To: lastword@newscientist.com
Subject: "freefalling, how high is the limit..."

Normally, jumps are made from below 14,000 feet, a limit set by risk of anoxia. During jumps from higher altitudes, the apparent thickening of the air sets limits too.

In the lower atmosphere a skydiver accelerates downwards for about 10 seconds until the increasing drag matches his weight, at a "terminal" velocity of about 55 m per second. Then, on descent into thicker air, this natural velocity decreases. For most free falls, skydivers are actually decelerating.

In higher, thinner air, you would accelerate freely for longer before overshooting the terminal velocity of the thickening air, after which the drag force peaks out. It amounts to an impact with the atmosphere.

Falling from 100,000 feet in 1960, Colonel Kittinger felt this force as a choking feeling, which the simulation shows as peaking at 1.2 gees at about 75 000 ft. See attached graph.

A fall from 250,000 feet would give a 3 gee impact with the atmosphere at about 100,000 feet, which would relax over 20 seconds or so, after which the jump would become an otherwise uneventful skydive.

A skydiver re-entering from low orbit need not suffer much more than 3 gee if he (or she, women make better skydivers) shapes up for lift across the airflow in order to spread out the impact with the atmosphere.

In that instance, air drag takes the form of highly compressed air immediately in front of his or her body. As it is proportionately hot, the glowing air film is likely to wrinkle the surface of our skydiver's visor, spoiling a wonderful view. That is when a surfboard would come in handy.

Roger Clifton
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(I write as a skydiver of 2000 jumps, and programmer of the simulator used here ...)

I trust my style is adequately tongue in cheek.

The simulations however are quite accurate when subsonic (Kittinger never went supersonic), however the reentry simulations are inaccurate insofar as supersonic drag tends to be linear rather than by the square of velocity.

Scroll through the attached text file to see the graph. The data at the head of file allows the simulation to be run with tweaked variables. The executable for the simulator can be provided if your artist wants to rerun the simulation before redrawing the graph for publication.

