

## More Notes on the Lindbergh-Weems Hour Angle Watch

By Edward Popko

The Lindbergh-Weems watch was designed to be a precision Greenwich Mean Time (GMT) keeper. Its innovative second-setting center dial allowed it to be synchronized to some time standard to the precise second. Just as important is how the design of various dials make the repetitive calculation of the Greenwich Hour Angle (GHA) of the sun much easier and less error prone.

Many celestial navigation calculations require the Greenwich Hour Angle of the apparent sun. This important angle combines GMT and day's Equation of Time (EoT) to first find Greenwich Apparent Time (GAT) and then to convert GAT to an angle. This latter conversion – GAT (time) to GHA (arc-angle) is what this watch does. In effect, the watch is a circular slide rule that maps one to the other.

The distinction between GMT and GAT is very important. Keep in mind, this watch, any watch, keeps mean time and not apparent time. The Equation of Time is what maps one type of time to the other.

For most calculations the use of the various watch dials is straight forward and GAT calculations are quite simple and it's obvious how the EoT affects GMT when converting to GAT. However, when the GMT is very near or on a whole hour, EoT compensation may cause the hour-hand conversion to arc-angle to be 15 degrees more or less than what is displayed on the central watch dial. Users must be aware of this subtlety. See comment (3) below in *How to Find GHA*.

The Use Cases that follow explain step by step how hour/minute/second time plus EoT are read to give the final Greenwich Hour Angle of the sun. Each watch hand points to an arc angle to be added up for the total angle.

Contrary to many claims made by Longines and many watch internet chronometer forums, this watch does NOT directly compute longitude unless you happen to be somewhere on the Greenwich meridian itself. For longitude, you also need to know your Local Hour Angle. There are different techniques for that, none involve the Lindbergh watch set to GMT.

### Dial and Time Hand Functions

- Bezel rotates to compensate for whole minutes of Equation of Time (EoT). Rotate counter clock-wise when positive, clock-wise when negative. If EoT is 00:00, align bezel 15° mark with 12:00 dial
- Hour hand reads whole degrees from face dial (is performing  $\text{hrs} \times 15$  degrees)
- Minute hand reads degrees and whole 15/30/45 minutes arc from bezel

- Second hand reads arc minutes and seconds (dots between arc minutes) from central dial
- Center dial tick displays additional EoT seconds correction to GHA's arc minutes and seconds (dots between arc minutes) to be added for +EoT or subtracted if -EoT

## How to Find GHA

1. When Equation of Time is zero, align 15 degrees on bezel with 12:00. Otherwise rotate and align 15 with whole minutes of EoT counter clock-wise when positive, clock-wise when EoT is negative.
2. GMT is a 24-hour system, however this watch's display is 12-hours. If watch is reading an AM time, start list with 180° because the sun is on the lower meridian at midnight and GHA is measured west from Greenwich Meridian. Otherwise start list with 0°.
3. **Very important!** The Greenwich Hour Angle (GHA) is based on solar time or Greenwich Apparent Time (GAT) and not GMT per se. ( $GAT = GMT + EoT$ ). When EoT is 00:00, GAT is equals GMT otherwise EoT must be added to GMT. When EoT is not zero and GMT is very near to or on-the-hour, care must be taken to see if the addition of EoT shifts the apparent hour one hour ahead or behind from what is displayed on the watch.
4. Add to the list the GHA's hour conversion to the list. It is a multiple of 15° and conveniently found on the main dial. Be aware that the application of EoT to times near or on the hour may shift the hour-hand multiplier 15 degrees more or less and shift AM to PM or vice versa.
5. Read minute hand's whole degrees value plus any whole increment of 15/30/45 arc-minutes read from the bezel. Add to list.
6. Read second hand on central dial, copy whole arc-minutes and whole 14/30/45 arc-seconds (dots between arc-minutes) to the list.
7. Read central face EoT tick mark. This last correction never exceeds 15" arc. Its sign is positive if EoT is positive, negative otherwise. Note that EoT minutes, were already compensated for when the bezel was rotated in step 1. The sign of EoT seconds arc is the same as EoT minutes.
8. GHA is sum of list

Watch reads PM 04:37:12

$$\text{GMT } 04:37:12 + \text{EoT } 04:50 = \text{GAT } 04:42:02^2$$

Bezel counter clockwise 4 minutes for +EoT [1], 50 seconds on center dial (marked).

60° hour hand main dial [2]

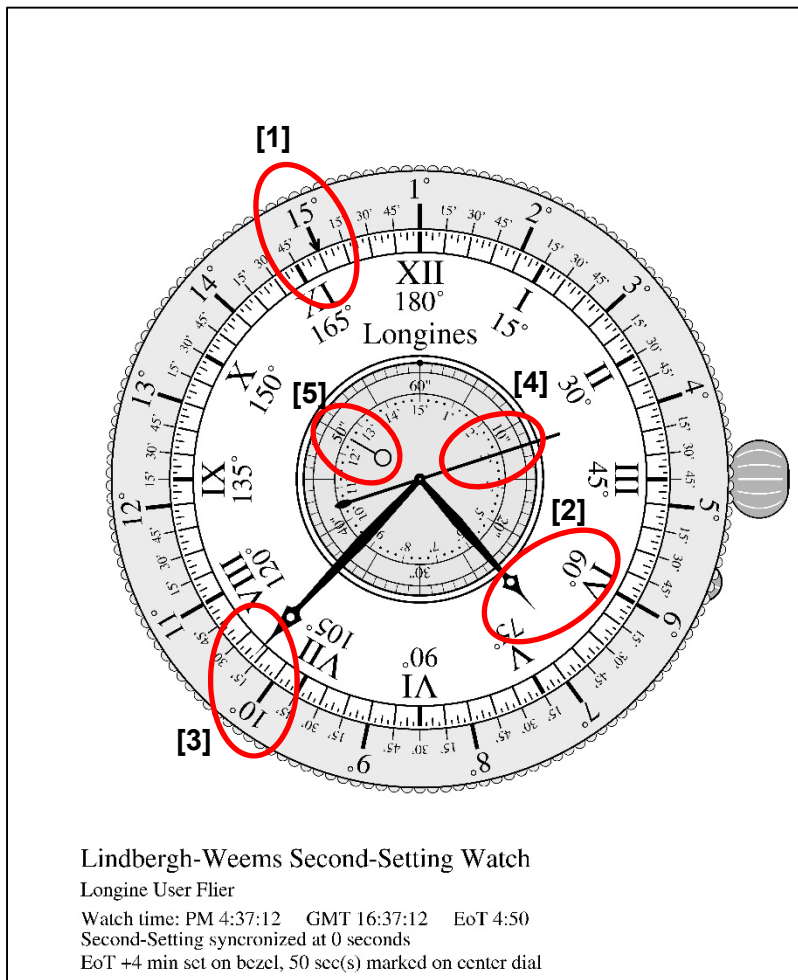
10° 15' minute hand bezel dial [3]

