Manufacturing the Berlin Television Tower

Berlin television tower, illuminated

"Up high" was where the trainees at SPE Berlin wanted to be with their workpiece, the Berlin television tower. Their enthusiasm paid dividends. With their workpiece, the trainees won the internal CNC4you competition and rejoiced in receiving a cash prize and free entry tickets for a German premium league football match of their choice. You can also manufacture the television tower and bring home Berlin's landmark.

The television tower consists of several turned parts and the base produced as milled part. The base contains the battery and the microswitch for the dome illumination.

All information, tool data, drawings, ShopTurn/ShopMill work plans and DIN programs required for making a reproduction copy are summarized under:

www.siemens.com/cnc4you

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1. Safety note

Working with machines is always associated with numerous hazards. It is therefore imperative that the legal and company safety regulations are also observed during the production of the television tower.

2. Preliminary remark

The following description is intended for persons acquainted with CNC machines and who have experience with or knowledge of SINUMERIK CNCs with Sinumerik control. All the technical data listed here corresponds to the machines, tools, materials, machining plans, programs and drawings used to produce the prototype. Because of the very varying conditions in other workshops, this data is only of exemplary character for a reproduction. Nevertheless, a problem-free reproduction should be possible in most cases.

The illuminated television tower consists of four components. These are:

- The base that contains a milled recess for the battery compartment and a microswitch.
- The tower with a through-hole of diameter 3.5 mm and a length of 120 mm for routing the cable.
- The illuminated sphere: The illumination is achieved with drilled holes equipped with fiber-optic conductors to represent the windows of the television tower and distribute the light uniformly to the outside.
- The tower tip inserted in the sphere.

The programs were programmed and tested in ShopMill/ShopTurn 6.4 and in standard DIN. The program can normally be adapted easily to other SINUMERIK user interfaces, such as SINUMERIK Operate. A simulation and any adaptations must always be performed on the available machine.

You can download without charge all CAD drawings, programs and manufacturing notes for the workpieces from **www.siemens.de/cnc4you** in the registered Internet area "My SINUMERIK". We make the following files and formats available there:
NC programs/drawings as PDF / 2D/3D data

3. Unmachined workpiece parts and other components

- Rd 8 Al Cu Mg Sil F37; component: Tip (approx. 100 mm)
- Rd 25 Al Cu Mg Sil F37; component: Sphere and tower (approx. 100 mm)
- Rd 120 Al Cu Mg Sil F37; component: Base (approx. 50 mm)
- White LED 3 mm (1 unit)
- LiFY decoder braided cord, red (approx. 200 mm)
- LiFY decoder braided cord, white (approx. 200 mm)
- Toolcraft epoxy adhesive (1 tube)
- Plastic fiber-optic conductor (approx. 250 mm)
- Battery cell holder (1 unit)
- Slider switch (1 unit)
- Battery cell (1 unit)


4. Milling machines, turning machines, programs and work plans

- Turning machines of the DMG CTX Alpha series, equipped with SINUMERIK
- DMG DMU 50 milling machines, DMG eVo Linear, equipped with SINUMERIK 840D sl
- Conventional turning and milling machines
- **Workpiece folder (turning) FERNSEHTURM.WPD**
  Simpler version of the television tower as ShopTurn programs. The dome does not have any illumination openings.
  antenne2.mpf, kuppel.mpf, turm.mpf
- **Workpiece folder (turning) FERNSEHTURM_KUGEL.WPD**.
  DIN program for the dome/sphere with illumination openings
  FERNSEHTURM.MPF, KUGEL_BOHRUNGEN.MPF, FERNSEHTURM_KONTUR.SPF, FERNSEHTURM_KONTUR2.SPF, WWP.SPF
- **Workpiece folder (turning) FERNSEHTURMSPITZE.WPD**
  DIN program for the television tower tip. This is produced in three work steps with three different tip contours.
  programm.mpf, spitze1.spf, spitze2.spf, spitze3.spf, wwp.spf
- **Workpiece folder (turning) TURM_BELEUCHTET.WPD**
  DIN program for turning the tower lower body.
  haupt.mpf, KONTURTURM.SPF
- **Workpiece folder (milling) FERNSEHTURMFUSS.WPD**
  ShopMill program for milling the lower side of the base .
  FERNSEHTURMFUSS_1SEITE.MPF
- **Workpiece folder (milling) FERNSEHTURMFUSS_SEITE_2.WPD**
  DIN program for milling the upper side of the base.
  FERNSEHTURMFUSS_SEITE_2.MPF


5. Tools used

Milling and turning tools for the television tower

All turning tools for the exterior machining have cutting tips with 35° tip angle. All drilling and milling tools are made of HSS.

