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WIND MEASUREMENTS BY PARACHUTE

Sven Nordstroem

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16. Abstract

Earlier results of wind measurements by radar observation of a parachute rather than a balloon justify continued investigations by releasing parachutes at higher altitudes. Tests used the 8 cm "Lotta" grenade as well as 12 cm M/70 and 10.5 m/62 grenades, released at altitudes between 2000 and 6400 meters. The parachutes were tracked by "AP" and "RFK". In later experiments wind data were also obtained for comparison by tracking hydrogen-filled balloons in part with the CORA system, in part with radar. Generally radar picked up the objects without visual assistance. Wind measurements from parachutes correlated well with those obtained by balloon. Even when the radar locked on to a part of a grenade, descending faster than the parachute, some of the measurements obtained were good. Bodies with a greater rate of descent than parachutes, with less or no tendency toward drift and with sufficient surface for radar tracking, ought to provide reliable results. The existence of vertically well defined winds of jet stream type at low altitudes was established.

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WIND MEASUREMENTS BY PARACHUTE

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Summary

Wind measurement by means of radar tracking of a parachute instead of a balloon has been tried previously with satisfactory results. It has therefore been considered sensible to continue the experiments but to release the parachutes at higher altitudes.

The ammunition used was the 8 cm Lotta finned illuminating shell, the 12 cm M/70 finned illuminating shell and the 10.5 cm M/62 illuminating shell with separation altitudes between ca. 2000 m and ca. 6400 m. The parachutes were tracked by radar from both AP and RFK[1]. For comparison the wind was during later experiments measured also while tracking hydrogen filled balloons according to the CORA system or by using radar.

The radar was as a rule able to pick up the test object without visual assistance. The winds measured by means of the parachute were generally in satisfactory agreement with the results obtained with the balloon except for errors made when using the latter due to mistakes in ground data. Although the radar sometimes locked on to only a part of the grenade body which was falling considerably faster than the parachute fairly satisfactory results could be obtained. Bodies with a greater rate when descending than parachutes and with lesser or no tendency for drifting ought to furnish reliable results. According to an Austrialian report spheres of suitable size and weight should be useful for this purpose. The occurrence at low altitudes of well delimited /2
and markedly deviating winds (of jet stream type) were demonstrated. When making wind measurements throughout one full day the importance of correct and frequent measurements of the wind, e.g. during tabular firing, was demonstrated by means of evaluating the trajectories.

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INTRODUCTION

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Various methods for determining wind force and wind direction have been discussed within the ballistic-meteorological field. One method, selected for having been tested primarily as a method for replacing balloon measurements, consisted of measurements using parachutes, i.e. tests executed by means of a descending instead of an ascending object.

The first experiments were made during August of 1977 when parachutes lifted to an altitude of maximum 1600 m by means of rockets or helicopters were tracked during their descent by means of different measuring instruments [Nordstroem and Wickerts, 1978]. The results of these tests demonstrated that the method ought to provide results comparable to balloon measurements when the correct kind of parachutes were used. However, the missiles used had a too low maximum altitudinal range. Therefore tests releasing the parachutes at considerably higher elevations should be made, if possible while using illuminating ammunition for artillery guns of different calibers. This has now been done during both March and December of 1978 at the AP, Karlsborg. Additional tests during March of 1979 at the firing range on the Torshamn Peninsula furnished no results due to defects in the radar station used for these experiments.

ARRANGEMENT OF THE TESTS

The following types of weapons and ammunition were used for these experiments, intended to test the possibilities of making measurements at higher altitudes and through a cloud cover:

May 24, 1978	An 8 cm M/29 grenade launcher using finned illuminating "Lotta" shells but without the illuminating unit.
Dec. 5 - 7, 1978	A 10.5 cm M/4140 howitzer using an illuminating M/62 shell and a 12 cm M/41 grenade launcher using a finned illuminating M/70 shell.
Measuring instruments	A Plessey Wind-Finding Radar WF 3 placed on the Skansen redoubts at the AP; a Marconi Radar PE 09, placed at R 1022 of RFK.

Conventional radar measurements of hydrogen filled balloons were used as reference method and during later tests also the so-called CORA method. This is based on a radio-receiver attached to the balloon and providing opportunities for tracking the path of the balloon by means of the LORAN system. On the basis of the phase shift between the signals from these specially selected transmitters the changes in geographical position of the balloon can be determined. The force and the direction of the winds can then be estimated with an accuracy of better than 2 m/s in respect to the wind force on the basis of such changes in position over set time intervals. Below the balloon a radio sonde is suspended furnishing continuous data on air pressure, temperature and relative humidity. From these data the altitude of the ballon can be calculated. /5

The course of the experiments is illustrated in Table 1. There it is stated which object was involved in each test as well as what measuring instruments were used. For both test occasions the point of separation was calculated for the projectiles in question from tabular data or by calculating the trajectory, whereby the adjustment data for the radar (altitudinal and latitudinal angles as well as inclination distance) to that point were calculated and furnished to the operator. There was no directing of the antennas by visual means. Thus, the tests corresponded to measurements through a cloud cover.

Regarding data on the illumination shells used, see pages 33 to 35 (pp. 35 - 37 orig.).

During the test firings made in May, 1978, the first parachute drifted quickly in over land, posing a risk for accident when landing. For the following two rounds, the guns were moved from the battery farther down toward the lake. In addition both the preparation and the fuze time intervals were abbreviated so that the risk of having the parachute drift in over inhabited areas could be eliminated. Simultaneously the separation altitude was lowered from ca. 1850 m to ca. 950 m at an inclination distance of ca. 3900 m from the radar.

During the tests in December the fuze time was set at ca. 8 seconds after reaching maximum trajectory altitude. It was intended that the body of the shell should then have a downward directed speed and disappear faster from the measuring sector of the radar than the parachute. Otherwise when locking /6 on to automatic tracking the radar might pick up the shell which gives a stronger radar echo than the parachute and its illuminating unit. This happened a few times. The timed separation point was at ca. 6500 m altitude for the 10.5 cm illuminating shell and at ca. 3200 m for the 12 cm finned illuminating shell.

RESULTS

Data on the winds recorded by means of the different test objects are given in Figures 1 - 12. The first two diagrams contain the data obtained with the 8 cm "Lotta" finned illuminating shell as well as the parallel balloon measurements executed at RFK. For comparison, normal data on the wind, taken by F 6, are furnished in Figure 2 as well. Round no 1 was picked up by both radar stations. However, the parachute drifted in over land so fast that it soon became obscured for the AP radar by the Skansen redoubts. Round no. 2 was not picked up by the Plessey instruments since the PE locked on to the body of the shell only. Round no. 3 was picked up at 7000 m altitude by the Plessey alone. However, the agreement between the parachute and the balloon data is even better than that between the balloon measurements made by RFK and by F 6.

Figures 3 - 12 illustrate the data obtained during the latter series of tests where, the data from each parachute measured are compared with the nearest balloon measurements.[3] Series 1 used 10.5 cm illuminating shells while series 2 used 12 cm finned illuminating shells.

The balloons were tracked by the CORA method and/or the radar stations to an altitude between 7000 m and 9000 m in order to provide data on the winds at the maximum altitude of the trajectories during a simultaneous tabular test firing. To achieve an altitudinal scale easier to handle data have been included in Figures 3 - 11 from somewhat higher up than the separation /7
altitude of the parachutes.

When using the CORA system the wind data were calculated in the form of means and as equalization of a series of means. At first data on the ground level winds measured were included. However, due to an instrument defect

[3]For the sake of lucidity all test data have not been included in Figures 3 - 12.

an erroneous ground speed was inserted resulting in that the CORA wind speeds are frequently too low up to an elevation of ca. 1000 m (see Figures 7 - 11).

Radar tracking of the parachutes results often in an oscillating graph which may depend on the fact that the parachute swings more or less in relation to the surrounding air. During the actual measurements a similar result was, however, obtained during radar measurements of a balloon; cf. for instance Figures 3 - 5. Then the reason can hardly be swinging since although the load below the balloon (radio receiver, radio sonde, etc.) may swing around somewhat below the balloon, this will hardly give the balloon itself any tendency to drifting off in any direction. When data are available from both CORA and radar, the CORA graph represents often the mean curve of the radar data. More will be said about this phenomenon below.

The wind data according to the parachute measurements and according to the CORA method agree often satisfactorily although the former are much more irregular. It is interesting to observe how closely the graphs from both radar stations concur during simultaneous tracking of parachutes as shown in Figures 9 and 10. The result was the same when both radar stations tracked a balloon. In Figure 12 data are given of the tracking of balloon no. 8 by CORA and by both radars. The CORA evaluation of this tracking was incomplete so that only a few scattered points could be used for the diagram. Both /8
radar graphs follow each other closely, especially in respect to wind speeds. It is quite obvious that these graphs reflect the actual movements of the balloon (or, in other cases, the parachute) such as it was recorded at 30 second intervals without any smoothing out between the measuring points. The reason may be a combination of the self-drift of the test object and the air turbulence.

In a few cases the radar locked on to a part of the projectile instead of the parachute. This happened during Series 1, Round no. 2 (Figure 5). The descending speed of the body tracked was here ca. 24 m/s against ca. 12 m/s for the parachute. From about 5000 m altitude down to about 2500 - 2000 m this body furnished almost the same data on the wind as the nearest balloon. Below that altitude there were considerable deviations. During Series 1, Round no. 4, the RFK tracked the parachute while the Plessey radar locked on to a projectile part, in this case following it at a speed of ca. 30 m/s.

This, too, demonstrates that measurements of a body can furnish satisfactory results, especially in respect to the speeds following the first point measured. That value is definitely unreliable in many of the cases measured.

Finally, during Series 2, Round no. 2 (Figure 8) the AP radar tracked first a body falling at a rate of 8.3 m/s from ca. 2600 m altitude down to ca. 200 m. Thereafter, following a short search, the parachute was picked up at 1500 m altitude and tracked from there at a descending rate of 2.7 m/s down to a minimum altitude. In this case the graphs of both bodies when descending agree well with that of the "balloon wind". Up to an altitude of 1000 m CORA lags behind in respect to wind speed. It ought to be possible to use bodies falling at a much greater rate than the parachutes tested (ca. 11 m/s and 2 - 3 m/s, respectively) on the condition that they have an adequately large surface reflecting the radar and that they drop without drifting sideways by themself. In an Australian report Burger [1978] tells of the construction of a high altitude rocket intended for releasing a /9
passive sphere, ca. 12 cm in diameter, at 20 km altitude for measuring winds. According to that report, Stage 1 of the actual commission involved a theoretical exploration of the possibilities of measuring winds by means of a freely falling sphere. Since Stage 2 was planned to involve practical tests, it seems that Stage 1 furnished positive results. A report on the latter stage has been ordered.

APPLICATION OF THE WIND MEASUREMENTS

Measurements of the wind in connection with artillery firing can be used in various ways. During test firings, especially during tabular firings, it is essential to know the winds within the atmospheric strata passed by the projectiles during their trajectories. The wind data can be used for both adjusting the firing range to the normal state and for evaluating the Doppler radar data when determining the aerodynamic resistance of the projectile. In the first case a so-called ballistic wind must be calculated, i.e. a value characteristic of the entire projectile trajectory, in turn calculated from the mean wind force within each of the altitudinal strata, whereby the wind force within each layer is given a weight value corresponding to its effect on the firing range. In ballistic handbooks there are usually tables on the weight coefficients for the parabolic trajectories in relation to a number of altitudinal strata. In short, it can be stated that the top layer has the highest value and that the sum total of the weight coefficients is always = 1.0. A computer program has been devised by the Bofors Co. which calculates the ballistic winds based, in principle, on an optional number of measuring points. (During the operation discussed here, the winds measured were first recalculated as winds along or across the actual projectile trajectories.) Some examples will demonstrate the effect of the ballistic winds and the importance of using representative wind data.

When calculating trajectories as well as during the refining of the /10
firing ranges established, ballistic winds must be considered. Previously a graph of the air resistance, effective on a 7.5 projectile with a 4.0 caliber secantogival tip (type 1011), had been calculated on the basis of the retardation determined by means of Doppler radar measurements of the trajectory speed of the projectile. Based on this a series of trajectories without any wind effect were first estimated. From that result the maximum altitude and firing ranges can be calculated. Then the ballistic winds at such maximum altitudinal trajectories at a firing direction of 10^{-} and 1200^{-} were calculated on the basis of the wind measurements made on December 6, 1978.

Figures 13 and 14 illustrate the ballistic winds calculated on the basis of the measurements made on balloons and parachutes, respectively. In Figures 15 - 18 the firing ranges thus obtained have been inserted as a function of the time of the day when the wind measurements in question were executed. Thereby the firing is imagined as directed on a bearing of 1200 points (the "conventional" AP bearing when firing) or on a bearing of 10 points. Different muzzle velocities v_o and inclination E were selected in order to cover as large a variation as possible in altitude and latitude. Finally, in Figures 19 and 20 the effect of the winds on some firing ranges has been demonstrated on the basis of winds measured by means of both balloon and parachute. It can be seen from these diagrams that the winds have a considerable effect on the firing ranges and that this effect can vary considerably over the course of a day. This demonstrates the need for frequent wind measurements and the fact that both test methods (balloon and parachute) furnish very similar results although some deviations exist but largely due to the fact that the CORA data below 1000 m altitude are frequently too low.

During March 1979 tests using 10.3 cam illuminating rockets and 12 cm illuminating shells were to be executed at the Navy Firing Range on the Torshamn Peninsula. It had been planned that measurements should be made /11
at an altitude higher than previously possible. However, this experiment did not succeed because the Plessey radar at the site proved to be irreparably damaged. The single result obtained was that it proved possible to lock on to and track the parachute from a 10.3 cm rocket.

CONCLUSIONS DRAWN FROM THE TESTS

A parachute with an illuminating unit or the body of a shell can be picked up by a pre-adjusted radar at a considerable altitude, in this case as high as ca. 5500 m.

