentiate between either psychological or physiological factors which may be prerequisite to good shooting. Briefly, this study is concerned with describing the manner by which some subjects succeed in a specialized activity demanded by the situation, and with describing the manner by which some subjects are unable to do so.

Previous Studies of the Factors in Marksmanship

Traditionally, the Armed Services emphasize five factors as being of utmost importance in marksmanship (12, 21, 23):

(a) Breathing
(b) Aiming
(c) Holding the rifle

(d) Trigger control
(e) Position

Trigger control is considered by training manuals to be the most important factor. "Coordination" of the five factors is also stressed as being essential to becoming an expert marksman.

A review of the literature on this subject reveals comparatively few studies pertinent to this investigation. The pertinent studies can be considered under the following headings:

(a) Psychomotor studies
(b) Studies of eye dominance

Psychomotor Studies:

One study in this area reported in the journals is the one where Gates (9) in 1918 attempted to study in the laboratory the abilities of an expert marksman. He compared the performance of an expert marksman with that of ten students on various psychomotor tasks, such as the steadiness test and a rate of tapping test. From this study he concluded:

(a) Muscular steadiness of body members was important but not absolutely essential.
(b) Muscular control of the fingers in manipulating the trigger played a role.
(c) The expert marksman showed no indication of exceptional vision.
(d) To select marksmen, tests of native, not acquired ability were needed.

Gates did not use a rifle in this study. He justified this exclusion by stating that in actual shooting, experience plays too large a role and he hoped to measure innate rather than acquired abilities.

Seashore and Adams (14) investigated the relationship between measurements of steadiness and marksmanship. The various measures they used were the Miles ataxiameter, the Beal and Hall ataxiagraph, the Seashore modification of Whipple's Steadiness Test and Adam's modification of Gates' Rifle Steadiness Test. These various tests were administered as a battery to an "unselected" group of fifty subjects. The results from this group's performance on the various tests were intercorrelated. These intercorrelations ranged from .44 to .59, the median being .48. Seashore and Adams interpreted these results to mean that a "general steadiness" factor was present and a common factor running through the various tests.

The same tests were then given to six members of the University Rifle Team. Their performance on the tests was compared to those of the unselected group. The results showed that the rifle team exceeded the subjects in the unselected group on the battery. However, one rifleman did not do so. In addition, it was found on the individual tests that the riflemen placed consistently at the 8th, 9th and 10th deciles of the unselected group. Seashore and Adams state that the ranks of the riflemen "coincided almost perfectly with their ranks in actual inter-collegiate competition."

Spaeth and Dunham (17) report a study in which they tested 72 U.S. Army marksmen on a steadiness test that was Dunlap's modification of the Whipple Steadiness Test. Their subjects were classified from "expert" to "unqualified." Their results show that a rank order coefficient of correlation of

.61 $\pm$ .11 was found between performance on the steadiness test and scores obtained on the targets. In their interpretation of their results they suggest that the results may indicate that practice on the range improves steadiness or that steadiness is a factor underlying development of skill in rifle shooting.

Belton, Blair and Humphreys (4) used the same battery of tests as Seashore and Adams (14) and found that practice over a ten day period produced improvement in muscular steadiness. However, when this improvement was compared with the entire range of individual differences of their 50 subjects, the average improvement in steadiness was very small (.4 standard deviations). They concluded from their results that since a training period ten times as long as that used in testing produced so little improvement in the subjects' performance, it seems doubtful that transfer in training from rifle shooting could explain the superior steadiness of riflemen on the tests.

Humphreys, Buxton and Taylor (11) extended the work of Seashore and Adams (14) and Spaeth and Dunham (17) because "these suggestions of a 'general factor' underlying development of skills," if verified, would have both theoretical and practical value. They used:

(a) Miles' ataxiameter as a measure of postural steadiness.
(b) Seashore's modification of Whipple's steadiness test as a measure of both "stationary" and "thrusting" steadiness.

(c) A rifle steadiness test.

Their subjects consisted of:

(a) The National Championship five man rifle team of the University of Oregon.
(b) Eleven other men ranking next to the above.
(c) Thirteen third year military students.
(d) Fourteen first year military students.

The results of the various tests are reported as follows:

(a) R = .77 between marksmanship and four tests of steadiness and r = .72 between rifle steadiness and marksmanship.
(b) "The results corroborate those obtained by Spaeth and Dunham, i.e. marksmanship can be predicted to a considerable extent at least from steadiness."
(c) "In this group of marksmen, experience is also as prognostic as rifle steadiness, probably because of the association between the latter and experience, whatever the underlying reasons may be."

They conclude:

(a) A good rifleman becomes such because of practice.
(b) On the whole, people with good capacity for marksmanship like to shoot and tend to specialize in it.
(c) Whether muscular steadiness is a result of training or a basic capacity for neuro-muscular coordination cannot be inferred from their data.

Serebrennikov (15) reports that he found a positive correlation between motor development and the rank order in shooting as estimated by commanders.

It will be noted from the above studies

that there has been a preoccupation with the search for possible innate capacities in marksmanship and that in this regard, the studies have been inconclusive. In addition, it would appear that much of the apparatus used in the studies is somewhat removed from the activity that it attempts to predict. As a result, the empirical validity of the measures may be questioned. As pointed out by Super (18) the trend in the use of psychomotor measures in the prediction of various other performances is to have the apparatus used resemble the task to be predicted as closely as possible. Also, because of the small groups used, especially the skilled groups, it is not surprising that inconclusive results were obtained. Finally, no attempt was made to relate specific performance to specific target results.

Studies of the Relationship of Eye Dominance to Marksmanship:

Banister (1) reports an investigation in which he studied the effect of the dominant eye on the shooting ability of 1,000 British infantrymen. His results show that the dominant eye is an important factor affecting ability with the rifle. It appears that the man with the right eye dominant has a considerable advantage (all things being equal) over the other men when required to shoot from the right shoulder.

In the same article Banister reports an inquiry in which he claims to have demonstrated that visual acuity did not correlate with ability to shoot with a rifle, since many of the best shots (Cambridge University Rifle Association) had very

defective sight. He says, "It is obviously necessary that the would-be marksman be able to see his target distinctly, but apart from particular atmospheric conditions, it is of no consequence whether for this purpose he uses naked eye or wears spectacles."

In Banister's studies, a number of tests were tried out on various groups of men of different degrees of ability as rifle shots, and eventually three tests, which promised to be diagnostic of shooting ability were selected. These tests were designed:

(a) To test consistency in pointing with the right hand at various targets when not seen (2).
(b) To test ability to press a trigger without jerking or rotating the hand (3).
(c) To determine the dominant eye.

Banister states that "Little need be said of these tests (tests (a) and (b) above) for, though the abilities they tapped appeared to be diagnostic, their importance was comparatively small as compared with that of the dominant eye." He notes that the dominant eye by no means always is the one with the higher acuity and is not necessarily the same as the dominant hand. However, he makes the point that there is considerable agreement between "handedness" and "eyedness."

Finally, Banister suggests some general factors that may affect results:

(a) Emotional reactions.
(b) Differences in the length of service.
(c) Lack of uniformity of incentives.
(d) Poor vision due to uncorrected refractive errors.

The ability to shoot well, he concludes, appears to lead to the development of a higher degree of "soldierliness" as defined in his study.

Drake (6) reports a study designed to discover whether rifle marksmanship can be determined prior to training. His sample consisted of the "best," "average" and "poorest" marksmen in an R.O.T.C. Unit. The measures used by him were as follows:

(a) Two forms of a paper and pencil test of visual perception.
(b) The telebinocular test.
(c) A test of touch.
(d) A test of muscle perception.
(e) An eye-hand coordination test.
(f) A visual acuity test.

He found that the error score on one form of the visual perception test correlated -.60 with marksmanship, that acuity of aiming eye correlated .40 with marksmanship, and that the tactual perception test correlated -.30 with marksmanship. The other tests, he concludes, gave no significant results.

Lebensohn (13) suggests that ocular dominance plays a subordinate role in marksmanship and that both eyes be used in aiming. Simpson and Sommer (16) used 190 English students who practiced rifle shooting. They tested the students' eyes with regard to lateral and vertical imbalance, visual efficiency, eye coordination and distance fusion. They found that the correlations between marksmanship and the various visual tests were negligible, and concluded that it did not matter if the preferred eye was used or

not.

Finally, Crider (5) studied two companies of untrained Naval recruits and later 856 men's marksmanship scores in relation to eye dominance. He found that those men who were purely sinistral made the worst scores and that those men who were purely dextral made the best. Incidentally, he notes that there is a need for a reliable and valid battery of tests for eye dominance.

Of interest in the foregoing summary of the eye dominance are the contradictory conclusions arrived at by the various investigations. It is suggested here that perhaps some of these inconsistencies are due to the inadequacies of present tests of eye dominance as suggested by Crider (5). Also, it should be noted the relatively subordinate role given to "trigger control" as being diagnostic of marksmanship in Banister's studies (1) quite the opposite of the importance of it as stressed by the service manuals (12, 21, 23).

Contributions of the Various Training Manuals to the Theory of Shooting:

Since respiration and stock pressure are the two major factors in marksmanship dealt with in the study, it is with regard to these factors that the Navy and Army training manuals will be reviewed especially.

Respiration:

The official Canadian Army handbook

"Shoot to Live" (12) states that "breathing is . . . . essential to good shooting. It has been estimated the 95 percent of Canadian Army riflemen do not breathe properly while using their rifles, and as a consequence, their scores are not as good as they are capable of producing." The statement suggests two things: first of all, that respiration is an important factor in marksmanship and secondly, that the optimal breathing patterns necessary to good marksmanship are known.

This breathing pattern is generally stated as follows: "Correct breathing resolves itself into relaxed, normal breathing, interrupted by a heavy, normal sigh just before firing. This sigh is naturally followed by a pause in breathing -- a brief period when you virtually do not breathe -- and it is during that pause that your rifle is steadiest, thus giving you the opportunity to squeeze the trigger." It is "During the short period of aiming and firing the shot (that) the firer will have to stop breathing." (12) Just how long this aiming time should be is not clearly stated in the manuals. However, because of the importance of this period in later discussions, an attempt will be made to state the case as clearly as possible.

In "Shoot to Live" (12) Johnson states "The musketry class can learn proper breathing by holding the breath for periods of 30 seconds." Later (p 76) he states "To fit the sigh into marksmanship, the recruit only has to momentarily stop breathing, immediately after he has given the sigh and to pause

long enough to squeeze the trigger . . . . If the recruit holds his breath longer than 20 seconds, stop him . . . . Eventually, through practice, the recruit will be able to approximate the expert's 10 seconds interval between the sigh and the squeeze of the trigger."

The Infantry Training Vol. 1 Pamphlet 3 (20) states "The general tendency in the recruit is for him to hold his breath for far too long a period, a fault that causes much strain and unsteadiness; this tendency must be checked instantly."

The Royal Naval Handbook (21) makes no specific reference to this point and so cannot be discussed.

The foregoing quotations appear to state the position of the training manuals adequately. Two points only need to be summarized for future reference:

(a) The emphasis upon a sigh just before firing.
(b) The manuals recommend holding the breath during the period of aiming and firing. This period is 10 seconds for the expert.

Holding

According to Rifle 1946 (Provisional) the "right hand must be the master hand for every shot fired. It must grip the small of the butt so firmly that no extra pressure can be applied. This vice-like grip, which plays the most important part in obtaining absolute steadiness, should be well forward; this will allow the forefinger . . . . to be around the trigger with the bony part (between the first and second joints) actually on the trigger.

At the same time, the right hand must pull back the rifle very firmly into the shoulder. Whenever the butt is brought into the shoulder, the forefinger must take the first pressure on the trigger." The main function of the left hand is to act as a support for the forward end of the rifle. This is essentially the same instruction emphasized in "Shoot to Live" and the Infantry Training Pamphlet No. 3 Vol. I.

The main point to be noted here is the emphasis upon a "vice-like" grip upon the butt stock.

Finally, a summary will be given of the main procedures for firing a shot as recommended in the various manuals (12, 20, 23):

(a) The rifleman must concentrate upon each shot.
(b) The time for a deliberate shot should not be more than 5 seconds from the moment correct holding starts.
(c) Just before accurate aim is taken, breathing should be restrained.
(d) "The hold and aim must at least be maintained until the bullet has left the barrel."

The Use of the .22 Rifle on the Miniature Range for Training in Marksmanship

Since the present study was carried out on a miniature range, it is considered advisable to discuss briefly what the service manuals and other sources have to say concerning the values and limitations of such ranges as training grounds:

1. Values of the miniature range: (The following values are taken from the Infantry Training Pamphlet Vol. I No. 3.)

(a) It is valuable for the earlier stages of training as well as later practice.

(b) For the recruit, its advantages are:

(i) Lack of noise; negligible kick from the rifle helps prevent gun shyness.
(ii) Promotes keenness by introducing competition.
(iii) Allows him to apply lessons learned and to prepare for the open range.

From the Small Arms Training Vol. I Pamphlet No. 18 (22) the following statement concerning the value of the miniature range is made: " Miniature ranges are most suitable for the early rifle training of the recruit where elementary lessons in aiming, holding, trigger pressing and many of the main factors which make for accurate shooting can be practised."

2. The limitations of the miniature range: (The following limitations were noted in the ORG Report No. 8/49 (19, Appendix D))

(a) "The idea of leading the recruit through the miniature and 30 yrds. range in order that the shock of firing .303 will be less, is basically wrong. In the great majority of cases the recruit is lulled with a false sense of security when firing a .22 rifle. He does not hold it firmly. He does not have to apply in practice what he is taught."
(b) He is not firing his own rifle.
(c) There is no kick or bang. The recruit therefore takes longer to get over his gun shyness when taken on the open range.
(d) The lighting conditions are too artificial.

In concluding the brief discussion of the background material to this present study, attention should be called to some of the inconsistencies in the positions taken by various investigators:

1. There appears to be one group of workers who emphasize vision, especially ocular dominance, as being of prime

importance in marksmanship. Other investigators consider ocular dominance of negligible importance. The training manuals do not consider the factor of vision at all.

2. Muscular steadiness seems to be emphasized to a degree by all the sources, but there is disagreement or at least inconsistencies in the various conclusiions as to whether or not such steadiness improves with practice.

3. There are at least two diametrically opposed views as to the values of the miniature range as a training device.

The contributions that this study may be able to make in resolving some of these inconsistencies must wait until the concluding chapter wherein the attempt will be made to relate the results obtained here to those results and recommendations quoted in this introductory statement.

CHAPTER II

SITUATION, EQUIPMENT, MATERIALS, AND SUBJECTS

The Situation

The .22 indoor range at the University of British Columbia was used for the study. This range is a 25 yard miniature range and is used by the C.O.T.C. and the University Rifle Club for training purposes and competitions. This particular range permits three individuals to fire simultaneously from the prone position.

The lighting consisted of seven 200 watt lights shielded and directed toward the backstop; a shielded lamp at the firing point; a light approximately half way down the range; and finally, a spectators' light shielded and approximately 12 feet back of the firing point.

The targets were fastened to a wooden backstop behind which was a metal stop butt.

The range, though narrow, was considered adequate for the purposes of this investigation since only one subject fired at a time. The subject fired from a prone position 25 yards from the target.

The recording equipment for this study was enclosed in a box which stood against the wall of the range in a position 4 feet behind and to the right of the subject. The experimenter sat at a table located approximately 12 feet behind the subject, from which point he could record the shots as they were fired and also manage the recording apparatus.

The Equipment

The main equipment used in this study and described in detail in this section consisted of:

(a) A Lee Enfield rifle with a No. 1 tube, so equiped as to permit the measurement of stock pressure and aiming time.

(b) A "General Radio" recording camera which permitted a continuous record of the changes in respiratory, pressure and aiming time patterns as subject fired.

(c) A pneumograph and a sphygmomanometer to measure the respiratory changes.

The entire recording apparatus was enclosed in a light-proof box. This box contained an instrument panel and the 35 mm. "General Radio" recording camera. The dimensions of this box were $3\frac{1}{2}'$ x $2\frac{1}{2}'$ x $2\frac{1}{2}'$. The inside walls of the box were painted a flat black. Although the top was removable for the adjustment of the apparatus, the interior was light-proof. On one

side of the box were outlet holes for a pneumograph tube, power intake and electric cable from the panel. The camera was controlled by a switch on the side of the box. A shielded peephole at one end of the box permitted the experimenter to adjust the setting of the pneumograph needle. The base of the box consisted of a 4'9" x 5" plank on one end of which was fixed the instrument panel and on the other end, on a fixed mount, (3'9" or the focal distance away) was the camera.

The camera could be loaded with 100 feet of 35 mm. film. The lens setting was f 11 with a focal distance of 4 feet. This camera ran at the rate of 6 seconds to one inch of film. Since it had no shutter, a continuous graphic record of the subject's respiration, pressure on the stock, time of firing, aiming time, as indicated on the panel, was obtained.

The panel, made of black plastic, was $16\frac{1}{4}$" x 18" so constructed as to permit the recording of respiration, pressure on the stock, time of firing and aiming time. On the panel was a dial on which the pneumograph needle moved up and down. This dial was a $\frac{1}{2}$" x $5\frac{1}{2}$" slot located 7/8" from the top of the panel and approximately $\frac{3}{4}$" in from one side.

In line with the middle of the respiration dial, but 1 9/16" below it, was situated the light which indicated the firing time. One and 3/8" below this light was the row of 1/8" holes (six in all) which indicated stock pressure.

On the back of the panel, fastened in a single row below the pneumograph tambour, were the seven $\frac{1}{2}$ watt

bulbs. The power for these lights was obtained via two 1½ volt dry cell batteries connected in series. The lead from each light ran through a single cable to a switch located above the trigger on the left hand side of the rifle.

The respiration indicator rode on a tambour which in turn was connected to the pneumograph by a length of ¼" thick wall rubber tubing. A sphymomanometer inserted in this rubber tubing by a glass "T" permitted E to centre the pneumograph needle for each S.

The respiration dial was marked off in a series of parallel lines and lighted by two ½ volt lights fastened to an oblong of lucite behind the dial. This light was diffused over the dial by means of a piece of opaque drafting cotton fastened to the lucite.

The rifle used was a Lee Enfield with a No. 1 tube permitting the firing of .22 cartridges. The weight of the rifle was identical with the .303 service rifle. The fore sight was a blade sight and the rear sight was a ¼" peep sight. The butt was what is termed "normal length."

Although the various pieces of apparatus to be described hereunder were fastened to the rifle, care was taken so that they would not interfere with the weight or balance of the rifle. (Fig. 7)

One and 1/8" behind the trigger guard

in the butt stock was located the movable pad (2 5/8" x 1 1/4") used to register stock pressure. The pad rested upon a flat 11 1/8" spring which lay in a groove down the length of the butt. The amount of pressure needed to light the various pressure lights on the panel was regulated by a coiled spring enclosed in a threaded cap and situated just forward of the pad. The pressure pad was in contact with a leafed switch above the trigger. This switch was connected by an electric cord to the panel lights.

Behind the bolt was a small wheel on a spring connected to the leafed switch. When the breach was open, the bolt rested upon this wheel depressing it and breaking the electric contact. When the rifle was fired, the wheel was raised by a spring, thus closing the circuit and lighting the firing light on the panel.

E used a pair of X12 service binoculars to see where each shot fell on the target.

The Keystone No. 46 Visual Survey Telebinocular was used to check the vision of each S.

The Materials

Mimeographed sheets containing six miniature targets were used by E. to record shots as they were fired. Record forms for data on height, weight, age, training, awards, and number of rounds fire previously were used for each S.

Keystone Visual Survey Tests School

Survey Cumulative Record Form No. 3 was used to record the results made in six visual tests given to each S.

The targets used were the No. 18 small target (4 ft.) 200/25 yds. generally used on Naval indoor .22 ranges. The ammunition used was Dominion .22 long.

A direction sheet that was read to the S before he began to fire.

The Subjects

All the subjects used in the study were volunteers from two groups of university students. Group I consisted of 44 members of the C.O.T.C., U.N.T.D. and R.C.A.F. University Flight at the University of British Columbia. These men were informed of the study by notices posted on the bulletin boards in the U.B.C. armouries. Group II consisted of 64 university students not belonging to the above mentioned groups. These men volunteered after reading a notice which stressed that they need not have had any shooting experience.

Thus, the total number of subjects used in the experiment was 108. Of this number, only 77 were used in the various stages of the analysis as 31 subjects had to be eliminated for the following reasons:

(a) Failure to complete their tasks or failure to complete all targets in the required time.
(b) Breakdown of the recording apparatus (earlier trials only).
(c) Elimination of female subjects. (In the initial stages of the investigation, it was hoped that a number of female

subjects who had never fired a rifle might be used to obtain a measure of the performance of completely inexperienced shots. However, because of the weight of the rifle, and because of the length of time required to obtain their records, these subjects were eliminated.)