3' second hand center dial [4]

+ +12' 30" center dial tick EoT seconds compensation, sign is positive since fast [5]

---

70° 30' 30" GHA



<sup>2</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Ex 10.jpg

# *Use Cases*

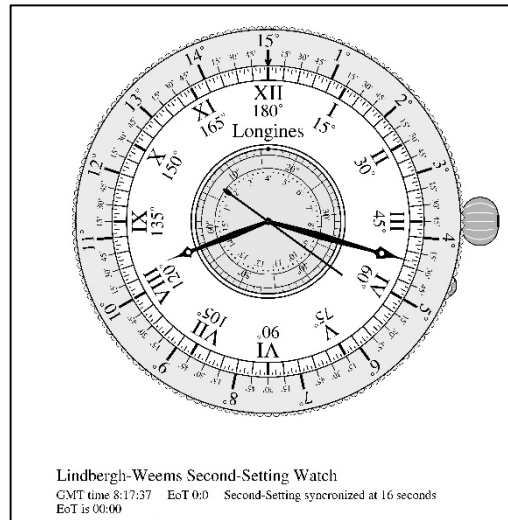
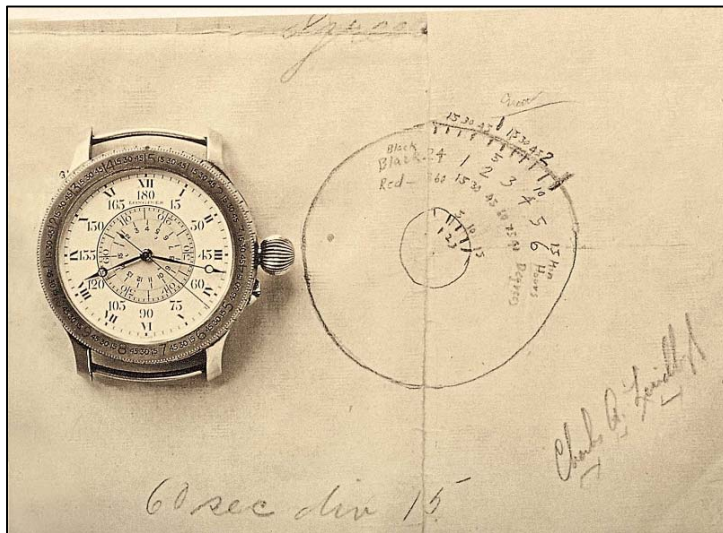
**Concept Drawing for Longines' Second-Setting Watch**

**GMT 08:17:37 EoT 00:00<sup>3</sup>**

No bezel or center dial compensation for EoT. Second-Setting center face rotation 16 seconds for synchronizing the second hand at zero seconds.

- 180° sun is on the lower meridian at midnight
- 120° hour hand
- 4° 15' minute hand
- + 9' 15" second hand

-----  
304° 24' 15" GHA



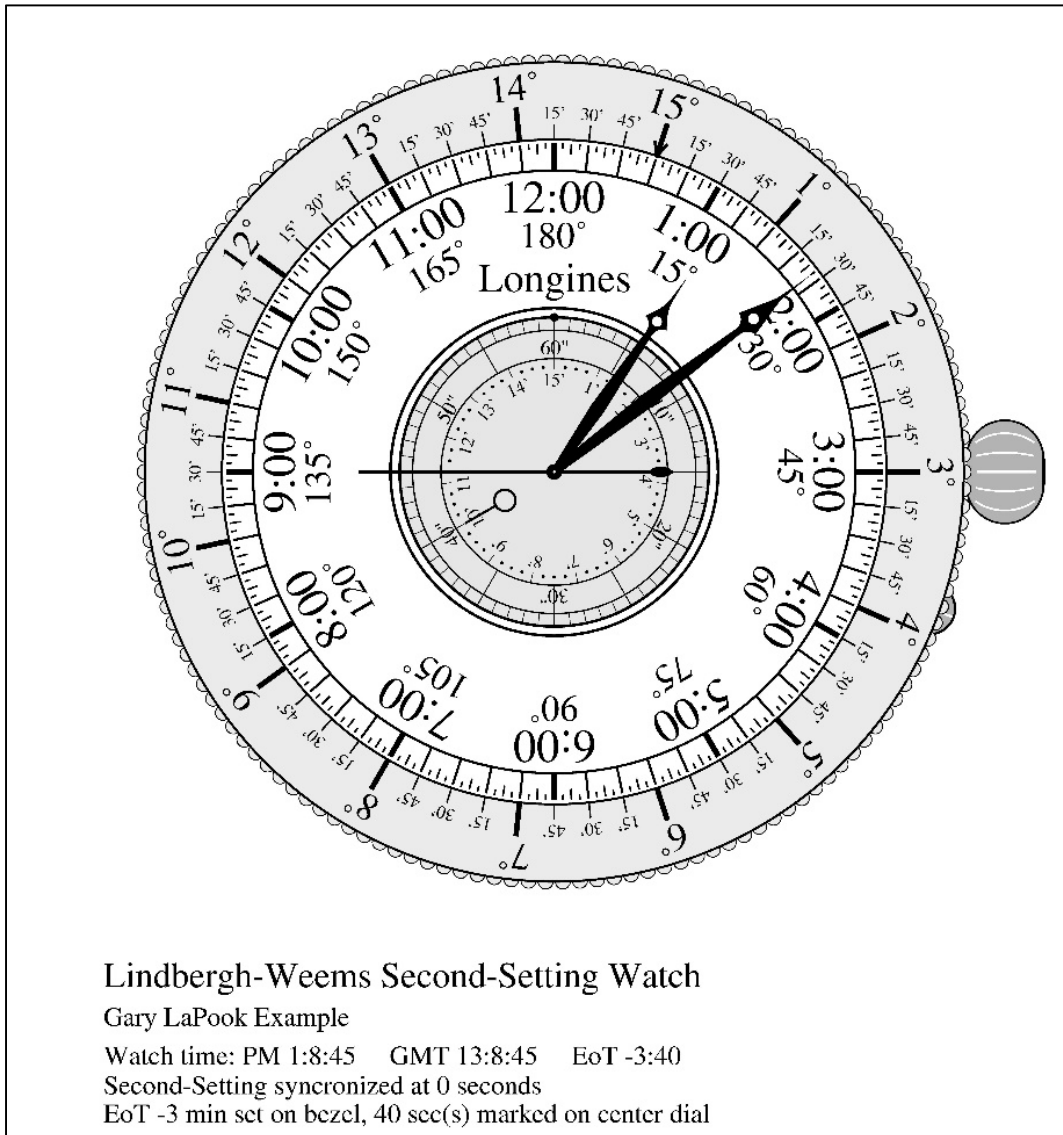
<sup>3</sup> Photo: [www.hautetime.com/celebrating-the-lindbergh-hour-angle-watch-with-longines/83312/](http://www.hautetime.com/celebrating-the-lindbergh-hour-angle-watch-with-longines/83312/),  
Graphic: Lindbergh-Weems Second-Setting Watch v8 Sketch.jpg