The parachutes used as illuminating units will under certain conditions swing around considerably, resulting in that they drift in a spiral fashion. This is a great disadvantage when measuring the wind. If the method of measuring by means of parachutes is going to be developed further, parachutes with a lesser tendency for dangling must be developed. However, a greater rate of descent seems fully acceptable.

The balloons used for the CORA tests seem also to have a tendency to swing around. This does not show up in the CORA wind data since there is an equalization when calculating the balloon winds. This is not so when primarily evaluating the parachute winds and here the drifting of the body itself is reflected in the graphs. When calculating the ballistic winds or when adjusting to straight lines (polygonal trains) by means of a computer, this drifting is balanced out.

A series of wind measurements executed during the same day demonstrates the necessity of frequent wind measurements during firing of artillery with high requirements on accuracy. A "low level jet stream", i.e. a high wind speed within a thin stratum at low elevation, occurred during the actual tests. On December 5 there was a drastic change by ca. 90° in wind direction between ca. 1500 m and 2000 m altitudes. On December 6 the wind speed varied from 4 m/s

at ground level to ca. 15 m/s at 700 m and then back to a constant speed /12
of ca. 5 - 6 m/s above 1000 m altitude. This effect lasted throughout the day (from ca. 0930 to ca. 1500 hr). This emphasizes the necessity of frequent altitudinal measuring points. If there are large intervals when measuring in the altitudinal direction such a strong variation in wind speeds within a relatively limited stratum could result in a single deviating value which might easily be discarded as an erroneous date.

FURTHER DEVELOPMENT OF THE TEST METHOD

The task of the ballistic-meteorological committee regarding the method of measuring winds by means of a descending body has been completed with these tests. They have proven that the method is useful, that with previously not tested material and with an in part inexperienced personnel it furnishes results of equal value as balloon measurements, and that a certain development remains to be done before the method is ready to be used for routine measurements in the field.

A development for practical use falls beyond the limits of this commitment and is therefore handed over to whom it may interest. The further work should be directed toward more stable parachutes. Whether a special ammunition for measuring winds should be developed is perhaps an economic problem. A faster rate of descent than that of illuminating ammunition is acceptable from the point of view of the measurements and even desirable in order to shorten the time required for these measurements.

The possibility of using spheres or other bodies instead of parachutes should also be investigated.

REFERENCES

1. Burger, F.G., "The Aerodynamic Design of a Rocket Test Vehicle for Phase 2 of the AFSTAMS Task," Technical Report WSRL - 0004 - Tr, Department of Defence, Defence Research Center, Salisbury, Australia, 1978.

2. Nordstroem, S. and S. Wickerts, "Prov med vindvisering mot fallskaerm," [Wind measurements by parachute], FOA Report C 20238-D2, Research Institute of the Swedish National Defence, Stockholm, 1978.

TABLE 1.

COURSE OF THE MEASUREMENTS.

Date 1978	Time	Series no/ Round no	E°	Fuze Time s	Measuring Instruments WF3	PE[illegible]	CORA	Remarks
05-24	1030	0/1	85 3/16	16	(x)[1]	x	——	[1] Partial tracking.
	1102	Balloon			-	x	——	
	1310	0/2	45	14	-	(x)[2]	——	[2] Tracked body of shell.
	1320	0/3	45	14	x	-	——	
	1352	Balloon			-	x	——	
12-05	1235	Balloon 1			-	-	——	
	1323	1/1	64	42.5	-	x	——	
	1400	Balloon 2			x	(x)[3]	x	[3] Tracked to 4000 m.
	1444	1/2	64	42.5	-	x[4]	——	[4] Tracked body of shell.
	1507	Balloon 3			-	x	-[5]	[5] No data from CORA.
12-06	0930	Balloon 4			-	——	x	
	1008	1/3	64	42.5	-	——	——	
	1030	2/1	80	33.5	x	——	——	
	1103	Balloon 5			x	——	x	
	1247	2/2	80	33.5	x[6]	——	——	[6] Lost but relocated.
	1308	Balloon 6			x	——	x	
	1352	2/3	80	33.5	x	x	——	
	1423	1/4	64	42.5	x[7]	x[8]	——	[7] Tracked body of shell. [8] Tracked to 1000 m.
	1443	Balloon 7			——	——	x	
	1449	2/4	80	33.5	x	x	——	
12-07	0932	Balloon 8			——	——	x	
	1131	2/5	80	33.5	-	——	——	
	1320	Balloon 9	80	33.5	——	——	x	
	1348	2/6	80	33.5	-	-	——	
	1417	2/7	80	33.5	-	x	——	
	1500	Balloon 10			——	——	x	

Series 0 — 8 cm grenade launcher; "Lotta" finned illuminating shell; Lng[a] 6.

Series 1 — 10.5 cm howitzer M/4140; 10.5 illuminating shell M/67; Lng 7.

Series 2 — 12 cm grenade launcher M/41; finned illuminating shell M/70; Lng 9.

Fuze Time — (Time until separation) set by means of fuze unit.

Measuring Instruments — x = tracking
- = no tracking
—— = did not participate in test.

[a] Expansion unknown.

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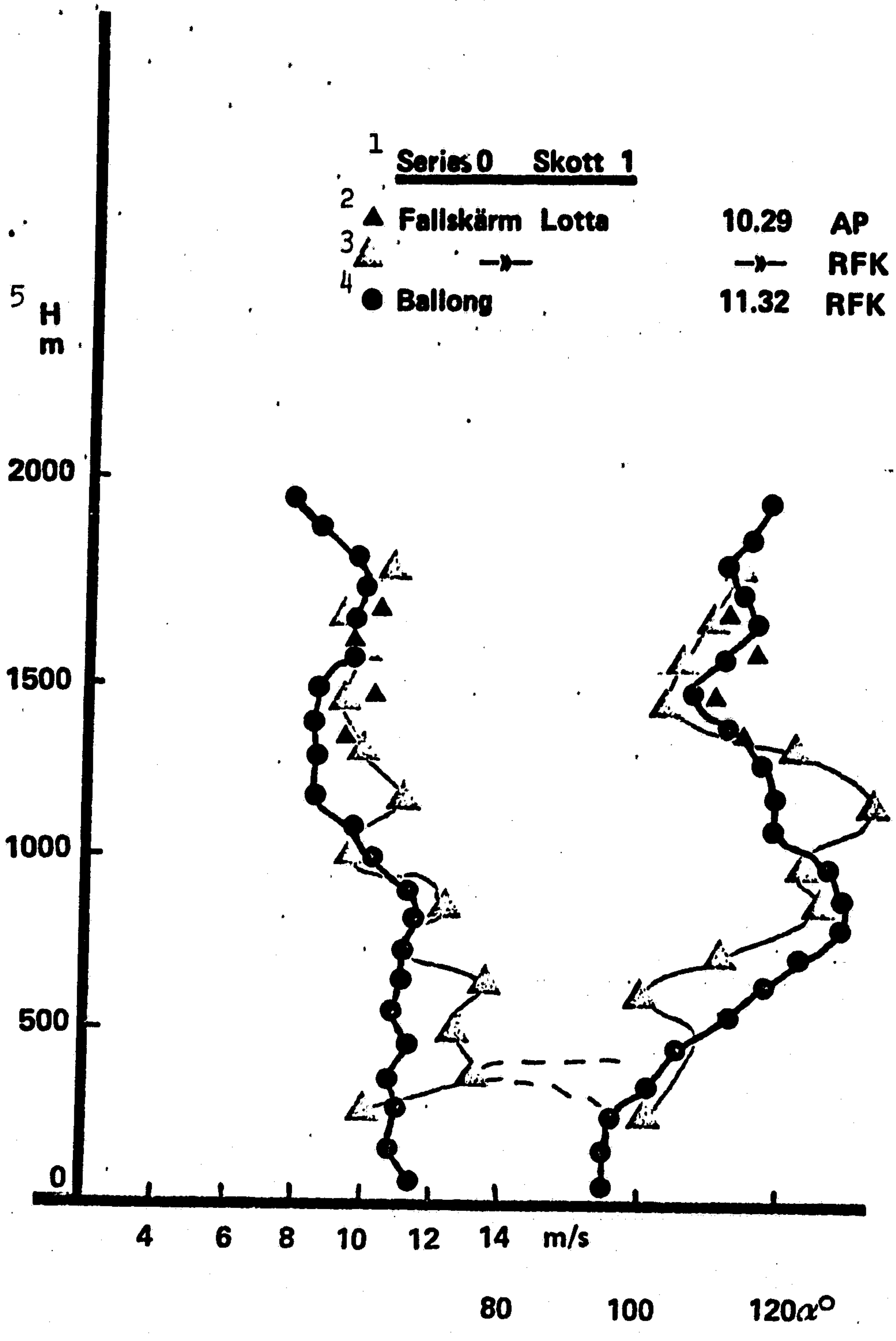

Figure 1. Winds measured with 8 cm finned illuminating shell and balloon.
Key: 1. Series no 0, Round no 1.
2. Lotta parachute; 1029 hr, AP
3. Lotta parachute; 1029 hr, RFK
4. Balloon; 1132 hr, RFK
5. Altitude m.

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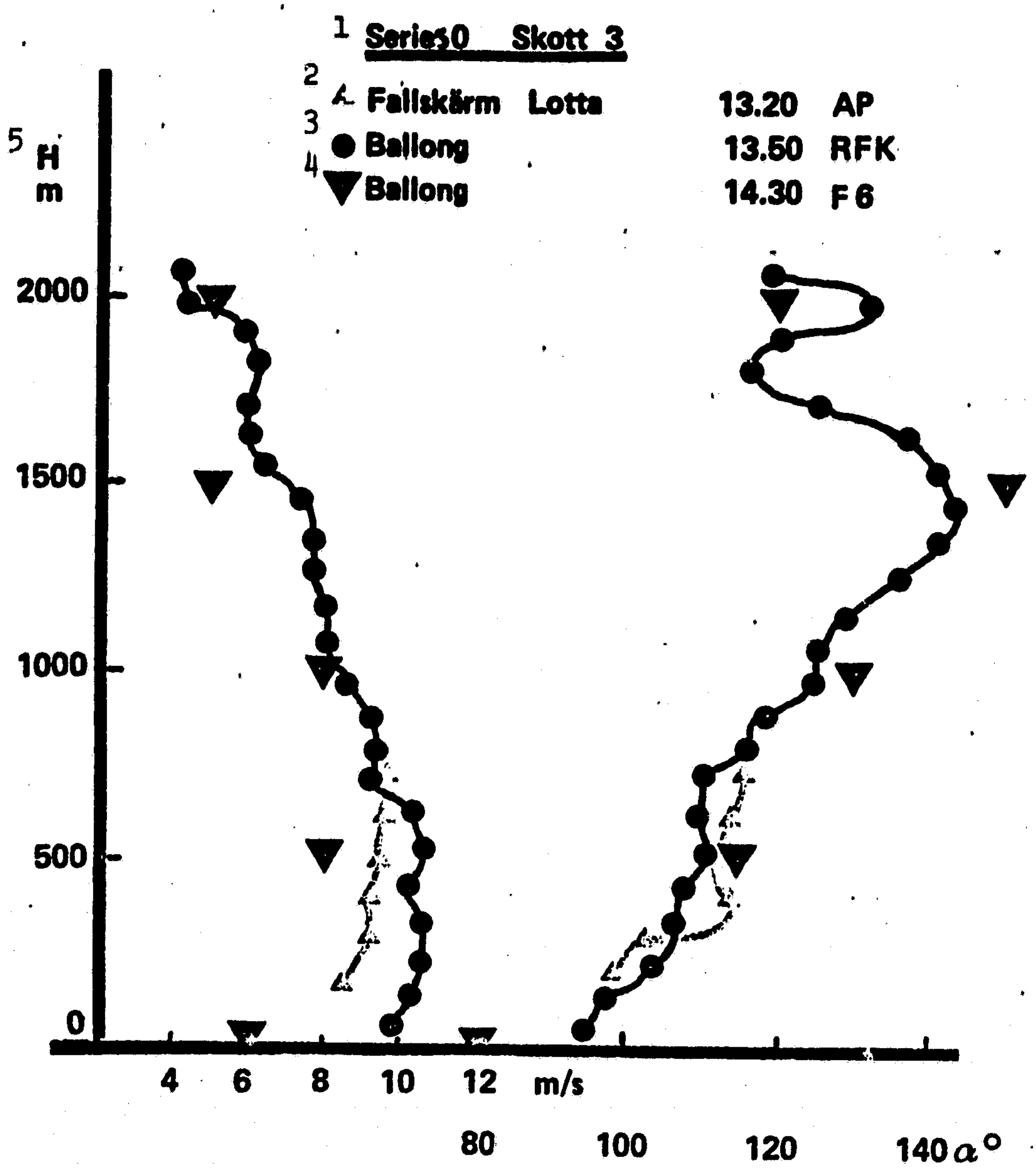

Figure 2. Winds measured with 8 cm finned illuminating shell and balloon.
Key: 1. Series 0, Round 3
2. Lotta parachute; 1320 hr, AP.
3. Balloon; 1350 hr, RFK
4. Balloon; 1430 hr, F 6
5. Altitude, m.

