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SOUND RANGING.

ISSUED BY THE GENERAL STAFF.

MARCH, 1917.

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This pamphlet is printed in order that Artillery Officers may know the possibilities of Sound Ranging. It is now established that Sound Ranging will give the following results :—

1. Fix the position of an hostile gun within 50 yards with one good observation and within 25 yards with a series of observations.
2. Give the calibre of the hostile gun and the position where the shells fired by it fall.
3. Indicate what hostile batteries are firing.
4. Indicate the place where the shells from our own guns burst. It is thus possible to range our own guns and, by the "differential method," this can be done with great accuracy, when the gun or battery which is being ranged is firing at a hostile gun which is also in action.

It is hoped that it may shortly be possible to utilize the Sound Ranging apparatus to give muzzle velocities.

It is important that Artillery Officers should realize that the results obtained by Sound Ranging can be relied upon.

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Method.

Figure 1 explains the method by which locations are obtained by Sound Ranging and the general disposition of the recording apparatus.

Suppose we have two stations at M_1 and M_2 (Figure 1) and that both record the time of arrival of the report of a gun. If this gun lies anywhere on the line CP, which is the right bisector of the line M_1 M_2, the sound will arrive simultaneously at M_1 and M_2. If the gun is to the right of this line, at such point as P_1, then its report arrives at M_1 before it arrives at M_2, and the further it is to the right the greater will the time interval between M_1 and M_2 be. If the gun is to the left the sound gets to M_2 first. Suppose that the sound arrives at M_1 a time "t," before it gets to M_2, then the gun must be located on a certain hyperbola with M_1 and M_2 as foci, and it is easy to calculate the constants of this hyperbola.

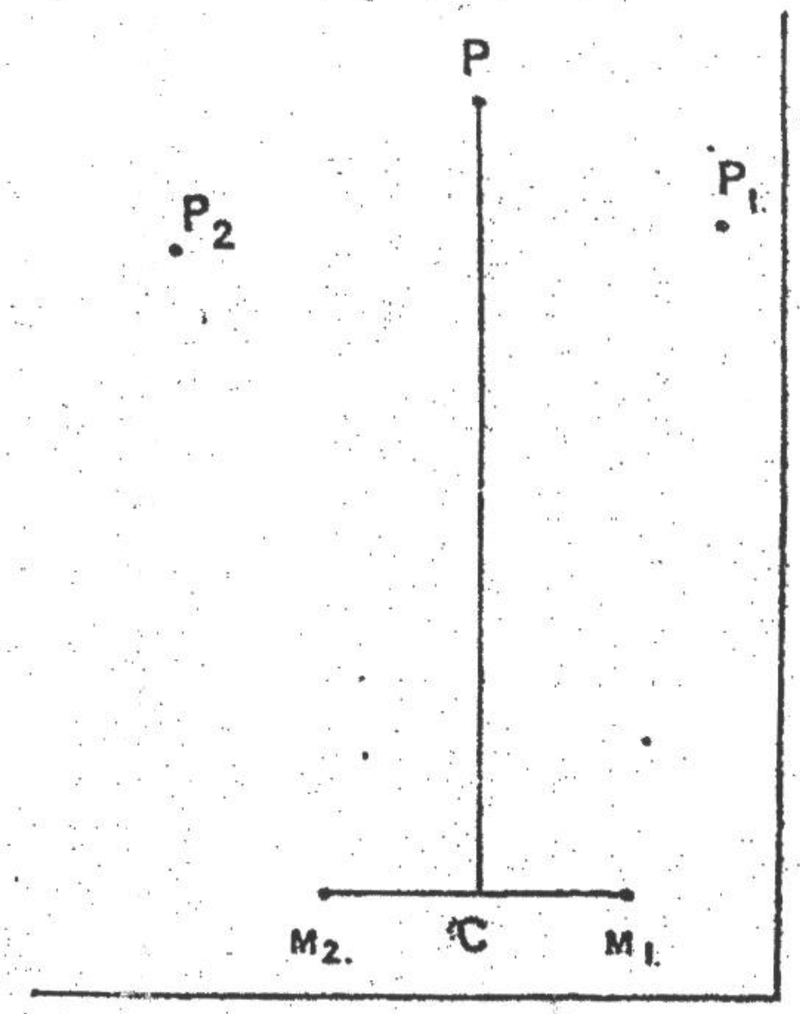
In practice, this hyperbola approximates very closely to its asymptote near the German gun position, so that without appreciable error one may take the asymptote. It is, therefore, possible to draw a scale of time intervals along the edge of a map board, on which the positions of the recording stations are plotted, in such a way that if a definite time interval "t" is recorded, the gun must lie on a line passing through C and through the division "t" on the scale.