**Example 1 - LaPook Watch 01:08:45      GMT 01:08:45 + EoT -03:40 = GAT 01:05:05 <sup>4</sup>**

Bezel clockwise 3 minutes for -EoT, 40 seconds on center dial (marked)

- 180°      sun is on the lower meridian at midnight
- 15°      hour hand main dial
- 1° 15'    minute hand bezel dial
- 11' 15"   second hand center dial
- + -10'    center dial EoT seconds compensation, negative sign since slow

-----  
196° 16' 15" GHA



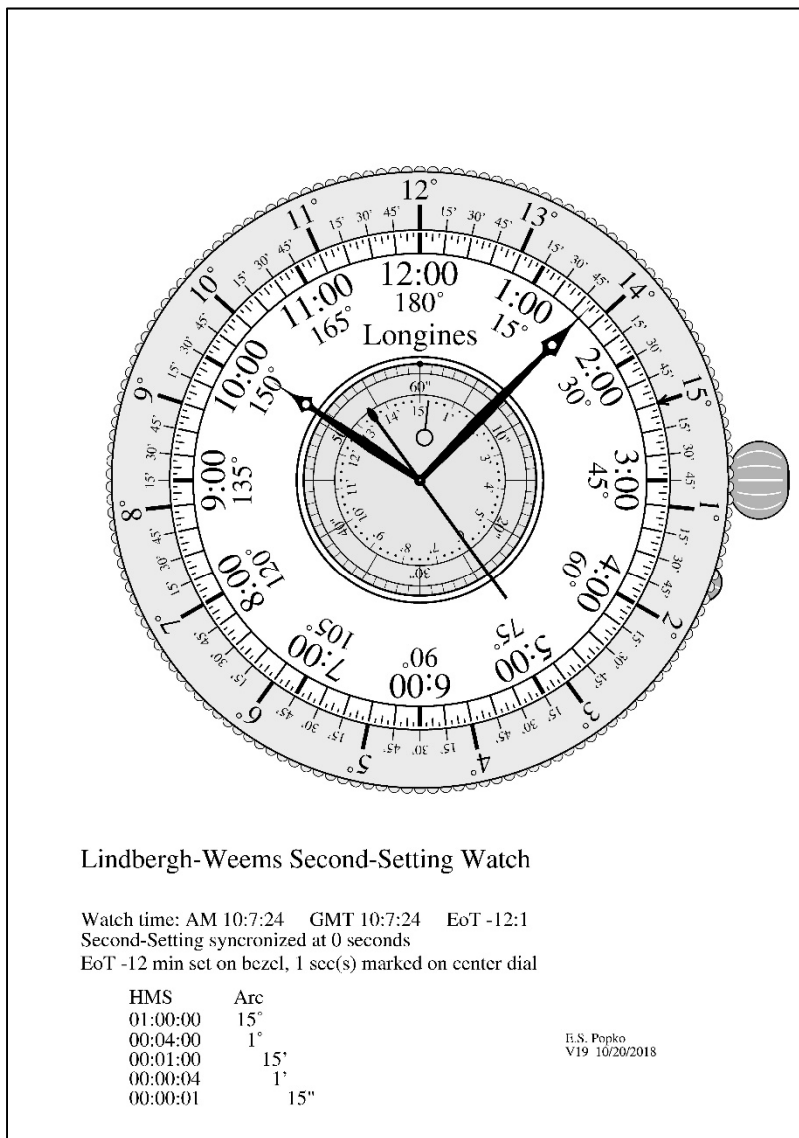
<sup>4</sup> Graphic: Lindbergh-Weems Second-Setting Watch v8 Ex 12.jpg

**Example 2 – Watch AM 10:07:24      GMT 10:07:24 + EoT -12:01 = 09:55:23<sup>5</sup>**

Bezel clockwise 12 minutes for -EoT, 01 second on center dial (marked)

EoT shifts apparent time hour-to-arc multiplier by one hour less, 135° is used instead of 150°