FERNSEHTURM.WPD

Program	Tools / short name	Description
ANTENNE2	SCHLICHTD_A	Turning tool for the exterior with finishing insert with cutting radius R0.4
	ABSTECH_A	Parting tool with 3 mm tip width
KUPPEL	SCHLICHTD_A	Turning tool for the exterior with finishing insert with cutting radius R0.4
	Anbo	NC spotdrill with 8 mm diameter and 90° tip angle
	Spibo_3.8	Spiral drill with 3.8 mm diameter
	REIBEH7	Reamer with 4H7 diameter
	KopiDreh	Turning tool with SVVBN designation and cutting radius R0.4
	STECHD_A	Grooving tool with 3 mm tip width
TURM	SCHLICHTD_A	Turning tool for the exterior with finishing insert with cutting radius R0.4
	STECH_1	Grooving tool with 3 mm tip width
	ABSTECH_A	Parting tool with 3 mm tip width


FERNSEHTURM_KUGEL.WPD

Program	Tools / short name	Description
FERNSEHTURM	ANS	Limit stop (for example: clamp the round part in a collet chuck in a tool holder)
	SCHRUPD_A_35	Turning tool for the exterior with roughing insert with cutting radius R0.8
	SCHLICHTD_A	Turning tool for the exterior with finishing insert with cutting radius R0.4
	STECHD_A1.2	Grooving tool with 1 mm tip width
	SCHLICHTD_A2	Second turning tool for the exterior with finishing insert with cutting radius R0.4
KUGEL_BOHRUNGEN	ANS	Limit stop (for example: clamp the round part in a collet chuck in a tool holder)
	SCHRUPD_A	Turning tool for the exterior with roughing insert with cutting radius R0.8
	SCHLICHTD_A	Turning tool for the exterior with finishing insert with cutting radius R0.4
	SPIBO_3.9	Spiral drill with 3.9 mm diameter
	ANBO_4	NC spotdrill with 4 mm diameter and 90° tip angle
	SPIBO_1	Spiral drill with 1 mm diameter


FERNSEHTURMFUSS.WPD

Program	Tools / short name	Description
FERNSEHTURMFUSS_1SEITE	PLAN_50	Shell-end mill with 50 mm diameter
	BNF_14	Boring-groove milling tool with 14 mm diameter
	BNF_4	Boring-groove milling tool with 4 mm diameter
	BNF_2	Boring-groove milling tool with 2 mm diameter
	ANBO_8_90G	NC spotdrill with 8 mm diameter and 90° tip angle
	SPIBO_4.65	Spiral drill with 4.65 mm diameter
	GEWFO_5	Thread cutter for M5 thread

FERNSEHTURMFUSS_SEITE_2.WPD

Program	Tools / short name	Description
FERNSEHTURMFUSS_SEITE_4	BNF_12	Boring-groove milling tool with 12 mm diameter
	PLAN_50	Shell-end mill with 50 mm diameter
	KOPIF_2	Copying cutter with 2 mm diameter
	ANBO_90_10	NC spotdrill with 10 mm diameter and 90° tip angle
	SPIBO_6	Spiral drill with 6 mm diameter

