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THE OBJECTIFICATION OF THE NAVY
STANDARD PHYSICAL FITNESS TEST
BY THE
CONSTRUCTION OF THE MECHANICAL AND
ELECTRICAL EQUIPMENT PERTAINING TO
THE PROBLEM

Submitted by
Joseph Masino

BOSTON UNIVERSITY
SCHOOL OF EDUCATION

THE OBJECTIFICATION OF THE NAVY STANDARD PHYSICAL FITNESS TEST BY THE CONSTRUCTION OF THE MECHANICAL AND ELECTRICAL EQUIPMENT PERTAINING TO THE PROBLEM

Submitted by

Joseph Masino

(B. P. E., American College, 1938)

In partial fulfillment of requirements

for the degree of Master of Education

1945

First Reader: John M. Harmon, Professor of Education
Second Reader: Leslie W. Irwin, Associate Professor of Physical Education
Third Reader: Roy, O. Billett, Professor of Education

School of Education
August 1, 1945
2.0118

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The Navy Test And Its Significance

The Background of the Field of Measurements in Physical Education

The field of measurement in physical education has gained much ground and recognition through the voluminous testing programs carried out by the Army and Navy. One battery of tests which has given great impetus and considerable recognition to the field of physical education has been the so-called Navy Test. It includes the squat-thrust, sit-up, push-up, squat-jump, and chinning.

One of the major opportunities for improving this test is in a further objectification of the methods of administering each event in this battery. Therefore, it is the conviction of this writer that our best opportunity to make a contribution is in setting up a suggested procedure for each test which will be purely objective. It is generally agreed that one of the weaknesses of the program has been the great variability in techniques approved by individual instructors either in the Army, Navy, public schools, or colleges. It will require many years of increased effort in teacher training to greatly improve this weakness. Therefore, we shall here endeavor to set up apparatus conceived in the physics laboratory which can be used and will automatically record successful and unsuccessful techniques in operation. To

that end, we have devoted considerable time and effort in a public school situation in order that we may test the proposed procedure in a practical situation and under the observation of a trained teacher.

The Navy Standard Physical Fitness Test

The Navy Test consists of five fold events designed and employed to test strength, endurance, stamina and some degree of agility.

More specifically speaking the events are given for the following purposes:

The Events:

1. Squat-Thrusts.

   Purpose. -- To test speed, power, agility and endurance of the trainee.

2. Sit-Ups.

   Purpose. -- To test the strength and endurance of the abdominal muscles of the trainee.

3. Push-Ups.

   Purpose. -- To test the strength and endurance of the "pushing muscles" of arms and shoulder girdle of the trainee.

4. Squat-Jumps.

   Purpose. -- To test the strength and endurance of the muscles of the legs of the trainee.

5. Chinning (Pull-Ups).

Purpose. -- To test the strength and endurance of the "pulling muscles" of arms and shoulders of the trainee.

The same five fold test battery and test scores mentioned above may be used in a more specific way by the Armed Service or instructors in their endeavor to better instruct and to diagnose the difficulties and shortcomings of their trainees for the purpose of improving their subjects and instructions.

In summary, then, we may conclude that the test intelligently administered may throw light upon the following factors:

1. As a means of determining the physical status of the trainee or inductee upon arrival for training.
2. As a means of providing information that will assist in more intelligently formulating a physical fitness program to meet the individual needs.
3. As a means of motivating more activity to develop a higher plane of physical fitness.
4. As a means of measuring the physical fitness of Navy personnel in one activity in comparison with the personnel in other activities.
5. As a means of measuring progress in relation to the physical fitness of the men after being in service a specific length of time.
6. As a means of determining whether or not the physical fitness program is accomplishing its desired results.

May it be re-emphasized that unless the test makes some such contributions as those outlined above, or if the Naval Physical Fitness Personnel, having administered the battery of tests does not make immediate constructive use of its results, the test would be better omitted; for only when properly used is the test worth the time and effort in relation to the physical fitness program which is basic to the military training program.

The P. F. I. Test

The P. F. I. Test measures the physical capacity or strength by means of mechanical apparatus. It includes seven batteries, dynamic and static testing of the somatic structure. The primary purpose of the P. F. I. is to measure certain vital phases or manifestations of physical fitness which are susceptible of improvement through physical activities.

The P. F. I. Test

1.*Lung Capacity -- Measured with wet spirometer in cubic inches. The subject throws back his shoulders, lifts his head, takes a deep breath, then blows. Bend forward to be sure all air is let out of lungs. Two trials are given; and the better one recorded.

2.-3. Right and Left Grip -- Measured in pounds by grasping hand dynamometer and squeezing.

4. Back Lift -- Measured by lifting with knees straight, using the back and leg dynamometer.

*Lung capacity is not a strength measure but an anthropometric measure introduced by tradition rather than scientific insight.

5. Leg Lift -- Measured by lifting, carrying weight on the thighs with back and leg dynamometer.
6. Push-Ups (Boys) -- Measured by push-ups from straight-arm-hang on parallel bar, as many times as possible.
   Dipping or Push-Ups (Girls) -- Measured by push-ups from front leaning-rest position on stall bar bench, as many times as possible.
7. Pull-Ups (Boys) -- Measured by chinning or pull-ups on rings, as many times as possible.
   Chinning or Pull-Ups (Girls) -- Measured by chinning from hang lying position (body straight, weight resting on heels, hands grasping rings or horizontal cross bar which is at chest height for the individual. Arms make angle of 90° with plane of body)as many times as possible.
8. *Add the scores above. The total is S. I. or Strength Index of subject.

The Army Air-Force Test

The Events:

1. Sit-Ups

   Purpose. -- To determine the abdominal strength and endurance of the air cadet.
2. Pull-Ups.

   Purpose. -- To determine the arm and shoulder girdle strength of the air cadet.

*Scoring - Tests and Measurements in Health and Physical Education, C. H. McCloy, Chapter IV, Pg. 31-37.

3. 300 - Yd. Run

Purpose: -- To determine the respiratory and cardio-vascular endurance of the air cadet.

*The Naval Pre-Flight Physical Fitness Test

The Events:

1. Jump-Reach

Purpose: -- To test explosiveness, spring and agility, co-ordination and strength of the muscular mass, primarily those of lower extremities and allied areas of the entire body.

2. Push-Up

Purpose: -- To test strength of the muscle groups forming the upper extremities, pectoral girdle and trunk. Muscles of the lower extremities and abdominal region serve as assisting agents in the push-up cycle.