180°      sun is on the lower meridian at midnight  
 135°      hour hand main dial multiplier, GAT is previous full hour, use 9:00  
 13° 45'    minute hand bezel dial  
         6'      second hand center dial  
 +    -15"    center dial tick EoT seconds compensation, negative sign since slow  
 -----  
 328° 50' 45" GHA



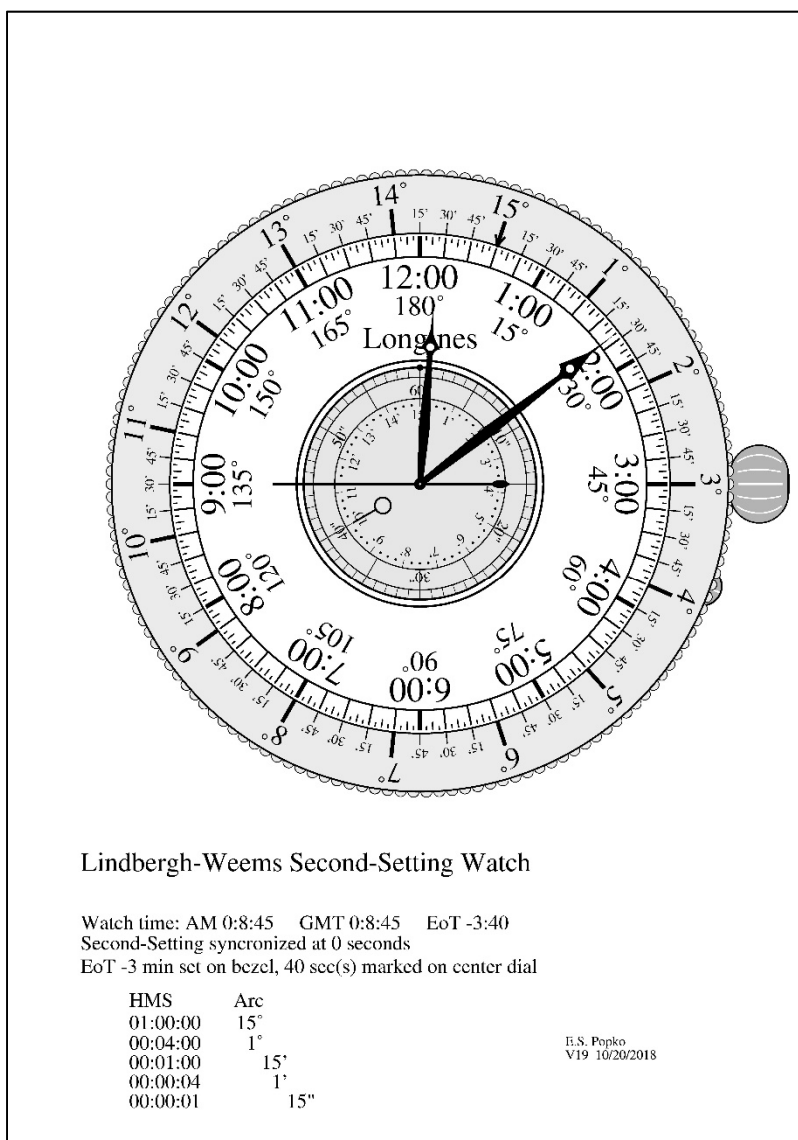
<sup>5</sup> Graphic: Lindbergh-Weems Second-Setting Watch v8 Ex 13b.jpg

**Example 3 – Watch AM 00:08:45      GMT 00:08:45 + EoT -03:40 = GAT 00:05:05 <sup>6</sup>**

Bezel clockwise 3 minutes for -EoT, 40 seconds on center dial (marked)

180°      sun is on the lower meridian at midnight  
 0°      hour hand less than a full hour main dial  
 1° 15"    minute hand bezel dial  
 11' 15"    second hand center dial  
 + -10'    center dial tick EoT seconds compensation, negative sign since slow

-----  
 181° 16' 15" GHA



<sup>6</sup> Graphic: Lindbergh-Weems Second-Setting Watch v8 Ex 17.jpg



**Example 4 - Watch AM 10:10:09      GMT 10:10:09 + EoT 00:00 = GAT 10:10:09 <sup>7 8</sup>**

Note center dial rotated clockwise seven seconds to synchronize the watch's second hand with zero.  
 Bezel counter clockwise 4 minutes for +EoT, no seconds on center dial.

180°      sun is on the lower meridian at midnight  
 150°      hour hand main dial multiplier  
   2° 30'    minute hand bezel dial  
 +    2' 15"    second hand center dial

-----  
 332° 32' 15"    GHA



Lindbergh-Weems Second-Setting Watch  
 Watch photo  
 Watch time: AM 10:10:9    GMT 10:10:9    EoT 0:0  
 Second-Setting synchronized at 53 seconds

HMS	Arc	
01:00:00	15°	
00:04:00	1°	
00:01:00	15'	
00:00:04	1"	
00:00:01	15"	