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*     F
  102800           2          10         100         100         152
      30       18000         277          10           1           0
```

0	22	30	0	10	5000
0	7	-20	0	70	7
20	0	70	6	71	20
20	6	100	20	20	5
180	53	53	5	180	53
53	5	180	53	53	5
180	53	53	0	0	0
0	0	0	0	0	

KITTINGER'S RECORD HIGH ALTITUDE JUMP

In August, 1960, Colonel Joe Kittinger left a balloon at 102,800 ft. He used a drogue that more than compensated for the weight of his extra gear, but allowed him to fall fast as though falling freely. The feat is generally acknowledged as the standing record for high altitude freefall.

Now legendary, the story has become associated with hearsay figures. Among the contradictory data, a consistency is obtained when a simulation is run using a drag of 2.3 x that needed to balance the weight of the high altitude gear. In the absence of other information, the simulation assumes the drogue had similar drag throughout the fall, and relies on the report that he opened at 18 000 ft after 277 seconds. See graph.

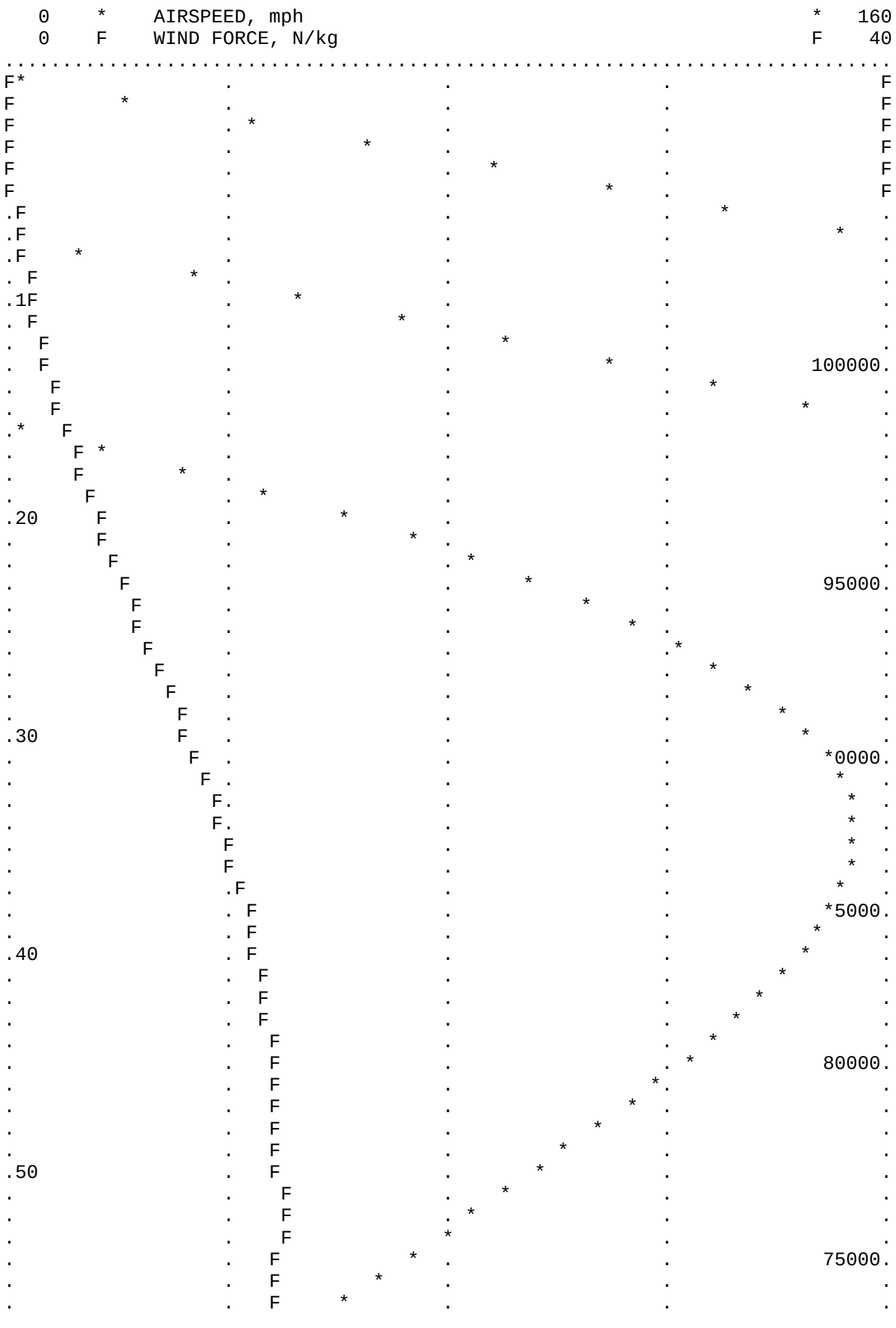