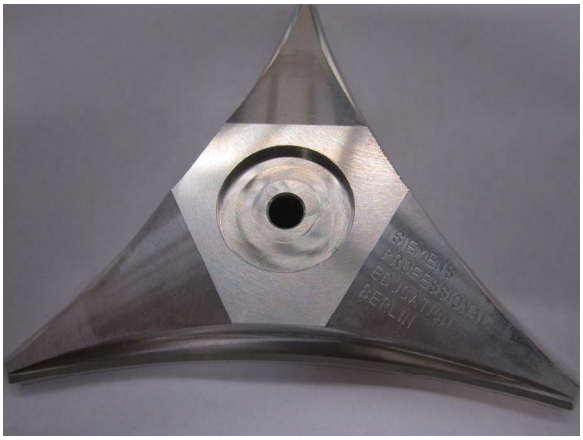

FERNSEHTURMSPITZE.WPD

Program	Tools / short name	Description
PROGRAM	ANS	Limit stop (for example: clamp the round part in a collet chuck in a tool holder)
	SCHRUPD_A	Turning tool for the exterior with roughing insert with cutting radius R0.8
	SCHLICHTD_A	Turning tool for the exterior with finishing insert with cutting radius R0.4
	STECHD_A	Grooving tool with 3 mm tip width

TURM_BELEUCHTET.WPD

Program	Tools / short name	Description
Main	ANS	Limit stop (for example: clamp the round part in a collet chuck in a tool holder)
	SCHRUPD_A	Turning tool for the exterior with roughing insert with cutting radius R0.8
	STECHD_A	Grooving tool with 3 mm tip width


6. Manufacturing the base



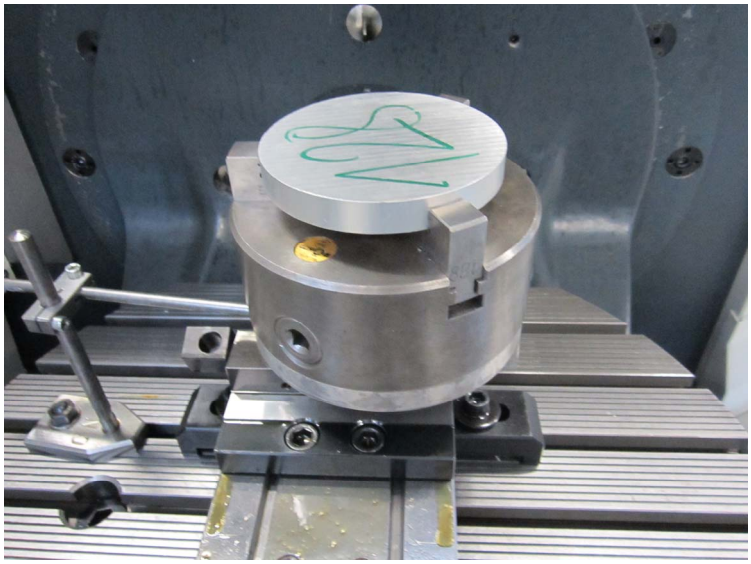
The base is produced on the CNC milling machine in two clampings. The raw part, diameter 120 mm, is clamped in a three-jaw chuck. Initially, the lower side of the base was machined. This includes the manufacturing of the end face, the battery compartment holder, the switch holder and the locating thread (second clamping).

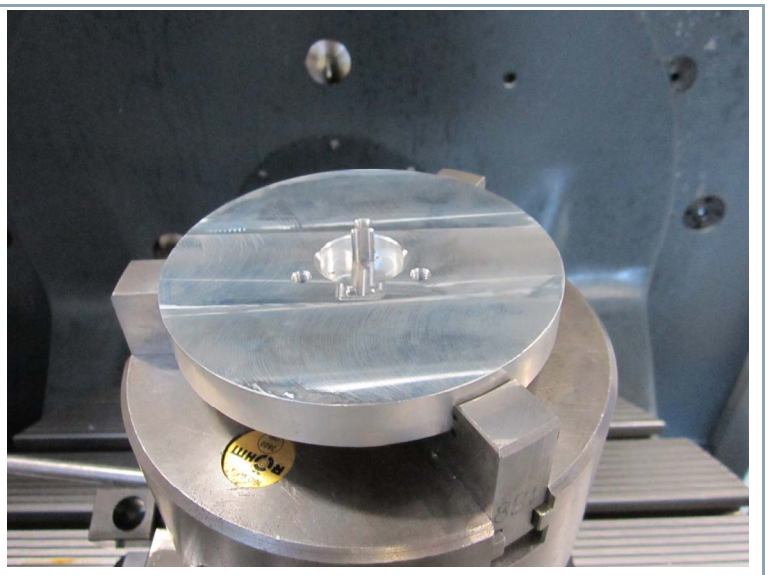
The upper side includes the manufacturing of the end face, the radiuses, the locating hole and the angular surfaces.