Complete and detailed analyses were made of the shots of 19 subjects in Group I and 21 subjects in Group II. The manner in which these subjects were chosen for detailed study will be discussed in the sections to follow.

CHAPTER III

THE METHOD

The Plan of the Research

The basic argument for the research runs as follows.

If the principal factors under consideration here, i.e. breathing pattern, stock pressure, aiming time and position are important in marksmanship, then it should be possible to demonstrate their importance either by one or all of the following procedures:

(a) By comparing good marksmen with poor marksmen in terms of factors studied.
(b) By comparing the patterns of breathing, stock pressure and aiming time which obtain for dead-on-th-bull and in-the-bullseye shots fired by the Good Marksman Group with: shots in the same area fired by the Poor Marksman Group; and shots which fall outside the bull in various designated areas of the target fired by both the Good Marksman Group and the Poor Marksman Group.
(c) By comparing, one with the other, the patterns of breathing, stock pressure and aiming time which obtain

for shots fired by the Good Marksman Group and the Poor Marksman Group falling in areas other than the bullseye.

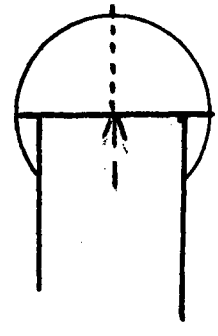
The Procedure

While each S fired ten shots on three consecutive days using the specially equipped rifle, his responses in terms of respiration, pressure exerted on the rifle, firing time to each shot, length of time in aiming and prone position taken while firing were recorded under controlled conditions.

The experimental procedure was as follows:

1. The subjects reported to the range on the day assigned to them. They were then read the following statement:

"This is a study of some of the factors in marksmanship. All that you have to do is fire five rounds at each of two targets on three days, preferably consecutive. You may take any prone position you wish and fire at will in your accustomed manner. The only requirement is that you take up the same point of aim on the bull for each shot as indicated on this diagram.



Do not group your shots out of the bull area. This is not a competition but I will be comparing the shots made by the C.O.T.C., U.N.T.D. and other groups, so I want you to do your best."

It was hoped to accomplish three things with this statement:

(a) To give each S an idea of what the nature of the study was without any specific mention of what was being sought. It is true that the experienced ones would have some idea of what was being measured, but this should only have the effect of having them emphasize what they had already learned.

(b) It was important for the study that each S take up the same point of aim for each shot. The E mentioned this again from time to time to remind the S if he appeared to be grouping his shots outside of the bull area. Results to be discussed later indicate that the subjects followed this rule.

(c) It was hoped that the suggestion of comparison with other groups would motivate the subjects to do their best and that emphasizing that the study was not a contest would avoid any undue tension on the part of the subjects. Such tension, if present to a marked degree, would complicate further the interpretation of the results.

2. The S was asked to assume his firing position on the mat.

3. The pneumograph was fastened about the S just below his diaphragm. He was told to exhale before the pneumograph was fastened. Preliminary trials indicated that this position gave the largest sweep on the panel dial.

4. The S was told to be still for a moment, not to touch the rifle and to breathe normally. By means of the sphygmomanometer the E centred the moving needle on the panel which indicated the respiratory changes.

5. The S was instructed briefly concerning safety rules.

6. The target was placed in position by E.

7. The E returned to the spectator's table behind S and checked the subject's number, his position in the firing order for the day and the target number strip. These precautions were rigidly adhered to so that the film strip might be accurately identified later.

8. E switched on the recording apparatus and told S that he might fire when he wished.

9. E watched with binoculars each shot fired, plotting its position on the subject's miniature target before him.

10. Notes were made by E of general movements, behavior and position of S beside the miniature target.

11. When S finished each trial, he was told when to report again.

12. As mentioned earlier, an attempt was made to have S come to the range on three consecutive days. Although this was not always possible, all subjects fired their required 30 rounds within a week from starting or else they were eliminated from the study. This precaution was taken to prevent S from practicing between trials. It was hoped by this means to minimize practice effects.

13. The S was not told by E how his shots were falling or shown his targets until he had completed the trials. This was to avoid having S correct his aim and compensate in any other manner for poor shots.

14. Finally, after all trials were completed, every subject's vision was tested on the Keystone Telebinocular. Six tests in all were used:

    (a) Simultaneous fusion.
    (b) Vertical imbalance.
    (c) Lateral imbalance.
    (d) Fusion.
    (e) Right eye usable vision.
    (f) Left eye usable vision.
    (All tests were at the far point.)

The Controls

The following controls were observed:

Control of the Subject:

(a) The S was told the general nature of the study.

(b) He was told precisely what performance was required. In this manner, some control was maintained over the ideational and motor set of each S.

(c) The motivational set of the S was also controlled to a degree by the statement read to him.

(d) The height of each S was noted together with the ease with which he was able to reach the trigger. If the S encountered difficulty firing with the normal butt, there would be an additional variable to be taken into account in the interpretation of the data.

Control of the Situation:

Each trial was carried out in the same range under identical lighting conditions. The firing mat was kept in the same position so that although each S might take up any prone position he chose, he would always be the same distance from the target and always be in the same relative position with regard to the target. The E always sat about 12 feet behind S. If another subject was waiting, he sat still further back of E and was not allowed to talk to the S firing or to encourage or interfere with him in any way.

Apparatus Used to Control:

(a) The experimental variable, i.e. respiration, pressure on stock, aiming time and firing time were all controlled by apparatus in the following manner:

i. Respiratory changes by the pneumograph.
ii. Pressure on the stock by lights connected to the pressure pad on the rifle. If the subject's grip was strong, all 6 lights went on for the time that grip was maintained and the various lights went on and off as the S slackened or strengthened his grip on the stock.
iii. Rifle was zeroed by R.C.E.M.E.
iv. Aiming time and fire time by a light which lit when the rifle bolt was released by the trigger.
v. Position was controlled partly by the position of the firing mat and the directions as mentioned earlier, together with notes and diagrams made beside the miniature targets by E while S fired.

(b) Other variables controlled by apparatus and equipment:

i. Vision checked by the telebinocular.
ii. Record sheet for the subject's age, height, weight, previous rifle training and experience and number of rounds fired.
iii. Each target was fastened in the identical position on the backstop for all subjects and all trials.
iv. Binoculars were used to record each shot's position as fired.
v. Every factor except position and past experience permits the used of a quantitative scale that could be used in comparing the performances of the various subjects.
vi. Every factor except vision, past experience and position was recorded on a continuous 35 mm. film strip in graphic form by a shutterless camera.

vii. Finally, the selection of the sample assured that there would be subjects who had received formal training together with subjects who had not. The repetition of the task and the number of shots fired assured to a large extent that E obtained representative samples of each subject's ability as a marksman, in addition to allowing for chance errors affecting particular shots.

CHAPTER IV

RESULTS AND DISCUSSION

The Logic of the Statistical Analysis

1. The targets were scored in accordance with Dominion Marksmanship standards. An average total score was then obtained for all subjects, the maximum score possible being 50.

2. A combined distribution of these average total scores was then made. The groups were combined at the beginning of the analysis because although the sampling procedures seemed to assure the fact that two groups (one service trained, the other relatively untrained) were present, the E could not be absolutely certain of this. Therefore, the assumption was made that the two samples were from the same population.

3. The top and bottom quartiles were calculated. This gave a group of good and a group of poor marksmen, the relative skill of each group thus being accurately defined in terms of obtained scores. The assumption here was that if the factors studied did differentiate, then they would do so between these groups. As it turned out, the lower quarter, except for one individual, belonged to the group from the general university population. However, the top quarter contained three persons from the general university population. A study of their past experience records revealed that all three had had Army training. Now this could be taken into

account. As stated earlier, the statistical procedure permitted the defining of the groups quantitatively.

4. A lucite grid was made so that the position of each shot could be read from x=o y=o which represented a dead-on bullseye in terms of a coordinate system.

5. The number of shots falling in all areas on the target was then tallied. The results are shown in Figs. 1 and 2. It will be noted from this that the question as to whether or not each S was taking up the same point of aim is answered. Fig. 1, representing the shots for the Good Marksman Group speaks for itself. Fig. 2, representing the shots for the Poor Marksman Group also indicated that they were trying for the bullseye each time. Although not all shots are in the bullseye area, the shots are grouped in concentric circles about it, with the areas having the highest frequencies nearest the bull. If the subjects had not been trying for the bullseye, the grouping would be in one of the quadrants.

6. All the film for these subjects was sorted, cut and read. The film was read in the following manner:

   (a) First, 10 x 10 graph paper was fastened to a glass plate which was placed over a lighted box.

   (b) Each film strip was placed on the graph paper and read with a magnifying glass.

   (c) Beginning at the FP (fire point) and moving to the left, points were read off the curve for every 1/10th" up to 4/10" and then every 3/10" for 4.8". Next, beginning at the FP and moving to the right, points on the curve were read for every 1/10" for 2". Similarly, the amount of pressure on the stock in terms of the number of six possible lights on at each of these points was also read off and recorded on prepared forms (Appendix E).

   (d) The length in inches between CF (aiming time) was determined. By this procedure it was found that except for extremely long strips, the entire breathing and pressure record for each S for every shot could be determined quantitatively. It should be mentioned here that the respiration needle's movements were photographed against a graph, the mid point of which was taken as 5 so that all respiration changes would be positive. The pressure was recorded in terms of the number of lights on at any given point from one to six.

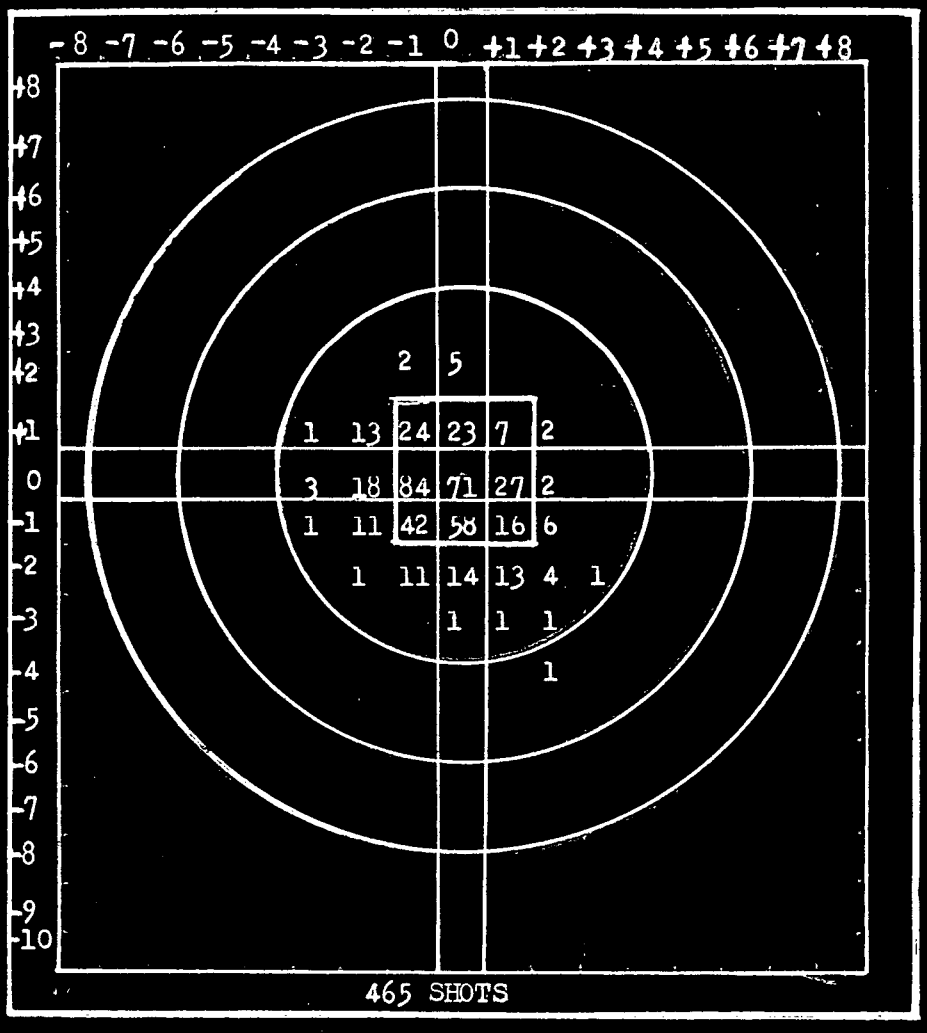


FIG.1. Target areas involved for the shots fired by 19 Good Marksmen.

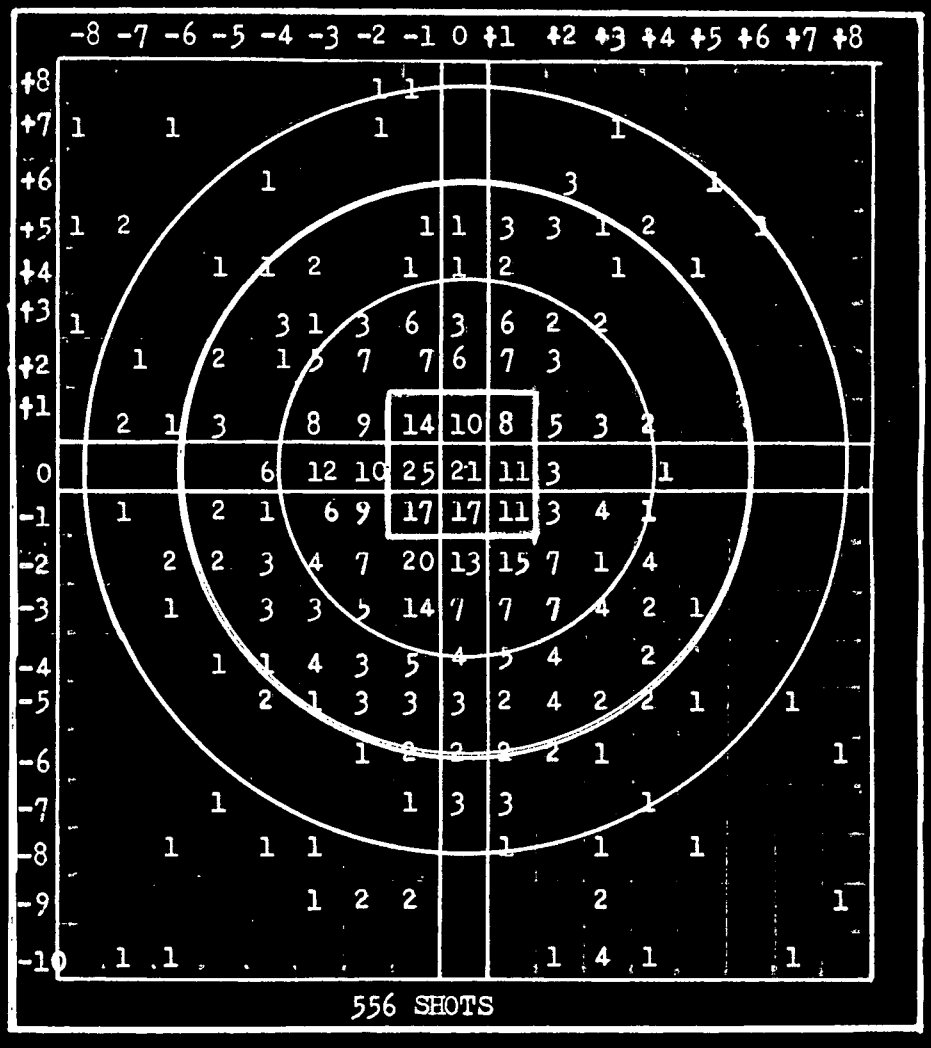


FIG.2. Target areas involved for the shots fired by 21 Poor Marksmen.

(e) Since it was known that the camera's reels moved at .6 seconds to 1/10", all linear measures were transposed into time units.

7. After all targets had been scored and all film was read, the next step in the analysis consisted in determining whether there were any general respiration trends present. Therefore, graphs were made of the respiration trends of a selection of poor and good marksmen to see if, by inspection, such trends could be distinguished. Although this procedure did suggest some points, on the whole it was unsatisfactory.

8. In so far as respiration was concerned, the S in any particular interval had three choices. He could hold his breath, he could inhale or he could exhale. Thus, for every interval of the film, the number of subjects either holding, inhaling or exhaling was tallied.

9. The percentage of total shots accompanied by held, inhaled or exhaled breath for each interval was determined. These results were graphed and gave Fig. 3.

10. Now, although a general trend was shown in Fig. 3, it could not be determined from this alone whether the general trend was associated with good or poor shots.

11. It was therefore decided to divide all the shots for both good and poor marksmen into a number of groups.

12. Once again, the number of shots associated with held, inhaled or exhaled breath in each interval was tallied, but this time all shots were grouped into their various areas on the target.

13. The X^2 technique was used to determine the chance occurrence of the arrangement of shots in the respiratory position (held, exhale and inhale) for each time interval. No X^2 value in this regard was considered significant if it was greater than the .05 level of probability. Most distributions were at the .01 level of probability. In this manner then, respiration curves representative of group trends in the specified areas of the target were determined. The stability of the whole curves could be determined by an adaption of the X^2 technique.

All of the other factors were treated with statistical techniques adapted to their particular requirements.

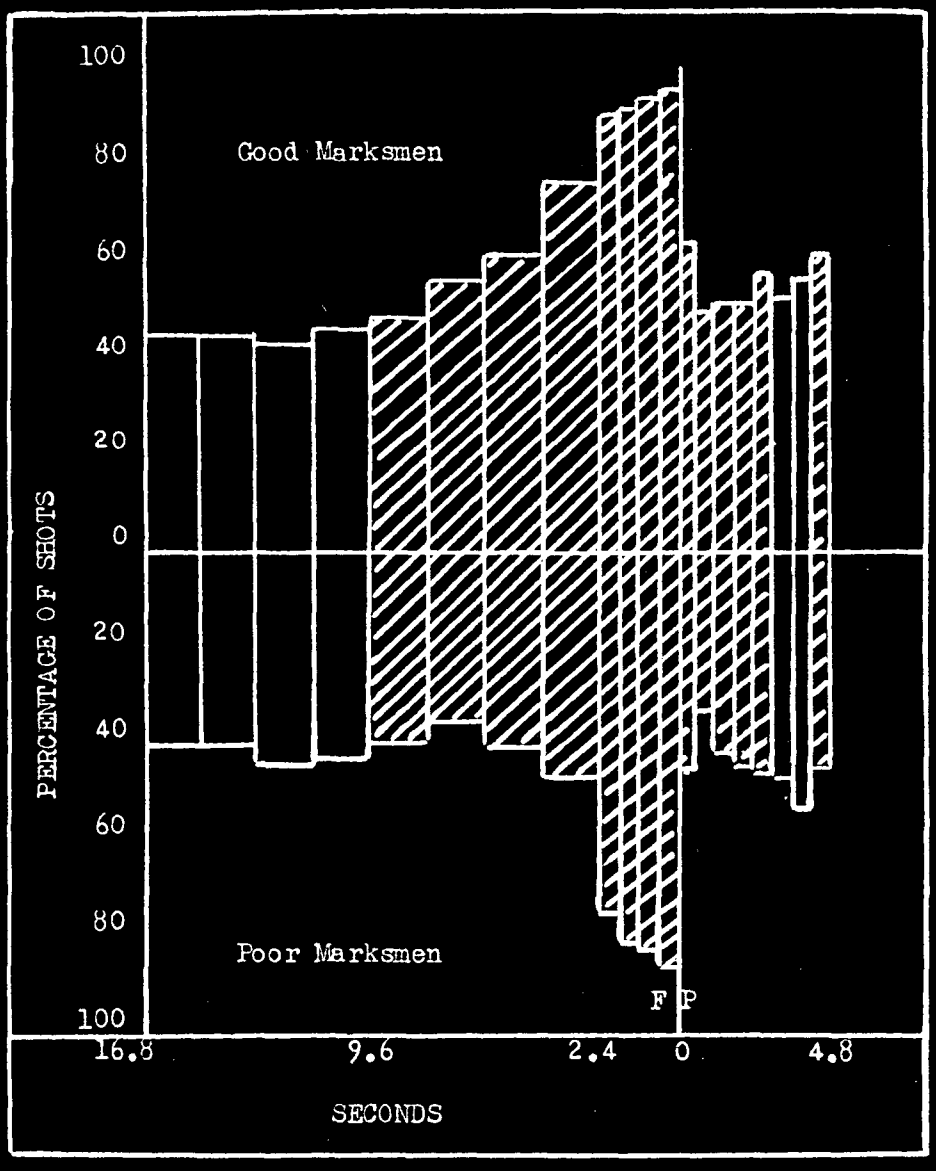


FIG.3. Histographic comparison of the Good and Poor Marksmen with regard to the percentage of shots associated with held breath .