3. Chinning

Purpose: -- To test the strength of the muscle groups of the upper extremities, pectoral girdle and trunk region.

4. Speed-Agility Run

(394 feet course)

Purpose: -- To test velocity and agility of the cadet and also such qualities as: strength, balance, neuro-muscular co-ordination and condition, visual reaction,etcs.

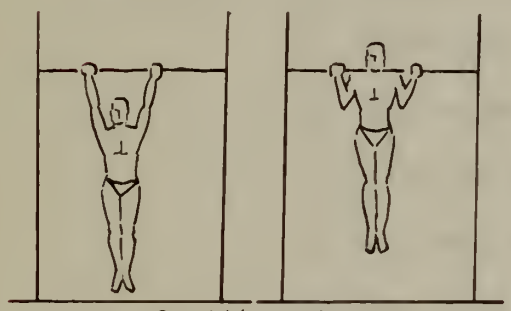
* The Pre-Flight includes additional elements in its categorical physical fitness scheme such as pack and step test, anthropometrical measurements of chest and abdominal circumferences, screening and divergencies.

Consult Mass Exercise, Tests, Games for detailed clarifications published by U.S. Naval Institute, Annapolis, Md., 1943 Pg. 121-154.

The Indiana University Motor Fitness Index Test

The Events:

1. Chinning or Straddle Chinning[1]
2. Push-Ups
3. Vertical Jump or Standing Broad Jump

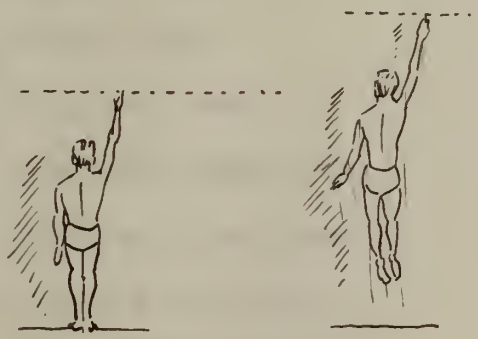


CHINNING

STRADDLE CHINNING

PUSH-UP

STANDING BROAD JUMP



VERTICAL JUMP

Test Events For The I. U. Motor Fitness Index

[1] Adopted from drawing of Miller, B., Bookwalter, K.W., and Schlafer, G. E., Physical Fitness for Boys, A.S. Barnes & Co., New York, 1943, Pg. 334.

The Victory Corps Tests

The Victory Corps Tests have been grouped into three categories according to the general muscle groups primarily tested, namely, (1) arm and shoulder girdle, (2) abdomen and back, and (3) legs.[1]

Category I (Arm and Shoulder Girdle)

1. Push-ups
2. Pull-ups
3. Dips on parallel bars
4. 15-foot rope climb
5. Bar vault

Category II (Abdomen and Back)

6. Sit-ups
7. Hanging half lever
8. Leg lift
9. Forward bend
10. Back twist

Category III (Legs)

11. Potato race
12. Jump and reach
13. Standing broad jump
14. Running broad jump
15. Running high jump
16. 100-yard dash
17. 440-yard run
18. 880-yard run

[1] Physical Fitness Through Physical Education, For the Victory Corps, U. S. Office of Education, Pamphlet Number 2, Pg. 73-74.

The Achievement Test for College and University Students

The battery included here has been selected as a measure of strength, agility, endurance, speed, and skill.[1] It is not assumed that the practice of the selected battery and events will aid in the development of general qualities in these matters, for it is recognized that skills are specific; balance is specific; and even such a quality as endurance has large specific elements. An effort has been made to use test items which require little, if any, equipment which have some practical application to natural activities, and which are identical with, or typical of, tests used by our armed forces.

It is recommended and urged that each institution of secondary learning use the battery as a minimum essential in their physical fitness testing program.

The Battery:

Events	Factors
1. Pull-Ups	Arm Strength
2. Push-Ups	Arm Strength
3. Rope Climb (20 Sec.)	Arm Strength & Velocity
4. Sit-Ups	Abdominal Strength
5. Squat Thrusts	Endurance,Power,Speed & Agility
6. Jump-Reach	Velocity in Distance
7. Squat-Jumps	Endurance,Explosiveness,Power & Agility
8. Standing Broad Jump	Velocity in Distance
9. 100-Yard Dash (20 Sec.)	Velocity in Time
10. 880-Yard Run (Min.&Sec.)	Endurance and Velocity

[1] Handbook on Physical Fitness For Students in Colleges and Universities, U.S. Office of Education, Washington, 1943 Pg. 53-58.

[1]Test Elements and the Factors They Measure

Elements	Factors
1. Age	Maturity
2. Brace (Iowa Revision)	Motor Ability
3. Chin (Pull-Ups)	Arm Strength
4.*Classification I	Hulk and Maturity
5. Dips on Parallels	Arm Strength
6.*Drop-Off {Time on 440 / Time on 60}	Endurance
7.*General Motor Capacity	Motor Ability (Absolute)
8.*General Motor Quotient	Motor Ability (Relative)
9. Height	Height (Size)
10.(I.U.)Motor Fitness Indices	Motor Ability (Fitness,Power)
11. One Mile Run	Endurance
12. Push-Ups	Arm Strength
13. Quarter Mile Run	Endurance and Velocity
14. Rope Climb	Arm Strength
15. Sixty Yard Dash	Velocity in Time
16. Squat-Thrust (Burpee Test)	Agility (Some Endurance)
17. Standing Broad Jump	Velocity in Distance
18. Straddle (Angle)Chinning	Arm Strength
19. Test of a Man	General Motor Fitness
20. Vertical Jump {Jump and Reach}	Velocity in Distance
21. Weight	Size (Nutrition)

* These items are not administered but may be computed from other items in the list.

[1] Miller, B., Bookwalter, K.W., and Schlafer, G.E., Physical Fitness for Boys, A. S. Barnes & Co., New York, 1943,Pg. 322.

The paramount reason for the presentation and brevity of the various standard batteries or tests in this research is to give a brief resume' of the various measures employed by the physical educator in the realms of measurements. This resume' is not to be interpreted or construed as a composite or complete review of the inexhaustible material in the field of tests and measurements, but to bring vividly forth that further probing of literature of some four hundred or more titles, shows definitely a high degree of universal usage of events which constitute the Navy Test. These events of squat-thrusts, sit-ups, push-ups, squat-jumps, and chinning become an indispensable battery or batteries of measurements in other standard tests in order to determine qualities of strength, endurance, power, explosiveness, speed, and agility in the human being. Hence, similarity of events is commonplace and the crux of the various standard batteries in the field of measurement in physical education.