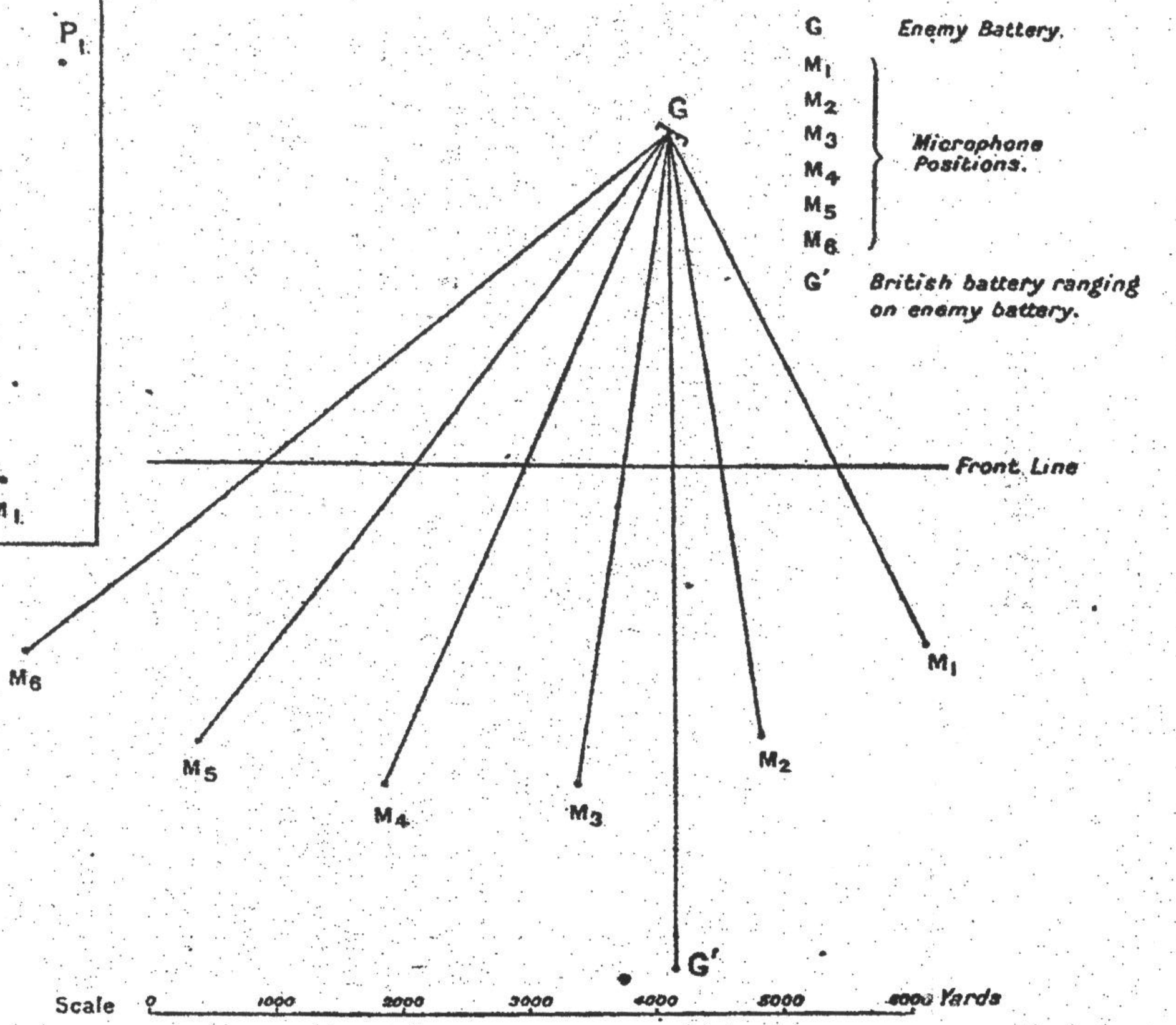
Two points, M_1 and M_2, thus give a line on which the gun must lie, and three points combine to give two lines intersecting in the gun position. In practice it is customary to have six positions, the distance between neighbouring stations being about 1,500 yards and the length of the whole base about 7,500 yards. The base is placed about 2,000 yards from the front line. At each of these stations there is a microphone, these being connected electrically to a central recording station.