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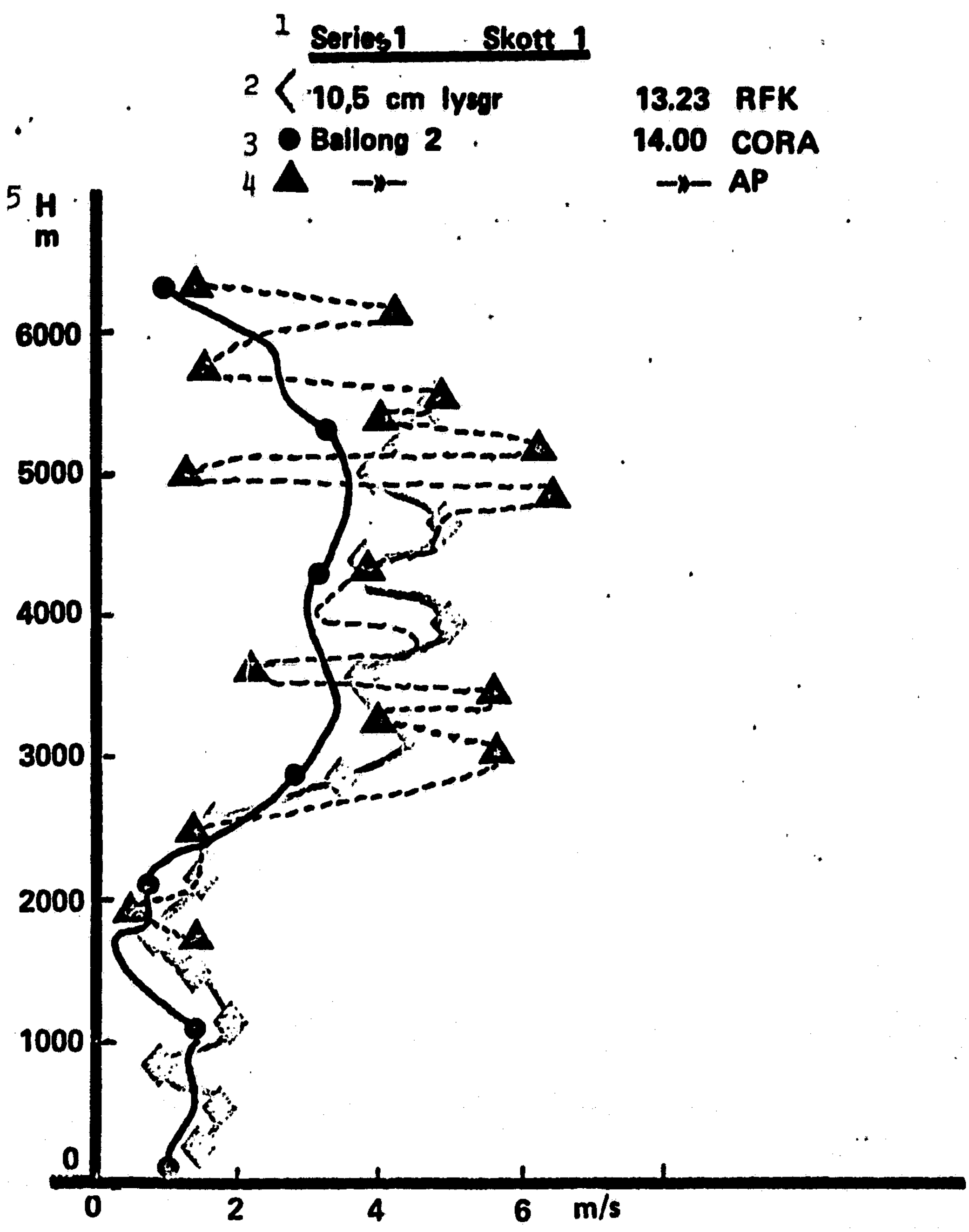

Figure 3. Wind measured with 10.5 cm illuminating shell and balloon.
Key: 1. Series 1, Round 1
2. 10.5 cm illuminating shell; 1323 hr, RFK
3. Balloon no 2; 1400 hr, CORA
4. Balloon no 2; 1400 hr, AP.
5. Altitude, m.

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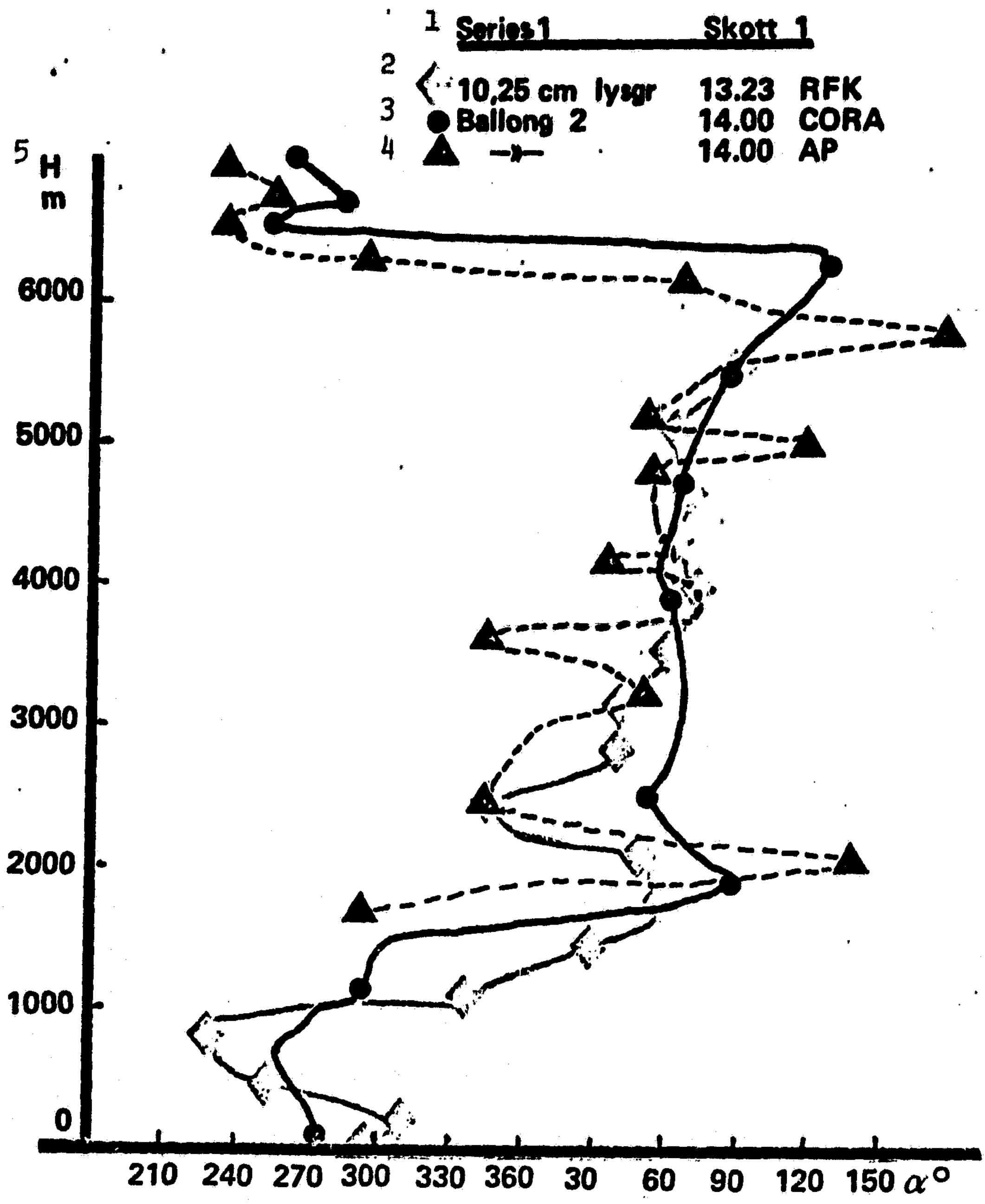

Figure 4. Winds measured with 10.5 cm illuminating shell and balloon.
Key: 1. Series 1, Round 1
2. 10.25 cm illuminating shell; 1323 hr, RFK
3. Balloon no. 2; 1400 hr, CORA
4. Balloon no. 2; 1400 hr, AP
5. Altitude, m.

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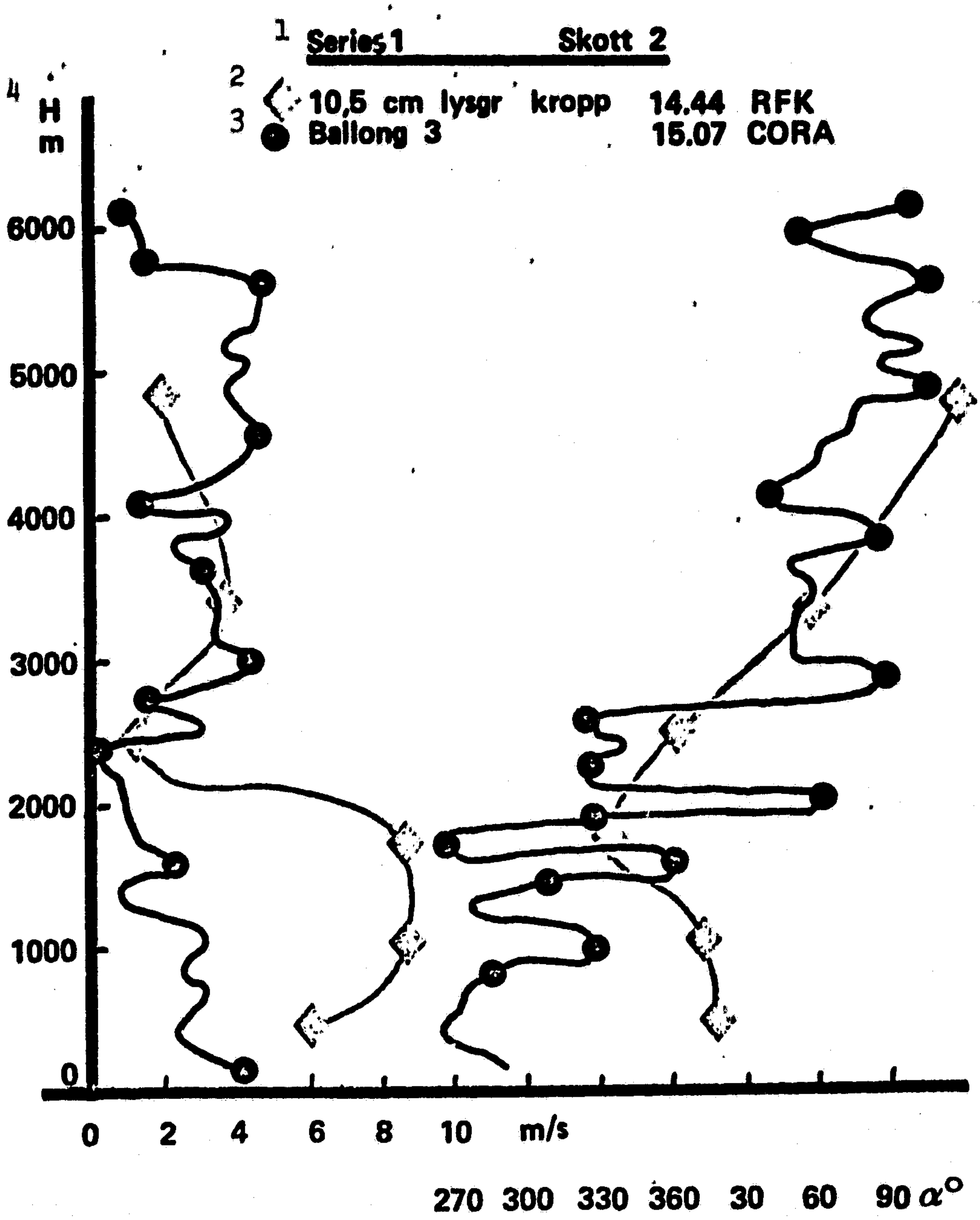

Figure 5. Winds measured with 10.5 cm illuminating shell and balloon.
Key: 1. Series 1, Round 2
2. 10.5 cm illuminating body; 1444 hr, RFK
3. Balloon no. 3; 1507 hr, CORA
4. Altitude, m.

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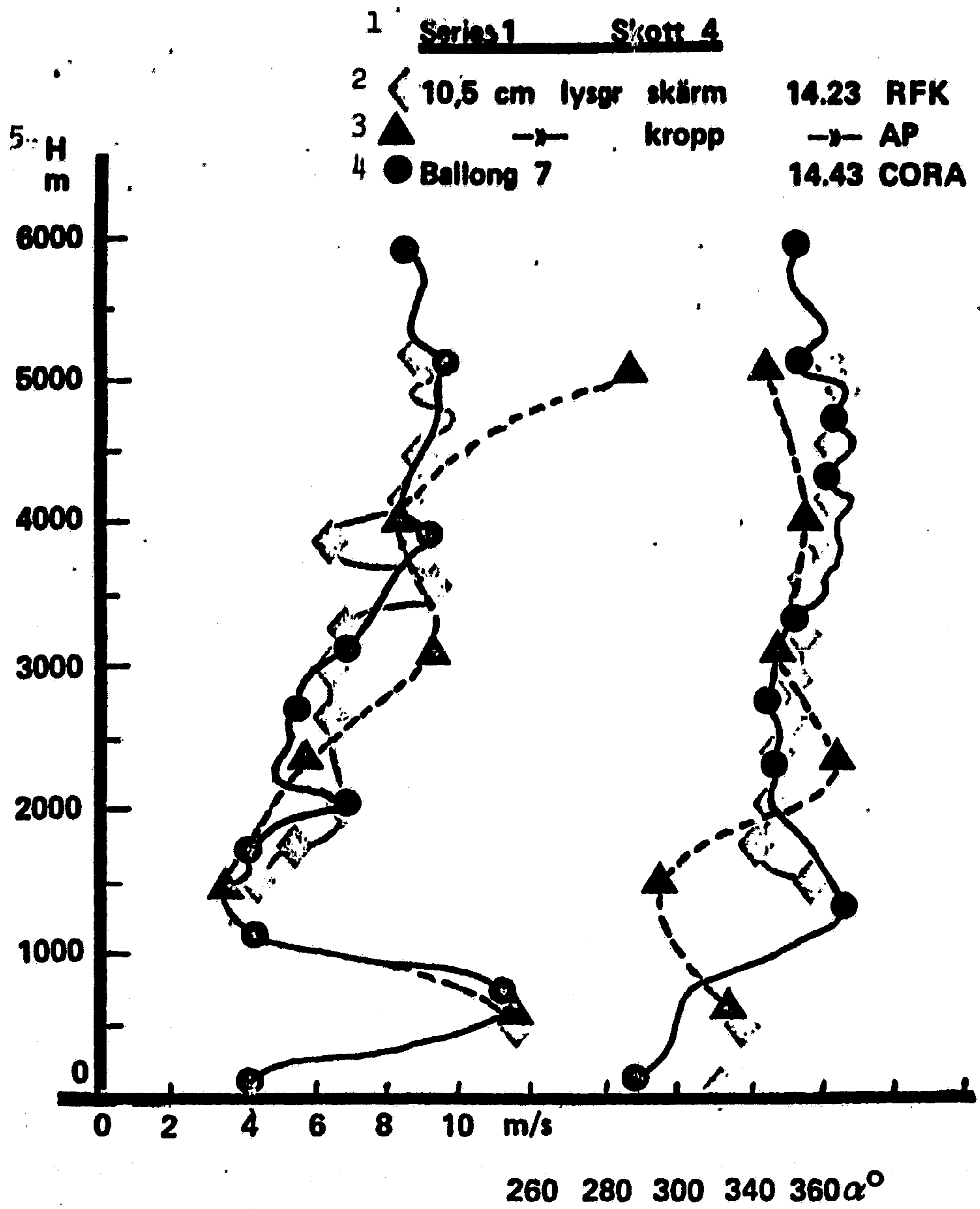

Figure 6. Winds measured with 10.5 cm illuminating shell and balloon.
Key: 1. Series 1, Round 4
2. 10.5 cm illuminating shell, parachute;;1423 hr, RFK
3. 10.5 cm illuminating shell, body; 1423 hr, AP
4. Balloon no. 7 1443 hr, CORA
5. Altitude, m.