Consideration of Results

Preliminary considerations

Fig. 4 shows a distribution of the average total scores of 77 marksmen. Inspection of the distribution shows that it is significantly skewed negatively ($Sk/^{S}sk = 87.4$). Statistically, this distribution is a real divergence from the normal curve, i.e., the skewness is not a result of chance fluctuation. This distribution corresponds then to what might be expected since it represents the combined scores made by a group of trained and a group of relatively untrained marksmen. That is, one would expect that even in the case where the subjects were untrained, that factors other than chance would determine the position of the shots on the target. This, and the presence of trained marksmen, is probably responsible for the skewness.

Later considerations demonstrate this first assumption to be the case. For example, on the basis of a single factor (respiration) it appears that groups of shots falling in specified areas of the target are associated with certain characteristic respiratory trends, even in the case of untrained individuals. Therefore, if each S was trying to hit the bullseye, and there is evidence that he was, then the problem is to determine why, in some cases, he did not do so.

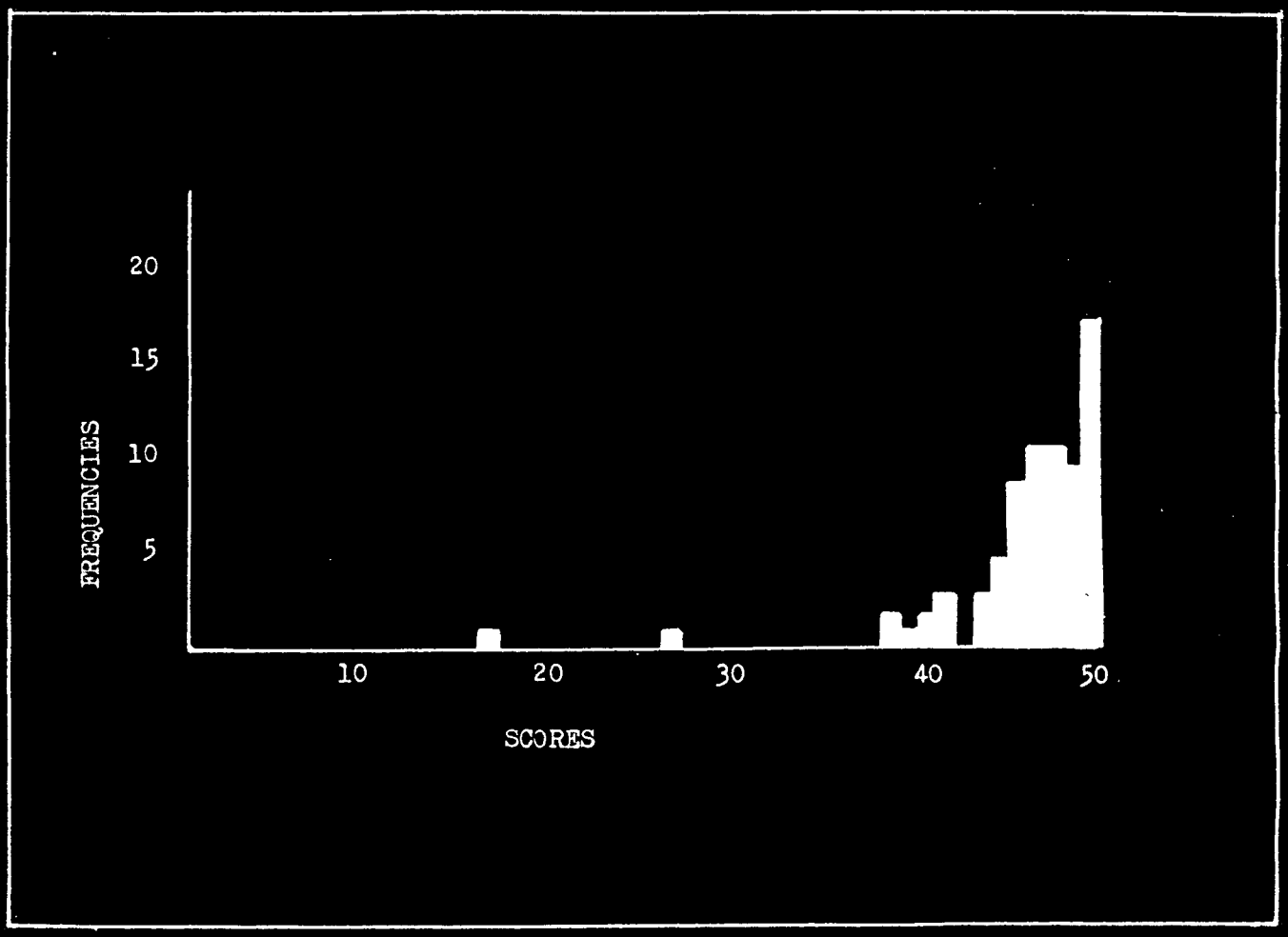


FIG.4. Histogram representing the average total scores of 77 marksmen.

If the assumption that factors other than chance factors were responsible for the clustering of scores in the upper range of the distribution is accepted then, it is justifiable to investigate reasons for this in terms of the factors studied to see if they operate together to determine the scores obtained.

As stated earlier, the upper and lower quarters of this combined group were taken as defining the Good Marksman Group and the Poor Marksman Group respectively. In average total scores, then, Group I (the good marksmen) is composed of subjects who had an average total score of 48.8 or greater. Group II (the poor marksmen) consisted of all those individuals who had an average score of 45.1 and below. The median score for the combined group is 47.

Table I shows the composition of Group I. Here, the 19 individuals composing the group are arranged in order of merit with regard to average scores and the table includes material concerning each S with regard to past experience and vision. The information, except for the vision tests, was obtained by questionnaire. As will be noted, some of the information with regard to age and height was omitted by the subjects. In the later group, this defect was remedied by obtaining the information at the time of firing.

The reason the height of the S was taken into consideration was to have some check on the adequacy of

TABLE I

THE COMPOSITION OF THE GOOD MARKSMAN GROUP

S	Mean Score	Kind of Training	Length of Training	Awards	Handedness	Owns Rifle	Approx. Rounds Fired	Aiming Eye Favored	Keystone Vision Tests 1	2	3	4	5	6	Age	Ht.
1	49.9	COTC	?	Yes	R	No	10000	R	N	N	N	N	96%	92%	?	5'10"x
2	49.8	Cadet	7 yrs.	Yes	L	.22	?	L	N	N	N	N	105	98	20	5'6"
3	49.8	COTC	?	Yes	R	No	2100	R	N	N	N	N	102	98	?	?
4	49.8	COTC	?	Nil	R	No	?	R	N	N	N	N	105	105	?	?
5	49.7	Cadet	?	Yes	R	No	300	R	N	N	N	N	105	105	19	6'
6	49.7	COTC	?	Nil	R	.22	2000	R	N	N	N	N	102	103	22	5'8"
7	49.7	Cadet	5 yrs.	Yes	R	No	?	R	N	N	N	N	105	105	?	?
8	49.7	Army	5 yrs.	Nil	R	No	?	R	N	o	R	e	c	o	r	d
9	49.5	COTC	?	Nil	R	No	?	R	N	N	N	N	105	103	22	5'11"
10	49.5	Army	2 yrs.	Nil	R	No	1000+	R	N	N	N	N	105	105	18	6'2"
11	49.5	Cadet	5 yrs.	Nil	R	No	?	R	N	N	N	N	105	105	19	5'10"
12	49.3	COTC	?	Nil	R	No	?	R	N	N	N	N	105	103	20	5'10"
13	49.2	COTC	4 mos.	Nil	R	No	30+	R	N	N	N	N	103	103	22	5'8"
14	49.2	COTC	4 mos.	Nil	R	.22	250	R	N	N	N	N	105	105	21	6'
15	49.1	Cadet	4 yrs.	Nil	R	No	1000+	R	N	N	N	N	102	102	?	? x
16	49.0	Army	Perm.	Yes	R	No	5000	R	N	N	N	N	98	103	?	?
17	49.0	COTC	?	Nil	R	No	?	R	N	o	R	e	c	o	r	d
18	48.8	Army	5 yrs.	Yes	R	No	?	R	N	N	N	N	105	65	?	5'6"
19	48.8	Cadet	5 yrs	Yes	R	No	3000+	R	N	N	N	N	102	103	21	6'

x - wore glasses while firing
For meaning of vision tests see Appendix D.

the butt length of the rifle which was N (normal.) Since none of these subjects complained about this and since each was an experienced shot, it is safe to assume that the probability is that the butt length was adequate. This is an important point to be established for if the butt were too long or too short it might interfere with trigger control.

The table shows that all subjects in this group were members of the C.O.T.C., Cadets or the Army. Thus, undoubtedly all had had some formal rifle training. In addition, it will be noted that some of these subjects had earned various awards for marksmanship.

When the eye favored by each S for aiming is taken into account, the vision appears adequate. On this point, however, the E was not entirely satisfied with the instrument (Keystone Visual Survey) used. He did not think that the data obtained warranted any analysis beyond inspection, although it was felt that despite these inadequacies, some check upon the subject's vision was obtained.

Table No. 2 shows the composition of Group II. Here again the 21 subjects are arranged in order of merit with regard to average scores. In this group, the information is more complete. It is more certain for instance, that the butt length was adequate. It will be noted that with the exception of four men, the subjects had no formal training. The reasons for not eliminating these four subjects from the group and thus ostensibly obtaining an

TABLE II

THE COMPOSITION OF THE POOR MARKSMAN GROUP

S	Mean Score	Kind of Training	Length of Training	Awards	Handedness	Owns Rifle	Approx. Rounds Fired	Aiming Eye Favored	Keystone Vision Tests 1	2	3	4	5	6	Age	Ht.
1	45.1	Nil	N.A.	No	L	No	Nil	R	N	N	N	N	50%	50%	30	6'
2	45.0	COTC	?	No	R	No	200	R	n	o	R	e	c	o	r	d.
3	45.0	Nil	N.A.	No	L	No	Nil	L	N	N	N	N	105	105	22	6'
4	44.7	Nil	N.A.	No	L	.22	500	L	N	N	N	N	105	105	19	6'
5	44.5	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	103	103	19	5'8"
6	44.3	Nil	N.A.	No	R	.22	500	R	N	N	N	N	92	102	19	5'7"
7	44.3	Cadet	?	No	R	No	500	R	N	N	N	N	105	105	19	6'
8	44.1	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	105	105	23	5'7" x
9	43.7	Nil	N.A.	No	R	.22	300	R	N	N	N	N	105	103	21	6'
10	43.7	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	105	103	20	5'11"
11	43.5	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	65	98	26	6'
12	41.7	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	102	100	20	5'8"
13	41.5	Cadet	2 yrs.	No	R	No	500	R	N	N	N	N	105	100	20	5'10"
14	41.3	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	50	84	19	5'8" x
15	40.8	Cadet	?	No	R	No	200	R	N	N	N	N	84	98	25	5'7"
16	40.0	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	105	103	19	5'7"
17	39.7	Cadet	2 yrs.	No	R	.22	1000	R	N	N	N	N	105	96	22	5'9"
18	38.5	Nil	N.A.	No	R	.22	500	R	N	o	R	e	cor	d	20	5'11"
19	38.0	Nil	N.A.	No	R	.22	100	R	N	N	N	N	98	103	20	5'8"
20	26.8	RCAF	?	No	L	.22	2000	L	N	N	N	N	92	84	24	6'2"
21	16.1	Nil	N.A.	No	R	No	Nil	R	N	N	N	N	105	96	29	5'6"

x - wore glasses while firing
N.A. - not applicable
For meaning of vision tests see Appendix D.

untrained group should be considered. There were several reasons for this:

(a) This group represented statistically the lowest quarter of the distribution of average total scores by all subjects. It was therefore felt that for the analysis to be logically and statistically consistent, all subjects falling in this quarter should be considered.

(b) The fact that the other subjects in the group claimed to have had no training did not mean that such was the case. In other words, the E wanted as far as possible to avoid making any unwarranted generalizations based upon a supposed completely untrained group.

(c) As rather complete records were kept of each subject's performance, any possible deviations from the group could be noted later if necessary. In other words, if the factors considered were responsible for the scattering of the shots, then they would be in operation throughout this group.

It will be noted that according to the vision tests, S-1 has low usable vision at the far point which may account partly for his poor shooting, especially since his is the highest average total score in the group. When the eye favored in aiming is taken into account for each subject, it would appear that according to the vision tests given, the group's vision was adequate for the task. An interesting point here is that seven of this relatively untrained group owned their own rifles compared with the trained group's total of three. This is another point in favor of retaining the four subjects mentioned earlier, because of the fact that some in the group own rifles suggestsconsiderable experience in shooting, even though it would indicate that the subjects had had perhaps, no formal training.

Figures 1 and 2 show the scatter of shots on the target for Groups I and II, respectively. It can be seen that the shots of Group I are concentrated for the most part in the bullseye. Even those shots outside of that area are gathered relatively near to the bullseye. For this group, it is evident that the subjects who composed it were taking up the same point of aim as directed fro each shot. Figure 2 shows the scatter of shots for the Poor Marksmen (Group II) and reveals a much greater scattering of the shots fired. In this Group, 24 of the shots missed the target altogether. However, inspection of the chart shows that despite the wide scatter, the areas having the highest frequency of shots are nearest the bullseye and that all the shots are arranged in a circular fashion about the centre of the target. It seems reasonable to assume therefore, that though they were not always successful, the Poor Marksmen were making the effort to aim at the bullseye for each of their shots.

Figure 3 shows the respiration trends for the Good and Poor Marksmen. As mentioned earlier, the respiration data were analysed in terms of whether the S held his breath, inhaled or exhaled during each of the time intervals for 16.8 seconds prior to firing and 4.8 seconds after firing. This graph then represents the percentage of the total shots associated with the three respiratory categories for each interval. Ideally, each S should have had a record for a total of 30 shots. However, in some cases the film did not turn out well enough to be used. In others, especially the

Service groups, the E was unable to get the desired six targets from each S. Yet, most of the group did fire the required thirty rounds, but some did not. Most of the latter were Good Marksmen. As large a sample as possible was needed, therefore those subjects who had fired a minimum of 20 or more rounds were considered in the analysis. It should be repeated that most did fire 30 rounds.

The graph shows that in both Groups, as the firing point is approached, there is an increasing percentage of shots being associated with held breath. In the interval after firing there is a marked decrease in the number of shots associated with held breath.

In the area indicated by shading, the critical ratios between the groups of shots of Poor Marksmen and Good Marksmen range from 3 to 10.2 and it is interesting to note that between 9.6 seconds before the firing point to a minimum of 3.6 seconds after the FP there is a significant difference between the Groups with regard to the percentage of shots associated with held breath. Yet, it appears that just before firing, most Poor Marksmen's as well as Good Marksmen's shots were associated with this dominant respiratory trend.

Yet this graph omits a great deal. For instance, from it alone, it is impossible to determine whether or not this trend towards an increasing percentage of shots to be accompanied by held breath is associated with the best shots or the poorest shots in the groups. And again, it is impossible to determine whether the

rapid decrease in the percentage of shots accompanied by held breath after the fire point is associated only with the poorest or with the best shots in the group. It was necessary, therefore, to divide the shots for both the Poor Marksmen and the Good Marksmen according to where they fell on the target.

The target areas for which curves were determined for each group were as follows:

1. Those shots which were dead-on the bullseye. That is, where x=o, y=o for Group I (Good Marksmen) and Group II (Poor Marksmen). These curves were designated GMxoyo and PMxoyo respectively.

2. Those shots falling in the bullseye area excepting x=o, y=o shots and designated GM bull and PM bull.

3. Those shots falling on the y axis from the outside of the bullseye area to the top of the target, e.g. GM x = o, y = +2 to + 8, PM x = o, y = + 2 to + 8 and for those falling on the y axis below the bullseye to the bottom of the target, e.g. GM x = o, y = - 2 to - 10, PM x = o, y = - 2 to - 10 shots.

4. Those shots falling on the x axis on each side of the bullseye to the sides of the target, e.g. GM y = o, x = - 2 to - 8, PM y = o, x = -2 to -8 and GM y = o, x = + 2 to + 8, PM y = o, x = +2 to +8.

5. Those shots for both groups falling in the upper right quarter of the target (+ +) and designated GM + +, PM + +.

6. Those shots falling in the upper left quarter (- +) of the target and designated for each group therefore GM - +, PM - +.

7. Those shots falling in the lower left quarter of the target (- -) and designated for each group therefore GM - -, PM - -.

8. Those shots falling in the lower right quarter (+ -) of the target and designated GM + -, PM + -.

9. Only the Poor Marksmen fired off the target. These shots were designated PM off-target and were off low right.

As there were only two GM + + shots, 5 GM x = o, y = + 2 to + 8 shots and 2 GM y = o, x = + 2 to + 8 shots and 4 PM y = o, x = + 2 to + 8, only 17 curves were possible rather than the theoretical 21 possible curves. There were therefore, 10 respiratory curves for the Poor Marksmen and 7 for the Good Marksmen.

Discussion of the respiration and aiming time trends.

Figures 5 and 6 show diagramatically these 17 curves. Here, a horizontal line indicates a significant trend was associated with holding the breath in that interval. A line moving diagonally to the top of the chart indicates inhalation, and pointing downward indicates exhalation. In all cases only those intervals which showed a distribution of shots in the three categories which were significant at the .05 level or less are indicated by a line on the curve (see Appendix B).

From these diagrams, the following points should be noted:

1. All shots, whether fired by Poor Marksmen or by Good Marksmen are associated with held breath for a minimum of 2.4 seconds prior to the firing point.

2. All the shots fired by the Poor Marksmen which fell low on the target or off the target were associated with exhaling prior to the fire point.

3. The bullseye and x = o, y = o shots by the Good Marksmen are unique in the tendency to be accompanied by held breath throughout, and are especially notable for the fact that these shots alone are accompanied by a "follow through" in the respiratory pattern after the fire point.

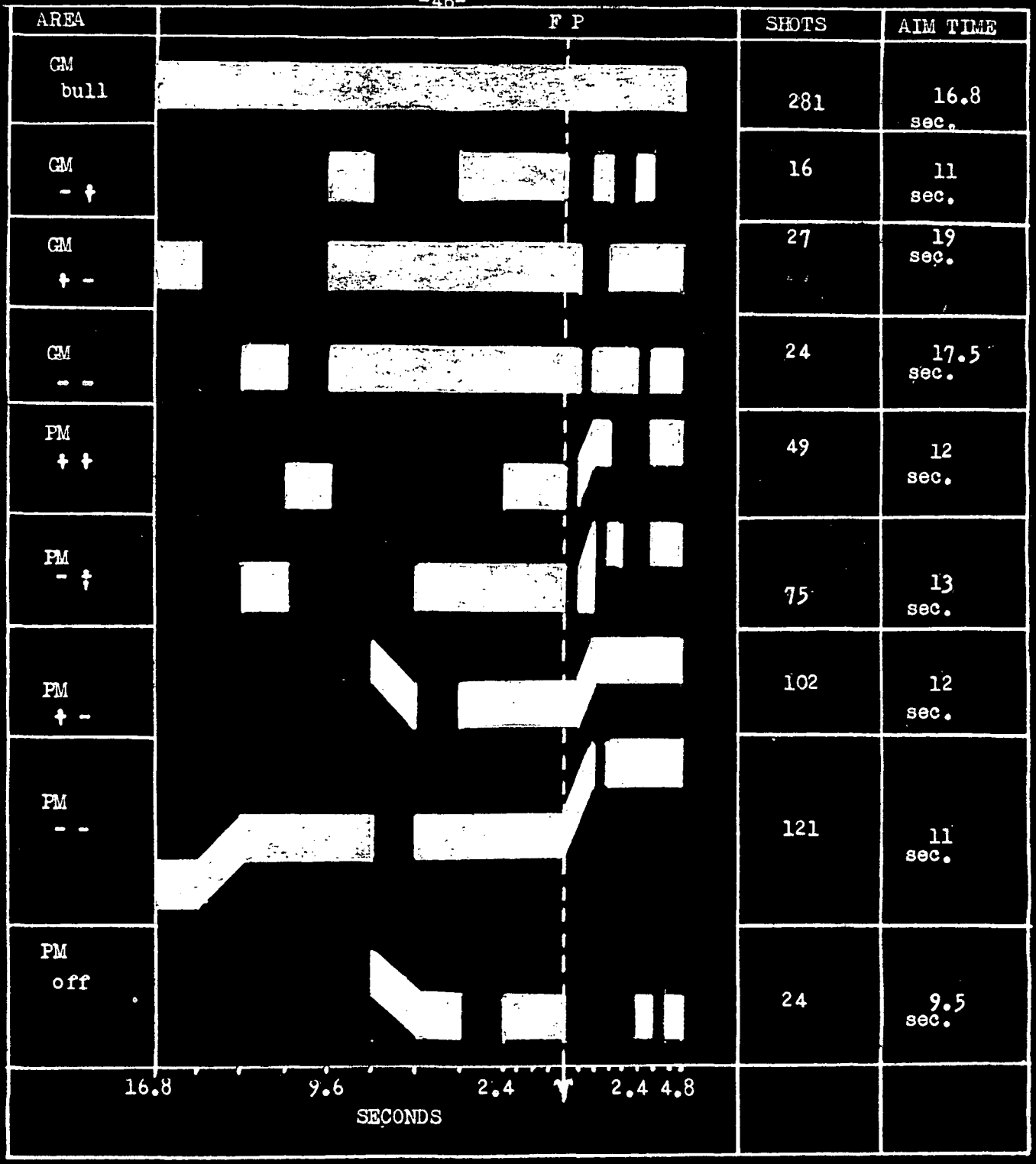


FIG.5. Diagrammatic representation of the significant tendencies in the respiration curves associated with shots falling in the major target areas - Good and Poor Marksmen.