At the recording station the currents from the microphone are received by a special type of recording galvanometer. This instrument is capable of measuring to 1/1000 second the time at which the microphone is affected by the report of a gun.

In front of the microphone base there is an advanced post for an observer. When he hears a German gun fire, he presses a key which sets in motion the whole of the recording apparatus. The

I.


P
P2
P1
M2.
C
M1.


G
Enemy Battery.
M1
M2
M3
M4
M5
M6
Microphone Positions.
G'
British battery ranging on enemy battery.
Front Line
M6
M5
M4
M3
M2
M1
G'
Scale
0
1000
2000
3000
4000
5000
6000 Yards

key is kept down for a time sufficient to allow the sound of the gun and the burst of its shell to reach the microphones, and then released. The time intervals are read from the record, and the result laid out on the map board.

The position of the gun and that of the burst of the shell are found. As well as this, the time of flight can be calculated and so the calibre of the gun can, in most cases, be determined. A report of the activity of a hostile battery therefore reads as follows :—

10.5 a.m., 77 mm. gun at 027a2740, shelling T6a.

The average time taken to report the activity of a battery is about ten minutes.

Accuracy of Locations.

Normally, a German gun is at a distance of about 6,000 yards from the microphone base. The results vary in their reliability according to the weather conditions and other sources of error. Under good conditions it has been found that the error in location rarely exceeds fifty yards. The results are divided into three classes—

Class A.—Error does not exceed 50 yards.
" B.— " " 100 "
" C.— " " 200 "

These figures do not refer to the accuracy of the results, but to their reliability. For instance, a Class C result may be within ten yards of the true position. They may be compared with the 100-per-cent. zone in the case of a gun. They indicate the reliance which is to be placed on them as estimated by the conditions under which they have been obtained. For instance, during December and January, one section obtained 260 locations of German batteries, of which one-third were Class A results. In no case did the error for these exceed 50 yards.

In locating a battery position the mean of the best results is taken. If many results have been obtained the mean should be within 25 yards of the true position. This is with reference to the trigonometrical points by which the microphones have been surveyed and is independent of the map error.

Conditions under which Work is Possible.

It is almost impossible to work when a wind of any strength is blowing from the microphone stations towards the hostile battery. Under these conditions the report of the gun never reaches the recording stations at all, being deflected upwards by the wind.

The records are considerably interfered with when a large amount of firing is taking place and a bombardment makes work impossible. Interruption of the record by other noises than gun fire or shell bursts has been overcome by improvements to the apparatus.

The microphone now used, while responding to a gun, however faint, as long as it is audible, is absolutely unaffected by other noises, such as speech, and is even unaffected by a rifle fired within 10 yards.

Work is also liable to be interrupted owing to the difficulty of maintaining the large amount of wire (about 40 miles) which connects the microphones to headquarters.

Other conditions do not affect the results. In particular, a Sound Ranging Section can carry on in fog or at night, when other means of ranging or gun location are impossible.

Ranging by Sound.

