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DETERMINATION OF THE RATES OF DESCENT OF A FALLING MAN AND OF A PARACHUTE TEST WEIGHT

(EQUIPMENT BRANCH REPORT)

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DETERMINATION OF THE RATES OF DESCENT OF A FALLING MAN AND OF A PARACHUTE TEST WEIGHT

OBJECT

1. The object of these experiments was to determine the instantaneous and maximum rates of descent of—

(a) A dummy man equipped with a dummy parachute pack and harness.

(b) A 200-pound lead weight with trailing dummy parachute pack.

2. There seemed to be no definite information as to the rate of acceleration and limiting velocity of a man after leaping from an airplane in flight. This knowledge is of vital importance to those designing and testing parachutes and to anyone who may at some time be forced to use a parachute at a low altitude or who may wish to delay the action of his parachute to avoid entanglement in falling wreckage or to evade enemy gunners in time of war.

3. It has been the practice of the Matériel Division to use lead weights and packs equipped with time fuzes to test experimental parachutes for strength, but it was not known definitely just what speed and momentum was obtained by a delay of any given number of seconds. The data obtained in these tests will assist in clarifying previous records and establishing a basis for future work of this nature.

CONCLUSIONS

1. It may be concluded from the results of these tests that a man equipped with a parachute pack, but allowing it to remain closed, will fall at a maximum rate of between 160 feet per second (109 miles per hour) and 175 feet per second (119 miles per hour), and that he will gain this velocity in about 12 seconds' time, having fallen about 1,400 or 1,500 feet.

2. It appears that the lead weight unit used in test No. 5 reaches a velocity of about 302 feet per second (206 miles per hour) in 15 seconds' time, having fallen about 3,000 feet, and is very near its maximum velocity at that time.

3. The photographic charts and plotted curves may be used to obtain velocities, accelerations, and distances.

RECOMMENDATIONS

1. It is recommended that this report be made available to all personnel on flying status so that they may be able to make more intelligent use of the parachute.

EQUIPMENT

1. The airplane used was a Douglas torpedo plane (DT type) equipped with bomb shackles and releases and dummy bays for drop-testing parachutes.

2. Two dummies were used, one the size of an average man and weighing 180 pounds complete with dummy pack; the other the same in size but weighing only 115 pounds complete.

3. The sources of light used in the first four tests were magnesium flares, commonly used on wing tips. In the fifth test (lead weight) a 12-volt, 35-ampere electric lamp was used. When the flare was used, it was clamped to a short piece of wood which formed an extension to one of the dummy's legs. The flare was ignited by a battery mounted in the airplane. The electric lamp was mounted just beneath the lead weight and received its current from a small battery housed in the dummy parachute pack. In each test the lights were so mounted that they were visible from the camera position before the dummy or weight was released from the airplane. Several attempts were made to use flares in connection with the lead weight, but they were invariably extinguished due to the high velocity before reaching the ground.

4. The lead weight was approximately cubical in shape. Two cables, 5 feet in length, connected the weight to the pack. The assembly was arranged so as to simulate as nearly as possible the resistance and weight conditions of high-speed parachute testing.

5. Automobile headlights were used to mark the course to be flown.

6. An ordinary view camera was used. The lens was of 12-inch focal length. In tests Nos. 1 and 2 the camera shutter was removed and a pendulum of proper length to swing in 1-second intervals was suspended in front of the lens. When the beam of light was in the vertical plane through the axis of the lens, the pendulum interrupted it uniformly at 1-second intervals. When the beam came in from the right or left of this plane the period from interruption to the end of the swing and back would be less than a second on one side and greater by the same amount on the other side. The effect on the film was alternate short and long dashes. This made it necessary, when scaling for distance on the first photograph, to use the mid-point of each dash as a reference point instead of the end of the dash. In subsequent tests a "between-the-lens" shutter was used. The shutter was normally held open by means of a spring and was closed momentarily once each second by a solenoid. The pendulum was removed from in front of the lens and arranged to make contact with a bubble of mercury at the bottom of each swing, thus closing the solenoid and battery circuit. The camera was set with the axis of the lens horizontal and the film vertical. The lens was elevated so that its axis came near the top of the film.