E.S. Popko  
 V19 10/20/2018

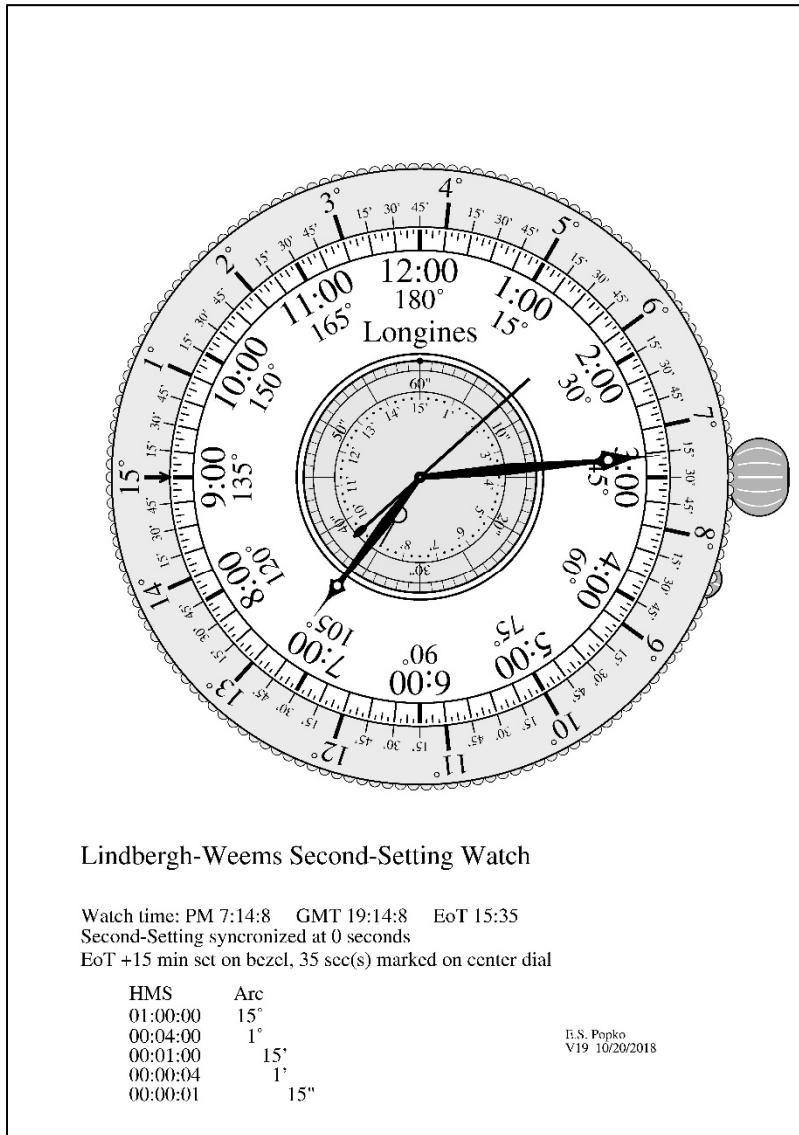
<sup>7</sup> Longines original production watch, [www.longines.com/watches/heritage-collection/l2-678-4-11-0](http://www.longines.com/watches/heritage-collection/l2-678-4-11-0)

<sup>8</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Actual.jpg

**Example 5 – Watch PM 07:14:08      GMT 19:14:08 + EoT 15:35 = GAT 19:29:43<sup>9</sup>**

Bezel counter clockwise 15 minutes for +EoT, 35 seconds on center dial (marked)

105°      hour hand main dial multiplier  
 7° 15'    minute hand bezel dial  
 2'        second hand center dial  
 + +8' 45" center dial tick EoT seconds compensation, positive sign since fast  
 -----  
 112° 25' 45" GHA



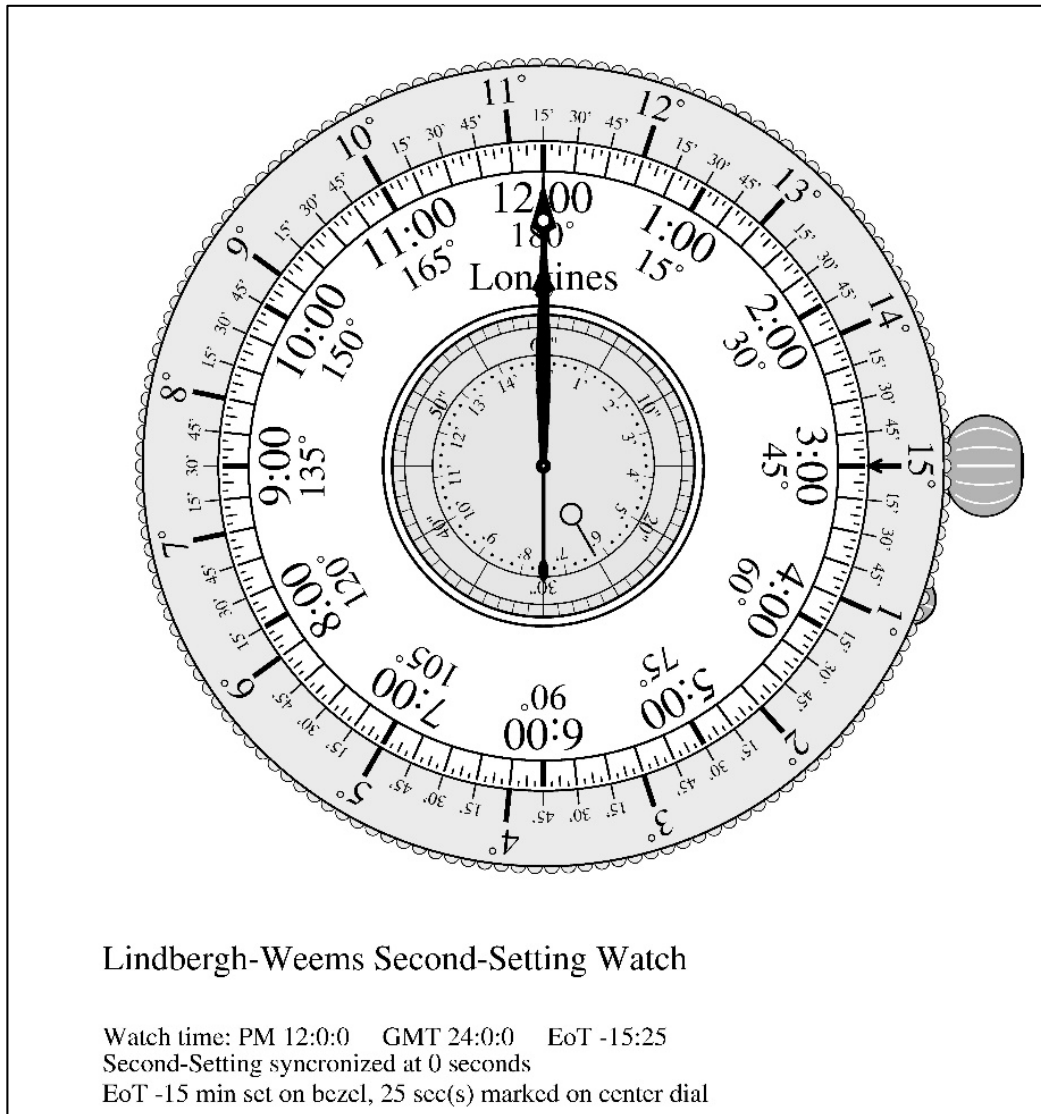
<sup>9</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Ex 20.jpg

**Example 6 – Watch 12:00:00 Noon      GMT 12:00:00 + EoT -15:25 = GAT 11:44:35 <sup>10</sup>**

Bezel clockwise 15 minutes for -EoT, 25 seconds on center dial (marked)

EoT shifts the apparent time from 12 noon to 11 AM.