If a hostile gun fires and is recorded, and one of our batteries fires at it immediately afterwards, the burst of our shell can be recorded under exactly the same conditions as the hostile gun. The errors in locating the gun are almost entirely due to estimations of wind and temperature. These cancel when comparing the results, so that the position of the burst with relation to the target can be given very accurately indeed. Under favourable conditions an accuracy of 25 yards for range and 10 yards for line can be guaranteed.

It is arranged beforehand which German batteries are to be taken on should opportunity occur, and direct telephone communication between the battery and the Sound Ranging Section is provided for. Directly good records are obtained of one of these batteries, our battery fires at it and the fall of each round is reported by the Sound Ranging Section. A result can be reported four minutes after firing the gun. As soon as the battery has got on the target four or five rounds are fired, without waiting for the correction to each round, and the Sound Ranging Section reports the result of these rounds after all are fired, thus making the ranging much more rapid.

It is possible to range on a battery which has been recorded some time previously. In this case allowance has to be made for the differences of wind and temperature on the two occasions. These can now be allowed for with considerable accuracy, and the whole error so introduced is not likely to exceed 50 yards. This greatly increases the opportunities for counter-battery work, as ranging can be carried out whenever the weather conditions are favourable.

Lastly, it is possible to range by sound on a pin point on the map. But here the error of the map is introduced, and the accuracy of the results is dependent on this error. When ranging on points close to the front line, the sound-ranging error does not exceed 25 yards, and ranging can be carried out under almost any weather conditions.

Ranging can be carried out with any calibre of gun or howitzer. With the smaller calibres it is necessary to range when there is not much interference by other firing. The fuze makes an

APPENDIX.

The attached tables give the results of actual trials of ranging by sound. In Table A the target was located by sound and the guns were ranged by the differential method. In Table B the position of the gun was taken from the map and corrections were made for wind and temperature. The wind conditions were by no means favourable.

Although the results in Table B may be considered satisfactory, they show constant errors in line (Rt.) and range (+). These errors are due to the wind, the rate and direction of which can never be perfectly known, and the advantage of the differential method is very apparent.

TABLE A.

EXPERIMENTAL SERIES, 6-INCH B.L. HOWITZER (SOUND-RANGING SECTION)
14TH MARCH, 1917.

Target=H. 1 c. 63.69=3,790 yards.

Round.	Fall of round.				Sound-ranging error.		Remarks.
	Calculated by sound ranging.		Measured by tape.				
	yards.	yards.	yards.	yards.	yards.	yards.	
1	80 L	+60	78 L	+89	2 L	−29	
2	5 RT	−10	3 L	− 5	8 RT	− 5	
3	Line	+55	L	+53	11 RT	+ 2	
4	25 RT	± 0	3 RT	+18	22 RT	−18	
5	10 L	−75	13 L	−50	3 RT	−25	
6	5 L	± 0	1 L	−11	4 L	+11	
7	10 L	+50	1 L	+48	9 L	+ 4	
8	Unobserved		3 RT	− 5	...	...	
9	10 L	+30	2 L	+37	8 L	− 7	
10	5 RT	−20	3 RT	−30	2 RT	+10	
11	5 L	+10	8 RT	+20	13 L	−10	
12	Line	± 0	2 RT	− 2	2 L	+ 2	
13	5 RT	+10	13 RT	+ 7	8 L	+ 3	
14	Line	−15	6 L	−18	6 RT	+ 3	
15	5 L	+25	10 RT	+ 1	15 L	+24	
16	15 RT	−25	1 RT	+ 1	14 RT	−26	
17	5 RT	+45	12 RT	+56	7 L	−11	
18	10 RT	−13	3 L	− 3	13 RT	− 7	
19	20 RT	+25	14 RT	+20	6 RT	+ 5	
20	5 RT	−25	2 L	+ 5	7 RT	−30	
21	15 RT	+30	14 RT	+65	1 RT	−35	
22	5 L	± 0	10 L	+20	5 RT	−20	
23	Line	± 0	3 RT	+18	3 L	−18	
24	15 L	+20	21 L	− 2	6 RT	+22	
25	5 RT	+30	3 L	+20	8 RT	+10	

Mean error of series=7·52 RT and −14.
Mean algebraic error=1·7 RT−6·04.

enormous difference to the results. Delay action fuzes almost always give poor results, and if possible direct action should always be used.