PROCEDURE

1. All tests were conducted at night. When all was in readiness on the ground, the airplane would take off and climb to the prescribed altitude. The pilot signaled with a flash light when he was starting on the course, which was marked by blinking lights on the ground. At this time the timing pendulum was started and allowed to swing until the dummy or weight had reached the ground. The pilot maintained his proper altitude with a sensitive altimeter. It was important that he hold very closely to the proper altitude and that he did not pass too close to the camera, as the image would then not fall on the film. As he approached the first marker light on his course, he switched on the dummy light and a few seconds later released the dummy. At the conclusion of the test an automobile was faced toward the camera at two points some distance away in order to register two points on the film which, when connected by a line, would indicate horizontal at ground level.

DISCUSSION

1. Figures 1, 3, 5, 7, and 9 are reproductions of the original photographs upon which were superimposed a reference scale of distance. Figures 2, 4, 6, 8, and 10 are graphs plotted from data taken from the photographs. The ordinates of the velocity curves were found as follows: The point on the trajectory corresponding to the desired number of seconds (abscissa) is found by counting the dashes from the point where the trajectory starts to bend downward. The velocity at this point is considered to be equal to the sum of the distances covered in the half second preceding the point plus that covered in the half second following. Only the vertical components of distance and velocity were considered. The ordinates of the distance curves are the scaled vertical distances from the point of release to the point in question.

2. The fact that the dummy tumbled in some of the tests caused the light to be blanked out in certain places, but these breaks are readily distinguishable from the regular 1-second breaks. The light from the electric lamp used on the weight was also blanked occasionally by the small posts which support the filament.

3. In applying the reference scale to the photographs, it was not possible in all cases to extend the upper reference line horizontally in the plane of the paper because the course flown, although horizontal, was not truly parallel to the plane of the film. This upper reference line was in each case drawn so as to form an extension of the path of flight appearing on the photograph. The upper reference line was extended until it met the lower horizontal line which represents the horizon. From this point of intersection a straight line was run to each reference point on the trajectory. A vertical line was dropped from some point on the upper reference line to the horizon line and scaled in feet. Although the reference lines were extended to their common point of intersection with the horizon line, they were not traced beyond the vertical scale line.

4. The test which was made with the 115-pound dummy has no direct bearing on the main problem, but was included for the purpose of furnishing some information on the rate of descent of standard dummies used in the service for periodic testing of parachutes It is interesting to note from the graph that by reducing the weight from 180 to 115 pounds without reducing the size of the dummy, the maximum rate of fall was reduced from 175 feet per second to 125 feet per second.

5. It will be noted that in the case of the dummy tumbling rapidly, its maximum velocity was 160 feet per second, as against 175 feet per second where it fell straight or tumbled only slightly. Two other tests were completed, one very similar to No. 3, where the dummy tumbled rapidly, and another similar to No. 5 with the lead weight. The results obtained in these two tests check very closely with the results of tests Nos. 3 and 5, but the photographic negative was not sufficiently distinct to permit reproduction.

6. As stated above, in plotting distances and velocities, only the vertical components were used. To get the actual velocity or distance traveled along the path, it is only necessary to measure the actual length of the dashes and apply the scale which is printed on the photograph. It will be noted that the horizontal distances are foreshortened slightly, due to the fact that the airplane was in some cases receding slightly from the camera. The effect of this would be to shorten the recorded distances along the path by not more than 2 or 3 per cent for the first 4 or 5 seconds and by practically nothing for the remainder of the descent.

7. The velocity which the airplane imparts to the dummy diminishes as the velocity due to gravity increases, so that the resultant acceleration is not very great. If a man would jump from an airplane which is traveling at 120 miles per hour he would maintain very closely that same speed until he reached the ground or opened his parachute. If he left the airplane while traveling at a speed greater than 120 miles per hour his speed would rapidly diminish to that amount.