Chapter II

The Subjective Weaknesses Of The Administration Of The Navy Standard Physical Fitness Test Events

The Subjective Approach

The procedure and approach of the exposition is primarily to present the exact techniques for performing each event correctly and to explain the most common errors in performing the test battery. Therefore, in order to maintain clarity and simplicity of subject matter the method employed shall be: (1) to name the event and its purpose, (2) to name the method of performance in relation to the subjective method, and (3) to name the criticisms or weaknesses of the subjective administration of the events in their respective sequences with illustrations in order to clarify, reinforce, and supplement the descriptive material in the test battery.

The Navy Standard Physical Fitness Test Events*

A. Squat-Thrusts

1. Purpose -- To measure the speed, power, agility and endurance of the trainee.
2. Method of Performance:

   (a) Starting position. -- Position of attention.

   (b) Movements are -- (1) Upon the command "Ready-Go," given by the instructor, performer bends knees and hips and places hands on the floor at a convenient distance

* Events are taken according to administrative sequence.

in front of feet assuming a squat-rest position. Fingers pointing forward, arms may be between or outside or in front of bent knees; (2) performer then extends legs backward---bringing his body into an approximately horizontal-layout from shoulders to heels; (3) performer then returns to a squat-rest position; and (4) then stands erect. The latter position permits the performer to lean forward, but chest must be in front of an imaginary line drawn from chin to toes. The event is performed against time, the trainee moves from one gymnastic position to another as rapidly as possible for one minute. A score of one is given for the successful performance of each complete squat-thrust cycle.

*Figure 1 -- Squat-Thrusts

1 A. Starting position .

1 B. Squat-rest position .

1 C. Horizontal-layout position .

1 D. Returning to squat-rest position from position 1C.

1 E. Returning to starting position from position 1B.

*Consult Method of Performance for detailed explanation.

3. Criticisms of Subjective Administration of Squat-Thrusts.

By far the chief drawbacks which are observed are--(1) The fundamental position is one of a desultory nature rather than one of a good postural form. Performer appears in a more or less drooping position with an extremely rounded upper back rather than a position of proper posture; (2) upon going from one gymnastic position to another the full body range is not covered, therefore, in the second position of squat-rest a performer extends legs backward before the hands are placed on the floor or a semi-flexion of arms rather than a full extension; (3) the horizontal-layout is one of hip extension and knee flexion showing protruding buttocks or an exaggerated curvature in the smaller back with flexion of knees and the sagging of the abdominal contents---rather than a true alignment of the body-layout such as a straight line from the shoulder girdle to heel structure, (4) in returning from the squat-rest to the standing position the performer does not perform a complete extension of knees, hips or torso, consequently, not covering his full body range. The upright position is lacking in its proper postural form displaying a head markedly forward, a sunken or depressed chest, a protruding abdominal viscera, and exaggerated back curves which present a kyphotic convexity to its extreme degree. Hence, there appears a distorted configuration of the somatic structure in relation to the gymnastic event.

*Figure 2 -- Improper Squat-Thrust Positions

2A. Starting position.

2B. Squat-rest position.

2C. Horizontal-layout position.

2D. Returning to squat-rest position from position 2C.

2E. Returning to starting position from position 2B.

B. Sit-Ups

1. Purpose. -- To measure the strength and endurance of the abdominal muscles of the trainee.

2. Method of Performance.

(a) Starting position.-- Performer lies on his back, knees straight, feet twelve inches apart with examiner supporting performer's soles against his knees and grasping ankles. Meanwhile performer clasps hand behind neck.

(b) Movements are. -- (1) performer raises his upper torso bending at the hips, rotating body to the right, and bends forward from the hips simultaneously rotating in order to touch right elbow to left knee. Knees may be bent

* Consult Criticisms of Subjective Administration of Squat-Thrusts.

slightly as performer sits up. (2) Performer lowers body until his back again touches the floor; (3) performer again sits up, but performs with opposite elbow touch movement, left elbow to right knee; (4) he again lowers his body until contact is made with floor. He continues as many sit-ups as his muscular endurance permits. At no time in the process of testing may pausing from one gymnastic position to another be permitted. The movement must be continuous either when contacting the floor with back or when bending trunk forward to touch knees.

*Figure 3 - Sit-Ups

3 A. Starting position.

3 B. Support sitting position. Right elbow touching left knee.

3 C. Returning from position 3 B to position 3 A.

*Consult Method of Performance for detailed explanation.

3. Criticisms of Subjective Administration of Sit-Ups.

The following drawbacks are rather distinct and easily detected upon observation, namely: (1) The performer in raising trunk from lying position to a sitting position does not adhere to a proper postural configuration, his head is bent forward, hands are not clasped behind the neck, elbows are brought forward; (2) trunk is not straight from the hip joint in relation to its axial skeletal structure, knees are deeply flexed in order to shorten the normal body range; (3) lowering of trunk from touching knee sit-up position to lying position discloses poor form in relation to body range and skeletal structure and the resting of the trunk upon the floor.

*Figure 4 -- Improper Sit-Up Positions

4 A. Starting position.

4 B. Support sitting position. Right elbow touching left knee.

4 C. Returning from position 4B to position 4A.

* Consult Criticisms of Subjective Administration of Sit-Ups.

C. Push-Ups

1. Purpose. --- To test the strength and endurance of the "pushing muscles" of arms and shoulder girdle of the trainee.

2. Method of Performance.

(a) Starting position -- Performer takes a prone position on the floor, hands are on the floor at the sides of shoulders, with fingers pointed forward, toes are resting on floor. (Soles of feet approximately vertical.)

(b) Movements are -- (1) Performer raises body from the floor by extension of arms so that the body assumes a horizontal-layout, that is, straight from shoulders to heels with weight resting on hands and toes; (2) from the front leaning position the performer brings full flexions of arms by bending the elbows, thereby lowering body until chest touches the floor. Performer repeats movements as many times as possible. Rest on chest is not allowed under any circumstances.

*Figure 5. - Push-Ups

* Consult Method of Performance for detailed explanation.