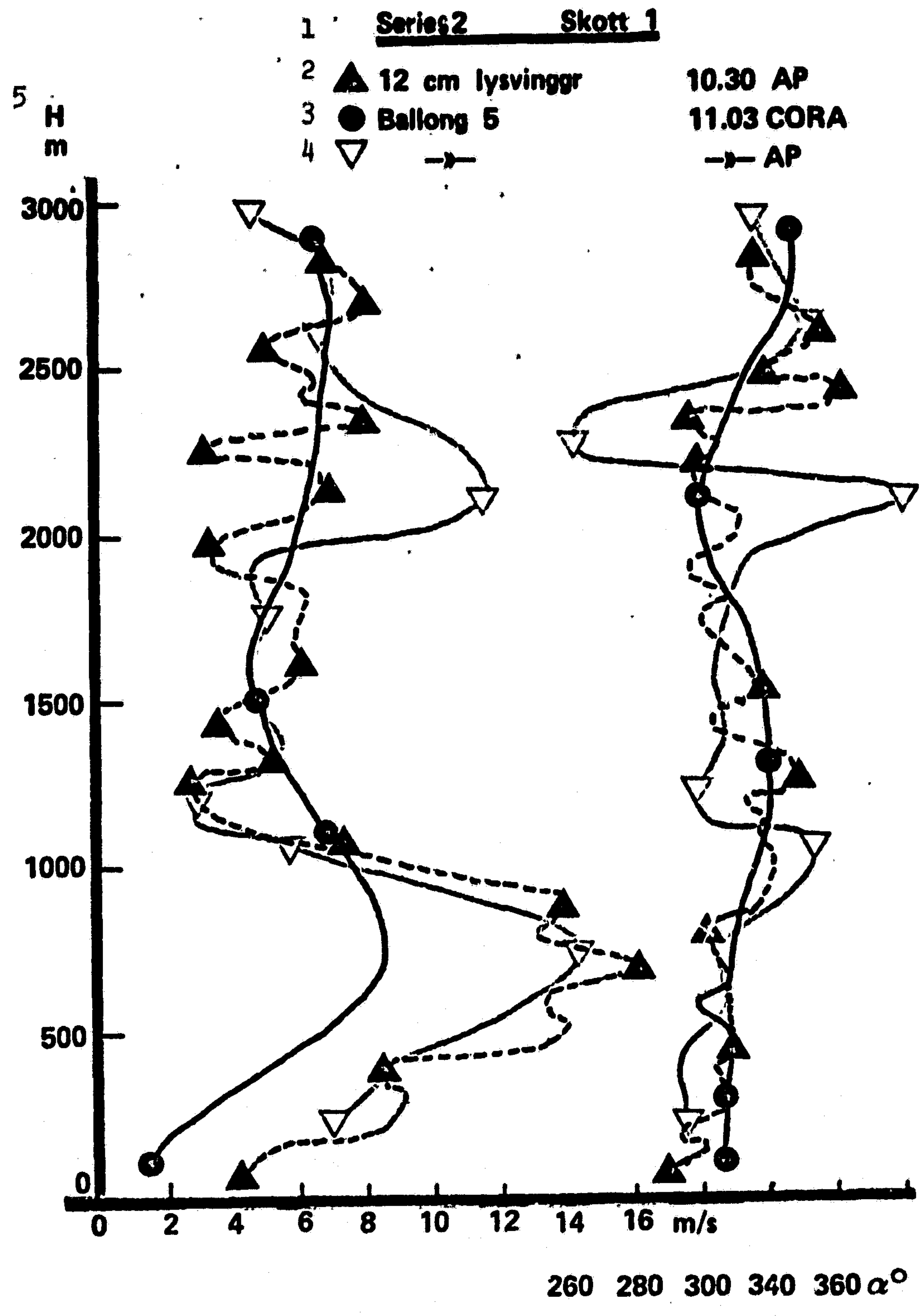

Figure 7. Winds measured with 12 cm finned illuminating shell and balloon.
Key: 1. Series 1, Round 1
2. 12 cm finned illuminating shell; 1030 hr, AP
3. Balloon no. 5; 1103 hr, CORA
4. Balloon no. 5; 1103 AP
5. Altitude, m.

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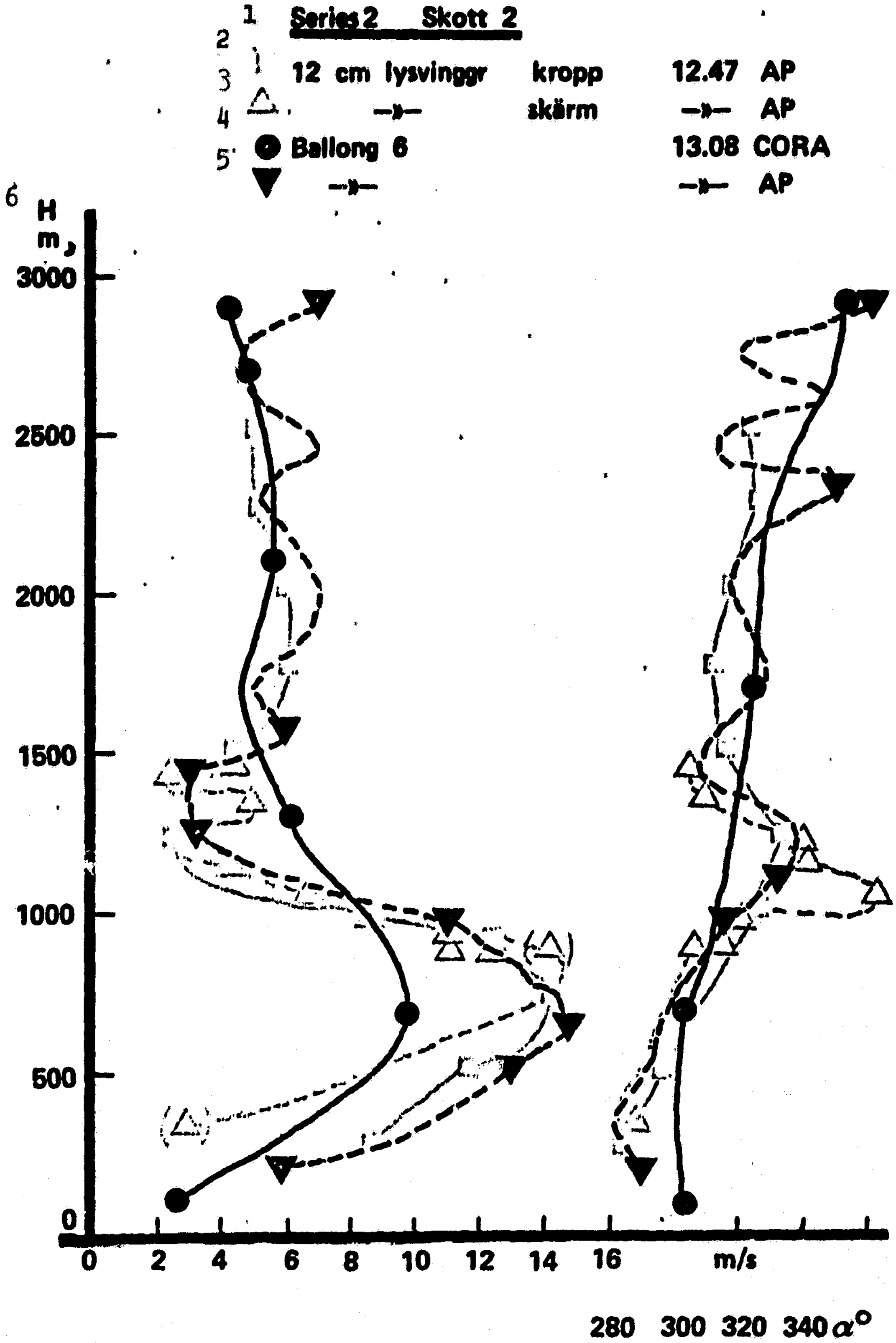

Figure 8. Winds measured with 12 cm finned illuminating shell and balloon.
Key: 1. Series 1, Round 2
2. 12 cm finned illuminating shell, body; 1247 hr, AP
3. 12 cm finned illuminating shell, parachute; 1247 hr, AP
4. Balloon no. 6; 1308 hr, CORA
5. Balloon no 6; 1308 hr, AP
6. Altitude, m.

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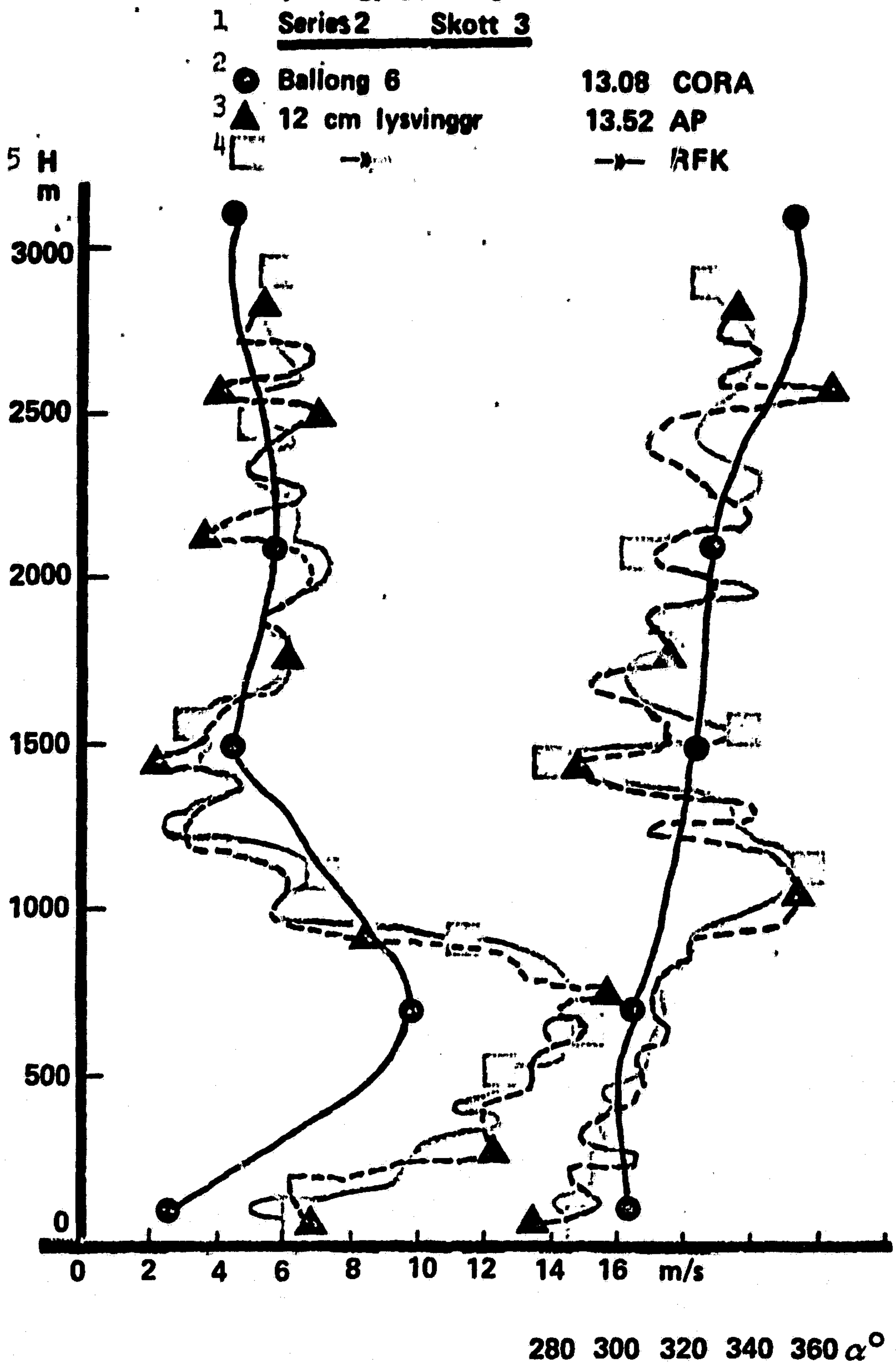

Figure 9. Winds measured with 12 cm finned illuminating shell and balloon.
Key: 1. Series 2, Round 3
2. Balloon no. 6 1308 hr, CORA
3. 12 cm finned illuminating shell; 1352 hr, AP
4. 12 cm finned illuminating shell; 1352 hr, RFK
5. Altitude, m.