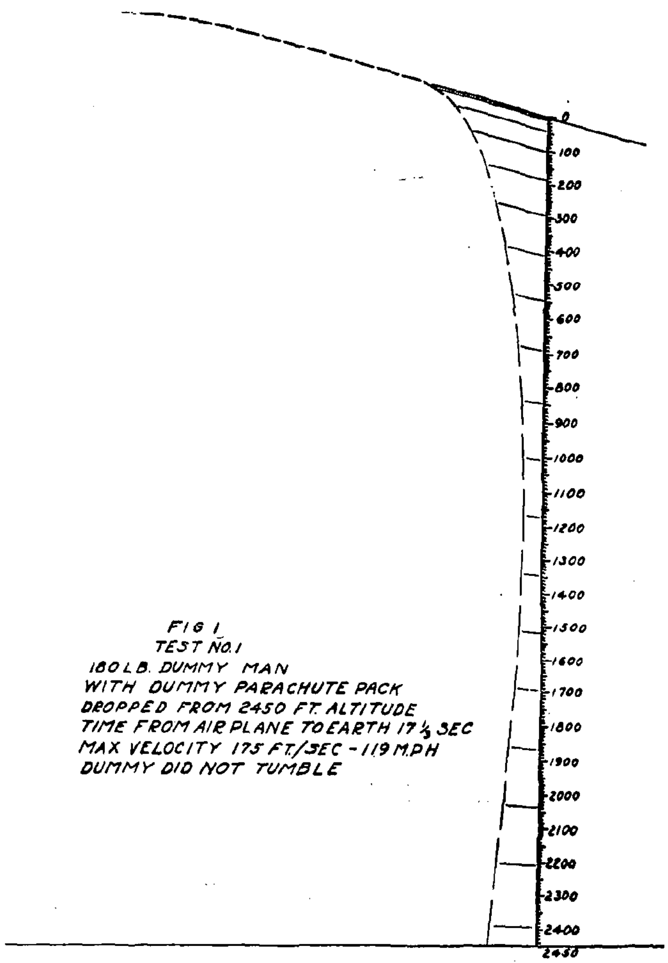


FIG 1
TEST NO. 1
180 LB. DUMMY MAN
WITH DUMMY PARACHUTE PACK
DROPPED FROM 2450 FT. ALTITUDE
TIME FROM AIR PLANE TO EARTH 17 1/3 SEC
MAX VELOCITY 175 FT./SEC - 119 M.P.H
DUMMY DID NOT TUMBLE

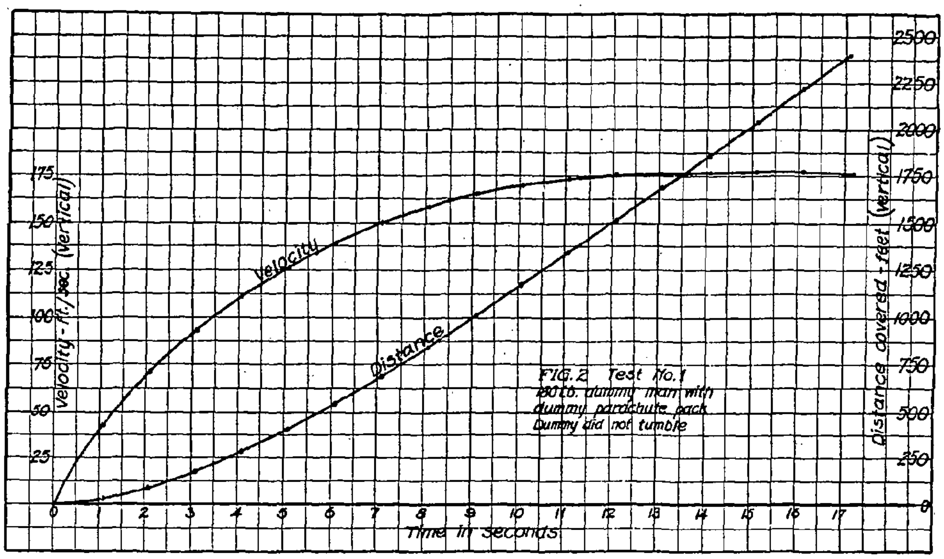


FIG. 2 Test No. 1
180 Lb. dummy man with
dummy parachute pack
Dummy did not tumble