5 A. Starting position.

5 B. Horizontal-layout position.

5 C. Horizontal-layout position with semi-flexion of arms, returning from position 5 B to starting position 5 D.

3. Criticisms of Subjective Administration of Push-Up.

(1) There is not a full extension of the arms from the prone position to the front leaning position. Performer does not bring about complete muscular contraction; (2) hips are extended and pushed upward and backward before shoulders are pushed up; (3) the horizontal position is one of hip extension or knee flexion showing a projecting seat area, an increased curvature of the smaller back with a flexion of knees, and a sagging abdomen if performer is obese in stature. Hence, the result is an embarassing and distorted concept of the human structure rather than a perfect linearity of the somatic segments showing a straight line from shoulders to heels with weight resting on hands and toes.

*Figure 6 - Improper Push-Up Positions.

*Consult Criticisms of Subjective Administration of Push-Ups.

6 A. Starting position.

6 B. Horizontal-layout position. Failure to travel full body range by performer.

6 C. Horizontal-layout position. Extension of hip region.

6 D. End position of push-up cycle showing performer resting on chest, abdominal region, and knees.

D. Squat-Jumps

1. Purpose. -- To test the strength and endurance of the muscles of the legs of the trainee.

2. Method of Performance

(a) Starting position. -- Standing; hands are clasped on top of head (palms down); feet are from 4-6 inches apart, with heel of left foot on a line with toes of right foot.

(b) Movements are.-- (1) From the standing position performer drops to a squat on right heel by flexion of hip and knee joints, respectively, and maintaining an upright trunk position hands clasped palms downward on the head; (2) he then immediately springs upward until knees are straight, and both feet clear off the floor. He interchanges the position of his feet so that right foot surplants left. He drops to squat on left heel; (3) he then springs upright again -- continuing the exercise as many times as possible.

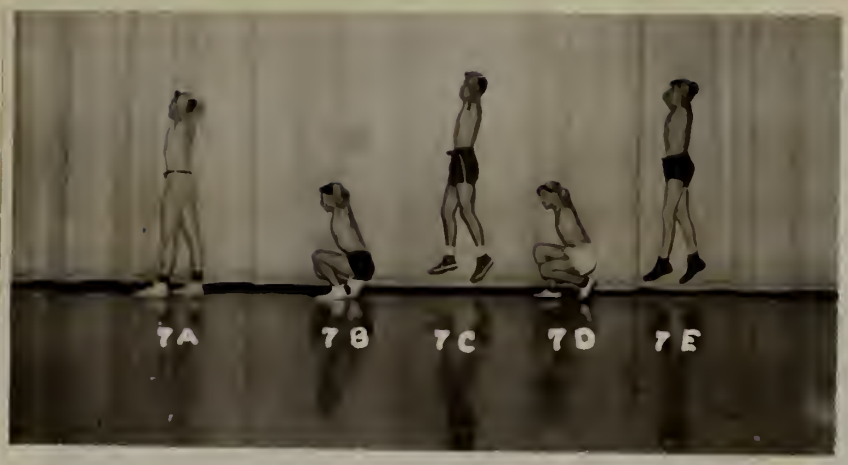


*Figure 7. - Squat Jumps

7 A. Starting position.

7 B. Squat on right heel position.

7 C. Spring position with interchanging of feet in the air.

7 D. Squat on left heel position.

7 E. Spring position with interchanging of feet in the air.

3. Criticisms of Subjective Administration of Squat-Jumps.

The most common errors are -- (1) Failure to squat down on rear heel; (2) in traveling from squat heel position to straight jumping position, failure to fully extend hips and knees and also to keep hands clasped over head; (3) failure to interchange position of feet while in air; (4) failure to maintain a proper postural form in moving from one gymnastic range to another.

*Consult Method of Performance for detailed explanation.

*Figure 8 -- Improper Squat-Jump Positions

8 A. Starting position.

8 B. Squat on right heel position.

8 C. Spring position in the air.

E. Pull-Ups.

1. Purpose. -- To test the strength and endurance of the "pulling muscles" of arms and shoulders of the trainee.

2. Method of Performance.

(a) Starting position -- Performer assumes a long arm hanging position with common or reverse grip on horizontal bar. Feet are to be clear of floor.

(b) Movements are. -- From the long arm hanging position performer pulls himself up by flexion of elbows until chin is above the level of horizontal cross bar; (2) from bent arm hanging position he lowers himself by extension of elbows going his full range until position 1 is assumed again. He continues as many

* Consult Criticisms of Subjective Administration of Squat-Jumps.

times as possible within his muscular potentialities.

* Figure 9 - Pull-Ups

9 A. Starting position.

9 B. Bent arm hanging position.

9 C. Returning to starting position from Position 9 B.

3. Criticisms of Subjective Administration of Pull-Ups.

Major drawbacks are: (1) Performer's failure to bring about a complete flexion of elbows while moving from long arm hanging position to bent arm hanging position; (2) consequently, resultant failure to raise chin above cross bar; (3) improper flexion of hips or knees, resulting in kipping or bending of torso with swinging of somatic structure in order to overcome gravitational force. A false measurement of the heaving musculature is secured; (4) performer's failure to cover complete body range in moving from bent arm hanging position to long arm hanging position in the gymnastic event.

*Consult Method of Performance for detailed explanation.

*Figure 10 -- Improper Pull-Up Positions

10 A. Starting position with improper grip position.

10 B. Bent arm hanging position with semi-flexion of arms.

10 C. Bent arm hanging position with semi-flexion of arms and flexion of knee.

10 D. Bent arm hanging position with kipping of body.

10 E. Long arm hanging position.

* Consult Criticisms of Subjective Administration of Pull-Ups.

Chapter III

A Critical Analysis Of The Objective Administration Of The Navy Standard Physical Fitness Test Events

The Objective Approach

One of the major opportunities for improving the Navy Test is in a further objectification of the methods of administering each event in this battery. It is the conviction of this writer that our best opportunity to make a contribution is in setting up a suggested procedure in each test which will be purely objective. It is generally agreed that one of the major weaknesses of the test battery has been the great variability in techniques approved by individual physical educators either in the Armed Service, public schools, or colleges. It will require many years of increased effort in teacher training to greatly improve this major weakness. Therefore, we shall here endeavor to set up apparatus conceived in the physics laboratory which can be used and will automatically record successful and unsuccessful techniques in operation. To that end, we shall devote considerable time and effort in order that we may present an objective procedure in a practical situation under the guidance of a trained physical educator.