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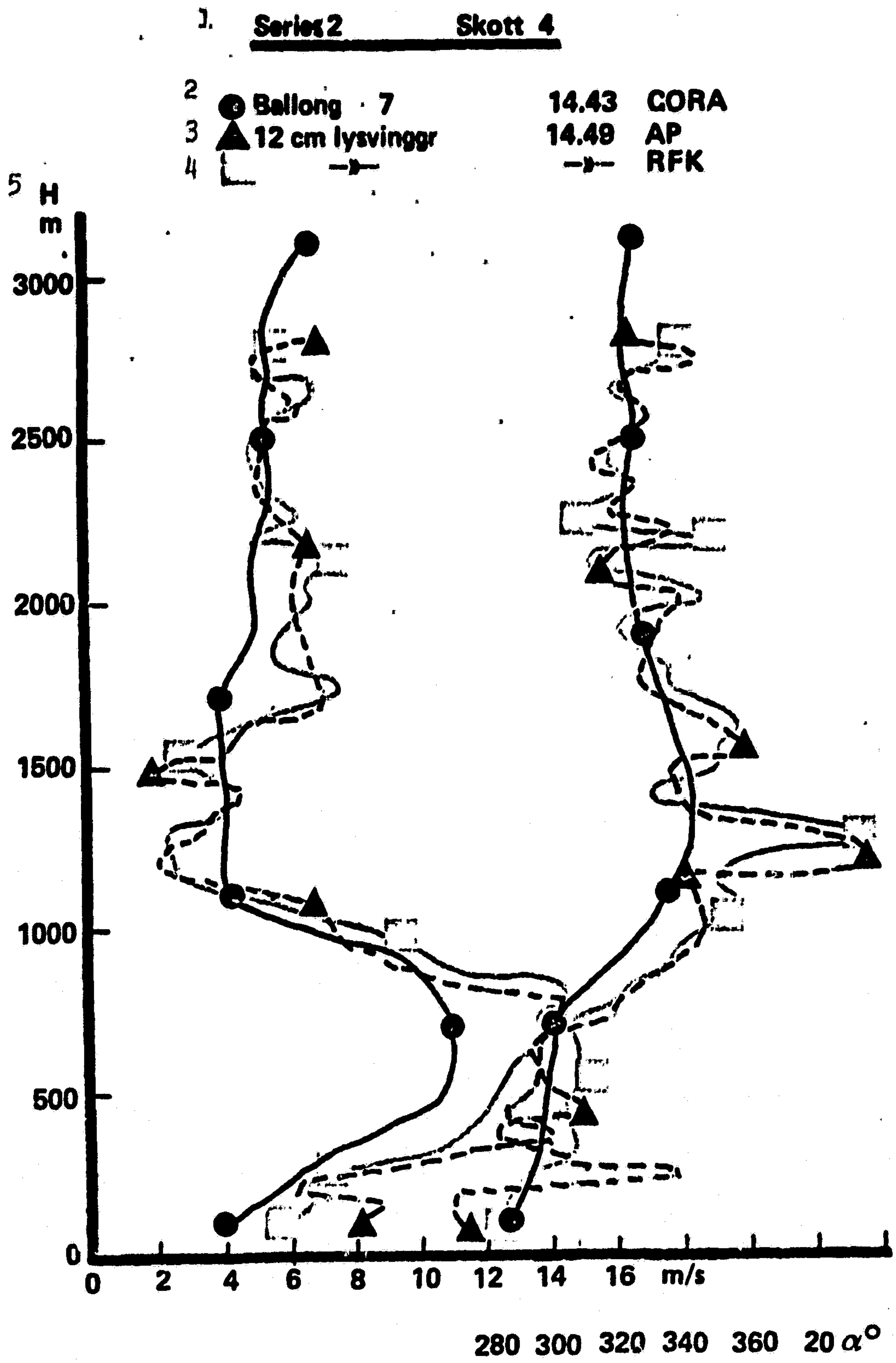

Figure 10. Winds measured with 12 cm finned illuminating shell and balloon.
Key: 1. Series 2, Round 4
2. Balloon no. 7; 1443 hr, CORA
3. 12 cm finned illuminating shell; 1449 hr, AP
4. 12 cm finned illuminating shell; 1449 hr, RFK
5. Altitude, m.

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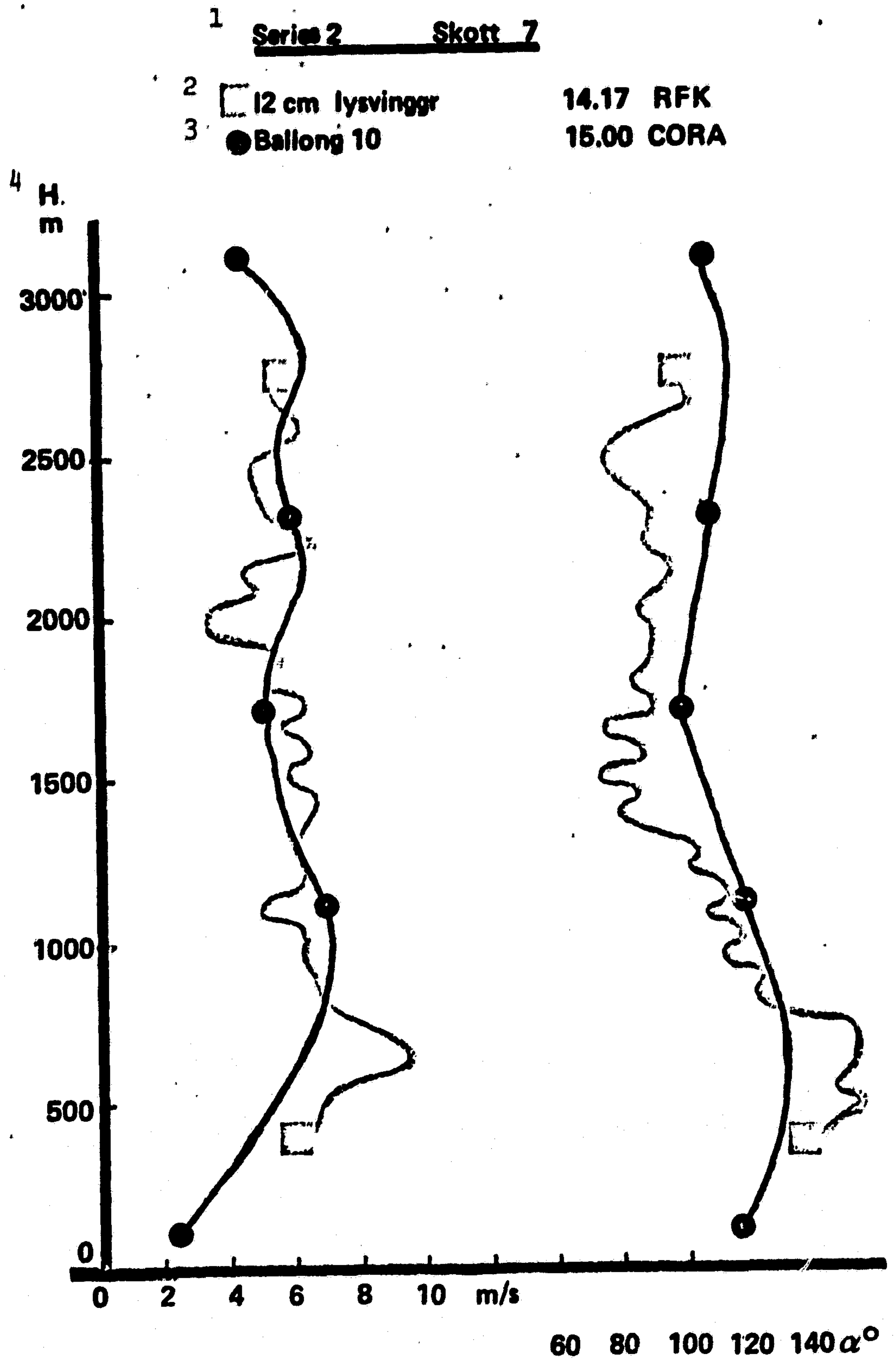

Figure 11. Winds measured with 12 cm finned illuminating shells and balloon.
Key: 1. Series 2, Round 7
2. 12 cm finned illuminating shell; 1417 hr, RFK
3. Balloon no. 10; 1500 hr, CORA
4. Altitude, m.

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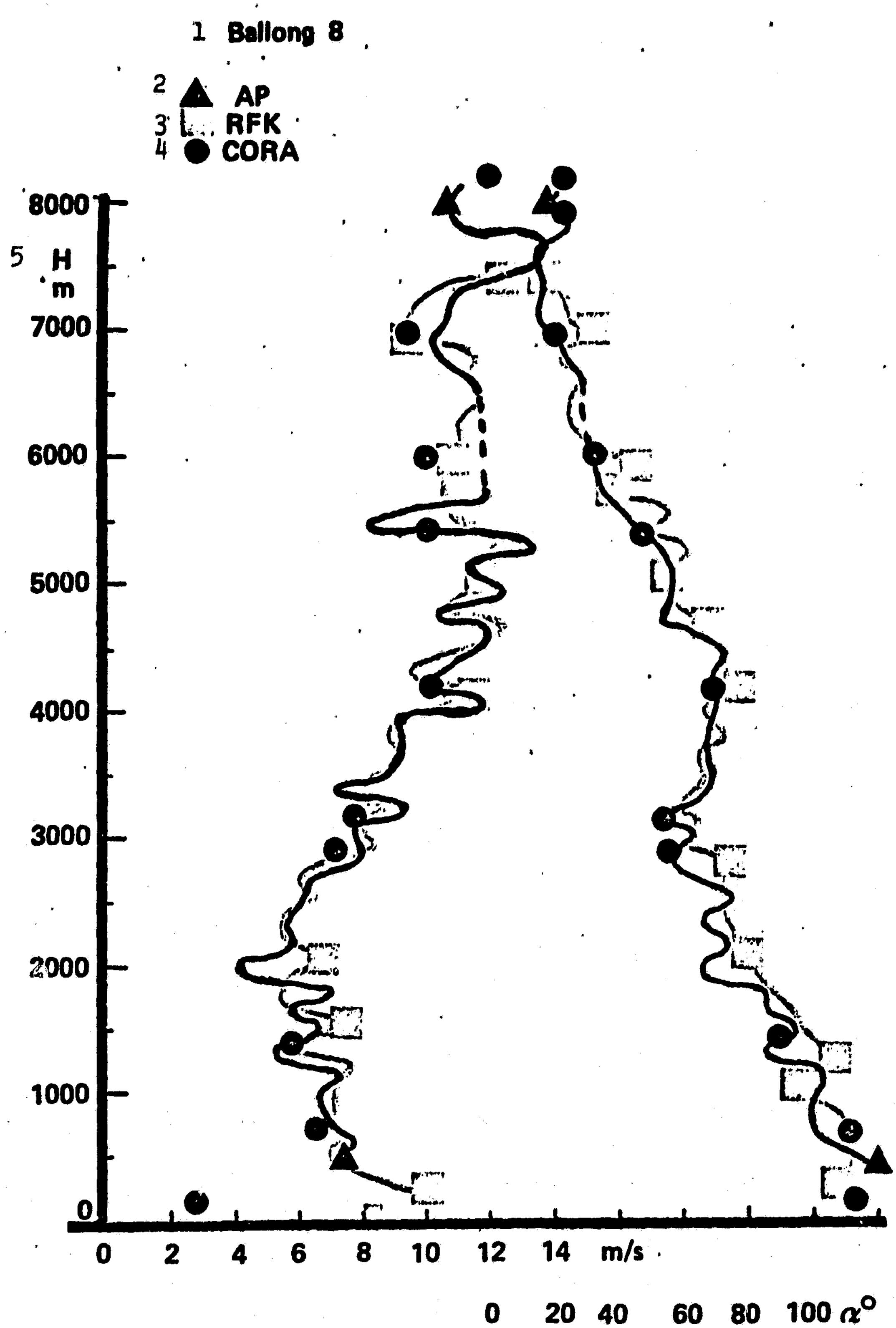

Figure 12. Wind measurements with balloon tracked by two radar stations and by means of the CORA system.
Key: 1. Balloon no. 8; 2. AP; 3. RFK; 4. CORA; 5. Altitude m.