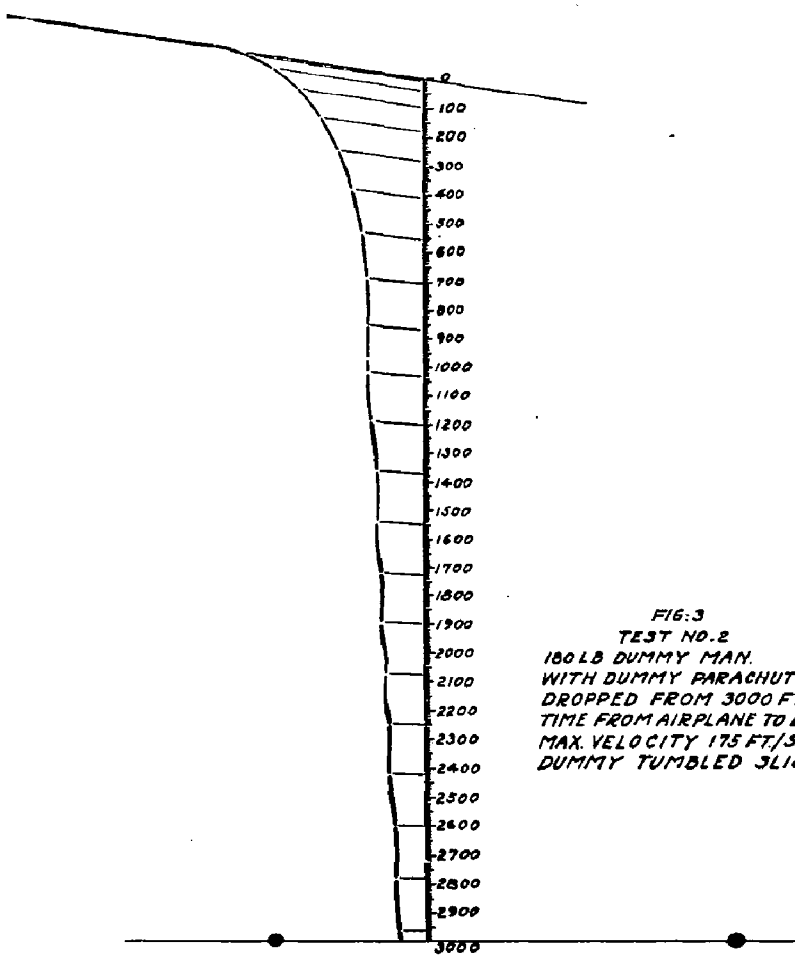
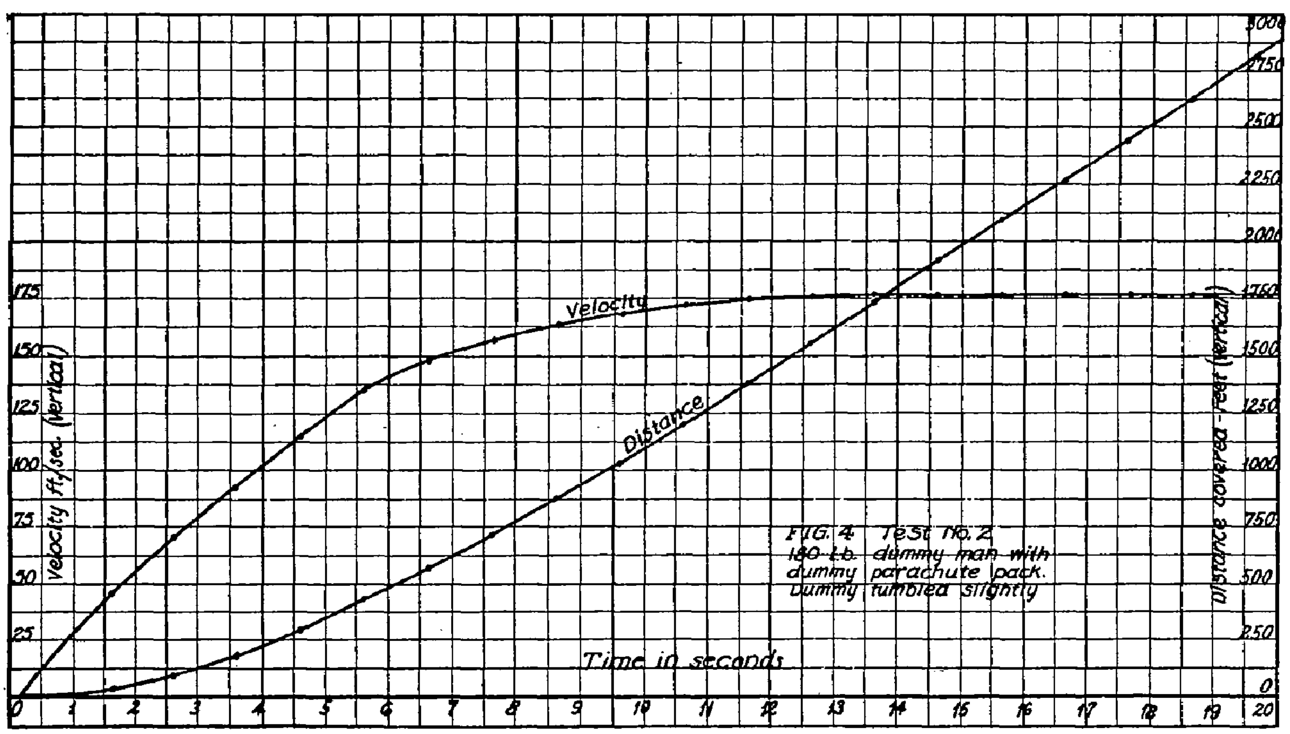