The procedure of the objective analysis, which shall be adhered to for matter of clarity and brevity and to obviate confusion, shall be namely: -- (1) State the event and its fundamental purpose, (2) the apparatus and electro-mechanical

appliances, (3) the electro-mechanical adjustments, (4) method of performance, (5) scoring of events, and (6) instructions to instructor. The objective method is based upon the use of the electro-mechanical adjustments. At no time is the instructor to interpret the results of the various movements of the test battery. The range of performance from one gymnastic position to another is to be measured and interpreted by photo-electric relays as performer travels from one gymnastic position to another in the test event.

The Sequence of Events

The Events:

A. Squat-Thrusts

1. Purpose: -- To test the neuro-muscular explosiveness, muscular endurance, agility and muscular co-ordination of the somatic form of the trainee.
2. Apparatus -- A non-skid rubber mat with two white foot imprints, three photo-electric cells, three magnetic computators, adjustable tri-pods, and mechanical accessories.
3. Electro-Mechanical Adjustments - See Figure 11.

Performer assumes the position of attention upon the non-skid rubber mat, placing both feet upon the white foot imprints of mat. Proper postural form must be adhered to by performer upon taking the fundamental position. While the above preliminary adjustments are being made by the performer, the instructor brings the

two head photo-electric cells which flank the performer to their proper positional adjustment. By loosening the thumb-knobs of the right and left photo-cells, respectively, the cells may be moved upward or downward upon its cylinderical shafts as required by the statute of the subject. This cell beam should be so aligned as to bi-sect the right and left temporal regions of the performer's head. This Electro-Mechanical Adjustment is called the Head Photo-Electro Position Number 1. Hence, the adjustment prepares the performer for the second photo-electric positional adjustment. The Squat-Rest Photo-Electric Position Number 2.

Performer is instructed to bend knees and hips and place hands on the floor in front of the feet; bringing subject to the squat-rest position. It is important for performer to flex knee and hip joints completely. (Instructor should ascertain the full body range by inspection and manual adjustments of subject.) When performer approaches the full squat-rest position, the instructor by means of mechanical adjustments raises or lowers the cells mounted upon movable tri-pods to their proper positions so that the electric ray bi-sects the gluteal protuberance of the right and left regions of the body, hence, concluding the Squat-Rest Photo-Electric Adjustment. From the latter position performer then extends legs backward until his body is approximately straight from shoulders to heels with weight resting on hands and toes. While performer holds the horizontal-layout position, the instructor makes the third

photo-electric adjustment, that is, the electric beam is so adjusted that it bi-sects and strikes the right and left heel structure of performer. (It is important for the performer to come to a full hip and knee extension and maintain a straight layout because any deviation will not bring about an electrical beam contact to the adjacent photo-electric cell eye.) This third adjustment is known as the Horizontal-Heel Layout Photo-Electric Position Number 3. From the horizontal position the performer returns to the squat-rest position, which has been prephoto-electrically adjusted so no readjustments are necessary as long as performer returns to the approximate range and position. From the squat-rest the performer by extension of knees and hips comes into the starting position which was pre-photo-electrically adjusted. Briefly, as long as performer moves within his full body range and photo-electric positional plane, he will receive full credit for his gymnastic efforts and movements. No score is to be recorded upon the magnetic computators of the photo-electric cells if any deviations from the above is apparent.

Figure 11. - The Electro-Mechanical Positional Adjustments for the Squat-Thrust Cycle.

11 A. Head Photo-Electric Position Number 1.

11 B. Squat-Rest Photo-Electric Position Number 2.

11 C. Horizontal-Heel Layout Photo-Electric Position Number 3.

11 D. Squat-Rest Photo-Electric Position Number 2.

11 E. Head Photo-Electric Position Number 1.

4. Method of Performance:

When the Electro-Mechanical Adjustments have been completed by the instructor the performer is ready for the actual testing process. Directions have been given to the performer to start upon the command "go" and continue for one minute performing as many squat-thrust as his muscular endurance permits by moving within the positional range adjustments. As soon as the "Go" command is given all switches are thrown into play bringing all photo-electric cells into readiness. Time device begins to record the time element while performer moves from

the starting position into the squat-rest position by flexion of knee and hip joints, placing hands on the floor at a convenient distance in front of feet. This results in breaking the Head Beam which bi-sects the right and left temporal region of performer's head while in the starting position, whereas the squat-rest position results in breaking the electrical beam which bi-sects the gluteal area of the performer. Consequently, the latter movement causes the Squat-Rest Photo-Electric Cell Computator to register the movement providing performer has traveled within the proper preadjusted range. The next gymnastic movement of the horizontal-layout is performed by extension of knee and hip joints which results in the breaking of the Heel Electrical Beam by the calcaneous (heel) structure. This causes the magnetic computator to record the gymnastic movement at the Horizontal-Heel Layout Photo-Electric Cell Computator. Upon reaching the horizontal-layout, the performer returns to the squat-rest position. This causes the gluteal region to bi-sect the Squat-Rest Photo-Electric Cell Beam again, recording the latter position. From the squat-rest position the performer brings the body into an upright position breaking the Head Photo-Electric Beam. This movement results in a recording of the upright position from the squat-rest position at the Head Photo-Electric Cell Computator. Performer continues the squat-thrust exercise by traveling from one gymnastic position to another until the time interval of 1 minute is ended. Thereupon, the automatic control shuts off all elec-

trical units. Upon the exhaustion of time element, electric bell rings to inform performer and instructor of the conclusion of event. (If performer disregards warning the photo-electric cells and computators will not record movements because electric current is governed by a time control device and is automatically shut off.)

5. Scoring of Event:

Instructor merely reads the computators for score. Each complete squat-thrust cycle includes 5 recordings, that is, two at the Head Photo-Electric Cell Computator, two at the Squat-Rest Photo-Electric Cell Computator , and one at the Horizontal-Heel Photo-Electric Cell Computator. If any of the magnetic computators do not register five recordings per cycle, the performer has failed to execute the preadjusted positional range of the various gymnastic movements in the squat-thrust cycle, therefore, accredited only for the full cycle. As long as performer travels within his full preadjusted range he will be credited for his gymnastic muscular expenditure, otherwise, no recording.

6. Instructions to Instructor:

Ascertain with utmost accuracy the various positional adjustments which have been described above according to the performer's anatomical and kinesiological limitations. Explain in simple language the directions and importance of the various gymnastic positions which performer must perform properly. The electrical mechanism will perform all necessary computations

and recordings. Therefore, there should be no apparent reason for miscalculation or misrecording of scores.