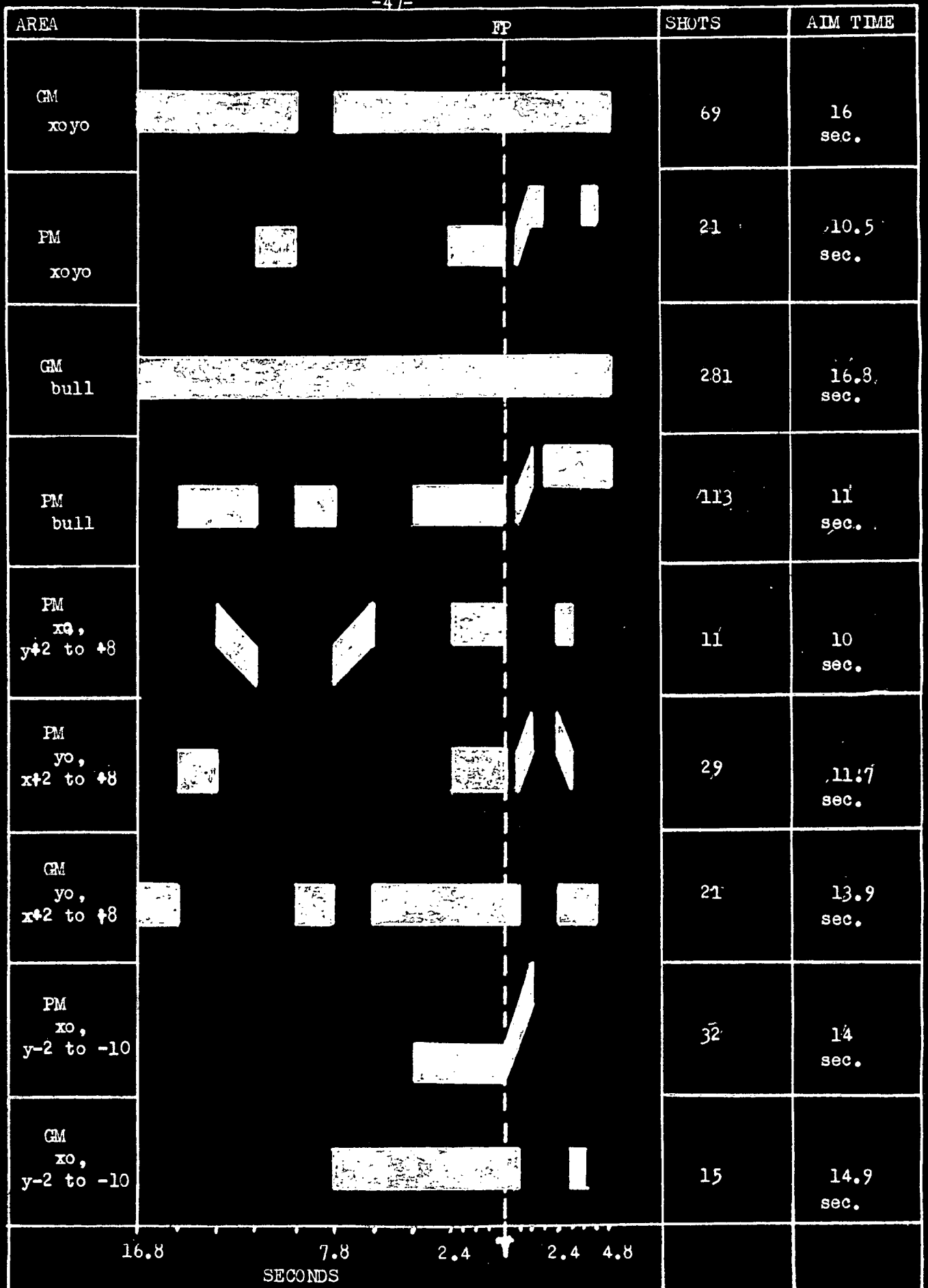


FIG.6. Diagrammatic representation of the significant tendencies in the respiration curves associated with shots falling in the bulls eye and minor target areas - Good and Poor Marksmen.

4. All the shots fired by poor marksmen show breathing in the .6 second interval after the fire point and a trend to inhaling in the following .6 second interval. The exception here is the curve for off-target shots which does not show a definite trend after the fire point except that it too is accompanied by breathing immediately after firing.

5. All shots except GM xoyo and GM bull are accompanied by breathing within 1.2 seconds after the fire point.

In addition to these points, it appears that the respiratory trends fall into groups. That is, there seem to be group similarities. This patterning becomes most apparent when the median aiming time for each trend is taken into consideration. With regard to the aiming time, the median time rather than the mean time was used to avoid giving undue weight to a very few exceptionally long periods which would not be so representative of the group trend.

In this regard then, the following points are noteworthy:

1. Both the GM bull and GM xoyo respiratory trends are very similar, this similarity being emphasized when their median aiming time (16.8 and 16 seconds respectively) is taken into account.

2. All high shots, whether by Poor Marksmen or Good Marksmen are similar in respiratory trends and in median aiming time. This is not so apparent in the Good Marksmen, but Appendix B indicates that even here there is a strong tendency to inhale after the fire point.

3. The two curves for the low shots of Good Marksmen are also similar in aiming time and general respiratory trends.

4. PM -- and PM ♦ - and PM off-target shots are all similar in respiratory trends. In addition, the first two trends are similar with regard to aiming time (11 and 12 seconds respectively). The PM off-target shots have the shortest aiming time, namely 9.5 seconds.

5. It will be noted that the GM - + and the PM bull shots are almost identical with regard to respiration trend and aiming time. Appendix B shows the tendency to inhale in the 1.2 second interval after firing in the GM - + shots. Thus it appears that these two groups are indistinguishable on the basis of respiration and aiming times alone.

6. With regard to those shots falling on the ordinates, the following points may be noted from Fig. 6.:

   (a) The PM xo y = -2 to -10 shots have the same marked inhaling immediately after the FP associated with the respiratory trend as do the PM -- shots. However, it will be noted that in this case, no direct evidence of exhaling before the FP is evident. The median aiming time here is 14 seconds.

   (b) The GM x = -2 to -8, y = o shots and the GM x = o, y = -2 to -10 shots are similar with regard to respiratory trends in several ways. Both groups of shots are associated with held breath in the .6 interval after the FP and both trends show breathing in the next interval. The median aiming time for the GM x = -2 to -8, y = o shots is 13.9 seconds and for the GM x = o, y = -2 to -10 shots is 14.9 seconds.

   (c) In the respiratory trend associated with the PM x = o, y = +2 to +8 shots there is exhaling from the 13.2 second interval to the 11.4 second interval before the FP followed by inhalation from the 7.8 second interval to the 6 second interval before the FP. This trend is followed by the minimum 2.4 second holding before the FP characteristic of all shots. Here too, there is breathing immediately after the FP. The median aiming time is 10 seconds.

   (d) Most characteristic with regard to the respiratory trend associated with the PM x = -2 to -8, y = o shots is the inhaling in the .6 second to the 1.2 second interval after firing and the exhaling in the 2.4 second to 3.0 second interval after FP. Median aiming time is 11.7 seconds.

We have considered only the respiratory trends in detail up to this point together with a brief mention of aiming time, therefore, few positive statements can be made. However,

some tentative points should be considered:

1. It is evident, especially with regard to the shots within the bullseye area fired by the Good Marksmen that there are rather distinctive respiratory patterns associated with these shots and that in addition, there appears to be what might be termed an optimal aiming time associated with these shots.

   These shots throughout are associated with held breath. Moreover, the "follow through" of this pattern after firing distinguishes these shots from all others fired by either group. Perhaps this "follow through" may be compared with that found in various sports, such as golf. In other words, a motor set which is held not only up to the fire point, but also for a considerable period (in this case 4.8 seconds) after firing, is one which would appear to be essential to good shooting. An objection may be made here. It has been noted that PM bull, and PM xoyo did not show this trend. This fact must be admitted. However, it should be noted that only relatively few of the Poor Marksmen's shots are in this area when compared with the number of shots fired by this Group and also when compared with the proportion of the Good Marksmen's shots in this area. Both these trends are very similar to those of shots falling high on the target. A possible explanation for their position is that another factor or factors are operating to overcome the effects of faulty respiration. In any event, the trend as shown by the Good Marksmen is not negated when considered as a factor conducive to good shooting, even though it may be possible to hit the bullseye by compensating for faulty breathing.

   Before leaving this point, the median aiming times of the shots in the bullseye by the Good Marksmen should be noted. Here it is found that the 16.8 and 16 second median aiming periods would appear to be optimum times. A consideration of the Good Marksmen's low shots, the trends for both of which are associated with the longest aiming times (17.5 and 19 seconds), suggests that despite certain similarities in respiratory trends before the firing point to the Good Marksmen's bullseye shots, the additional time taken to fire may be a factor in these shots falling low. Another factor, of course, would appear to be that the low shots are associated with breathing in the 1.2 second interval after the fire point. This is characteristic of all shots outside of the bullseye area.

2. The next most prominent respiratory trend is that of the PM off-target shots. Here, like most of the shots, there is breathing immediately after firing associated with the shots. In addition, beginning with the 7.8 second interval and continuing to the 6 second interval before the FP there is a significant tendency to exhale. Finally, the aiming time of 9.5 seconds is the shortest time associated with any trend. All of these tendencies would appear to favor poor shooting.

   The low shots fired by the Poor Marksmen are similar to the foregoing with regard to respiration. In the PM + - shots there is exhaling before the FP and inhaling within the 1.2 second interval following the FP. In the PM - - shots, although on first glance the trend appears not to be associated with the above, it seems still to be essentially the same. The gradual inhaling before the FP and the most marked inhaling directly after firing, suggests in general, a condition before firing similar to those shots accompanied by exhaling.

3. The low shots of the Good Marksmen are similar to each other in respiratory trends, but not so similar to the Poor Marksmen's low shots. However, it will be noted that both the GM - - and GM + - shots are associated with longer aiming time than the bullseye shots by the same group. Moreover, these trends show breathing in the 1.2 seconds after firing. However, to fully account for the low position of the shots, it will likely require the consideration of some other factor not discussed here. Thus, the fault in the case of the low shots seems more in the aiming time than in the respiration, while the fault in the case of the Poor Marksmen's low shots seems to be respiration primarily.

4. The resemblance both in firing time and respiratory trends associated with all high shots fired by both Groups should be noted. Unfortunately, there were too few shots in the GM + + for respiration curves to be determined. However, although there are these similaries present, the analysis to this point does not explain why some of the high shots fall in the upper right quarter while others fall in the upper left quarter.

5. It was hoped that a study of the respiration curves associated with the $x = o$, $y = +2$ to $+8$ shots and $x = o$, $y = -2$ to -10 shots fired by Good Marksmen and Poor Marksmen would reveal why, though these shots are in line with the bullseye they fall high on the target in the first case and low in the second.

However, no distinct trend for these shots alone was found. The low shots in these groups for the Poor Marksmen resemble the PM - - shots' trends. The shots fired by the Good Marksmen in this area resemble the GM + - shots and the GM - - shots. Thus, low shots in this area are similar to the shots fired low by both the Good and Poor Marksmen, respectively. Unfortunately, there is no GM x = o, y = +2 to +8 respiratory trend possible. However, in the case of the PM x = o, y = +2 to +8 respiratory trend, the inhaling indicated before FP may partially account for the high position of the shots.

The PM x = -2 to -8, y = o shots resemble the shots fired high or in the bullseye by the Poor Marksmen both in respiration time and aiming time. The GM x = -2 to -8, y = o respiratory trends resemble the shots by the Good Marksmen falling in the + - area. However, aiming time is less (13.9 seconds).

Summary of respiration and aiming time trends

The findings up to this point in the analysis are both incomplete and tentative since only two of the factors have been considered. Thus, they will have to be modified later. Some tentative conclusions with regard to the trends discussed may be made:

1. The respiratory trends associated with bullseye shots fired by the Good Marksmen are distinct from any other group, especially with regard to the "follow through" after firing.

2. Those shots falling high on the target and by both groups appear to be associated with a characteristic respiratory trend, especially after the FP. The bullseye shots by Poor Marksmen are also associated with this trend.

3. The low shots in the major areas by the Poor Marksmen resemble each other in respiratory trends.

4. Exhaling before firing, breathing immediately after firing and the shortest aiming time of all shots, seems to be the characteristic trend associated with off-target shots.

5. With regard to low shots by Good Marksmen, associated with them is breathing after the FP and an aiming time which is longer than the bullseye shots by the same Group.

6. Finally, the two factors, respiration and aiming time, seem to be sufficient in the main to account for high and low shots. However, they do not seem to be sufficient to account for shots falling to the right or to the left of the bull.

Discussion of the pressure trends

The following section is concerned with the results obtained from the analysis of the pressure records for the groups of Poor Marksmen and Good Marksmen already discussed in some detail in the previous section devoted to group respiratory trends. Figures 8 to 25 show the trends for all marksmen with regard to stock pressure. It can be seen that the dominant trend for both Good and Poor Marksmen is not to apply pressure at all upon the butt stock while firing.

Figure 7 represents diagramatically the relationship between the position of the pressure pad and the grip recommended by the training manuals.

The usual instructions for holding a rifle have already been quoted in Chapter I. Neither the trained nor the untrained groups as a whole conform to these regulations. There would appear to be several possible explanations for the fact that both the performances of the Good and Poor Marksmen show that the recommended procedure is not complied with:

1. The first possible explanation is that the pressure pad and its functioning were inadequate for the measurement of stock

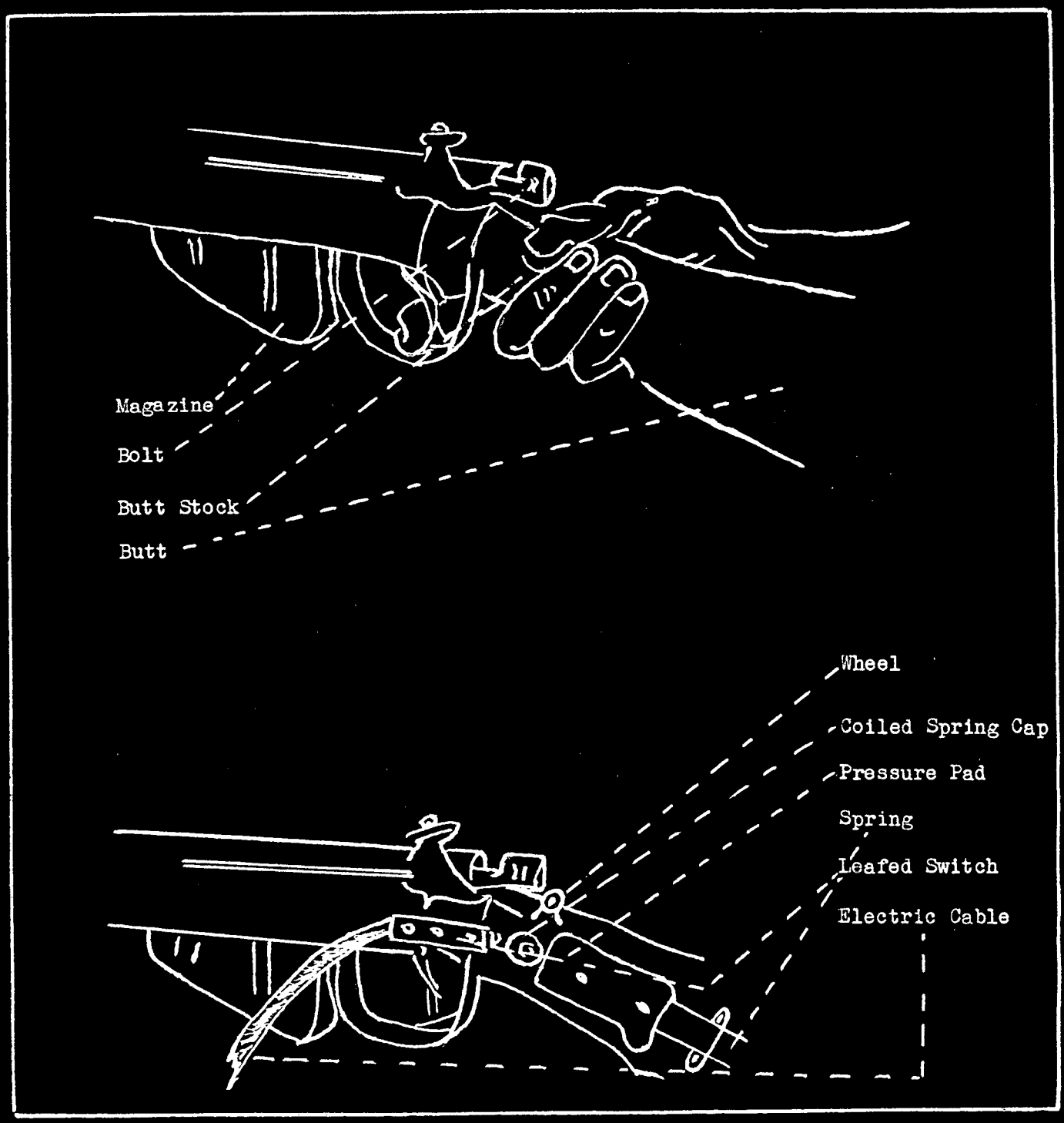


FIG.7. Diagram showing the relationship between the position of the pressure pad and the grip recommended by the Training Manuals.

pressure. Conceivably, it may be possible to grip the rifle stock in such a manner that it would not be recorded by the pad. However, such a grip is not recommended by present training techniques. The pad was placed in such a position that if the stock were gripped at all the pressure would be recorded.

2. The results obtained may be due to the fact that the rifle used had a .22 bore and therefore would not have the recoil of a standard .303. This fact might have influenced the shooting procedure of the trained marksmen especially. However, exactly why such trained men should find it necessary to vary their grip with the rifle being used is not explained. It may be that such a vice-like grip as recommended is an awkward grip which is avoided by marksmen unless made necessary to compensate for recoil.

3. When the fact that inexperienced shots also did not exert pressure in general is considered, a third explanation is suggested which may account for the entire phenomenon. Such an explanation is to the effect that perhaps the pad itself, because it was plastic and "gave" slightly with pressure and was therefore different in this respect from the rest of the stock caused the Subjects, as a result, to avoid it. This situation is roughly analogous to running a hand along a table top with the eyes closed and touching an area that is unlike the remainder of the table. The suggestion here is that in such a case the person would lift his finger to avoid the strange object.

   To test this hypothesis would require possibly two separate experiments -- one to ascertain the effects of instruction that explicitly called attention to the pad and its function, or another, to demonstrate whether or not the above analogy is sound.

Another point should be considered in this connection. This is that the manuals emphasize such a grip as already discussed not only to compensate for recoil but also to aid in the grouping of the shots near the bull. Again, this is likely the case with the .303. However, the performance by the Good Marksmen suggests that accurate shooting is not so dependent upon this factor

when using a rifle of small bore.

The major trend then, still remains one toward applying no pressure on the rifle stock. Yet, there appear to be certain pressure trends associated with shots falling in specified areas on the target. These trends will be considered now. Although in many cases they are not significant, when considered with the dominant respiratory trend, the secondary trends do supply some indication as to possible influences determining the position of the shots on the target.

The statistical method used in analyzing the pressure record was the same as that used in the analysis of the respiratory records, namely the X^2 technique.