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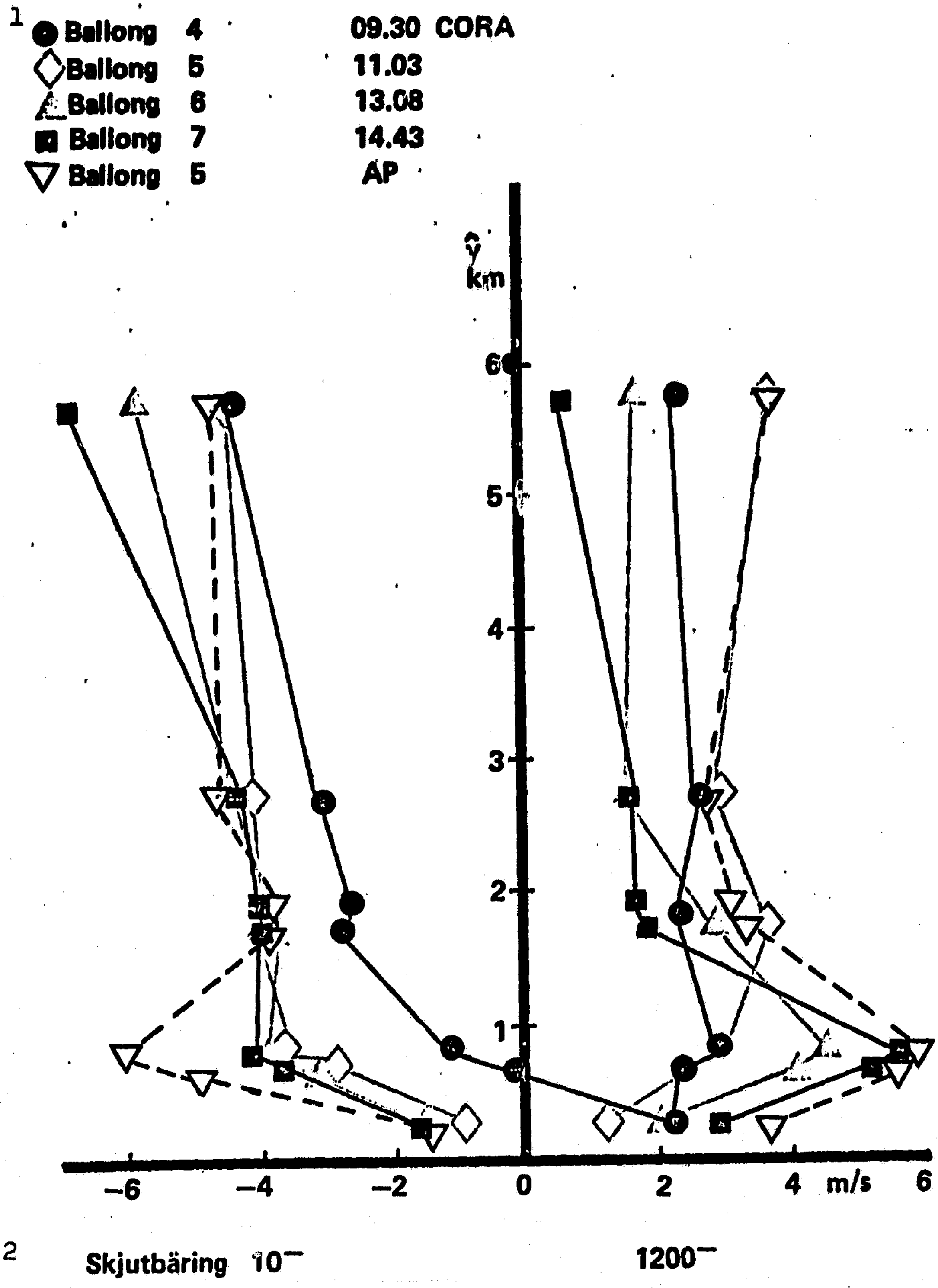

Figure 13. Ballistic winds of trajectories with different maximum altitudes and different bearings. Daily variation in winds measured with balloons.

Key: 1. Balloon no. 4; 0930 hr, Cora
2. Bearing when firing.

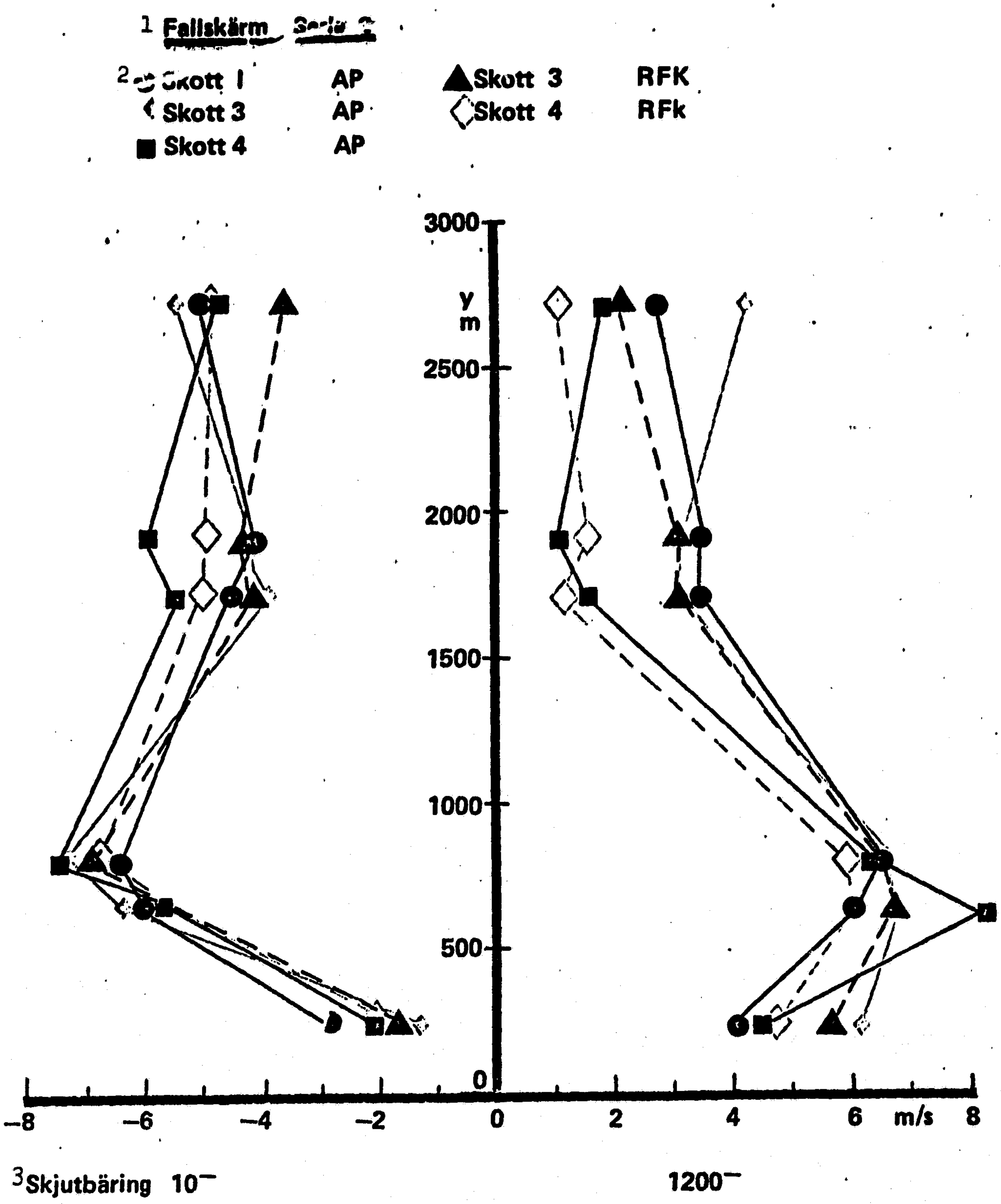

Figure 14. Ballistic winds of trajectories with different maximum altitudes and different bearings. Daily variation in winds measured with parachutes.
Key: 1. Parachutes, Series 2.
2. Round no. 1, AP (etc.)
3. Bearing when firing.

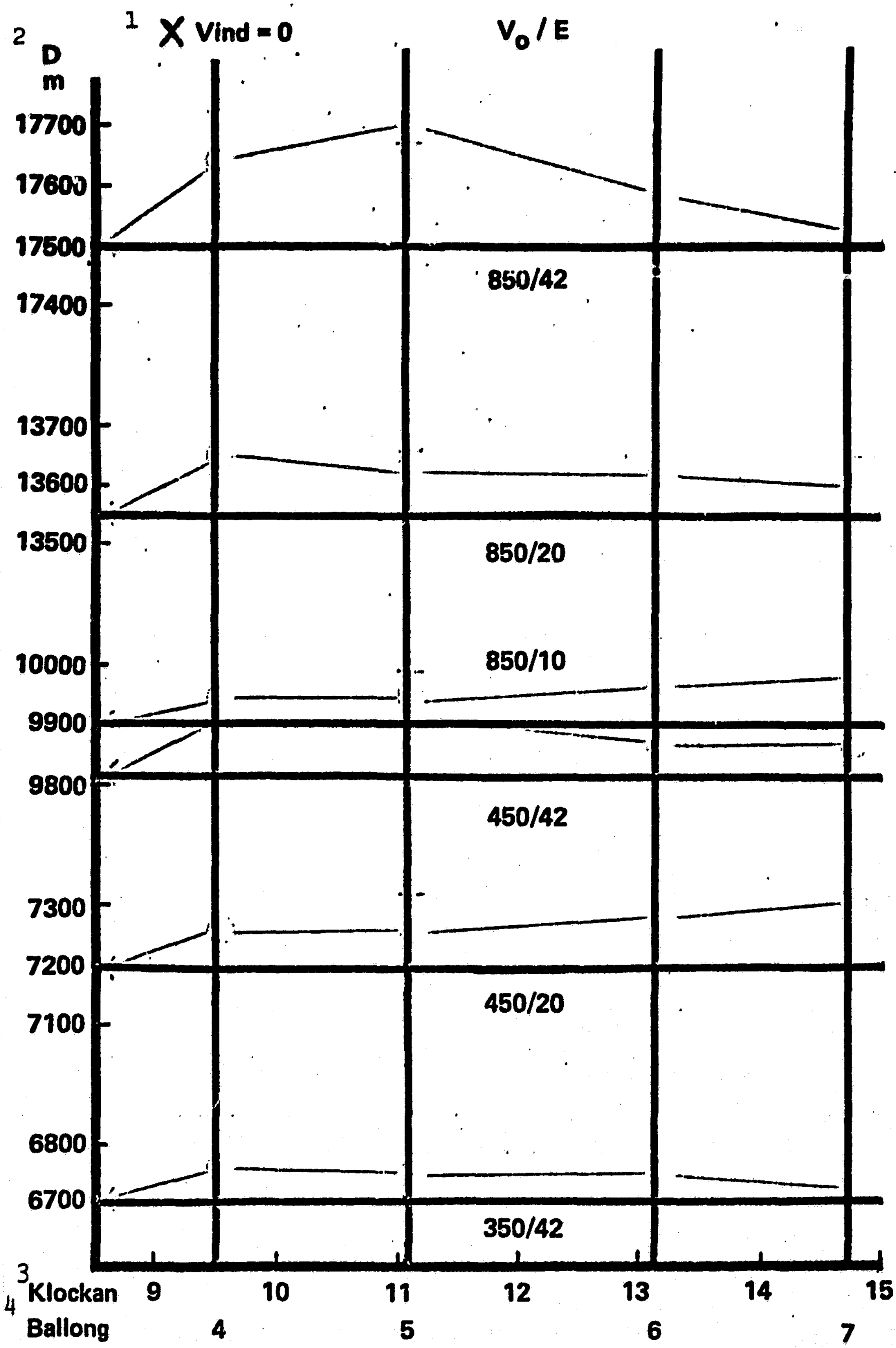

Figure 15. Diurnal effect of ballistic winds on the firing range at a bearing of 1200⁻. Winds measured with a balloon according to the CORA system. Key: 1. X wind = 0; 2. distance; 3. time; 4. balloon.

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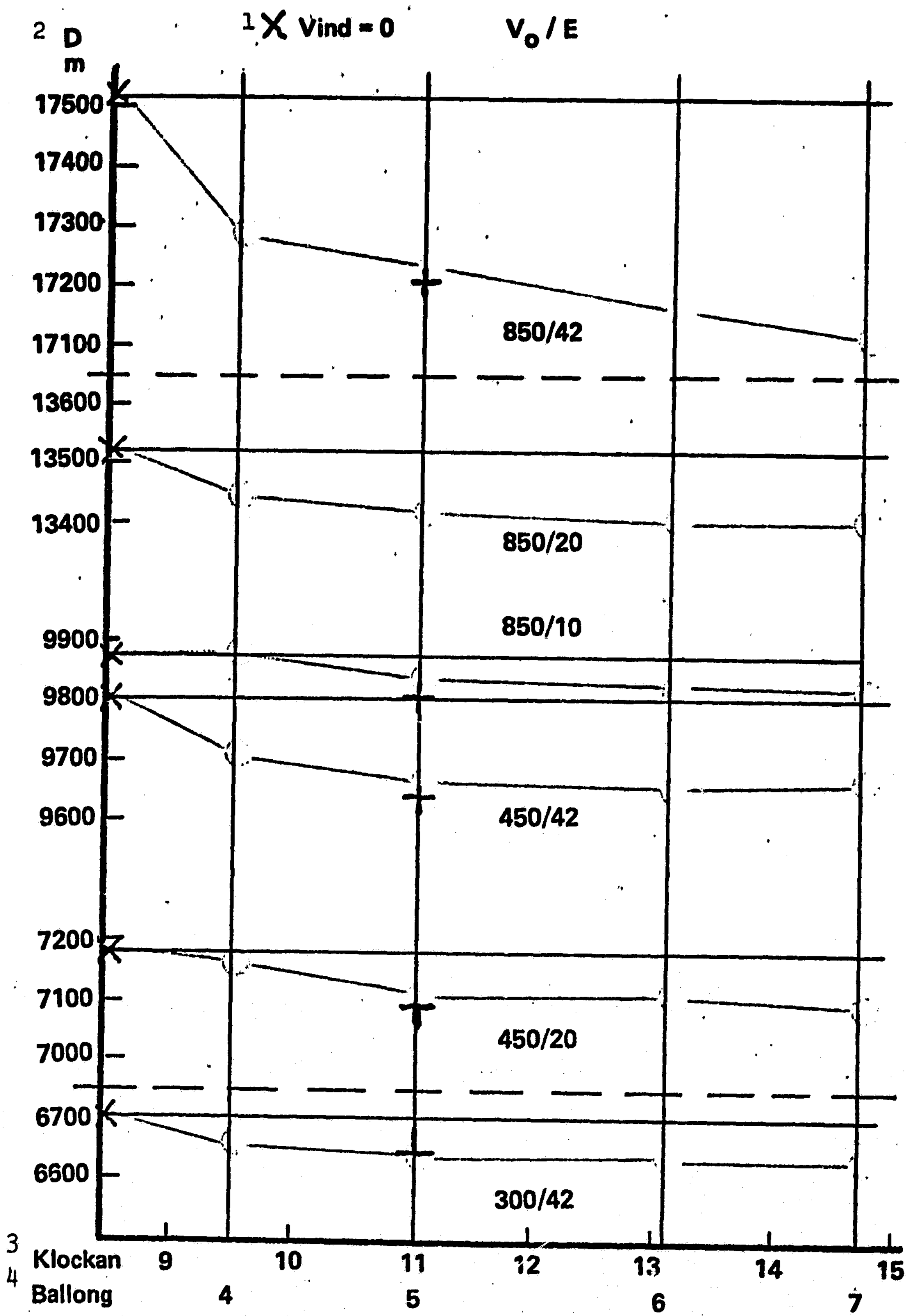

Figure 16. Diurnal effect of ballistic winds on the firing range at a bearing of 10¯. Wind measured with a balloon according to the CORA system. Key: 1. X wind = 0; 2. distance; 3. time; 4. balloon.