180°      sun is on the lower meridian at midnight  
 165°      hour hand main dial multiplier, GAT is previous full hour, use 11:00  
 11° 15'      minute hand bezel dial  
           0'      second hand center dial  
 +    -6'15"      center dial tick EoT seconds compensation, negative sign since slow  
 -----  
 356° 08' 45"      GHA



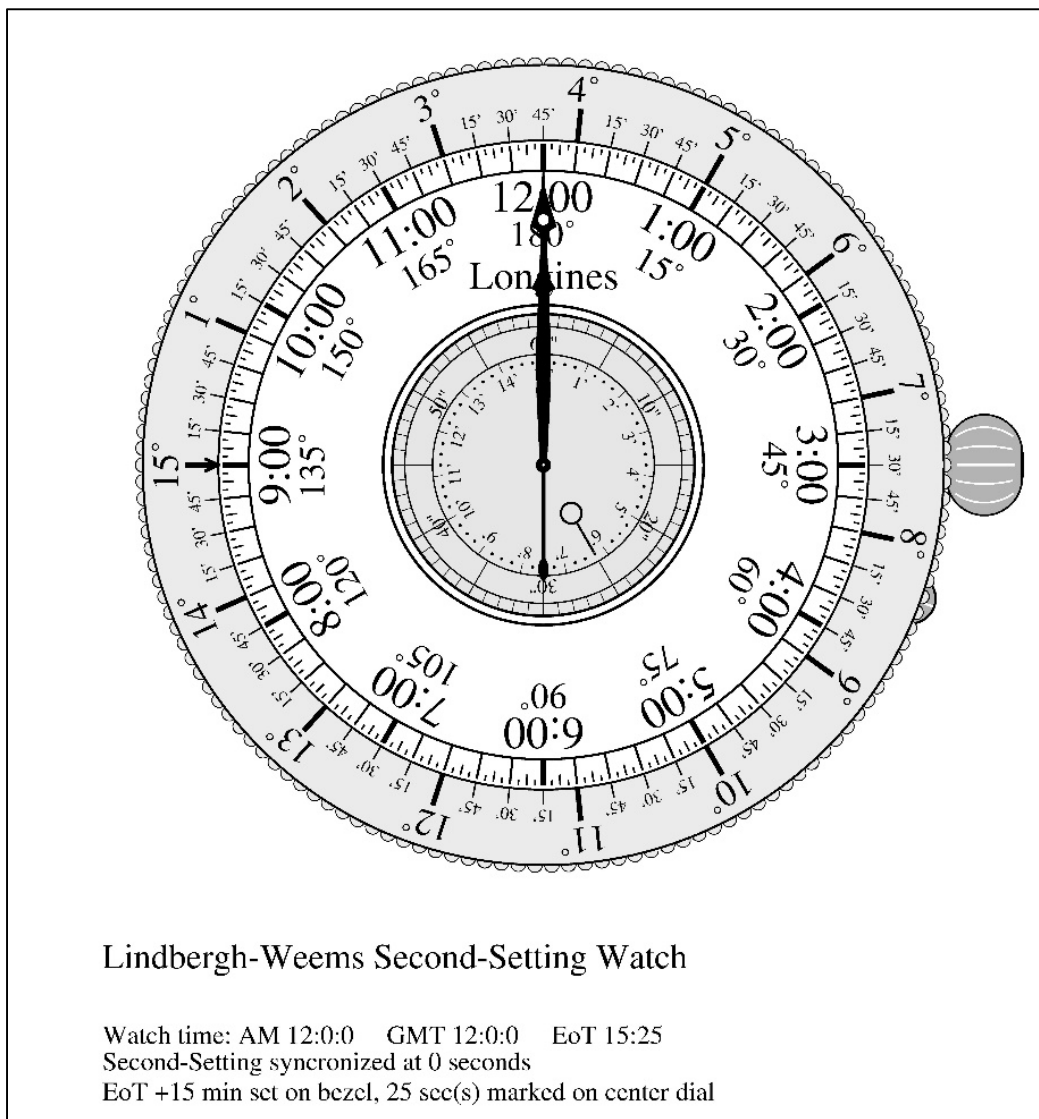
<sup>10</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Ex 24a.jpg

**Example 7 – Watch 12:00:00 Noon      GMT 12:00:00 + EoT 15:25 = GAT 12:15:25 <sup>11</sup>**

Bezel counter clockwise 15 minutes for EoT, 25 seconds on center dial (marked)

EoT shifts the hour hand less than a full hour into PM.