The rationale was that because in the various time intervals considered each S could exert pressure on the stock in varying degrees, he could within any specific interval either apply no pressure at all, or else he could apply any one of a number of varying degrees of pressure from slight pressure, sufficient only to be recorded as one light on the panel, to pressure strong enough to be recorded as the total number of lights (six in all) on the panel. There were individual differences in the amount of pressure exerted in the various time intervals by the various Subjects. A minority gradually increased the stock pressure. Others exerted pressure erratically or not at all. It was felt therefore, that in analyzing the group trends, these variations in the amount of pressure

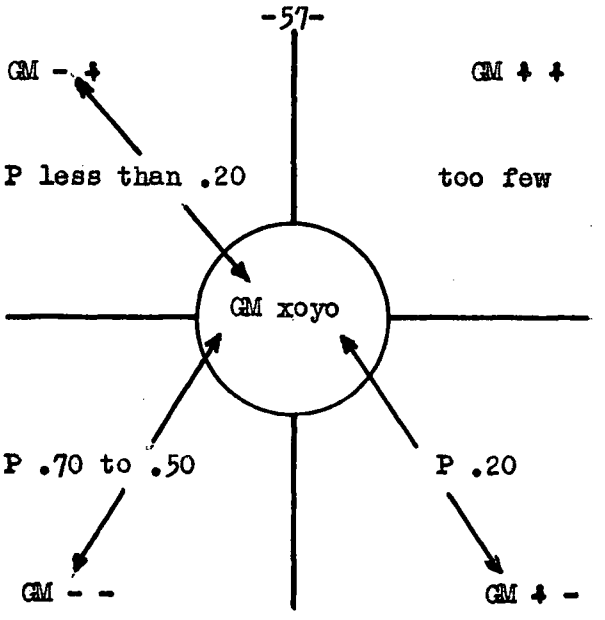


FIG. 8. Comparison of pressure trends at the firepoint: Good Marksmen's "dead-on" shots with Good Marksmen's shots in the other major target areas.

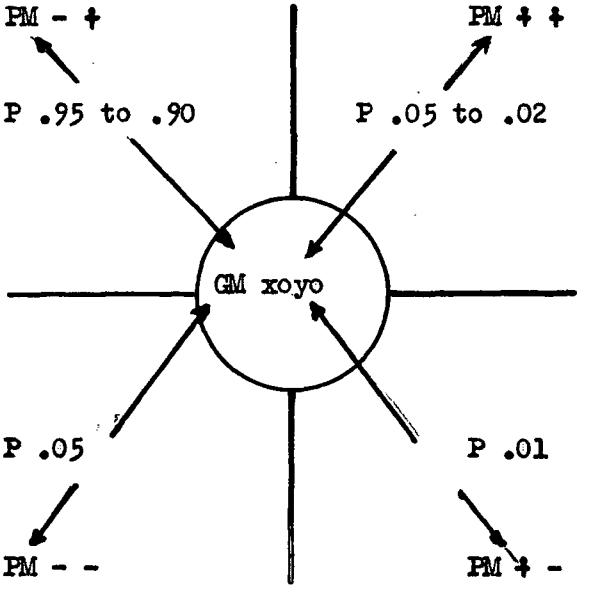


FIG. 9. Comparison of pressure trends at the firepoint: Good Marksmen's "dead-on" shots with Poor Marksmen's shots in the other major target areas.

exerted in the various intervals should be taken into account.

Hence, an X^2 and a P value were determined for the pressure trends shown by the two groups of marksmen in the .6 second interval before firing, at the FP, and in the .6 interval after firing. These intervals were selected for detailed study because logically, it would seem valid to assume that if any marked variations in pressure occurred at the time of firing or shortly before and after, they would be pressure changes that would influence the path taken by the bullet to the target.

For every area on the target previously considered in the respiratory analysis, various X^2 and P values (Appendix C) were calculated as indicated above in order to:

1. See if there were any differences between Good and Poor Marksmen with regard to the amount of pressure at the FP associated with their shots falling in the various target areas. (See figs. 8, 9, 10, 11, 12 and 13).

2. See whether or not for each group of marksmen there were significant changes in the amount of pressure exerted immediately before firing (.6 seconds) and firing (FP) for shots falling in the various target areas. (See figs. 15, 16, 22 and 23).

3. See whether or not for each group of marksmen there were significant pressure changes between the FP and immediately after firing (.6 seconds). (See figs. 17, 18, 24 and 25).

4. See if at the FP the amount of pressure exerted in the specified areas was significantly different for Good and Poor Marksmen. (See figs. 14).

5. See if the vertical and horizontal shots could be distinguished from shots in other areas by pressure alone. (See figs. 19, 20 and 21).

The secondary pressure trends will

now be considered in detail:

1. Concerning differences in the amount of pressure applied at the FP:

   (a) Comparison of the amount of pressure associated with GM xoyo shots and GM - +, GM + +, GM - - and GM + - shots. (Fig. 8) From Fig. 8, the following results are noteworthy:

      (i) There is no significant difference between the amount of pressure associated with the GM xoyo shots at the FP and GM shots in the other areas (- +, + -, - -) of the target.

      (ii) Though not significant (P.20), there is a tendency for GM xoyo shots to be associated with more pressure at the FP than GM - + and GM + - shots.

   (b) Comparison of the amount of pressure associated with GM xoyo shots and PM - +, PM + +, PM - - and PM + - shots. From Fig. 9 the following results are obtained:

      (i) There is a significant tendency for GMxoyo shots to be associated with more pressure at the FP than the PM + + (P .05 to .02) shots, the PM + - (P less than .01) and the PM - - (P .05) shots.

      (ii) It should be noted that there is no significant difference between the GM xoyo and the PM - + (P .95 to .90) shots with regard to the pressure associated with them at the FP.

   (c) Comparison of the amount of pressure associated at the FP with PM xoyo and PM - +, PM + +, PM - - and PM + - shots. From Fig. 10, the following results are obtained:

      (i) There is no significant difference between the PM xoyo shots and the PM + + (P .80 to .70), PM - + (P .70 to .50), PM - - (P more than .99) and PM + - (P .10) shots with regard to the amount of pressure associated with them at the FP.

      (ii) There is a tendency, though not significant (P .10), for the PM xoyo shots to be associated with more pressure at the FP than the PM + - shots.

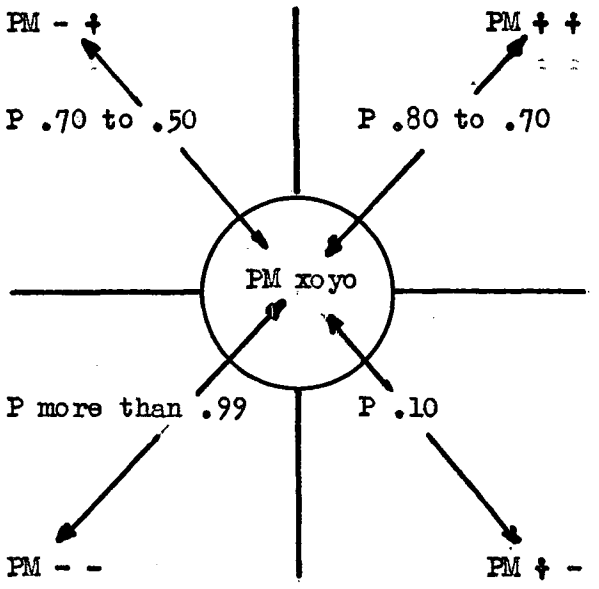


FIG. 10. Comparison of pressure trends at the fire point: Poor Marksmen's "dead-on" shots with Poor Marksmen's shots in the other major target areas.

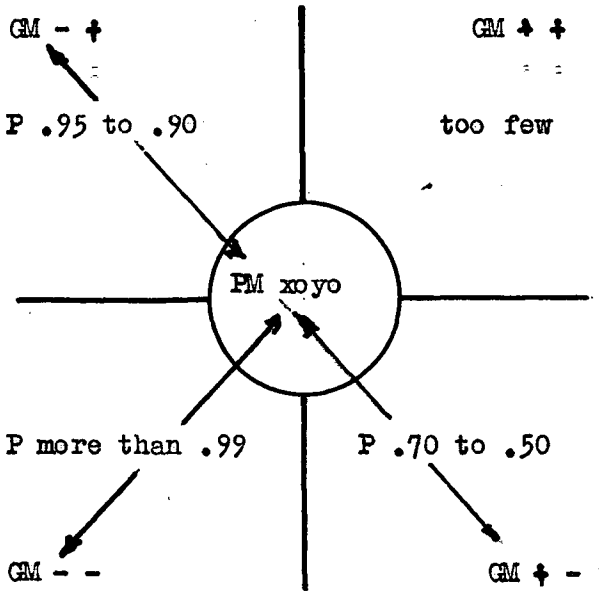


FIG. 11. Comparison of pressure trends at the fire point: Poor Marksmen's "dead-on" shots with Good Marksmen's shots in the other major target areas.

(d) Comparison of the amount of pressure associated at FP with PM xoyo shots and GM - +, GM + +, GM - - and GM + - shots. The following result is obtained from Fig. 11 to the effect that there is no significant difference in the amount of pressure associated with the PM xoyo shots and the GM - + (P .95 to .90), GM - - (P more than .99) and GM + - (P .70 to .50) shots.

(e) Comparison of the amount of pressure associated at FP with PM xoyo, PM bull, GM xoyo and GM bull shots. (See Fig. 12) Results:

(i) There is no significant difference with regard to the amount of pressure associated at the FP between GM xoyo and PM xoyo shots (P .95 to .90); GM xoyo and GM bull shots (P .95); PM xoyo and GM bull shots (P .95 to .90).

(ii) There is more similarity than difference with regard to the pressure at the FP between PM xoyo and PM bull shots (P .70 to .50).

(iii) There is a significant difference in the amount of pressure associated at the FP between GM xoyo and PM bull shots (P .02), more pressure being associated with the GM xoyo shots; and between GM bull and PM bull shots (P less than .01), more pressure being associated with the GM bull shots.

(f) Comparison with the amount of pressure associated at the FP with PM xoyo, GM xoyo and PM off-target shots. (Fig. 13) Results:

(i) There is no significant difference between the amount of pressure associated at the FP with PM xoyo shots and PM off-target shots (P .70 to .50).

(ii) There is no significant difference between the amount of pressure associated at the FP with GM xoyo shots and PM off-target shots, but in this case a P .30 to .20 suggests a possible trend for GM xoyo shots to be associated at the FP with more pressure than the PM off-target shots.

(g) Comparison with the amount of pressure associated at the FP between GM - + and PM - +; GM - - and PM - - shots;

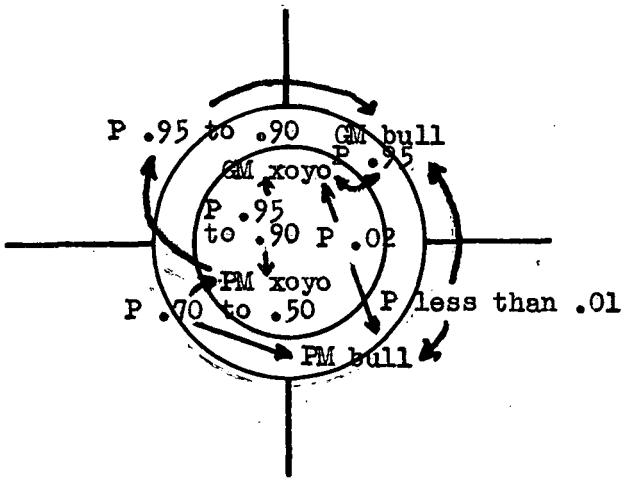


FIG. 12. Comparison of pressure trends at firepoint: Good Marksmen's "dead-on" and bull shots with Poor Marksmen's "dead-on" and bull shots.

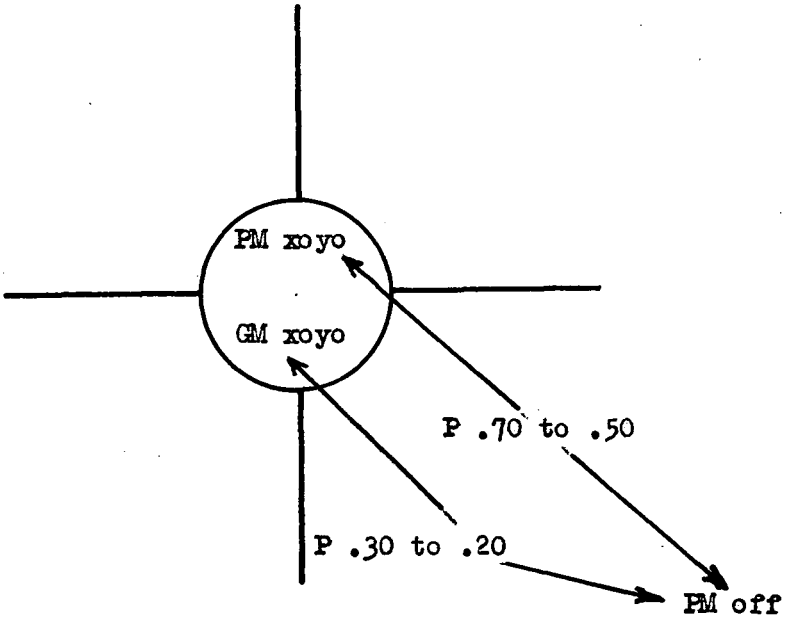


FIG. 13. Comparison of pressure trends at the firepoint: Good Marksmen's and Poor Marksmen's "dead-on" shots with Poor Marksmen's "off-target" shots.

GM + - and PM + - shots. From Fig. 14 the following results:

(i) There is a significant difference in the amount of pressure associated at the FP between GM - + and PM - + shots (P less than .01) and GM + - and PM + - (P less than .01) shots. In both cases, more pressure is associated with the GM shots.

(ii) There is no significant difference in the amount of pressure associated with the GM - - and PM - - shots (P .70 to .50)

2. Concerning the changes in the amount of pressure associated with shots in the interval .6 seconds before firing and the FP:

(a) Comparison of the amount of pressure associated with shots .6 seconds before firing and at the FP by Good Marksmen. Fig. 15. Results:

(i) In all the areas (GM - +, GM - -, GM + -, GM bull and GM xoyo) there is no significant change in the amount of pressure associated with the shots in these intervals.

(ii) However, there would appear to be a slight tendency for GM bull shots to be associated with more pressure at the FP.

(b) Comparison of the amount of pressure change associated with Poor Marksmen's shots in the various areas between .6 seconds before firing and the FP. See Fig. 16. Results:

(i) Again, there is no significant difference in the various areas between the amount of pressure associated with the shots in these intervals.

(ii) There is a tendency, however, for PM + + shots (P .30) to be associated with more pressure at the FP than .6 seconds before the FP.

3. Concerning changes in pressure associated with shots in the areas at the FP and .6 seconds after.

(a) Comparisons to determine changes in pressure associated with Good Marksmen's shots in the various areas at the

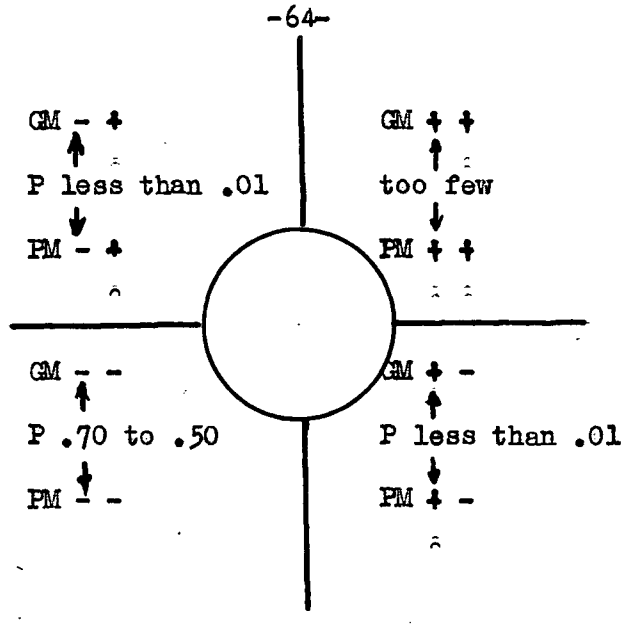


FIG. 14. Comparison of pressure trends at the firepoint: Good Marksmen's shots with Poor Marksmen's shots in the major target areas.

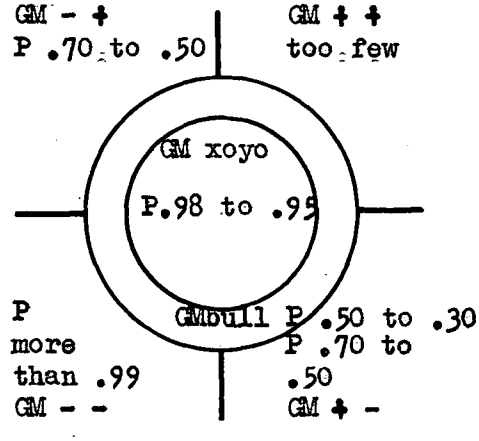


FIG. 15. Diagram indicating the significance of pressure changes between .6 seconds before the firepoint and the firepoint: Good Marksman Group.

FP and .6 second interval following. Fig. 17. Results:

(i) There is no significant decrease (P less than .01) in the amount of pressure associated with GM bull shots at the FP and in the .6 second interval afterwards.

(ii) There is a slight tendency (P .20 to .10) for GM + - shots to be associated with a decrease in pressure between the FP and .6 seconds afterwards.

(iii) There is no significant change in pressure associated with GM - +, GM - - shots and GM xoyo shots in this regard.

(b) Comparisons to determine changes in pressure associated with Poor Marksmen's shots between the FP and .6 seconds afterward. Fig. 18. Results:

(i) There is a significant decrease (P .02 to .01) in the amount of pressure associated with PM bull shots at the FP and in the following .6 second interval.

(ii) There is a significant decrease (P less than .01) in the amount of pressure associated with PM - - shots at the FP and in the following .6 second interval.

(iii) There is no significant change in this regard associated with PM xoyo, PM - + or PM + +, PM + - and PM off-target shots.

4. Concerning the differences in the amount of pressure at the FP between horizontal shots and vertical shots and associated shots in other areas. Fig. 19.

(a) Comparison of GM - +, GM - - shots and GM yo x -2 to -8 shots with regard to the amount of pressure at the FP. Fig. 19. Results:

(i) There is no significant difference in this regard between pressure associated at the FP with GM yo, x -2 to -10 and GM - + shots (P .30 to .20) or GM - - shots (P .50 to .30).

(b) Comparison of GM - - shots and GM + - shots with GM xo, y -2 to -10 shots with regard to the amount of pressure

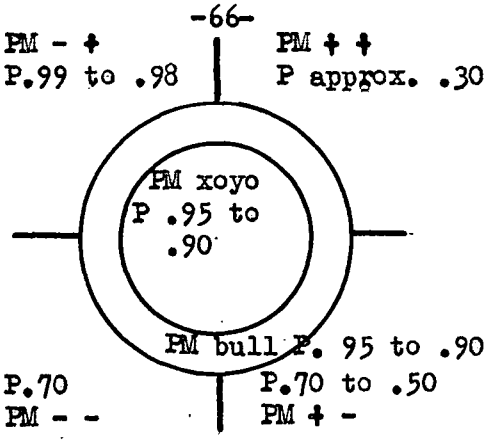


FIG. 16. Diagram indicating the significance of pressure changes between .6 seconds before the firepoint and the firepoint: Poor Marksman Group.

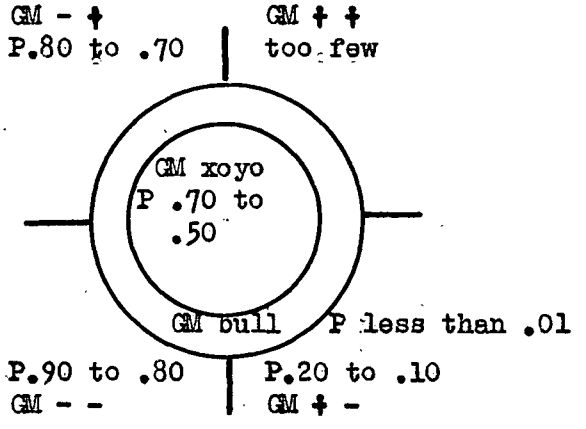


FIG. 17. Diagram indicating the significance of pressure changes between the firepoint and .6 seconds after the firepoint: Good Marksman Group.

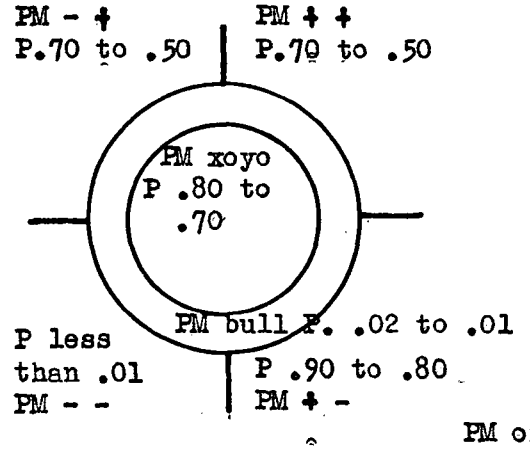


FIG. 18. Diagram indicating the significance of pressure changes between the firepoint and .6 seconds after the firepoint: Poor Marksman Group.

associated at the FP. Fig. 19.