FIG:3
TEST NO. 2
180 LB DUMMY MAN.
WITH DUMMY PARACHUTE PACK.
DROPPED FROM 3000 FT. ALTITUDE.
TIME FROM AIRPLANE TO EARTH 20.8 SEC.
MAX. VELOCITY 175 FT./SEC.~119 M.P.H.
DUMMY TUMBLED SLIGHTLY.



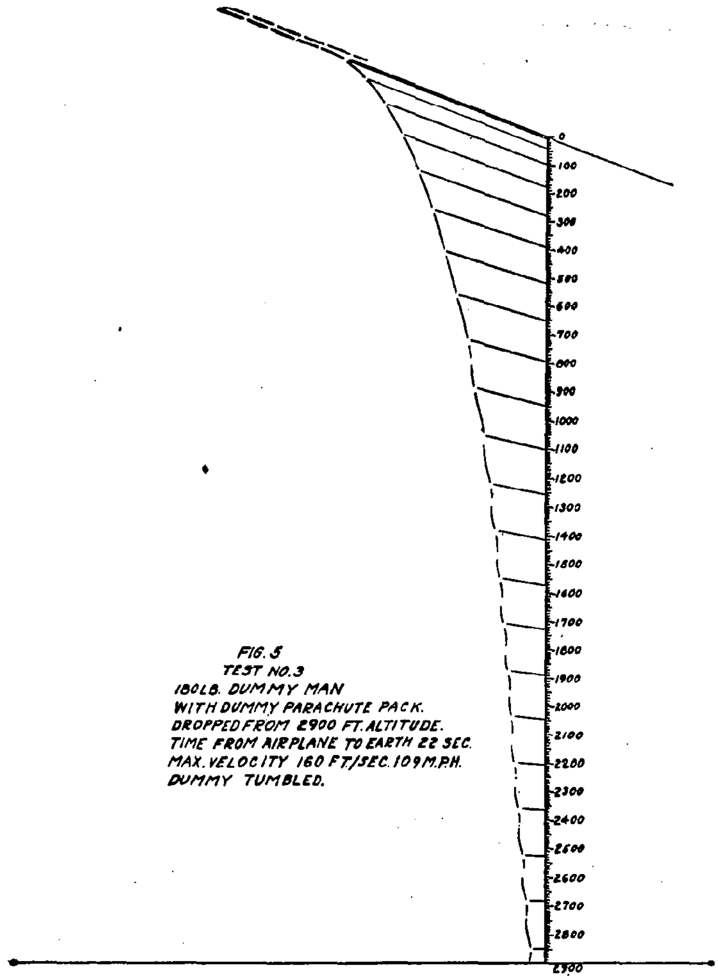


FIG. 5
TEST NO. 3
180 LB. DUMMY MAN
WITH DUMMY PARACHUTE PACK.
DROPPED FROM 2900 FT. ALTITUDE.
TIME FROM AIRPLANE TO EARTH 22 SEC.
MAX. VELOCITY 160 FT/SEC. 109 M.P.H.
DUMMY TUMBLED.