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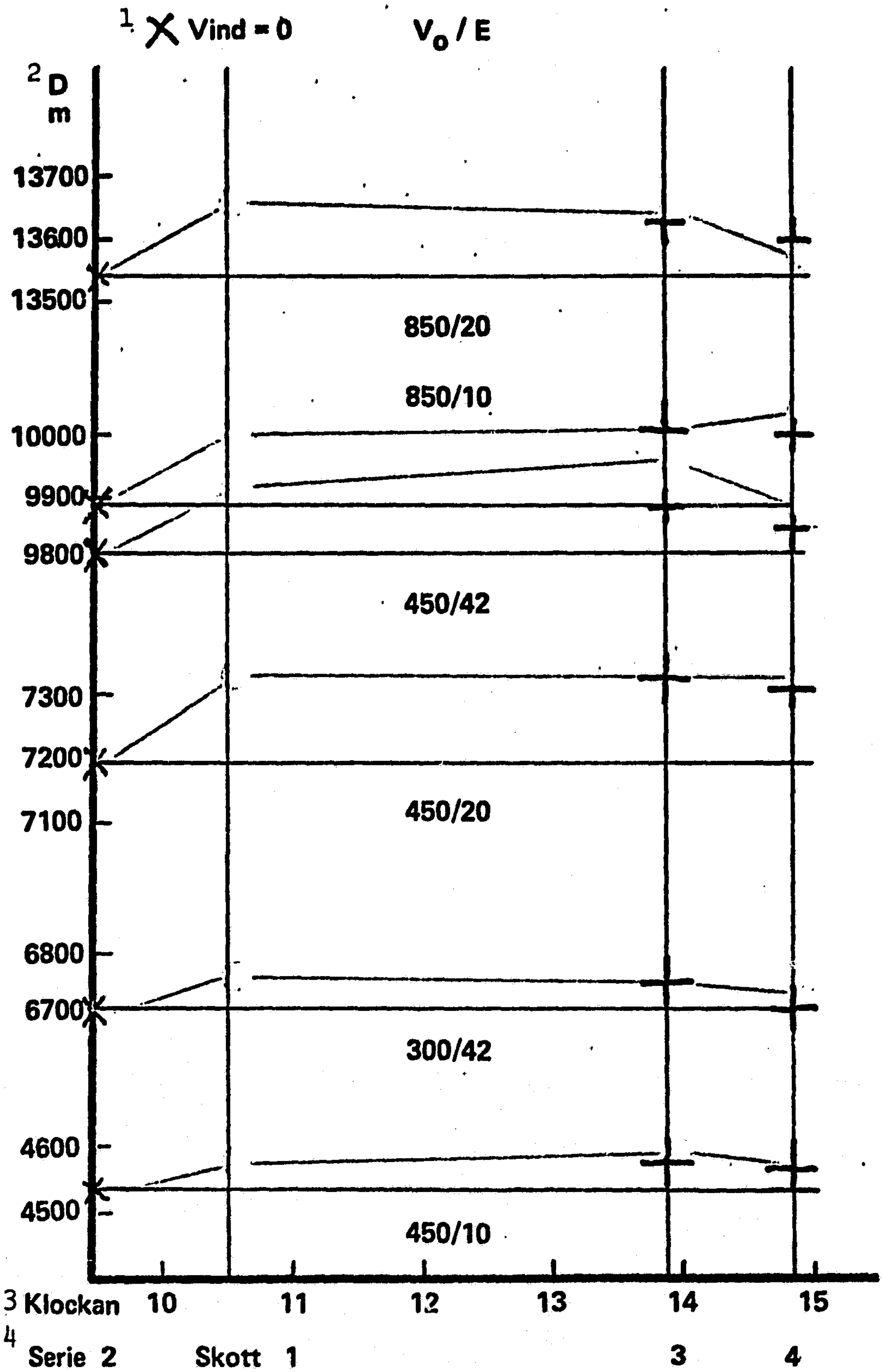

Figure 17. Diurnal effect of ballistic winds on the firing range at a bearing of 1200". Winds measured with parachutes.
Key: 1. X wind = 0; 2. distance; 3. time; 4. Series 2, round 1.

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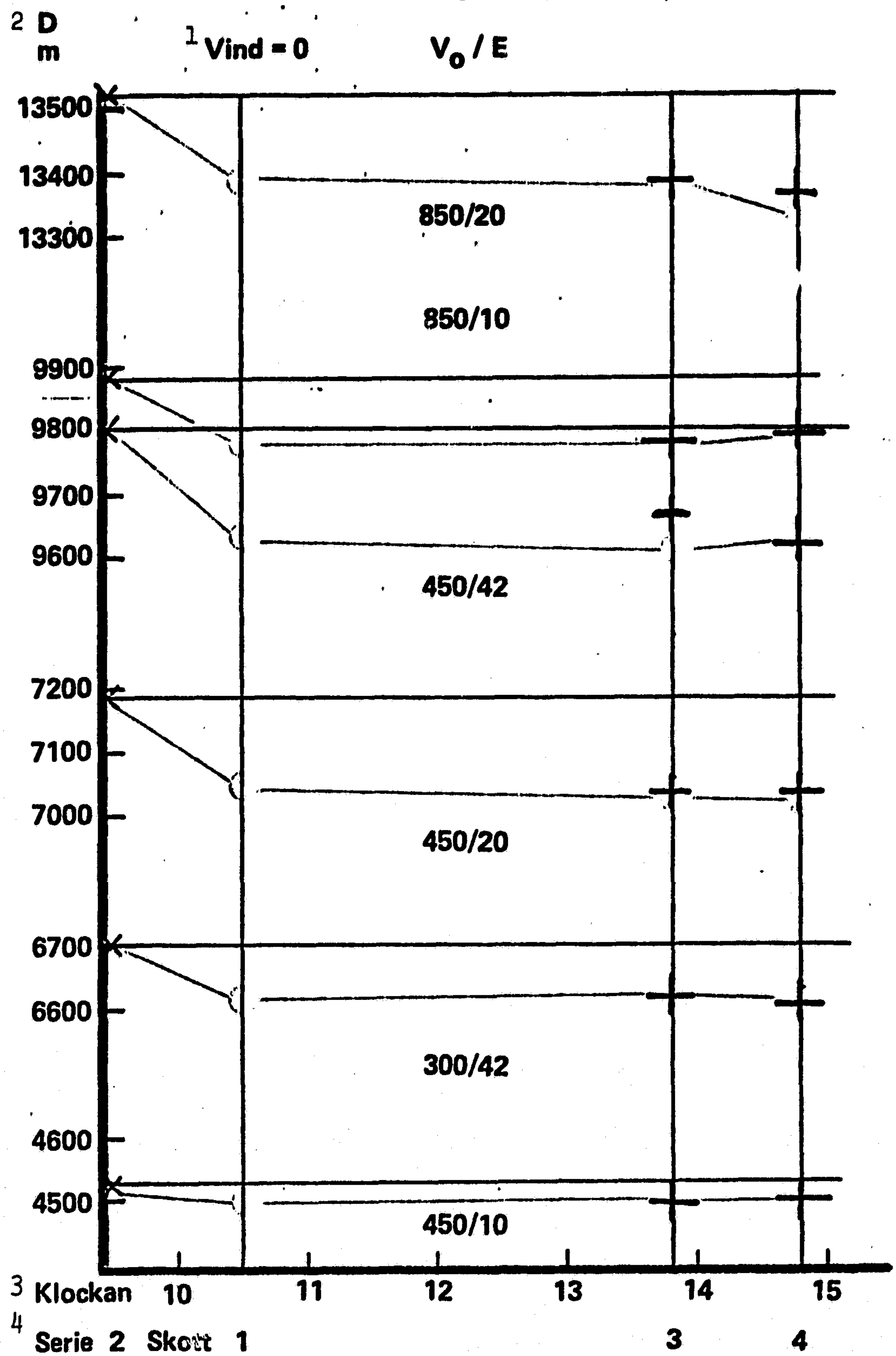

Figure 18. Diurnal effect of ballistic winds on the firing range at a bearing of 10¯. Winds measured with parachutes.
Key: 1 Wind = 0; 2. distance; 3. time; 4. Series 2, Round 1.

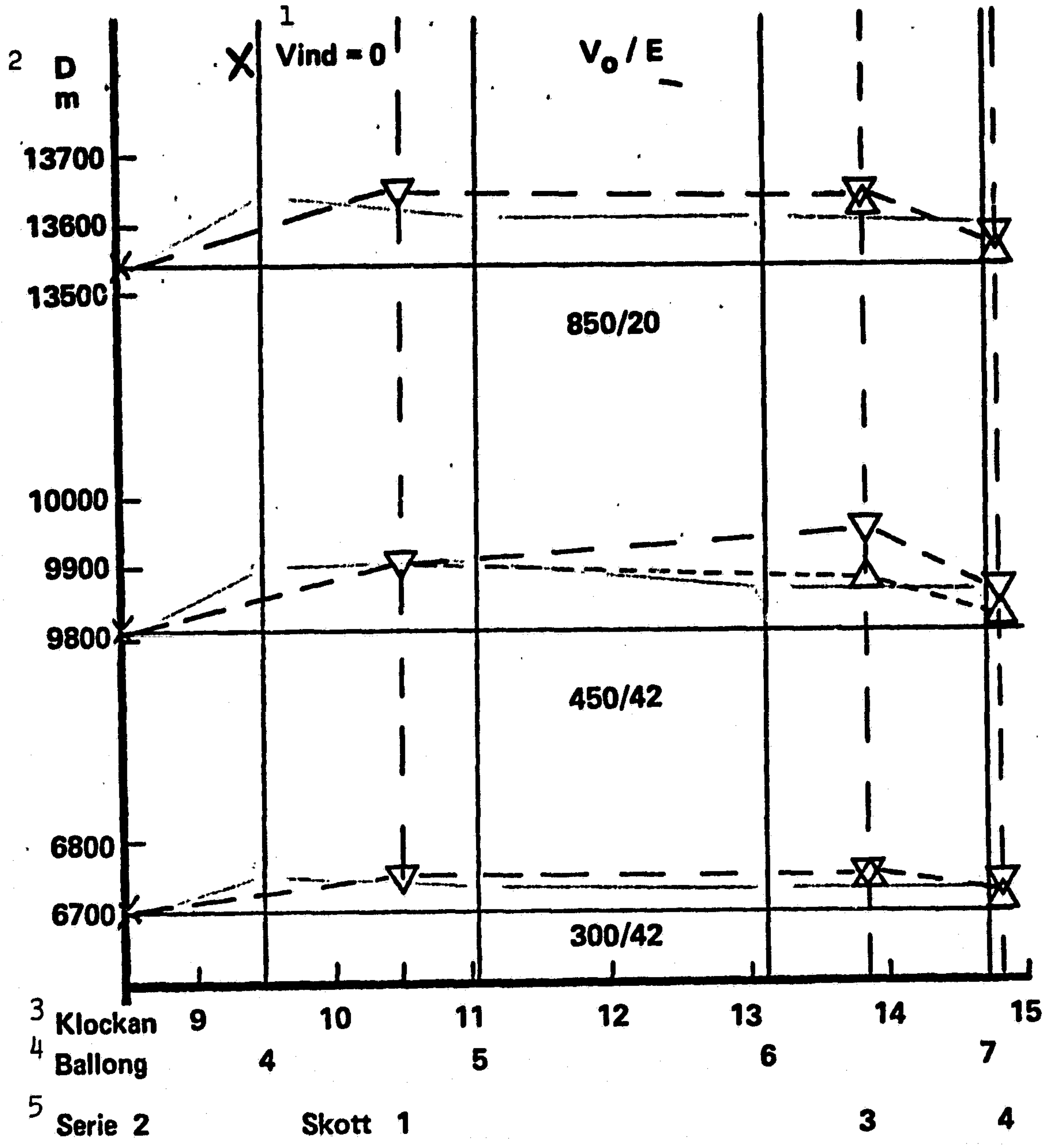

Figure 19. Comparison between diurnal effect of ballistic winds when measured either with balloon or with parachute. Bearing when firing 1200¯.

Key: 1. Wind = 0
2. Distance
3. Time
4. Balloon no. 4 (5, 6, 7)
5. Series 2, Round no 1 (3, 4).