(i) The results here indicate that there is no significant difference in this regard between GM xo, y -2 to -10 shots and GM - - shots (P .50 to .30) or GM + - shots (P .30 to .20).

(c) Comparison of PM xo, y +2 to +8, PM yo, x -2 to -8 and PM xo, y -2 to -10 shots with various areas on the targets with regard to the amount of pressure at the FP. Fig. 20. Results:

(i) There is no significant difference in the amount of pressure associated at the FP with PM - + shots and PM xo, y +2 to +8 shots (P .99 to .98).

(ii) There is no significant difference in the amount of pressure associated at the FP with PM - + shots and PM yo, x -2 to -8 shots (P .99 to .98).

(iii) There is no significant difference in the amount of pressure associated at the FP with PM - - shots and PM yo, x -2 to -8 shots (P .95 to .90).

(iv) There is no significant difference in the amount of pressure associated at the FP with PM - - shots and PM xo, y -8 to -10 shots (P .80).

(v) There is no significant difference in the amount of pressure associated at the FP with PM + - shots and PM xo, y -2 to -10 shots (P .98 to .95).

(vi) There is no significant difference in the amount of pressure associated at the FP with PM + + shots and PM xo, y +2 to +8 shots (P .98 to .95).

(d) Comparison of GM yo, x -2 to -8 and PM yo, x -2 to -8 shots; GM xo, y -2 to -10 shots and PM xo, y -2 to -10 shots. Fig. 21. This indicates that in both cases, (the former P .05 to .02 and the latter P .10 to .05) there is significantly more pressure associated with the GM shots.

(e) Comparison of pressure changes in the .6 second interval before firing and FP of Good Marksmen and Poor Marksmen's shots falling in the horizontal and vertical axes. Figs. 22 and 23. The results show that there are no significant pressure changes in the various areas.

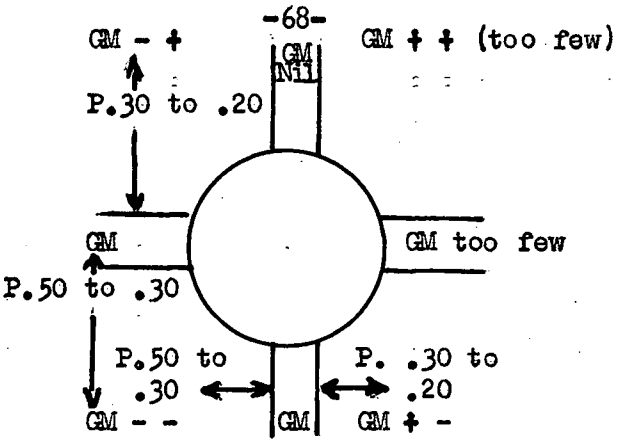


FIG. 19. Comparison of the vertical and horizontal shots in various target areas with regard to the amount of pressure at the firepoint: Good Marksman Group.

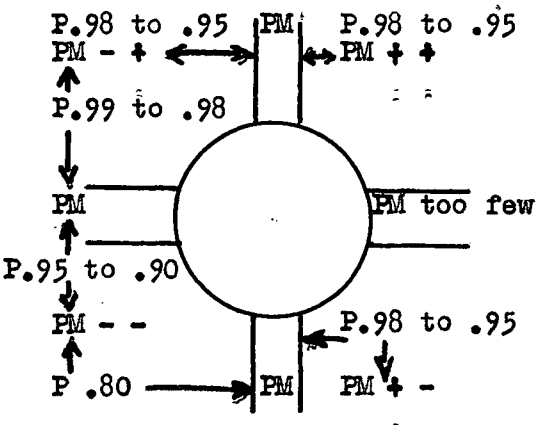


FIG. 20. Comparison of the vertical and horizontal shots in various target areas with regard to the amount of pressure at the firepoint: Poor Marksman Group.

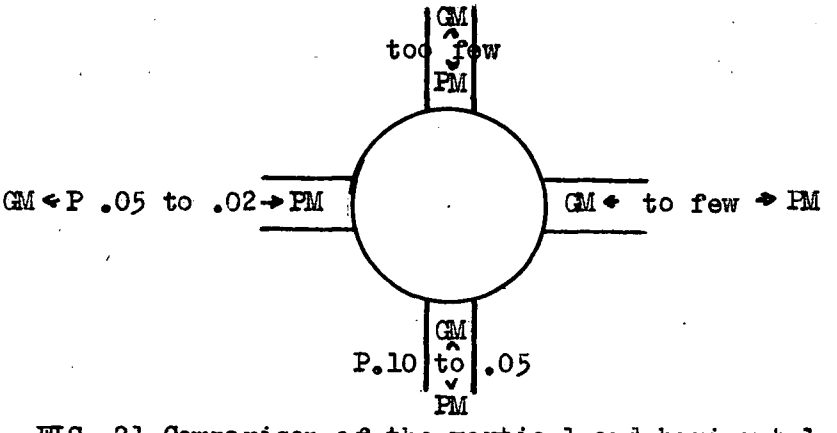


FIG. 21 Comparison of the vertical and horizontal shots fired by Good and Poor Marksmen with regard to the amount of pressure at the firepoint.

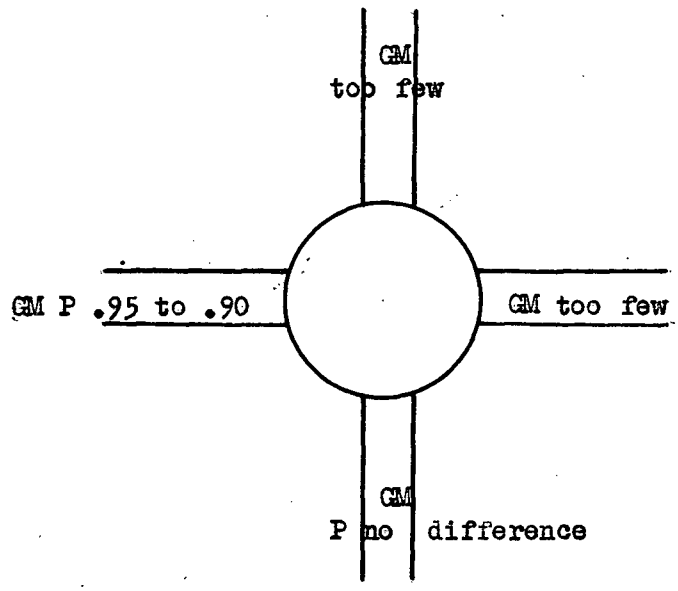


FIG. 22. Diagram indicating the significance of pressure changes between .6 seconds before the firepoint and the firepoint, associated with the vertical and horizontal shots: Good Marksman Group.

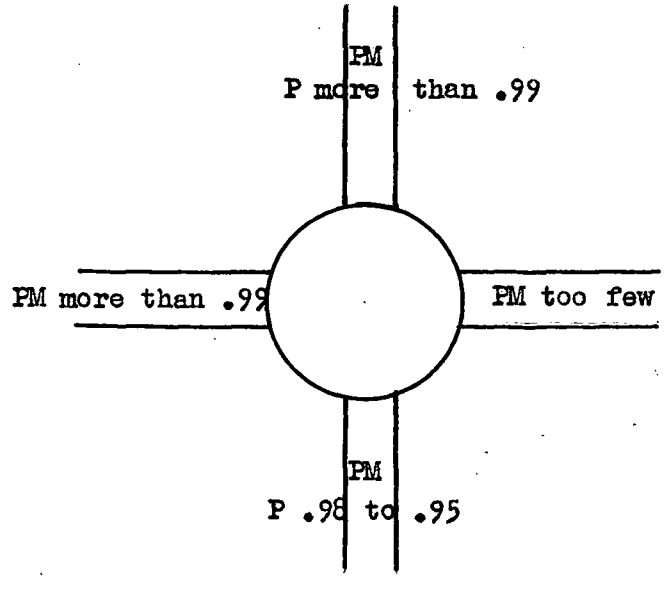


FIG 23. Diagram indicating the significance of pressure changes between .6 seconds before the firepoint and the firepoint, associated with the vertical and horizontal shots: Poor Marksman Group

(f) Comparison of the pressure changes at the FP and .6 seconds after firing of Poor Marksmen and Good Marksmen's shots falling in the horizontal and vertical axes. Figs. 24 and 25. The results indicate that there are no significant pressure changes in the areas.

Summary of pressure trends

The principal results may now be summarized in order that the primary and secondary pressure trends may be more conveniently related to corresponding respiratory and aiming time findings:

1. Despite the fact that in general, relatively little stock pressure was evidenced, it would appear to be significant that more pressure was associated with the Good Marksmen's shots in the high left (- +) and lower right (+ -) quarters of the target than with Poor Marksmen's shots in the same area. Also, it is apparent that in three areas of the target (+ +, - - and + -) less pressure was associated with the Poor Marksmen's shots than with the GM xoyo shots. On the other hand, neither the Good Marksmen's shots in the same areas nor the PM xoyo shots may be so distinguished.

2. Note should be made of the fact that neither the PM xoyo shots nor the GM xoyo shots can be distinguished from the Poor Marksmen's off-target shots by the amount of pressure exerted at the firing point.

3. The fact that there are no significant changes in the amount of pressure associated with any shots between .6 seconds before firing and the FP is noteworthy.

4. For later reference, it is important to note that both the GM bull and PM bull shots show a significant decrease in the amount of pressure associated with the shots immediately after firing. This same trend is shown in the PM - - shots.

5. Contrary to expectations, upon the basis of pressure alone, it is impossible to distinguish either lateral or vertical shots from shots falling in adjacent areas on the target.

In summary then, the foregoing

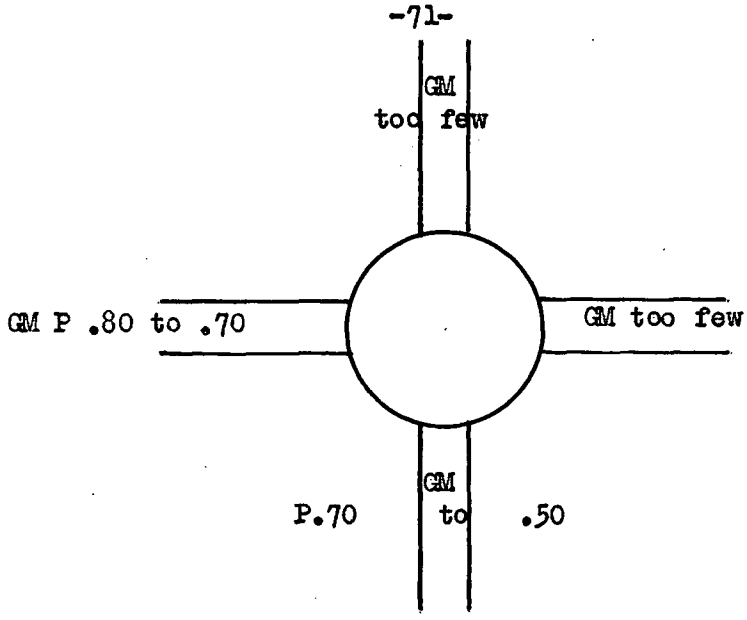


FIG. 24. Diagram indicating the significance of pressure changes between the firepoint and .6 seconds after the firepoint associated with the vertical and horizontal shots: Good Marksman Group.

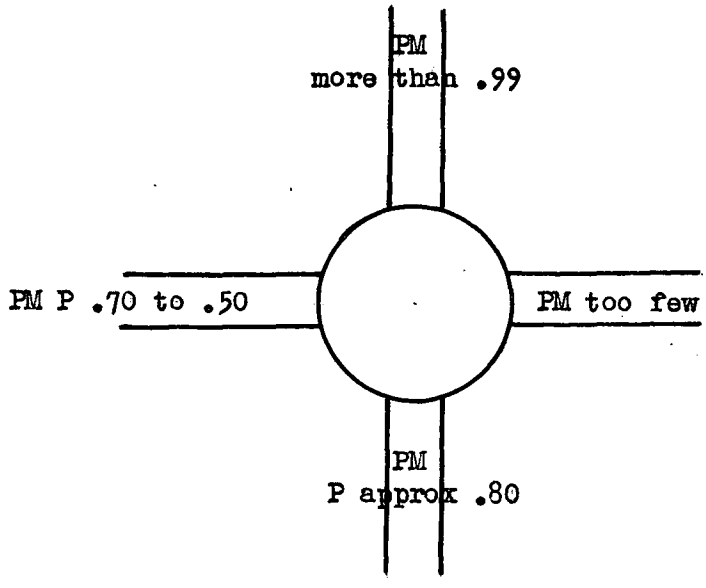


FIG. 25. Diagram indicating the significance of pressure changes between the firepoint and .6 seconds after the firepoint associated with the vertical and horizontal shots: Poor Marksman Group.

discussion would indicate that stock pressure alone is not a significant diagnostic factor for determining the position of a shot on the target when a rifle with a .22 bore is used. The secondary trends indicate that if the aim is on the bull and there is a sudden release of pressure immediately on firing, the shot may be deflected from the centre slightly, but not necessarily out of the bullseye. However, this conclusion is not clear cut since shots fired by Poor Marksmen falling in the lower left quarter show a similar trend. Yet, the direction of all the shots here is similar, i.e. both Groups' bullseye shots are grouped in the lower left corner of the bull to some extent. This would indicate that it is the respiratory plus the pressure trend in the case of the PM - - shots that accounts for their wider divergence from the bull.

Concluding this discussion then, there are three important points that can be made:

1. The "vice-like grip" rule recommended by the training manuals is not observed by the Good Marksmen when firing a service rifle with a .22 bore. This finding is in agreement with the conclusion arrived at by the ORG report No. 8/49 (19).

2. Neither shots fired by Good Marksmen nor shots fired by Poor Marksmen, whether they be good or poor, can be accounted for in terms of either the amount of pressure exerted at the FP or to any changes in the amount of pressure exerted immediately before or after firing.

3. Whether a shot falls in the bullseye, off the target, or in any of the other specified areas on the target, would not appear to be significantly dependent upon whether or not stock pressure is associated with it.

Incidental Observations

In this section will be considered

briefly some less formal observations of the Subject's performance made by the E during the experiment. To a large extent, these observations are less accurate in that they were less adequately controlled than the foregoing observations. However, it was considered advisable to include these data since they may, first of all, be suggestive of further areas of research in marksmanship and secondly, they may facilitate the adequate integration of the previously discussed findings. In this connection then, the first problem to be discussed is that of position.

Unfortunately, the procedures here made it almost impossible to assess accurately the positions assumed by the Subjects while firing owing mainly to the limited time available for dealing with each S. As noted earlier, each S had to report for three consecutive days and in order the E might be assured that they would do so, he was forced to schedule the time so that a minimum of delay in each Subject's appointment was incurred. Yet, under these less desirable conditions, the E was able to note the general prone position assumed by each S as he fired each shot and also note any shifts or changes in position made by each S as he fired.

An examination of the individual records revealed the following points with regard to position of each group:

1. Concerning the Good Marksmen's positions, the following points are noteworthy:

   (a) All but three of this Group assumed a firing position that was essentially the position recommended by the training manuals.

(b) The three Subjects who did not conform all assumed a position as follows: Their position was such that their bodies were at 90 degrees to the target and directly in line with it, their legs together and their toes down. The general elevation was noted at the time of firing as being somewhat higher than that of the remainder of their group, due to the fact, probably, that their elbows were placed closer to their body. These three Subjects were numbers 8, 9 and 15. Their average total scores were 49.7, 49.5 and 49.1 respectively which ranged them approximately third, fourth and seventh in the group.

(c) There was but one S in this group that was left-handed. His position was that recommended by the training manuals, but at an angle opposite to that assumed by the right-handed Subjects. This is understandable since it permitted the S to avoid firing across his body. This S was number 18, his average total score was 49.8, placing him second only to the best marksman in the group.

(d) Finally, it should be mentioned that there was no shifting in position or any other indications of strain or awkwardness of position noted in this group. It appeared that the Subjects in this group were able to maintain a relatively stable and steady position throughout.

2. Concerning the Poor Marksmen's position, the following points should be noted:

(a) In all but five Subjects of this group of 21 individuals, notes were made at the time of firing that indicated much shifting and adjusting of the initial position assumed.

(b) Only 8 members of this group took up a position similar to that recommended by the training manual and three of these 8 individuals showed indications, noted at the time as shifting, and other minor adjustments of position.

(c) The remainder of the group took up positions at right angles to the target -- legs together, toes pointed down. One of these individuals (S 20) crossed his legs and a second (S 16) bent his right knee.

(d) Four members of this group were left handed. These were S 1, S 3, S 4 and S 20. S 4 took up a position almost straight on the target but of such a nature that forced him to fire across his body. S 1, with an average total score of 45.1 was the best shot of the Poor Marksman Group. (Table 2).

From the foregoing discussion, it can be seen that little conclusive evidence for or against the prone firing position recommended by the Service training manuals can be inferred from these results. However, there is some indication that for most individuals, the recommended position is the more stable one and as such, is an aid in good shooting. Again this would likely be a decisive factor if an individual fired a .303 rifle.

The fact that four of the Poor Marksmen were left-handed might be indicative. Still, it should be kept in mind that in each of these cases the firing position was not the one ordinarily recommended but rather the position characteristic of the Poor Marksman Group as a whole and marked by shifting and minor adjustments indicative of muscular strain and tension. When this, and the fact that one of the Good Marksmen was also left-handed but tookup the recommended position with no shifting, though at an angle opposite to that of the right-handed Subjects and so avoided shooting across his body, is taken into account, it would appear that left-handedness per se is not an insurmountable obstacle to good shooting.

A second problem concerning the cooperation of the Subjects should be noted. This is to the effect that, contrary to expectations, though in general all the Subjects were remarkably cooperative, it was the group of Subjects not associated with any of the University Armed Services' Groups that was the most cooperative and punctual during the experiment. This is especially important since all Subjects were volunteers. This point is made here primarily as

further evidence of good motivation on the part of the Poor Marksmen since the vast majority of the Poor Marksmen were untrained and not associated with the campus Service Groups.

The explanation for this state of affairs is probably that the performance required was more of a novelty to the non-service people and therefore, was able to sustain their interest to a greater extent than it was for the Service people who probably volunteered primarily out of curiosity and then, finding that the investigation was a non-dramatic affair, continued their part in the experiment, either because they felt obliged to do so, or to take advantage of the opportunity to fire free ammunition.

In concluding this discussion, it is suggested first of all that there has been further evidence presented to support the assumption that the Poor Marksmen were well motivated, an assumption of great importance in any attempt at assessing their performance. Secondly, there has been presented some data which indicate that a stable firing position is essential for good shooting and that there is no evidence that the firing position recommended by the training manuals is not such a position. However, as the records indicate, both good and poor shots can be fired from the recommended position and also from other positions as noted above. Thus, the main factor here would seem to be stability of position rather than any stereotyped position. That is, conceivably various individualsmay find a variety of positions more comfortable for shooting and to the extent

that these positions are more comfortable, presumably they would require less shifting and so in turn would be stable.

Finally, there is no conclusive evidence that left-handedness is an insurmountable obstacle to good shooting. However, in these cases it does appear to be somewhat awkward and the main obstacle to be overcome is position. In this regard, note has been made of the solution adopted by one Good Marksman who was also left-handed.

CHAPTER V

CONCLUSION AND FINAL SUMMARY OF THE MAJOR FINDINGS

Because the various results were discussed in detail in the previous chapter, all that remains now is to draw together some of the more important trends in summary form so that the various influences may be seen more easily. This chapter then should serve two purposes. First of all, it should suggest possible applications of the findingsand more importantly, it should point out areas for further research with regard to the factors in marksmanship.

This first problem to be dealt with is that of describing the possible trends in respiration, pressure, aiming time and position that this study indicated as important factors in determining where the shots would fall on the target. In an attempt to deal with this problem, the two extreme cases (bullseye and the off-target shots) will be presented in detail.

A description of the trends associated with shots falling in the bullseye area in terms of the major factor studied

The median aiming times of the Good Marksman Group for shots falling in the bullseye area were 16.8 seconds for a bullseye and 16 seconds for a dead-on shot. It is suggested that these are the optimal aiming times. This is a considerably longer interval than that recommended by the official Army handbook "Shoot to Live" (see page 9). This handbook suggests 10 seconds as the optimal time. It should be noted here that although some of the Poor Marksmen's shots fell in the bullseye area, the aiming times associated with the Poor Marksmen's bull shots were characteristic of the shots fired by Poor Marksmen out of the bull rather than those in the bull fired by Good Marksmen.

This study indicates that in order to facilitate accurate shooting, the rifleman should hold his breath throughout the aiming period and he should continue to hold his breath ("follow through") for some seconds after firing. Once more it should be noted that this finding differs somewhat from recommended procedure with regard to respiration.