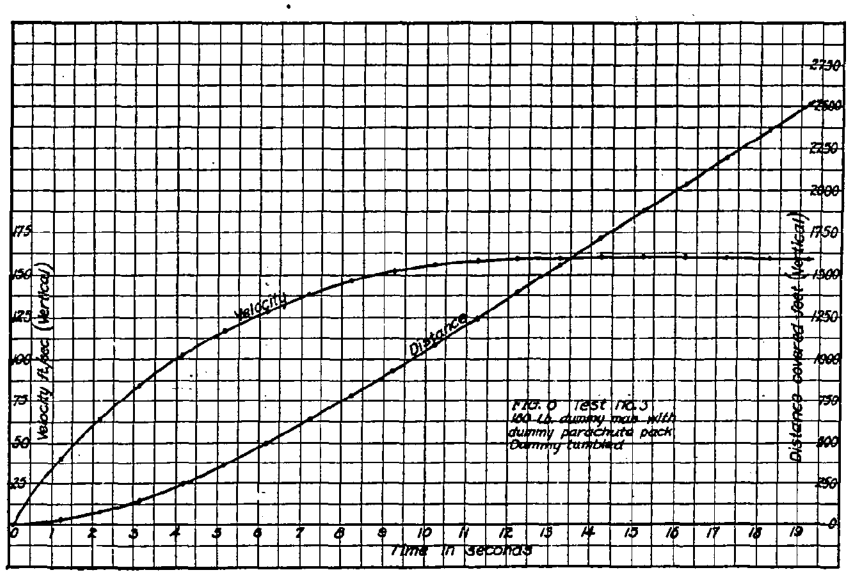


FIG. 6 Test No. 3
180 Lb. dummy man with
dummy parachute pack
Dummy tumbled

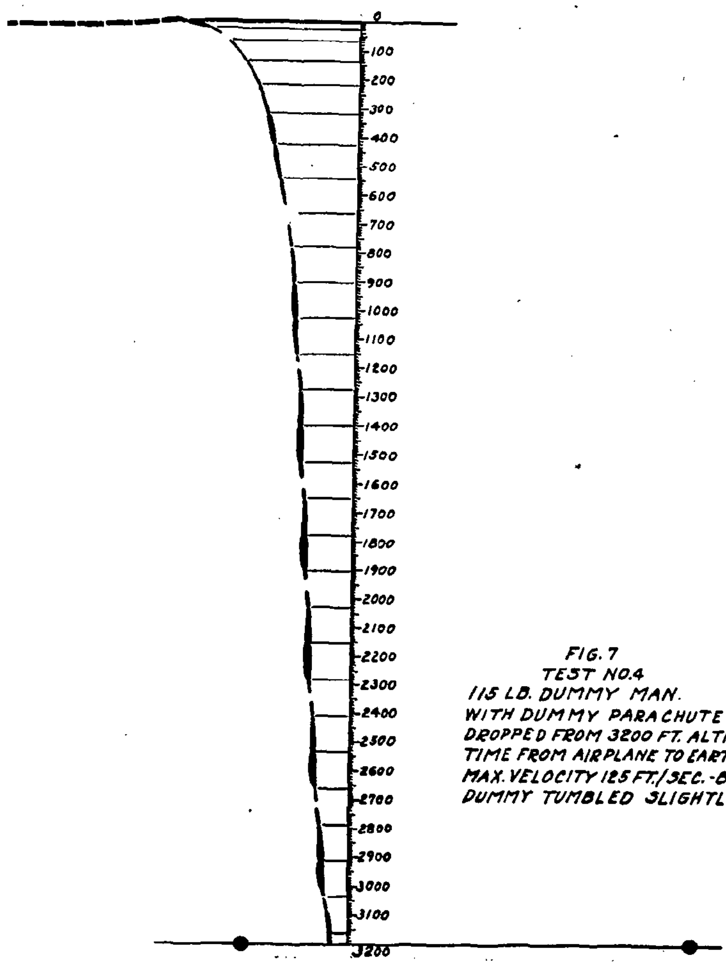


FIG. 7
TEST NO.4
115 LB. DUMMY MAN.
WITH DUMMY PARACHUTE PACK.
DROPPED FROM 3200 FT. ALTITUDE.