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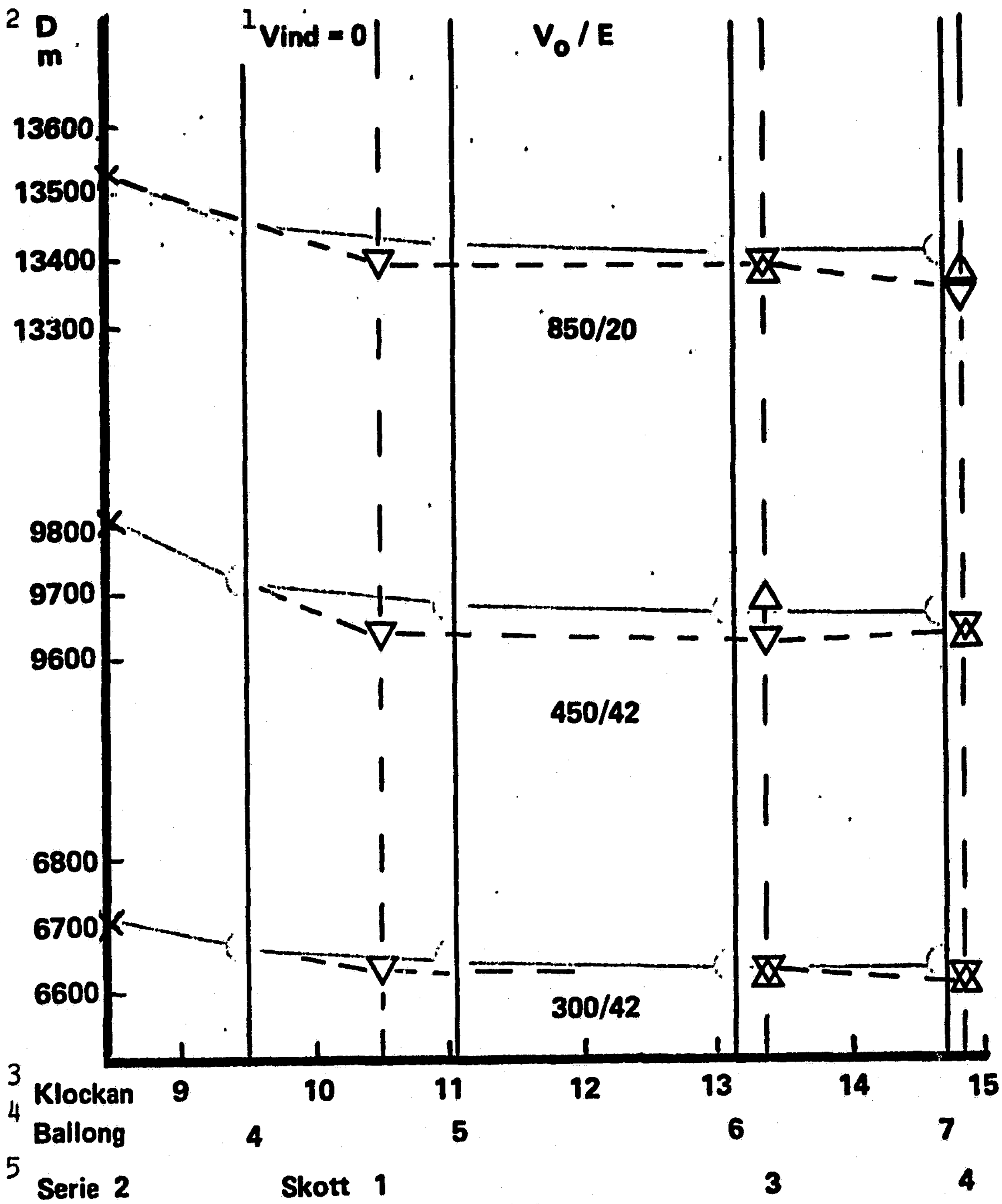

Figure 20. Comparison between diurnal effect of ballistic winds when measured either with balloon or with parachute. Bearing when firing 10¯.

Key: 1. Wind = 0
2. Distance
3. Time
4. Balloon no 4 (5, 6, 7)
5. Round no 1 (3, 4)

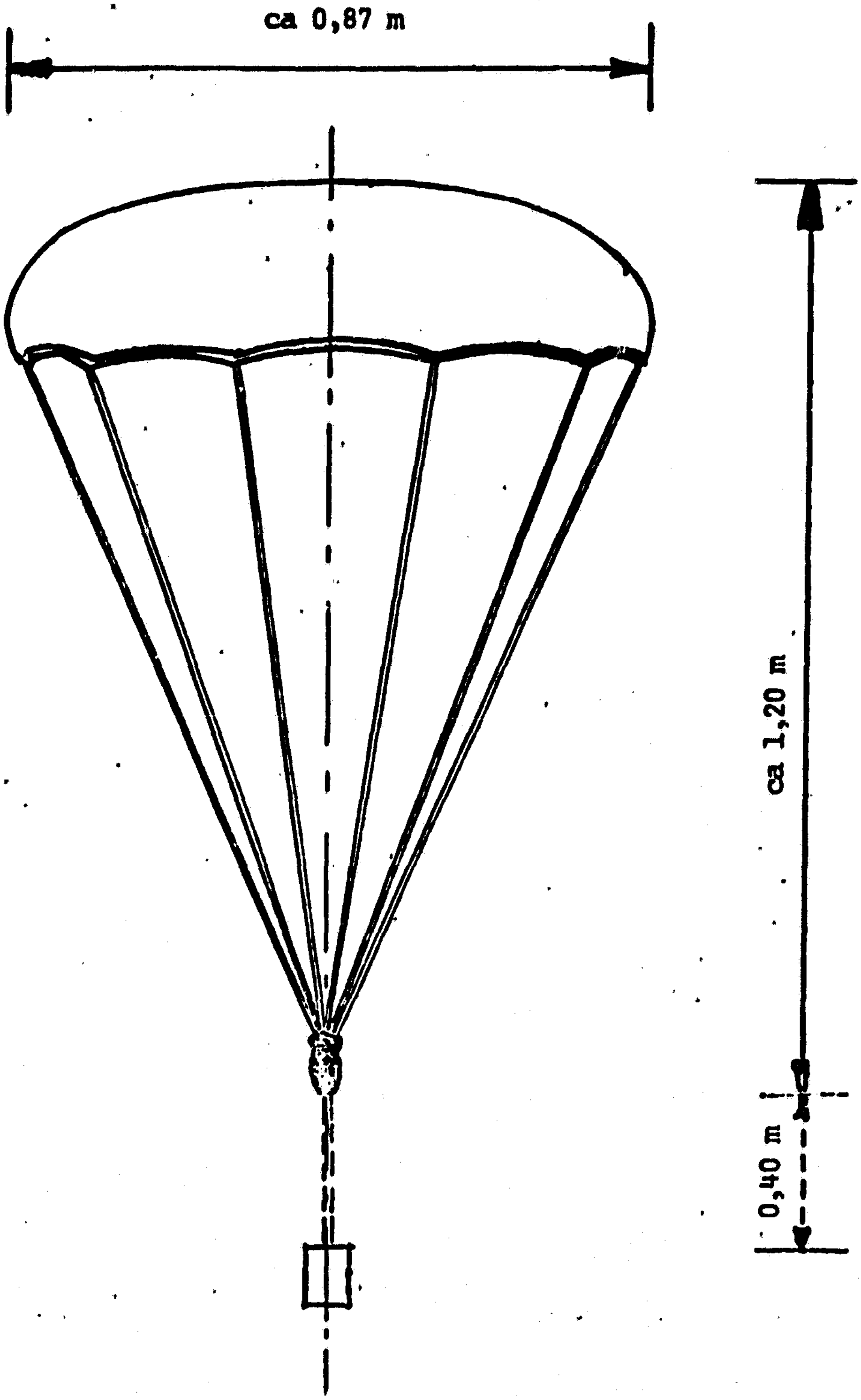

Figure 21. Data on illuminating unit of 8 cm finned illuminating shell m/67.
Weight of illuminating unit and parachute 0.70 - 0.10 kilo.

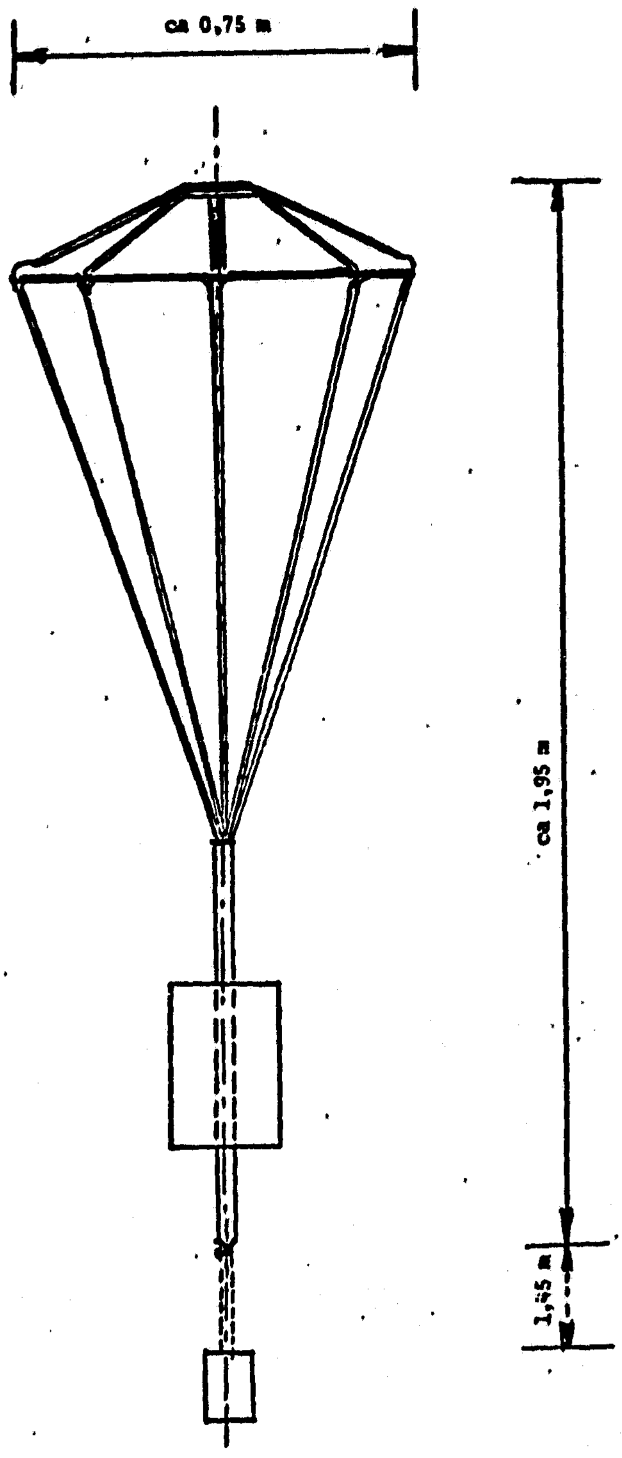

Figure 22. Data on illuminating unit of 10.5 cm illuminating shell m/62.
Weight of illuminating unit and parachute 1.55 - 0.77 kilo.

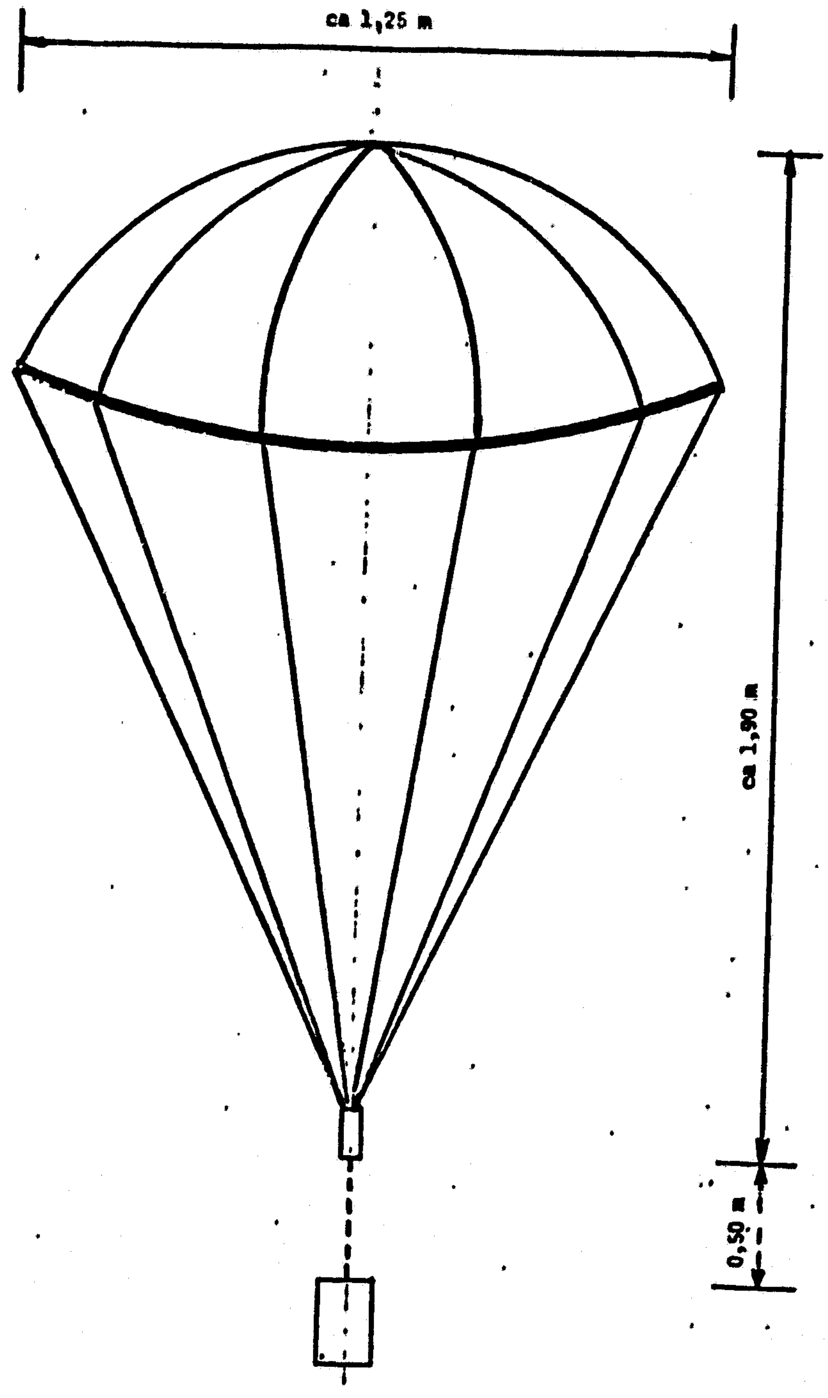

Figure 23. Data on illuminating unit of 12 cm finned illuminating shell m/70.
Weight of illuminating body and parachute
1.936 - 0.36 kilo.