B. Sit-Ups

1. Purpose: -- To test the muscular strength and endurance of the abdominal structure of the trainee.
2. Apparatus: -- Sit-up electro-mechanical board, two photo-electric cells, three stylets, three computators, and mechanical accessories.
3. Electro-Mechanical Adjustments -- See Figure 12.

Performer lies on back on the sit-up board, hooking feet under cross bar at the foot end of board; feet approximately 12 inches apart, clasping hands behind the neck. While performer is in the above position, the instructor makes the primary adjustments by means of mechanical adjustments. He lowers the photo-electric cell units so that the electrical beam bi-sects the Targus of the Left and Right Ears respectively. This Electro-Mechanical Adjustment is called the Ear Photo-Electric Position Number 1. From the latter position the performer raises his upper body, rotating it somewhat to the right, and bends forward far enough to touch right elbow to left knee. This gymnastic movement, permits the instructor to make the second Electro-Mechanical Adjustment by lowering the projecting stylet which flanks performer and just clears the knee cap of the right and left knees respectively. This adjustment is known as the Left Knee-Right Elbow Photo-Electric Position Number 2. Performer lowers his body until back

touches board again. The interscapular stylet, which projects from board into shoulder blade structure of performer, records the backward movement of subject and also breaks the Ear Beam which causes the magnetic computator to record the gymnastic movement. Performer again sits up, but this time rotates trunk to the left and touches left elbow to right knee. This latter gymnastic position results in the third Electro-Mechanical Adjustment known as the Right Knee-Left Elbow Photo-Electric Position Number 3 which corresponds to the Left Knee-Right Elbow Adjustment. Performer again lowers body until back touches interscapular stylet. He continues as many sit-ups as possible. Pausing is not permissible during the gymnastic movement.

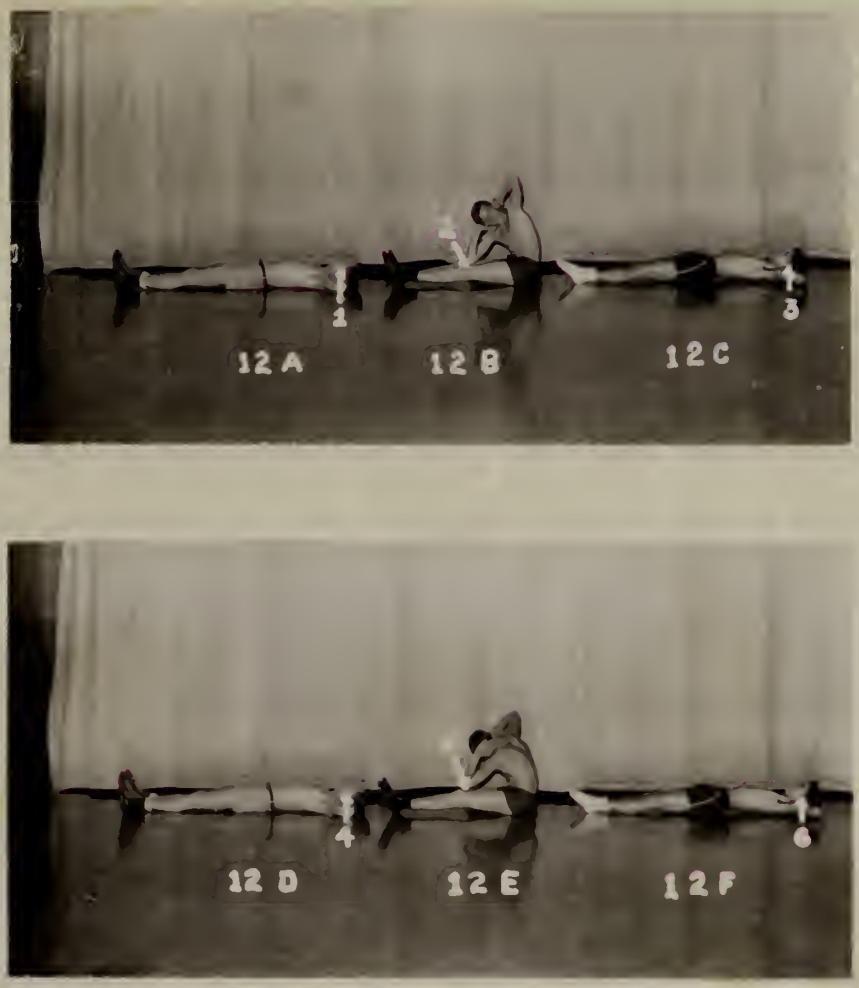


Figure 12. -- The Electro-Mechanical Positional Adjustments for the Sit-Up Cycle.

12 A. Ear Photo-Electric Position Number 1.

12 B. Left Knee- Right Elbow Stylet Position 2.

12 C. Ear Photo-Electric Position Number 1.

12 D. Ear Photo-Electric Position Number 1.

12 E. Right Knee-Left Elbow Stylet Position Number 2.

12 F. Ear Photo-Electric Position Number 1.

4. Method of Performance:

(1) Upon the command "go" the performer raises his upper body (this results in breaking the Ear Electrical Beam causing magnetic computator to record gymnastic movement) rotating it to the right, and bends forward far enough to depress the Left-Knee-Right Elbow Stylet which flanks performer. This results in stylet and elbow touching left knee and magnetic device records body movement at the Left Knee-Right Elbow Stylet Computator.

(2) Performer lowers his body until back contacts the inter-scapular stylet which records movement, simultaneously the Ear Beam is broken and recording by computators results.

(3) Performer again sits up, but now rotates trunk to the left and touches Right Knee-Left Elbow Stylet with left elbow. Stylet and elbow contact right knee which brings about a recording at magnetic device.

(4) He again lowers his body until back touches inter-scapular stylet which registers movement while body bi-sects Ear Beam causing a recording of the gymnastic movement by computator attached to the photo-electric cell unit. Performer continues as many sit-ups as possible. Continuous movement is required in performing sit-up cycle.

(5) Scoring of Event:

Instructor merely checks all computators for score. Each complete sit-up cycle includes 6 recordings, that is;

four at the Ear Photo-Electric Cell Unit, one at the Left Knee-Right Elbow Stylet Computator, and one at the Right Knee-Left Elbow Stylet Computator. If any of the magnetic computators, which are attached to the separate photo-electric cells and stylets, do not register 6 recordings per cycle, the performer has failed to perform within the preadjusted positional range. Therefore, he is accredited only for a full cycle. As long as performer travels within preadjusted range he will be credited for his gymnastic effort.