At 102,800 ft, the drag of the thin air is seen to be negligible. Kittinger accelerates away at one gee for perhaps 22 seconds before the wind drag reaches half a gee. Even so the speed is already 400 mph. Drag is gentle at first, again due to the 1.3% thin air.

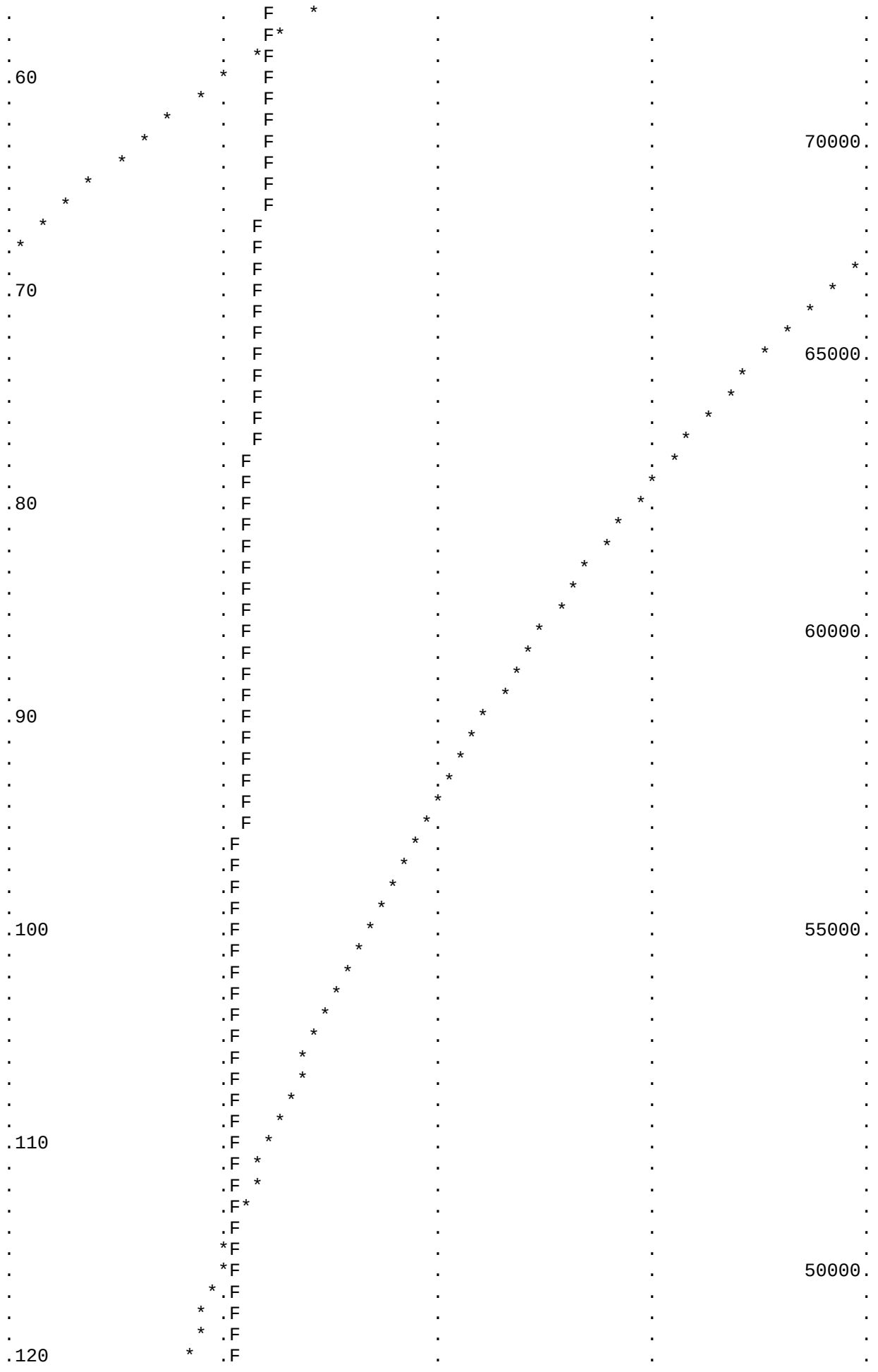
Maximum velocity is achieved at 87 000 ft after falling 35 seconds - several times longer to maximum as taken in ordinary jumps and to a correspondingly higher speed. At 470 mph it is not the 614 mph sometimes attributed and remains subsonic, being less than the 600 mph or so for the speed of sound at these temperatures. It is nevertheless a record airspeed for a falling human, drogue notwithstanding, and it is a record which still stands.