TIME FROM AIRPLANE TO EARTH 28.5 SEC.
MAX. VELOCITY 125 FT./SEC. - 85 M.P.H.
DUMMY TUMBLED SLIGHTLY.

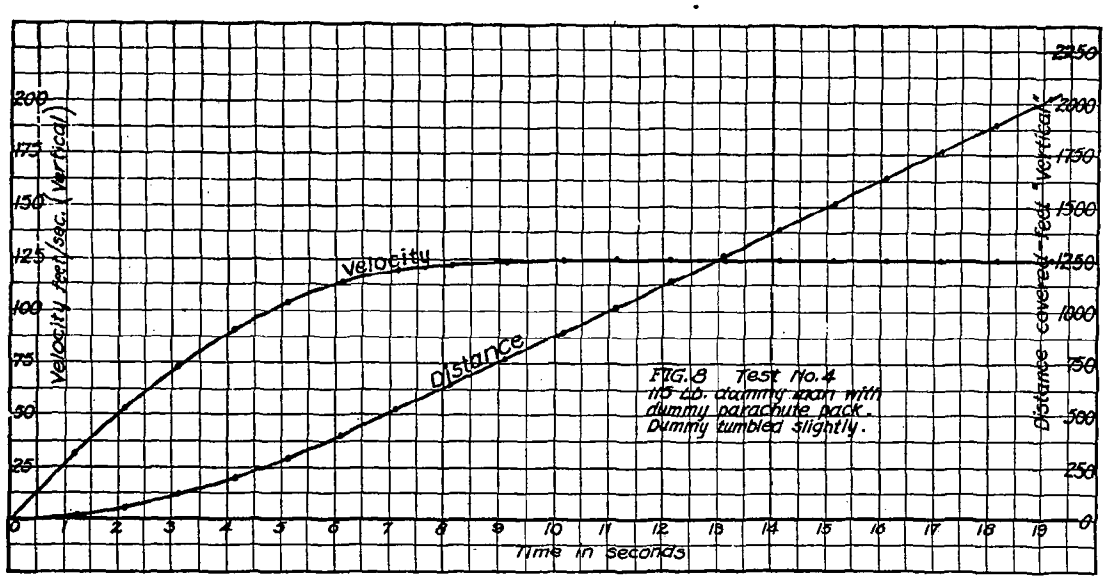


FIG. 8 Test No. 4
115 LB. dummy man with dummy parachute pack.
Dummy tumbled slightly.