0°	hour hand main dial multiplier
3° 45'	minute hand bezel dial
0'	second hand center dial
+    +6'15"	center dial tick EoT seconds compensation, positive sign since fast
-----	
3° 51' 15"	GHA



<sup>11</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Ex 24b.jpg

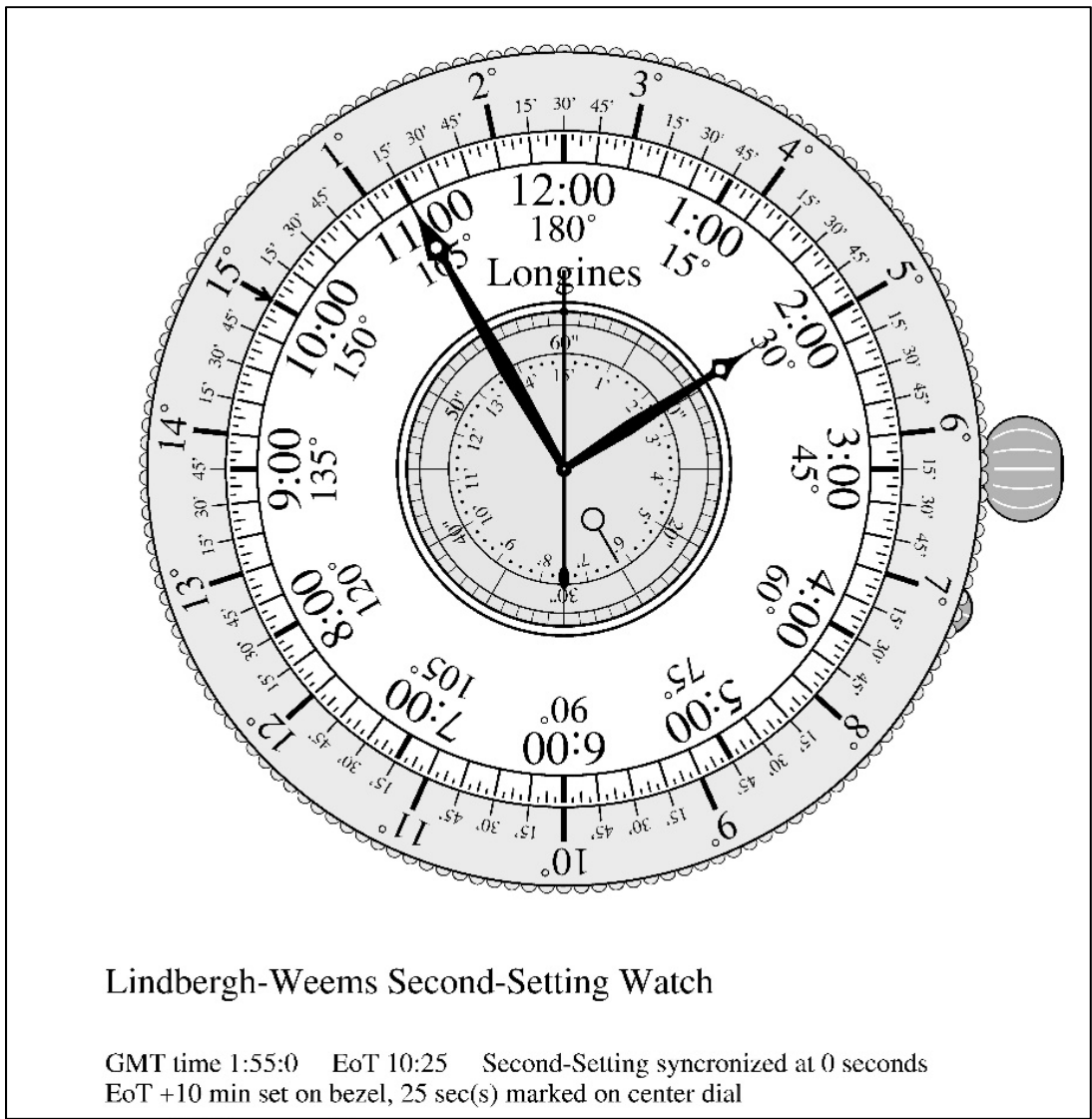
**Example 8 – Watch AM 01:55:00      GMT 01:55:00 + EoT 10:25 = GAT 02:05:25**<sup>12</sup>

Bezel counter clockwise 10 minutes for +EoT, 25 seconds on center dial (marked)

EoT shifts hour-to-arc multiplier to next hour, 30° is used instead of the 15°.

- 180°      sun is on the lower meridian at midnight
- 30°      hour hand main dial multiplier, GAT is next full hour, use 2:00
- 1° 15'    minute hand bezel dial
- 0'        second hand center dial
- + +6'15"    center dial tick EoT seconds compensation, positive sign since fast

-----  
211° 21' 15" GHA



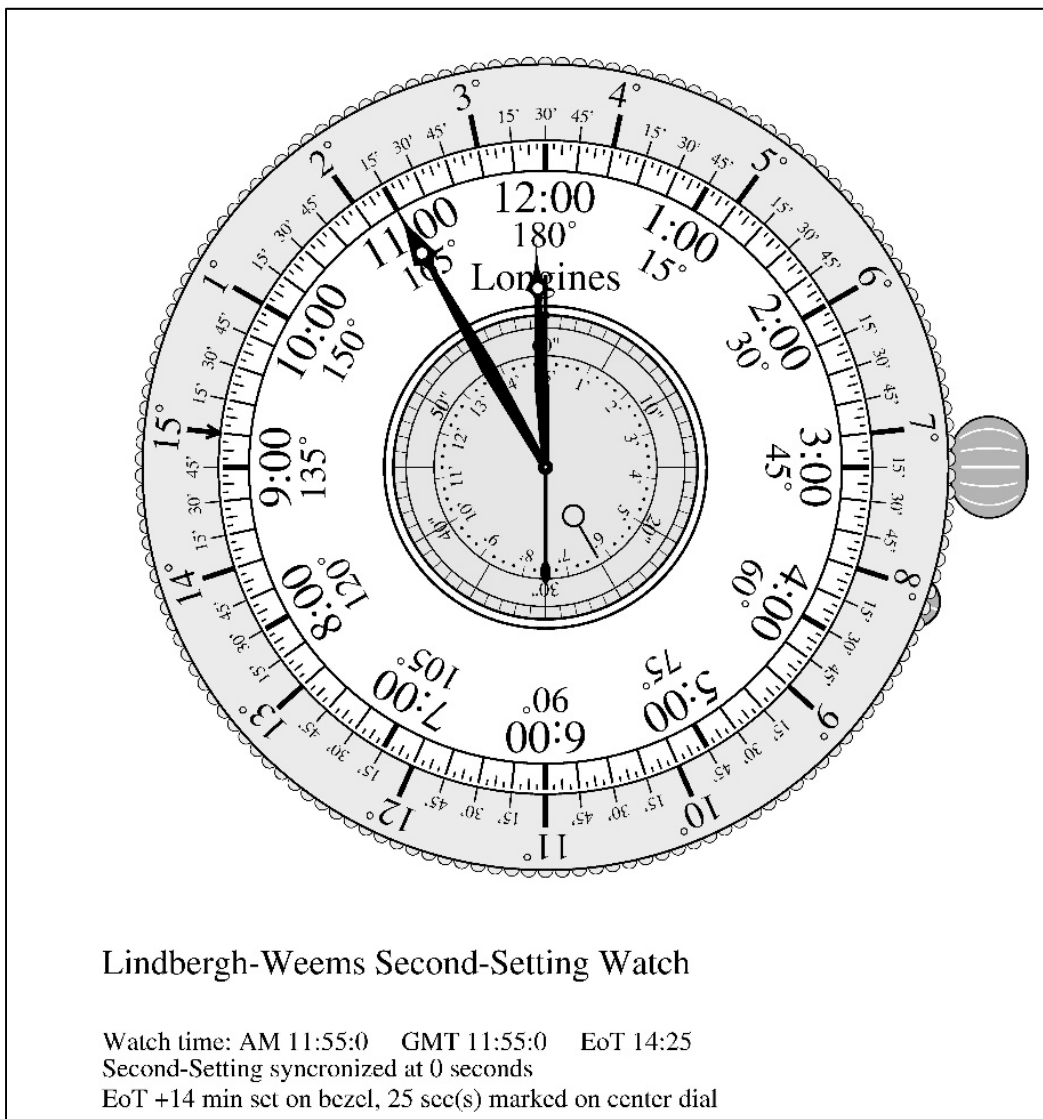
<sup>12</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Ex 27.jpg