He is losing altitude so fast that the air he meets is thickening quickly. The drag force increases and amounts to a minor impact with the atmosphere. At 1.2 gee it is not excessive, but may have contributed to the difficulty with breathing met by Kittinger for 50 seconds around this height. Wind force is seen to exceed one gee (10 N/kg) after 35 seconds and peak out around 50 seconds.

By 18000 ft, he has fallen for 277 seconds. At the delay of 4 minutes, 37 seconds, he is recorded to have deployed his main. The simulator shows him exceeding 100 mph.

KITTINGER'S RECORD HIGH ALTITUDE JUMP

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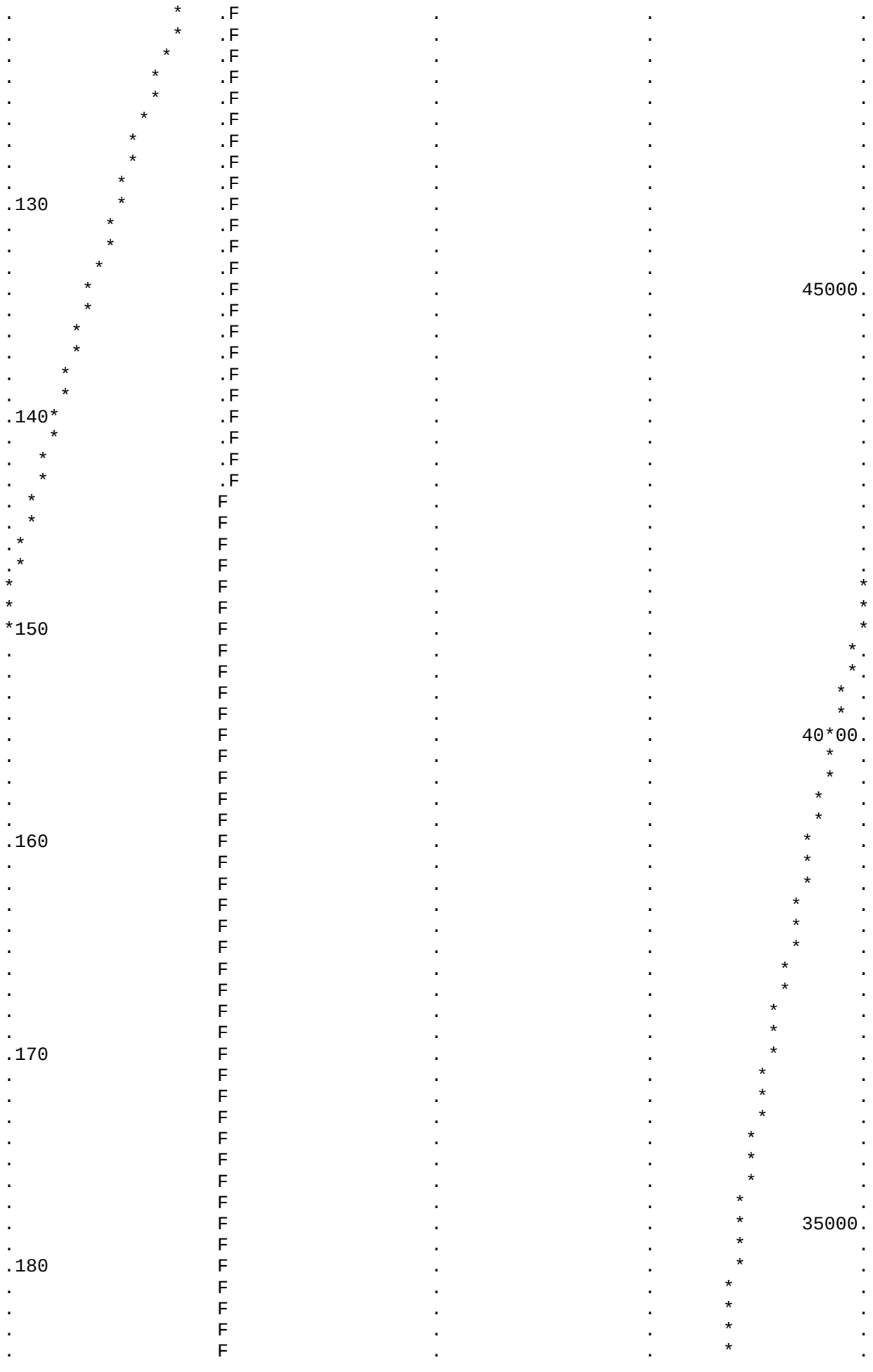
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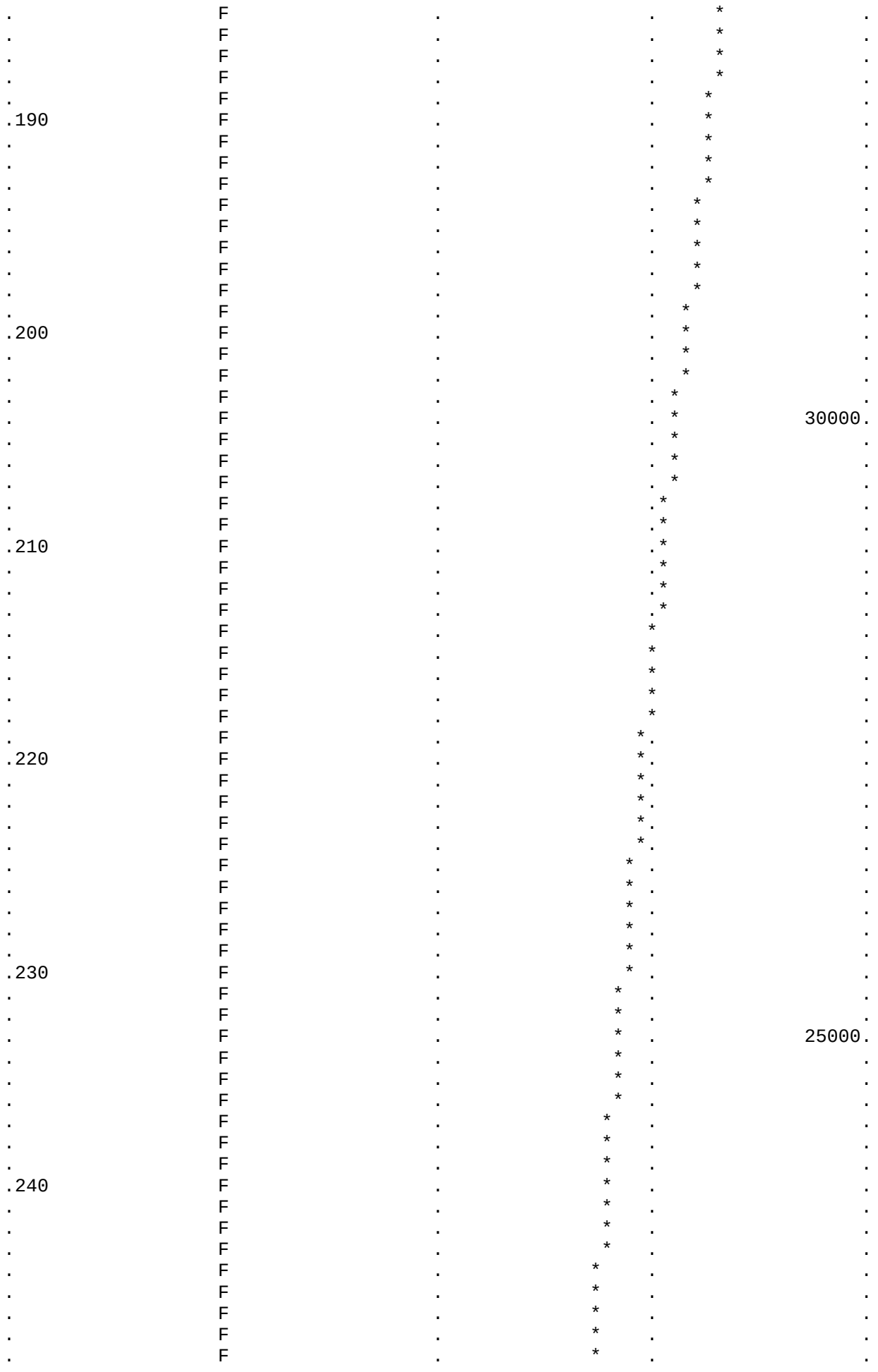
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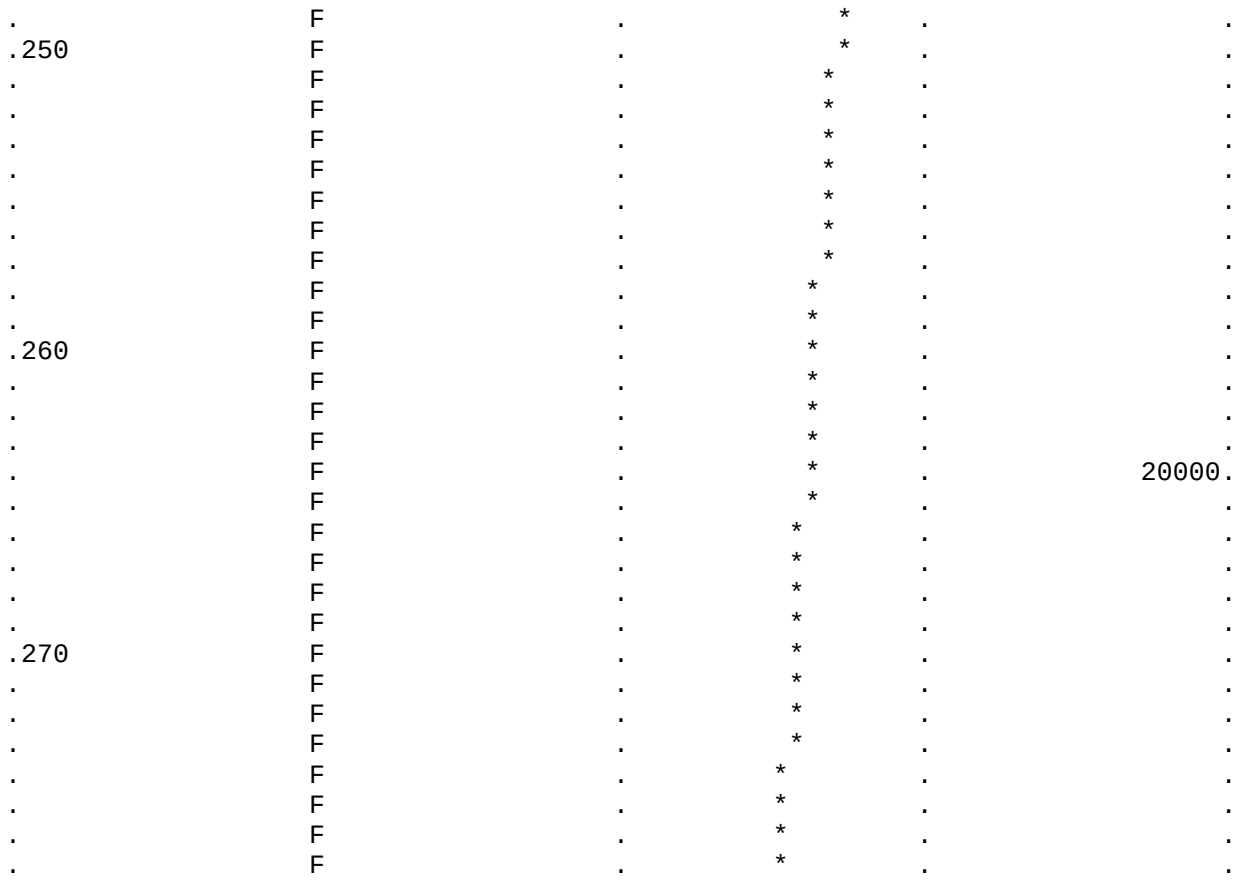
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270
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Abs.: 18100 ft 277.1 sec 0 m/s H 45 m/s V

HEIGHT, ft	18068.
AIRSPEED, mph	101.
MAX VEL, mph	473.
-at height, ft	87283.