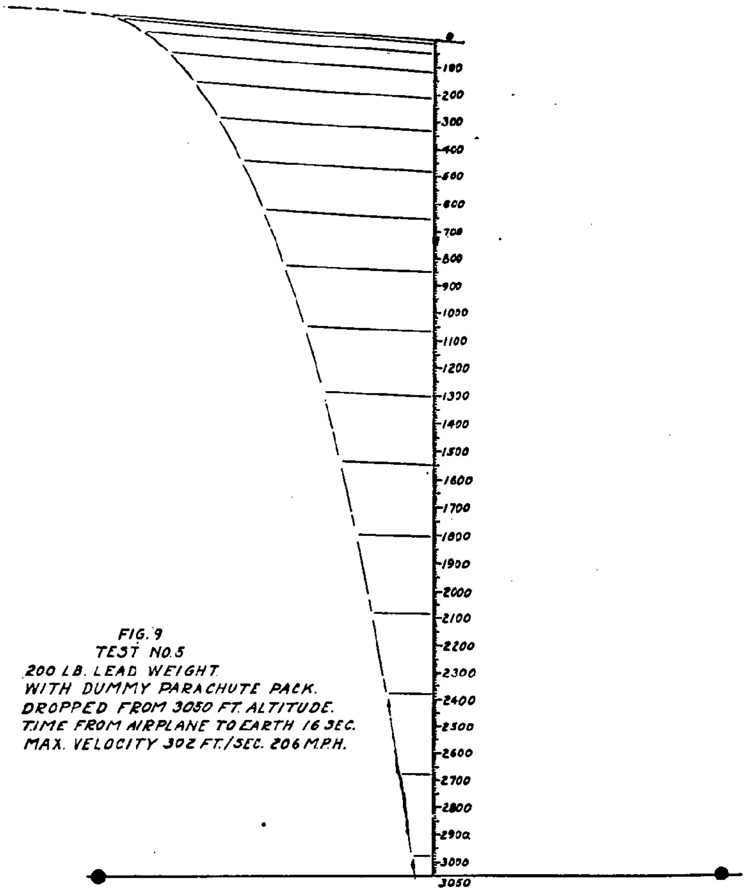


FIG. 9
TEST NO. 5
200 LB. LEAD WEIGHT
WITH DUMMY PARACHUTE PACK.
DROPPED FROM 3050 FT. ALTITUDE.
TIME FROM AIRPLANE TO EARTH 16 SEC.
MAX. VELOCITY 302 FT./SEC. 206 M.P.H.

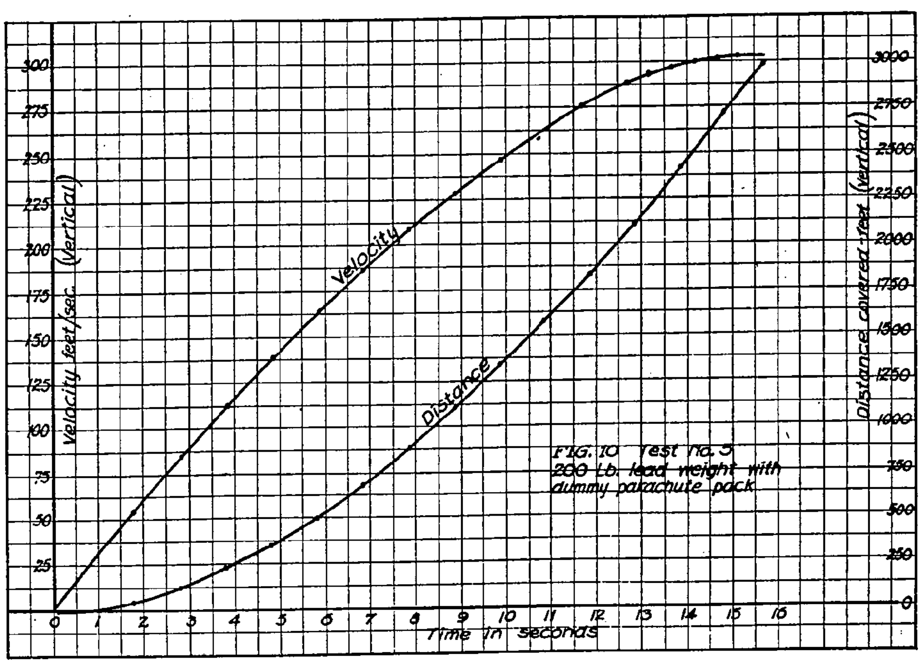


FIG. 10 Test No. 5
200 Lb. lead weight with
dummy parachute pack.