**Example 9 – Watch AM 11:55:00      GMT 11:55:00 + EoT 14:25 = GAT 12:09:25<sup>13</sup>**

Bezel counter clockwise 14 minutes for +EoT, 25 seconds on center dial (marked)

EoT shifts from AM to PM.

0°      hour hand main dial multiplier  
 2° 15'      minute hand bezel dial  
 0'      second hand center dial  
 + +6' 15"      center dial tick EoT seconds compensation, positive sign since fast  
 -----  
 2° 21' 15"      GHA



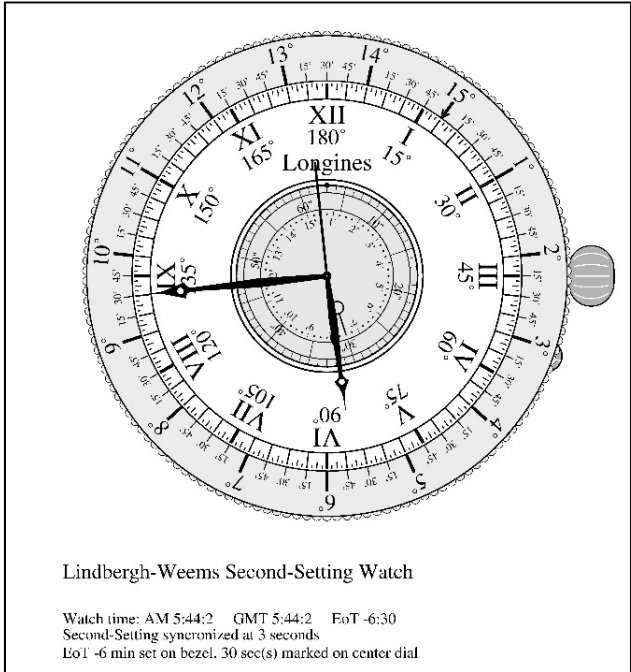
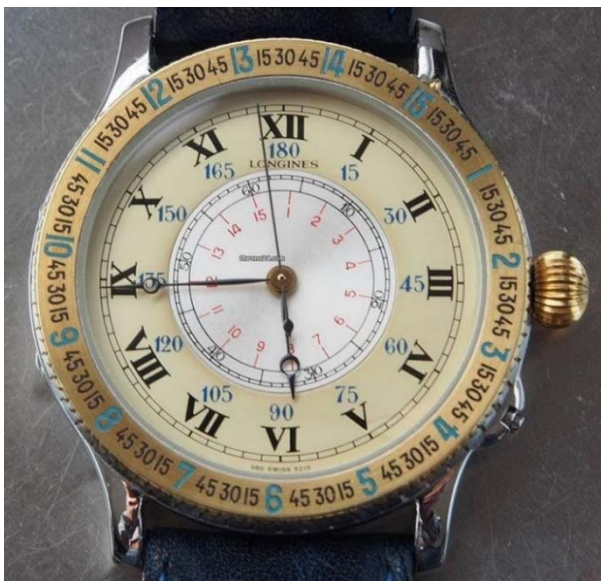
<sup>13</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Ex 28.jpg

**Example 10 – Watch AM 05:44:00      GMT 05:44:00 + EoT -06:30 = GAT 05:37:32 <sup>14 15</sup>**

Bezel clockwise 6 minutes for -EoT, 30 seconds on center dial (marked)

- 180°            sun is on the lower meridian at midnight
- 75°            hour hand main dial multiplier
- 9° 30'        minute hand bezel dial
- 30"        second hand center dial
- +    -7' 30"    center dial tick EoT seconds compensation, positive sign since fast

-----  
264° 23' 00" GHA



<sup>14</sup> [www.modernmontra.com/Utmerket-Verdi-Svart-Gullst%C3%A5-Longines-LINDBERH-HOUR-ANGLE-WATCH-Automatisk-Lindbergh-Hour-Angle-Herreklokke-xq7Afs11-p-2920.html](http://www.modernmontra.com/Utmerket-Verdi-Svart-Gullst%C3%A5-Longines-LINDBERH-HOUR-ANGLE-WATCH-Automatisk-Lindbergh-Hour-Angle-Herreklokke-xq7Afs11-p-2920.html)

<sup>15</sup> Graphic: Lindbergh-Weems Second-Setting Watch v9 Ex 29.jpg