(6) Instructions to Instructor:

Same as for Squat-Thrusts.

C. Push-Ups

1. Purpose: -- To test the strength and endurance of the "pushing muscles" of arms and shoulder girdle of the trainee.

2. Apparatus: -- Push-up board, three photo-electric cell units, three magnetic computators, and mechanical accessories.

3. Electro-Mechanical Adjustments - See Figure 13.

Performer lies face downward on push-up board; with palms of hand bi-secting white palm line of board; hands at sides of shoulders, with fingers forward; toes are resting on push-up board with soles pressing against adjustable foot blocks attached to board. Blocks may be adjusted to meet the anatomical variations of the many performers. These adjustable blocks prevent the performer from slipping backward while holding the horizontal-layout position. Hence, a perfect anatomical layout from head to heel is attained with the body weight resting

on hands and toes. While performer holds the above starting position, the instructor makes the primary Electro-Mechanical Adjustment by bringing the photo-electric cell units, which are mounted upon adjustable tri-pods at each side of performer's head to a position whereby the electrical beam bi-sects the chin--hence the Chin-Prone Lying Photo-Electric Position Number 1 Adjustment is attained.

(1) From the latter position performer raises his body by straightening his arms so that the body is straight from shoulders to heels, with weight resting on hands and toes; while performer holds this front leaning position the photo-cell beam is so adjusted that it bi-sects the shoulder area of the subject. This Electro-Mechanical Adjustment is known as the Shoulder-Front Leaning Photo-Electric Position Number 2. Another adjustment is made by a similar electric unit found along side of performer's hip region, that is; electric cells are so aligned and adjusted that a beam passes above the performer's gluteal region by 1 inch. This adjustment is called the Hip-Horizontal Layout Photo-Electric Position Number 3 which acts as a check unit in relation to body layout in front leaning position. (Flexion of hip joint by performer results in breaking hip region beam, causing a recording which shows subject did not maintain a horizontal-layout and no credit is awarded for gymnastic movement.)

(2) From the front leaning position performer lowers body by bending elbows until chin touches board momentarily, result-

ing in the breaking of Chin-Prone Lying Beam and recording of gymnastic movement by computator and completion of one push-up cycle. Performer continues the exercise as many times as possible, keeping a horizontal-layout throughout the event. Neither the chest nor the chin can rest on the board. The weight must be at all times supported by hands and toes, respectively.

Figure 13. - The Electro-Mechanical Positional Adjustments for the Push-Up Cycle.

13 A. Chin-Prone Lying Photo-Electric Position Number 1.

13 B. Shoulder-Front Leaning Photo Electric Position Number 2, Hip-Horizontal Layout Photo-Electric Check Unit.

13 C. Chin-Prone Lying Photo-Electric Position Number 1.

4. Method of Performance:

From the preadjusted prone starting position the performer raises body from the board by straightening his arms so that body is straight from shoulders to heels, with weight resting on hands and toes. This movement brings about the breaking of the electrical beam known as Chin-Prone Lying Photo-Electric Position Number 1. This beam bi-sects chin of performer, and results in the recording of the movement by means of the magnetic computator which is attached to the photo-electric cell.

When performer moves from the prone to the front leaning position, the latter position causes a recording to be made at the Shoulder-Front Leaning Photo-Electric Computator because the performer's shoulders have broken the Shoulder-Front Leaning Electrical Beam which bi-sects the shoulders of performer. If performer has failed to attain and maintain a linear layout by flexion of hips, the third electrical unit shall record flexion because the Hip-Horizontal Photo-Electric Beam has been broken. Therefore, no credit shall be given the performer. This third unit is primarily a checking device for adherence to proper form and layout in the push-up cycle. From the front leaning position performer lowers body by bending elbows until chest and chin momentarily contacts board; this results in the breaking of Chin-Prone Lying Electrical Beam again and recording by magnetic device of the completion of push-up cycle.

5. Scoring of Event:

Instructor merely checks all computators for score.

Each complete push-up cycle includes 3 recordings, that is; two at the Chin-Prone Lying Photo-Electric Unit and one at the Shoulder-Front Leaning Photo-Electric Unit. Hence, if Hip-Horizontal Layout Unit shows any score that must be deducted from respective cycle because performer did not adhere to pre-adjusted positional range movements and no credit is given.

6. Instruction to Instructor:

Same as for other gymnastic event in the test battery.

D. Squat-Jumps

1. Purpose: -- To test the strength and endurance of the muscles of the legs of the trainee.
2. Apparatus -- Two foot markers, two photo-electric cell units, two magnetic computating devices, and adjustable tri-pods.
3. Electro-Mechanical Adjustments-See Figure 14.

Performer assumes the following starting position -- standing; hands (palms down) clasped on top of head; feet are from 4 to 6 inches apart, with heel of left foot on a line with toes of right foot, both feet bi-secting the foot markers which are marked upon the floor with paint or chalk. Markers guide performer in maintaining the proper foot position in order that the electrical beam may record the gymnastic movement. From the above position the instructor makes the first Electro-Mechanical Adjustment by raising the cell unit 12 inches above performer's head. Hence, the first known adjustment

is completed --the Head-Jump Photo-Electric Position Number 1.

(1) From the standing position performer drops to a squat on right heel. This squat-heel position prepares performer for a second Electro-Mechanical Adjustment. By lowering and aligning the electrical cell units, the beam bi-sects the Right and Left Gluteal Region of the Body. This electrical positional adjustment is called the Squat-Heel Photo-Electric Position Number 2.

(2) He then immediately springs upward by extension of knee and hip joints and by plantar flexion of the foot propels the body upward with both knees straight. With both feet off the floor, he interchanges the position of his feet so that right foot is forward, and drops to a squat on left heel.

(3) He again springs to the upright position and continues the exercise as many times as possible. The upper body must assume a fairly erect position throughout the gymnastic event.

*Figure 14. - The Electro-Mechanical Positional Adjustments for Squat-Jump Cycle.

*Same recordings for right foot position.