This study also suggests that in order to hit the bullseye the shot need not be associated with stock pressure. It points out, however, that if stock pressure is applied, it should be maintained for at least .6 seconds after firing. If the pressure is not maintained, there is a tendency for the shot to be deflected from the centre of the bull to the lower left corner of the bull. However, if

the respiratory pattern on firing is that the the GM bull shots and not that of the PM - - shots, then according to the present finding, one would not expect that the change in pressure would result in any further deflection than that mentioned above.

It will be noted once more that these findings tend to be contrary to standard practice and, as mentioned earlier, tend to substantiate the findings of the ORG Report quoted.

Finally, this study does indicate that the firing position recommended by the training manuals is probably the most stable position for most riflemen and is therefore to be recommended as a prerequisite to good shooting.

A description of the trends associated with shots falling off the target in terms of the major factors studied

In this study it happened that most off-target shots fell low and to the right. The median aiming time was 9.5 seconds. Of interest in this connection is the fact that the median aiming time of the PM + - shots was 12 seconds and for the GM + - shots, 19 seconds. In this latter case, it will be noted (Figs. 5 and 6) that this extended aiming period is probably the factor distinguishing these shots from the GM bull shots. However, in the case in question, it will be noted that this aiming time is almost identical to that recommended by the training manual, yet the shortest median time associated with any shots in this study.

In terms of stock pressure, these shots are indistinguishable from the bullseye shots fired by either group.

The respiratory pattern for the off-target shots is as follows:

(a) Exhaling in the interval ranging from 7.8 seconds to 6 seconds before firing.

(b) This is followed by held breath, then a break, then held breath once more from 2.4 seconds before the fire point up to the fire point.

(c) Special note should be made that there is no "follow-through" in respect to respiration indicated here. That is, breathing occurs immediately on firing.

The firing position of the marksmen firing off-target shots is the one characteristic of the Poor Marksman Group, namely, the body straight on the target, legs together, toes down and characterized by shifting.

The values and limitations of the miniature range as a technique for training marksmen.

Reference to pages 13 and 14 will present in summary form, the two major views in this regard -- one recommending the use of the miniature range and the other not recommending it.

It can be seen at once that the findings of the study agree most closely with the recommendations of the ORG Report No. 8/49. If it can be granted that the method of measuring stock pressure in this study is adequate for assessing the frequency of occurrence of the "vice-like grip" recommended by the training manuals, then this study presents evidence confirming the ORG Report's statement that "He (the rifleman) does not hold it (the rifle) firmly" when the rifle being fired has a .22 bore.

In addition, if this study's results are

any criterian of performance by individuals trained to shoot in the Service manner, then the results confirm the same Report's statement that "He does not have to apply in practice what he is taught."

This study suggests one further important point. The results question the validity of the Service training methods when a Service rifle with a .22 bore is used. It may be true that the procedures taught with regard to the factors here are the correct procedures for firing a .303, but this study provides little evidence that these procedures are valid for instruction when an individual is shooting a .22.

Limitations of the study

Up to this point, the stress has been upon the possible values of this study. Now in order to complete the picture and to suggest possibilities for further research, some of the limitations of this investigation will be considered.

It will be recalled that in the Introduction several factors other than those considered in this study are stressed by the training manuals. These factors are "aiming and trigger control." It is true that several precautions and controls were observed in this study in an attempt to insure accurate aiming, and that certain of the results indicate that these precautions were observed. Still, a study of aiming tendencies, ie., movements of the barrel, might be of value. However, it may well prove to be the case that what is usually termed "aiming" will be found to be in reality the coordination of the other factors. This suggestion is in a sense supported by the

various studies reported in the Introduction which indicate that exceptional vision is not characteristic of good marksmen. The influence of "trigger control" was not assessed in this study. Despite the negative results reported by Banister, it is felt that this factor could be profitably investigated mainly because of the stress placed upon it in the training manuals.

Again, although some data on "position" are reported in this study, the factor was not as systematically investigated as it might have been. Finally, although the training manuals stress the function of the left hand as being solely one of support and stress that the right hand is to be the master hand, it might be profitable to investigate exactly what use is being made of the "supporting" hand while firing. This suggestion arises from the fact that although the shots falling above and below the bull seem to be reasonably well accounted for in terms of aiming time and respiration, it still remains to account for most of the shots falling to the left and to the right of the bull since stock pressure, originally believedto be of significance in this regard, has been shown by this study to be relatively unimportant except in two cases, i.e. PM bull and GM bull shots.

This study has been primarily concerned with group tendencies and therefore any recommendations with regard to the individual case must remain tentative until tested. However, the method of analysis carried out in this study is essentially the same approach used in psychometrics where the attempt is made to characterize

the typical case. For instance, Strong in Super (18), from an analysis of the interests of successful men in a given occupation, assessed the inventoried interests of the individual in terms of how closely his interests resemble those of the successful men in question. The rationale here is essentially the same.

Undoubtedly there are individual differences, but just as Super suggests that the chances of the individual being happy in an occupation are greater the closer his interests resemble the interests of a particular group, so in this study, it is suggested, in effect, that aperson has a better chance to hit the bullseye if the trends accompanying his shots resemble those accompanying the bullseye shots fired by the Good Marksmen.

It is recognized that a case can be made for questioning the usefulness of any average profile in dealing with the individual, yet the fact remains that psychometric testing has been found useful in individual counselling and until the suggestions made here are tried out, there is no reason to assume that they may not be useful in training marksmen.

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APPENDIX

A

THE CRITICAL RATIOS FOR THE INTERVALS CONSIDERED WITH REGARD TO THE NUMBER OF SHOTS ASSOCIATED WITH HELD BREATH

Interval	Percent of Poor Shots	Percent of Good Shots	Critical Ratio
9.6 sec.	39.6	49.3	3.03
7.8	35.7	57.4	7.1
6.0	40.5	61.6	6.8
4.2	47.0	76.6	10.2
2.4	74.5	90.7	7.0
1.8	79.5	92.2	6.05
1.2	81.9	94.7	6.7
.6	85.2	95.5	5.7
0.0 sec.	FIRE POINT		
.6	45.0	64.3	6.4
1.2	33.3	49.7	5.43
1.8	41.8	51.7	3.16
2.4	43.5	52.1	2.77
3.0	45.2	57.9	5.38
3.6	47.3	54.9	2.45
4.2	54.3	56.8	.806
4.8	44.8	61.2	5.52

APPENDIX

B

X^2 AND P VALUES FOR THE RESPIRATION TRENDS
GOOD MARKSMEN

Interval	xoyo shots X^2	xoyo shots P	xoyo shots Trend	bull shots X^2	bull shots P	bull shots Trend
16.8 sec.	11.6722	less than .01	Hold	12.4494	less than .01	Hold
15.0	11.851	less than .01	Hold	18.4459	less than .01	Hold
13.2	9.2905	less than .01	Hold	10.3146	less than .01	Hold
11.4	8.8515	.02 to .01	Hold	20.5793	less than .01	Hold
9.6	4.26	.20 to .10	Hold	24.7322	less than .01	Hold
7.8	21.92	less than .01	Hold	74.1859	less than .01	Hold
6.0	27.48	less than .01	Hold	105.5906	less than .01	Hold
4.2	58.78	less than .01	Hold	247.6851	less than .01	Hold
2.4	104.44	less than .01	Hold	432.4615	less than .01	Hold
1.8	99.77	less than .01	Hold	453.7603	less than .01	Hold
1.2	115.04	less than .01	Hold	481.6554	less than .01	Hold
0.6	115.4	less than .01	Hold	509.3270	less than .01	Hold
0.0 sec	- FIRE POINT -					
0.6	21.477	less than .01	Hold	150.9625	less than .01	Hold
1.2	14.173	less than .01	Hold	47.1727	less than .01	Hold
1.8	13.651	less than .01	Hold	48.1762	less than .01	Hold
2.4	10.784	less than .01	Hold	43.2430	less than .01	Hold
3.0	26.17	less than .01	Hold	69.1221	less than .01	Hold
3.6	23.383	less than .01	Hold	67.6698	less than .01	Hold
4.2	14.17	less than .01	Hold	69.1221	less than .01	Hold
4.8	21.917	less than .01	Hold	112.2521	less than .01	Hold

df = 2

X^2 AND P VALUES FOR THE RESPIRATION TRENDS
(CONTINUED)
GOOD MARKSMEN

Interval	- - Shots X^2	P	Trend	+ - Shots X^2	P	Trend
16.8 sec.	3.00	.90 to .80	Hold	9.5247	less than .01	Hold
15.0	7.00	approx. .70	Hold	0.5381	.80 to .70	Exhale
13.2	5.75	approx. .05	Hold	1.4608	.50 to .30	Hold
11.4	4.75	.10	Hold	4.6665	.10	Hold
9.6	7.75	.02	Hold	11.5555	less than .01	Hold
7.8	12.00	less than .01	Hold	11.5555	less than .01	Hold
6.0	10.75	less than .01	Hold	24.2221	less than .01	Hold
4.2	15.75	less than .01	Hold	38.00	less than .01	Hold
2.4	32.25	less than .01	Hold	42.6666	less than .01	Hold
1.8	48.00	less than .01	Hold	48.2222	less than .01	Hold
1.2	48.00	less than .01	Hold	54.00	less than .01	Hold
0.6	48.00	less than .01	Hold	48.2222	less than .01	Hold
0.0 sec.	- FIRE POINT -					
0.6	10.75	less than .01	Hold	20.6665	less than .01	Hold
1.2	4.75	.10	Hold	4.6665	.10	Hold
1.8	13.00	less than .01	Hold	0.6666	approx. .70	Hold
2.4	9.25	less than .01	Hold	10.8888	less than .01	Hold
3.0	9.25	less than .01	Hold	6.00	.05	Hold
3.6	4.00	.20 to .10	Hold	8.6665	.02 to .01	Hold
4.2	12.125	less than .01	Hold	8.00	.02	Hold
4.8	15.25	less than .01	Hold	13.5554	less than .01	Hold

df = 2

X^2 AND P VALUES FOR THE RESPIRATION TRENDS
(CONTINUED)
GOOD MARKSMEN

	- + shots			xo, y -2 to -10 shots		
Interval	X^2	P	Trend	X^2	P	Trend
16.8 sec.	.5002	approx. .80	Exhale-Inhale	2.8	.30 to .20	Inhale
15.0	4.6277	.10	Hold	2.8	.30 to .20	Exhale
13.2	.1250	.95 to .90	Exhale	1.6	.50 to .30	Inhale
11.4	.1250	.95 to .90	Hold	3.6	.20 to .10	Hold
9.6	7.6297	.05 to .02	Hold	1.2	.50	Hold-Inhale
7.8	3.1268	approx. .20	Hold-Exhale	11.2	less than .01	Hold
6.0	2.0011	.50 to .30	Hold	5.2	.10 to .05	Hold
4.2	9.8810	less than .01	Hold	19.6	less than .01	Hold
2.4	9.1305	.02 to .01	Hold	30.0	less than .01	Hold
1.8	21.5133	less than .01	Hold	24.4	less than .01	Hold
1.2	17.3858	less than .01	Hold	30.0	less than .01	Hold
0.6	16.6353	less than .01	Hold	30.0	less than .01	Hold
0.0 sec.	- FIRE POINT -					
0.6	.5002	approx .80	Hold-Inhale	6.0	.05	Hold
1.2	2.3764	.30	Inhale	2.8	.30 to .20	Hold
1.8	6.1287	less than .05	Hold	3.6	.20 to .10	Hold
2.4	2.6878	.30 to .20	Hold	5.2	.10 to .05	Hold
3.0	1.6259	.50 to .30	Hold	5.2	.10 to .05	Hold
3.6	6.5039	less than .05	Hold	7.6	.05 to .02	Hold
4.2	4.6277	.10	Hold	2.8	.30 to .20	Hold
4.8	3.8772	.20 to .10	Hold	1.2	.50	Hold

df = 2

X^2 AND P VALUES FOR THE RESPIRATORY TRENDS
(CONTINUED)
GOOD MARKSMEN

x -2 to -8, yo shots

Interval	X^2	P	Trend
16.8 sec.	7.6882	approx. .02	Hold
15.0	3.6981	.20 to .10	Hold
13.2	3.0984	.30 to .20	Hold
11.4	3.4285	.20	Hold
9.6	7.9999	.02	Hold
7.8	3.7142	.20 to .10	Hold
6.0	10.5714	less than .01	Hold
4.2	7.7142	.02	Hold
2.4	17.4285	less than .01	Hold
1.8	25.9999	less than .01	Hold
1.2	30.8570	less than .01	Hold
0.6	26.5714	less than .01	Hold
0.0 sec.	- - - - - - - - - - - - - - - - - -	FIRE POINT	- -
0.6	5.9999	.05	Hold
1.2	0.8570	.70 to .50	Hold-Inhale
1.8	1.9999	.50 to .30	Hold
2.4	1.1428	.70 to .50	Hold
3.0	17.4285	less than .01	Hold
3.6	17.4285	less than .01	Hold
4.2	5.9999	.05	Hold
4.8	3.7142	.20 to .10	Hold

df = 2

X^2 AND P VALUES FOR THE RESPIRATION TRENDS
POOR MARKSMEN

	xoyo shots			bull shots		
Interval	X^2	P	Trend	X^2	P	Trend
16.8 sec.	.3340	.90 to .80	Inhale	.3454	.90 to .80	Hold
15.0	3.6981	.20 to .10	Inhale	10.9809	less than .01	Hold
13.2	.8570	.70 to .50	Hold-Exhale	14.4835	less than .01	Hold
11.4	10.5714	less than .01	Hold	2.2681	approx. .30	Hold
9.6	.8570	.70 to .50	Hold-Exhale	7.2283	.05 to .02	Hold
7.8	1.9999	.50 to .30	Hold	2.1944	.50 to .30	Hold
6.0	.8570	.70 to .50	Hold-Inhale	.6908	approx. .70	Exhale
4.2	1.9999	.50 to .30	Hold	9.2558	less than .01	Hold
2.4	30.8570	less than .01	Hold	89.2134	less than .01	Hold
1.8	25.9999	less than .01	Hold	130.8380	less than .01	Hold
1.2	21.7142	less than .01	Hold	121.9716	less than .01	Hold
0.6	28.0000	less than .01	Hold	130.9432	less than .01	Hold
0.0 sec.	- FIRE POINT -					
0.6	2.5714	.30	Hold	4.3713	.10	Hold
1.2	5.9999	.05	Inhale	26.8826	less than .01	Inhale
1.8	5.9999	.05	Hold	4.5737	.10	Inhale
2.4	3.7142	.20 to .10	Hold	7.7692	.05 to .02	Hold
3.0	3.4285	.20 to .10	Hold-Exhale	8.0878	less than .02	Hold
3.6	3.4285	.20 to .10	Hold	5.3269	approx. .05	Hold
4.2	7.1428	.05 to .02	Hold	31.6609	less than .01	Hold
4.8	4.5714	.10	Hold	16.2107	less than .01	Hold

df = 2

X^2 AND P VALUES FOR THE RESPIRATION TRENDS (CONTINUED)

POOR MARKSMEN

Interval	- - shots X^2	P	Trend	+ - shots X^2	P	Trend
16.8 sec.	8.1930	.02 to .01	Hold	1.1251	.70 to .50	Hold
15.0	6.2753	.05 to .02	Inhale	2.0007	.50 to .30	Hold
13.2	13.95	less than .01	Hold	3.2038	.20	Hold
11.4	17.1253	less than .01	Hold	2.7522	.30 to .20	Hold
9.6	8.2486	.02 to .01	Hold	1.8235	.50 to .30	Hold
7.8	1.8017	.50 to .30	Exhale	8.1765	less than .02	Exhale
6.0	5.4715	.10 to .05	Hold	2.1765	.50 to .30	Hold
4.2	16.6790	less than .01	Hold	10.7674	less than .01	Hold
2.4	103.2153	less than .01	Hold	57.7058	less than .01	Hold
1.8	141.5488	less than .01	Hold	90.0588	less than .01	Hold
1.2	176.5998	less than .01	Hold	89.3529	less than .01	Hold
0.6	146.0616	less than .01	Hold	139.8235	less than .01	Hold
0.0 sec.	- -		FIRE POINT	- -		
0.6	6.8105	.05 to .02	Inhale	14.5294	less than .01	Hold
1.2	39.9372	less than .01	Inhale	38.6471	less than .01	Inhale
1.8	2.0002	.50 to .30	Hold-Inhale	11.5294	less than .01	Hold
2.4	5.9674	.05	Hold	18.1765	less than .01	Hold
3.0	7.0584	.05 to .02	Hold	68.5883	.05 to .02	Hold
3.6	12.7614	less than .01	Hold	18.5882	less than .01	Hold
4.2	5.6699	.10 to .05	Hold	26.3530	less than .01	Hold
4.8	5.9674	.05	Hold	11.5294	less than .01	Hold

df = 2

X^2 AND P VALUES FOR THE RESPIRATION TRENDS (CONTINUED)

POOR MARKSMEN

	- + shots			+ + shots		
Interval	X^2	P	Trend	X^2	P	Trend
16.8 sec.	3.6465	.20 to .10	Hold	4.3796	.20 to .10	Hold
15.0	2.6579	.30 to .20	Hold	3.3750	.20	Hold-Inhale
13.2	6.7878	less than .05	Hold	2.3750	.30	Hold
11.4	1.3427	.50	Hold	7.0219	.05 to .02	Hold
9.6	2.9456	.30 to .20	Hold	2.0004	.50 to .30	Hold
7.8	3.7563	.20 to .10	Hold	.2858	.90 to .80	Exhale
6.0	8.9600	less than .02	Hold	1.7555	.50 to .30	Inhale
4.2	14.4800	less than .01	Hold	3.9416	.20 to .10	Hold
2.4	73.6800	less than .01	Hold	39.2324	less than .01	Hold
1.8	77.8400	less than .01	Hold	51.4799	less than .01	Hold
1.2	77.7600	less than .01	Hold	60.5429	less than .01	Hold
0.6	75.1200	less than .01	Hold	62.0126	less than .01	Hold
0.0 sec.						
0.6	2.9600	.20 to .10	Hold	2.1229	.50 to .30	Hold
1.2	8.6400	less than .02	Inhale-Hold	13.5130	less than .01	Inhale
1.8	2.2400	approx. .30	Hold	12.7783	less than .01	Hold
2.4	13.0400	less than .01	Hold	5.4297	.10 to .05	Exhale
3.0	4.1600	.20 to .10	Hold	2.7353	.30 to .20	Hold
3.6	5.0400	.10 to .05	Hold	2.7353	.30 to .20	Inhale
4.2	32.7200	less than .01	Hold	8.1670	.02 to .01	Hold
4.8	8.6400	less than .02	Hold.	7.3892	.05 to .02	Hold

df = 2

X^2 AND P VALUES FOR THE RESPIRATION TRENDS
(CONTINUED)
POOR MARKSMEN

	off-target shots			xo, y + 2 to + 8 shots		
Interval	X^2	P	Trend	X^2	P	Trend
16.8 sec.	2.4339	.30	Hold	1.6303	.50 to .30	Exhale
15.0	.6083	.80 to .70	Hold	1.8999	.50 to .30	Inhale
13.2	1.75	.50 to .30	Inhale	5.6056	.10 to .05	Exhale
11.4	.25	approx. .90	Exhale	.8008	.70 to .50	Hold-Inhale
9.6	.75	approx. .70	Inhale	1.2714	approx. .50	Hold
7.8	6.125	.05 to .02	Exhale	5.0861	.10 to .05	Inhale
6.0	6.25	.05 to .02	Hold	1.2714	approx. .50	Exhale
4.2	4.0	.20 to .10	Hold	.7265	.70	Hold
2.4	12.25	less than .01	Hold	7.8109	.02	Hold
1.8	7.75	approx. .02	Hold	11.6256	less than .01	Hold
1.2	15.25	less than .01	Hold	7.8109	.02	Hold
0.6	15.25	less than .01	Hold	12.1707	less than .01	Hold
0.0	- FIRE POINT -					
0.6	.750	approx. .70	Hold	4.5412	.10	Hold
1.2	1.0	.70 to .50	Hold	1.2714	approx. .50	Hold
1.8	.750	approx. .70	Inhale	1.2714	approx. .50	Hold
2.4	1.75	.50 to .30	Inhale	2.3614	.30	Hold
3.0	12.25	less than .01	Hold	5.0861	.10 to .05	Hold
3.6	1.75	.50 to .30	Hold	1.2714	approx. .50	Hold
4.2	9.0	approx. .01	Hold	1.2714	approx. .50	Hold
4.8	2.25	.50 to .30	Hold	2.3614	.30	Exhale

df = 2

X^2 AND P VALUES FOR THE RESPIRATION TRENDS
(CONTINUED)
POOR MARKSMEN.