Measurement of Muzzle Velocities.

The error in recording a short time interval by the galvanometer can be reduced without difficulty to 1/5000 second. This has been applied to the measurement of muzzle velocities by the Experimental Section at the Overseas School of Gunnery. The shell passes through two wire screens about 20 yards apart, breaking two electrical contacts, and the times are recorded by the galvanometer. The muzzle velocity can be recorded with an error not exceeding 5 feet per second. At the front there is now a Sound Ranging Section to every Corps area, and it would be very easy to carry out this calculation for any gun where it is possible to erect the necessary screens.

History of Sound Ranging.

The Bull apparatus used at first by the Sound Ranging Sections was identical with that employed by the French Army. The first experimental section was sent to the front in October, 1915. In December, 1915, the results obtained were considered sufficiently promising to justify the formation of two sections to each Army. In June, 1916, a new type of microphone was invented, and this immensely improved the results, eliminating all the difficulties due to the "Onde de choc," and to interference by other noises than gun reports. It was decided in July, 1916, to form sections at the rate of 1 per corps. About this time, with increased experience, it was found possible to correct better for wind, and this more than halved the errors of the results. At the present time the whole front is covered by Sound Ranging Sections, and the work of location of hostile batteries is assisted largely by them. In particular, a Sound Ranging Section can establish with certainty the exact targets at which each hostile battery fires and its calibre, because it registers and places the burst of the shell as well as the report of the gun. Ranging on a hostile battery is, as yet, not carried out universally, because, although there is every theoretical reason to believe in the accuracy of the results, no direct tests have yet been made. It is hoped to carry these out shortly with the Experimental Sound Ranging Section.

[Note.—Since this was written these tests have been carried out, and the results will be found in the Appendix.]

TABLE B.

Experimental Series, 6-inch B.L. Howitzer (Sound Ranging), 14th March, 1917.

Target=Datum "B" 4208—4212 yards.

Round.	Fall of round.		Sound-ranging error.		Remarks.
	Calculated by sound ranging.	Measured by tape.			
	yards.	yards.	yards.	yards.	
1	10 L	Range	28 L	—13	18 RT	+13	
2	Line	—50	19 L	—73*	19 RT	+23	
3	10 L	Range	17 L	—58	7 RT	+58	
4	5 RT	—30	13 L	—40	18 RT	—10	
5	10 RT	+50	7 L	—15	17 RT	+65	
6	Line	—40	14 L	—36	14 RT	— 4	
7	Line	—50	18 L	—76	18 RT	+26	
8	Line	+25	10 L	+ 9	10 RT	+16	
9	10 RT	—25	19 L	—72	20 RT	+47	
10	15 RT	Range	13 L	—10	28 RT	+10	
11	5 L	—25	30 L	—65	25 RT	+40	
12	15 RT	+25	11 L	— 4	26 RT	+29	
13	5 L	+10	35 L	—23	20 RT	+33	
14	10 RT	—25	18 L	—30	28 RT	+ 5	
15	Line	Range	27 L	—26	27 RT	+26	
16	15 RT	—35	13 L	—50	28 RT	+15	
17	20 RT	—50	10 L	—72	30 RT	+22	
18	10 RT	+65	12 L	+50	22 RT	+15	
19	15 RT	Range	9 L	—12	24 RT	+12	
20	20 RT	Range	7 L	—15	27 RT	+15	

Mean error of series=24·2 (range) and 21·75 (line) yards.
Mean algebraic error=21·75 RT and +22·8 yards.

Note.—At "Switch Target" the mean error (5 rounds) was:—

+28·4 yards for range.
7·8 yards right for line.