14 A. Head-Jump Photo-Electric Position Number 1.

14 B. Squat-Heel Photo-Electric Position Number 2.

14 C. Head-Jump Photo-Electric Position Number 1.

4. Method of Performance:

Briefly, the procedure of performance is as follows: (1) From the standing position performer drops to a squat on right heel, maintaining a fairly erect upper body with hands clasped, palms downward on top of head. This squat-heel position results in the breaking of Squat-Heel Beam which bi-sects the Right and Left Gluteal Region of the Body, consequently, a recording takes place at the Squat-Heel Photo-Electric Computator. (2) Performer now springs upward until both knees are straight, and both feet clear of the floor, he interchanges the position of his feet so that right foot is now in advance of left, and drops to squat on left heel; (3) he then springs to the upright position again and continues the exercise as many times as possible. This spring jump movement results in a second electrical recording because the head has disrupted the Head-Jump Beam Path, breaking the ray and causing the registering of magnetic device by Head-Jump Photo-Electric Cell Unit Number 1. Hence, 2 recordings are necessary for 1 complete squat-jump cycle.

5. Scoring of Event:

Instructor merely checks all computators for score. Each complete squat-jump cycle includes 2 recordings, that is; one at the Head-Jump Photo-Electric Unit and one at Squat-Heel Photo-Electric Unit. Any deviation from the above recording

indicates performer has not traveled within preadjusted positional range and automatic deduction must result, accordingly.

6. Instructions to Instructor:

Same directions as under first event.

E. Pull-ups

1. Purpose: -- To test the strength and endurance of the "pulling muscles" of arms and shoulder girdle of the trainee.

2. Apparatus: -- Horizontal bar (seven feet nine inches is the preferred height) should be erected high enough so performer can hang at full arm length without feet touching the floor, two photo-electric cell units, two magnetic computators, adjustable and detachable clamping devices for electrical cells which are mounted on horizontal upright bars, right and left bars, respectively.

3. Electro-Mechanical Adjustments-- See Figure 15.

Performer takes the full arm hanging position upon the horizontal bar with common or reverse grip, feet are to be clear of the floor; as performer holds hanging position, the instructor makes the first Electro-Mechanical Adjustment by mechanical devices. He elevates the electrical cell units attached to horizontal upright bars until electrical beam bi-sects the Right and Left Ankle. When cells are in their proper position, the instructor locks units into position,

thereby completing the first electrical adjustment known as the Long Arm Hanging Ankle Photo-Electric Position Number 1. (1) From the hanging position performer pulls himself up until chin is brought above the level of the bar (he is not to flex hips or knees, kick or kip body but must chin self by flexion of elbows alone.) This latter movement calls for the second Electro-Mechanical Adjustment, that is; electrical cells are aligned so that beam bi-sects the Temporal Regions of the Performer. Hence, the second adjustment is known as the Bent Arm Hanging Photo-Electric Position Number 2. (2) From the bent arm hanging position performer lowers himself again until elbows are completely straight and he continues the exercise as many times as possible.

Figure 15. - The Electro-Mechanical Positional Adjustments for the Pull-Up Cycle.

15 A. Long Arm Hanging-Ankle Photo-Electric Position Number 1.

15 B. Bent Arm Hanging Photo-Electric Position 2.

15 C. Long Arm Hanging-Ankle Photo-Electric Position Number 1.

4. Method of Performance:

From the hanging position performer pulls himself up until chin is brought above the level of the cross bar. This gymnastic movement results in two photo-electrical recordings. First, by moving from the long arm hanging position to bent arm hanging, the Long Arm Hanging-Ankle Beam is broken and a recording is made at the latter computator. While bringing chin above the bar, the performer's head disrupts the Bent Arm Hanging Beam which bi-sects the Temporal Regions of the Head. Consequently, causing the computator, attached the Bent Arm Hanging Units, to record the second electrical score. Now, the performer lowers himself again until elbows are completely straight, thereby, breaking the Long Arm Hanging-Ankle Beam again for a second recording at the electrical computator. Hence, a pull-up cycle consists of 3 recordings.

5. Scoring of Event :

Instructor merely checks all electrical computators for score. Each complete push-up cycle includes 3 recordings, that is, two at Long Arm Hanging-Ankle Unit which indicates performer has covered his full preadjusted positional range in relation to the Electro-Mechanical Adjustments, and one

at the Bent Arm Hanging Unit.

6. Instructions to Instructor:

Same as for directions under other events.

Summary

The field of measurement in physical education has gained much ground and recognition through the voluminous testing programs carried out in the Army and Navy. One battery of tests which has given great impetus and considerable recognition to the field of physical education has been the so-called Navy Test. It includes the squat-thrust, sit-up, push-up, squat-jump, and chinning.

One of the major opportunities for improving this test is in a further objectification of the methods of administering each event in this battery. Therefore, it is the conviction of this writer that our best opportunity to make a contribution is in setting up a suggested procedure in each test which will be purely objective. It is generally agreed that one of the weaknesses of the program has been the great variability in techniques used by individual instructors either in the Army, Navy, public schools or colleges. It will require many years of increased effort in teacher training to greatly improve this weakness. Therefore, we have here endeavored to set up apparatus conceived in the physics laboratory which can be used and will automatically record successful and unsuccessful techniques in operation. To that end, we have devoted considerable time and effort in order that we may present an objective procedure in a practical situation under the guidance of a trained physical educator.

Modern physical education like current academic matter has been making increasingly extensive use of objective measurements based upon scientific study and research rather than upon tradition. These tests have been methodically evaluated and validated by scientific investigation and inquiry. It is with this thought in mind that the subjectivity of the Navy Standard Physical Fitness Test has been vigorously attacked and analyzed with due consideration for its various factors. The procedure has been as follows: - (1) to name the event and its purpose, (2) to name the method of performance in relation to the subjective approach, and (3) to name the criticisms or weaknesses of the subjective administration of the events in their respective sequence. Finally, having gained a comprehensive and methodical gymnastic view of the problem, it becomes unnecessary for further elaboration.

The procedure of the objective analysis, which has been presented for matter of clarity and brevity and to obviate confusion, has been namely: (1) State the event and its fundamental purpose, (2) the apparatus and electro-mechanical appliances, (3) the electro-mechanical adjustments, (4) method of performance, (5) scoring of events, and (6) instructions to instructor. The objective method is based upon the use of electro-mechanical adjustments. The instructor must not interpret the results of the various movements of the test battery, but the range of performance from one gymnastic position to another. This range is to be measured and inter-

preted by photo-electric relays as performer travels from one gymnastic range to another in the test battery.

Hence, the cardinal function of objective measurement is progressive elimination of chance or waste, thereby, making possible the progressive increase in rapidity and efficiency in attaining the desired objectives.

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