	xo, y-2 to -10 shots			yo, x -2 to -8 shots		
Interval	X^2	P	Trend	X^2	P	Trend
16.8 sec.	.5000	.80	Hold	.9288	.70 to .50	Hold
15.0	1.1430	.70 to .50	Hold	5.2160	.10 to .05	Hold
13.2	2.9644	.30 to .20	Inhale	2.6437	.30 to .20	Hold
11.4	2.4000	.30	Exhale-Hold	.0713	.98 to .95	Inhale
9.6	1.2261	.70 to .50	Hold	2.1371	.50 to .30	Inhale
7.8	.0645	.99 to .98	Exhale	.4825	approx. .80	Hold
6.0	2.6867	.30 to .20	Hold	1.9303	.50 to .30	Hold
4.2	6.8104	.05 to .02	Hold	.8962	.70 to .50	Hold
2.4	21.8057	less than .01	Hold	20.1309	less than .01	Hold
1.8	21.4273	less than .01	Hold	19.9241	less than .01	Hold
1.2	33.0522	less than .01	Hold	20.7513	less than .01	Hold
0.6	37.5508	less than .01	Hold	37.2974	less than .01	Hold
0.0-	- FIRE POINT -					
0.6	8.3100	.02 to .01	Inhale	1.3098	approx. .50	Hold
1.2	12.4336	less than .01	Inhale	10.8237	less than .01	Inhale
1.8	1.7495	.50 to .30	Hold	2.1371	.50 to .30	Hold
2.4	.8123	.70 to .50	Exhale	4.6190	.10	Exhale
3.0	4.1862	.20 to .10	Hold	6.2736	less than .05	Exhale
3.6	4.1862	.20 to .10	Hold	.2757	.95 to .80	Hold
4.2	2.6867	.30 to .20	Hold	2.5507	.30 to .20	Hold
4.8	3.0615	.30 to .20	Exhale-Hold	2.5507	.30 to .20	Exhale

df = 2

APPENDIX

C

X^2 AND P VALUES FOR THE STOCK PRESSURE TRENDS

df = 6

Figure	Area	X^2	P
8	GM xoyo and GM - +	8.8963	less than .20
	GM xoyo and GM + =	8.5354	approx. .20
	GM xoyo and GM = -	4.065	.70 to .50
9	GM xoyo and PM + -	27.8388	less than .01
	GM xoyo and PM + +	12.9192	.05 to .02
	GM xoyo and PM = +	1.7358	.95 to .90
	GM xoyo and PM - =	12.48	approx. .05
10	PM xoyo and PM - -	.9843	more than .99
	PM xoyo and PM - +	4.2014	.70 to .50
	PM xoyo and PM + -	10.6894	.10
	PM xoyo and PM + +	3.3602	.80 to .70
11	PM xoyo and GM + -	4.3852	.70 to .50
	PM xoyo and GM = +	2.1347	.95 to .90
	PM xoyo and GM - =	.0574	more than .99
12	GM xoyo and PM xoyo	1.9507	.95 to .90
	GM bull and GM xoyo	1.6178	approx. .95
	PM bull and PM xoyo	4.2034	.70 to .50
	PM bull and GM xoyo	15.1180	.02
	GM bull and PM bull	20.4320	less than .01
	PM xoyo and GM bull	2.1176	.95 to .90
13	GM xoyo and PM off	7.5710	.30 to .20
	PM xoyo and PM off	5.1033	.70 to .50

X^2 AND P VALUES FOR THE STOCK PRESSURE TRENDS df = 6

Figure	Area	X^2	P
14	GM -- and PM --	3.9833	.70 to .50
	GM -+ and PM -+	17.0077	less than .01
	GM +- and PM +-	39.6329	less than .01
15	GM xoyo	1.3603	.98 to .95
	GM bull	5.5694	.50 to .30
	GM - -	.3589	more than .99
	GM + -	4.1826	.70 to .50
	GM - +	4.04	.70 to .50
16	PM xoyo	1.9238	.95 to .90
	PM bull	2.1254	.95 to .90
	PM - -	3.8731	approx. .70
	PM + -	4.0051	.70 to .50
	PM - +	1.0072	.99 to .98
	PM + +	7.2747	approx. .30
	PM off	2.0869	.95 to .90
17	GM xoyo	5.3240	.70 to .50
	GM bull	28.3140	less than .01
	GM - +	3.20	.80 to .70
	GM + -	9.5555	.20 to .10
	GM - -	2.5528	.90 to .80
18	PM xoyo	3.6836	.80 to .70
	PM bull	15.5087	.02 to .01
	PM - +	5.1748	.70 to .50
	PM + +	4.2186	.70 to .50
	PM - -	26.6422	less than .01
	PM + -	2.6871	.90 to .80
	PM off	2.0869	.95 to .90

X^2 AND P VALUES FOR THE STOCK PRESSURE TRENDS — df = 6

Figure	Area	X^2	P
19	GM + - and GM xo, y -2 to -10	8.2665	.30 to .20
	GM - + and GM yo, x -2 to -8	7.4174	.30 to .20
	GM - - and GM xo, y -2 to -10	6.8598	.50 to .30
	GM - - and GM yo, x -2 to -8	6.7038	.50 to .30
20	PM - - and PM xo, y-2 to -10	3.1779	approx. .80
	PM + - and PM xo, y -2 to -10	1.5800	.98 to .95
	PM - - and PM yo, x -2 to -8	1.6681	.95 to .90
	PM - + and PM yo, x -2 to -8	.9733	.99 to .98
	PM - + and PM xo, y +2 to +8	.9460	.99 to .98
	PM + + and PM xo, y +2 to +8	1.4966	.98 to .95
21	PM yo, x -2 to -8 and GM yo, x -2 to -8	12.3229	.10 to .05
	PM xo, y -2 to -10 and GM xo, y -2 to -10	12.9498	.05 to .02
22	GM yo, x -2 to -8	1.7246	.95 to .90
	GM xo, y-2 to -10		more than .99
23	PM xo, y -2 to -10	1.3999	.98 to .95
	PM yo, x -2 to -8	.3529	more than .99
	PM xo, y +2 to +8		more than .99
24	GM yo, x -2 to -8	3.1349	.80 to .70
	GM xo, y -2 to -10	4.0606	.70 to .50
25	PM xo, y +2 to +8		more than .99
	PM xo, y -2 to -10	3.1475	approx. .80
	PM yo, x -2 to -8	4.2963	.70 to .50

APPENDIX

D

KEYSTONE VISUAL SURVEY TESTS

School Survey Cumulative Record Form No. 3

For Use with No. 46 Visual Survey Telebinocular

Name_____ Sex_____

Date_____ Teacher_____

Date of birth_____ (yr. mo. da.) C. Age_____ (year. mo.) M. Age_____ (yr. mo.) Grade_____

School_____ City_____

Address_____ Phone_____

Referred by _____

Approved by _____

Principal or_____

Wearing Glasses: Yes ___ No___

Snellen Standard (if desired)

With Glasses: Right____ Left____

Without Glasses: Right____ Left____

		Left Only	Right Only	Underconvergence and Low Usable Vision					Doubtful	EXPECTED	Doubtful	Overconvergence or High Usable Vision		
										2,3,4,10or11				
Set at Far Point	Test 1 (DB-10A) Simultaneous Vision (Far Point)													
	Test 2 (DB-8C) Vertical Imbalance (Far Point)	only	only											
	Test 3 (DB-9) Lateral Imbalance (Far Point)	only	15-14-13 - - 3-2-1 Numbers Only	15	14	13	12	11	10	9	8	7 6 5	4 3	2 1
	Test 4 (DB-4K) Fusion (Far Point)	only	only	Four, widely separated			Four, near each other		Four, then three		Four, then three	Four, near each other		Four, widely separated
	Test 5 (DB-3D) Right Eye, Usable Vision (Far Point)		No Dots Seen Unless Left Eye Is Occluded	1 T 50%	2 R 65%		3 L 84%	4 T 92%	5 B 96%	6 B 98% 7 L 100%	8 R 102%	9 T 103%		10 R 105%
	Test 6 (DB-2D) Left Eye, Usable Vision (Far Point)	No Dots Seen Unless Right Eye Is Occluded		1 B 50%	2 L 65%		3 R 84%	4 R 92%	5 T 96%	6 L 98% 7 B 100%	8 L 102%	9 R 103%		10 T 105%
	Test 7 (DB-6D) Stereopsis (Far Point)	+ only	only ●	1 +	2 ○	3 ✳	4 ○	5 □	6 □	7 ♡	8 +	9 ✳	10 + 11 ♡	12 ○
	Test 8 (DB-13) Instruction Only (Far Point)	1 I	2 C	3 Y	4 U	5 O	6 S	7 E	8 H	9 N	10 P	11 L	12 F	
Move to Near Point	Test 9 (DB-14) Color Perception (Far Point)	1 F	2 P	3 U	4 C	5 L	6 L	7 C	8 F	9 I	10 O	11 Y	12 C	ALL CORRECT
	Test 10 (DB-9B) Lateral Imbalance (Near Point)	only	12-11 - - - - 3-2-1 Numbers Only		10	9	8	7	6		5		4	3 2
	Test 11 (DB-5K) Fusion (Near Point)	only	only	Four, widely separated			Four, near each other		Four, then three		Four, then three	Four, near each other		Four, widely separated
	Test 12 (DB-16) Usable Vision—Right (Near Point)	1 D 10%	2 D 20%	3 L	4 D 30%	5 L	6 D 40%	7 D 50%	8 L	9 D 60%	10 L	11 D 70%	12 G	13 L 80%	14 L	15 D 90%	16 D 100%	17 G	18 D 102%	19 L	20 D 103%	21 D 105%	22 L
	Test 13 (DB-17) Usable Vision—Left (Near Point)	1 L	2 D 10%	3 D 20%	4 D 30%	5 L	6 D 40%	7 L	8 D 50%	9 D 60%	10 D 70%	11 L	12 L 80%	13 G	14 D 90%	15 L	16 D 100%	17 L	18 D 102%	19 L	20 G 103%	21 D 105%	22 L
	Test 14 (DB-15) Usable Vision—Both (Near Point)	1 D 10%	2 L	3 D 20%	4 D 30%	5 L	6 D 40%	7 D 50%	8 L	9 D 60%	10 D 70%	11 G	12 L 80%	13 L	14 D 90%	15 L	16 D 100%	17 L	18 D 102%	19 G	20 D 103%	21 D 105%	22 L

Complete directions for the administration of these tests will be found in the manual provided for this purpose.

The user should familiarize himself with the information given on the **backs of the cards.**

Pointing with a pencil or similar object will facilitate greatly the giving of most of these tests — and save time.

Interpretation of the Record Form. When all replies are checked in the "EXPECTED" column (set off by heavy lines) visual performance is considered to be satisfactory in so far as this test goes.

APPENDIX

E

RECORD FORM USED FOR READING FIIM

No.																						LENGTH	
TARGET No. Date:	1"	1"	1"	1"	1"	1"	1"	1"														COMMENTS	C-F	F-C
SHOT I																								
Shot I (lights)																								
SHOT II																								
Shot II (lights)																								
SHOT III																								
Shot III (lights)																								
SHOT IV																								
Shot Iv (lights)																								
SHOT V																								
Shot V (lights)																								

D.R.B. RIFLE PROJECT

DATE

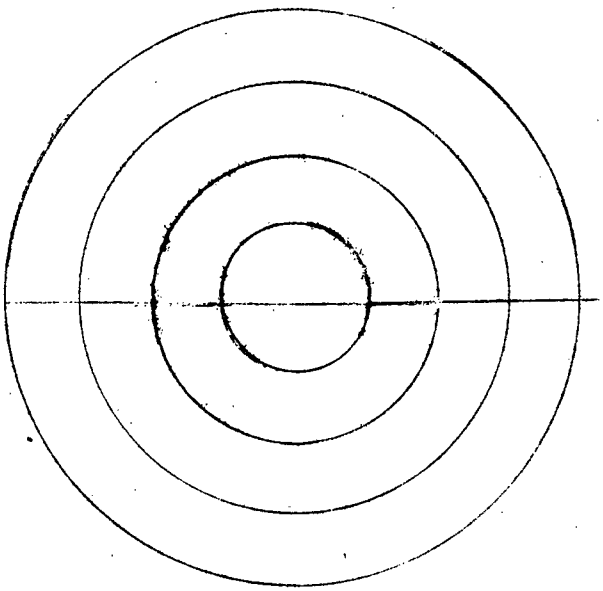
NAME		AGE
ADDRESS		PHONE

HEIGHT	WEIGHT	VISION

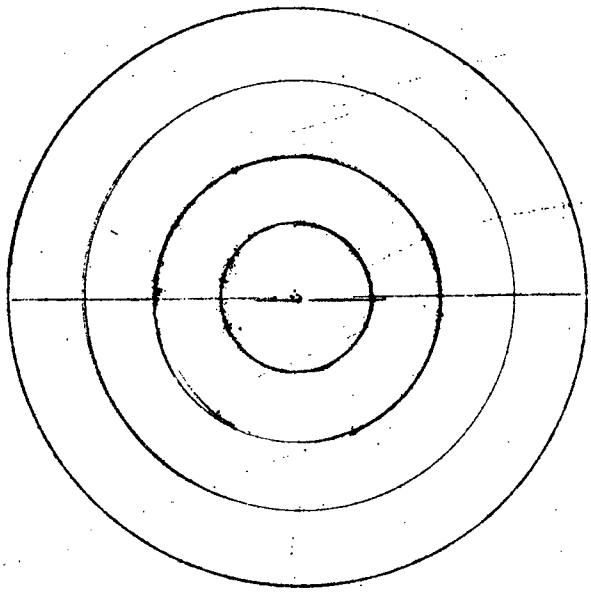
TARGET NO.				
ORTHODOX				
UNORTHODOX				
TIME				
POSITION				

D.R.B. RIFLE PROJECT

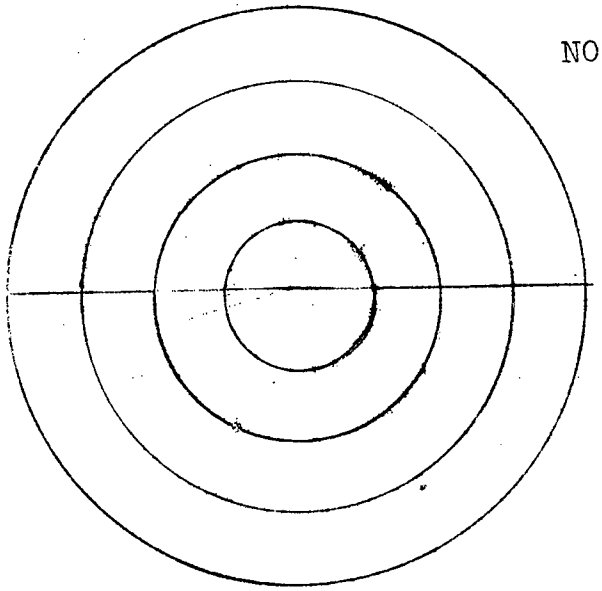
NAME _____ DATE _____



NO. _____



NO. _____



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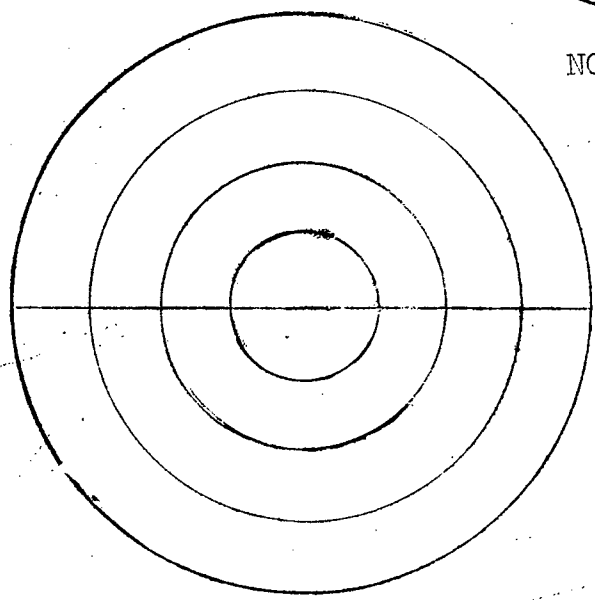

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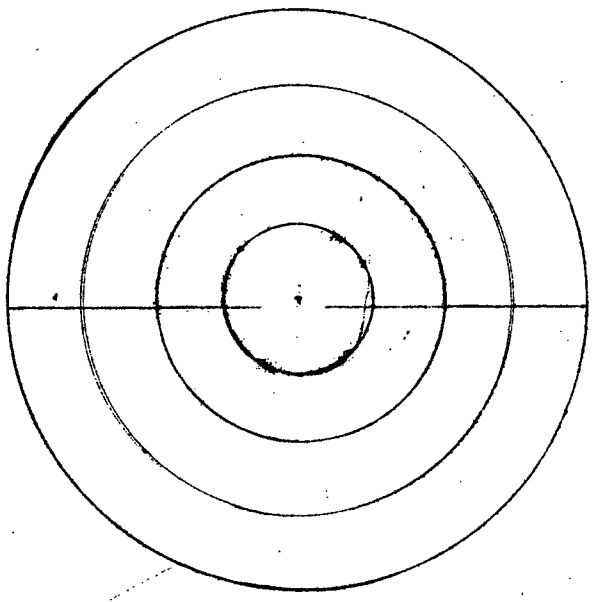

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APPENDIX
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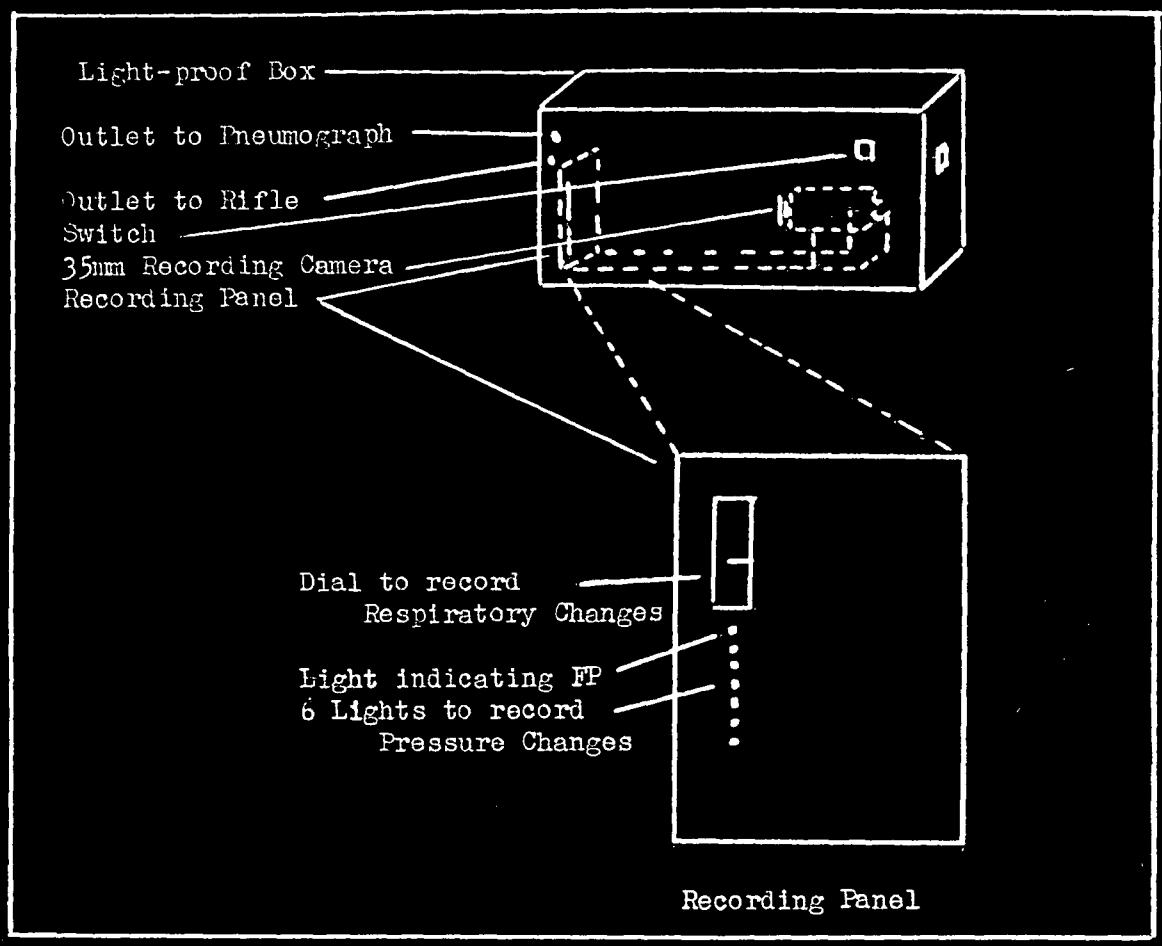

Outline diagram of the Recording Apparatus