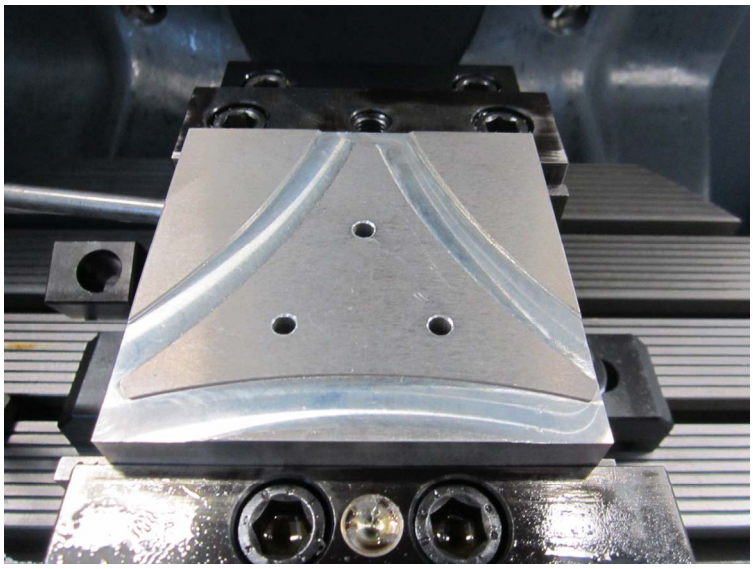
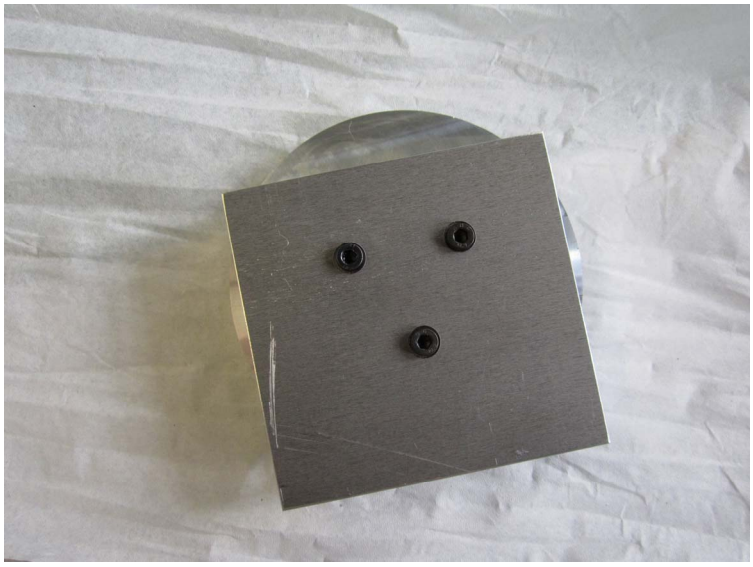
An additional jig is required for this. This includes three drilled holes for fastening the first clamping.

The special feature of particularly the second side is the 3+2 axis machining and the locating hole for accepting the tower.

Base clamping jig and tool

Description	Clamping situation
1. Clamping prior to the manufacturing	

1. Clamping after the manufacturing	
Battery compartment holder, switch holder and locating thread	

Jig in the machine vise	
Tighten the first side of the base from below	

2. Clamping after the manufacturing	

The unmachined part is clamped securely.

Machining steps on the milling machine

1. Approach the reference point of the machine
2. Import the programs
3. Enter the measured tools in the tool list
4. Insert the tools in the magazine
5. Set the workpiece zero point by scratching or touching
6. Perform the simulation
7. Start the manufacturing, execute the program
8. Clamp the workpiece on the lower side
9. Import the program
10. Repeat steps 3 to 7

7. Manufacturing the tower

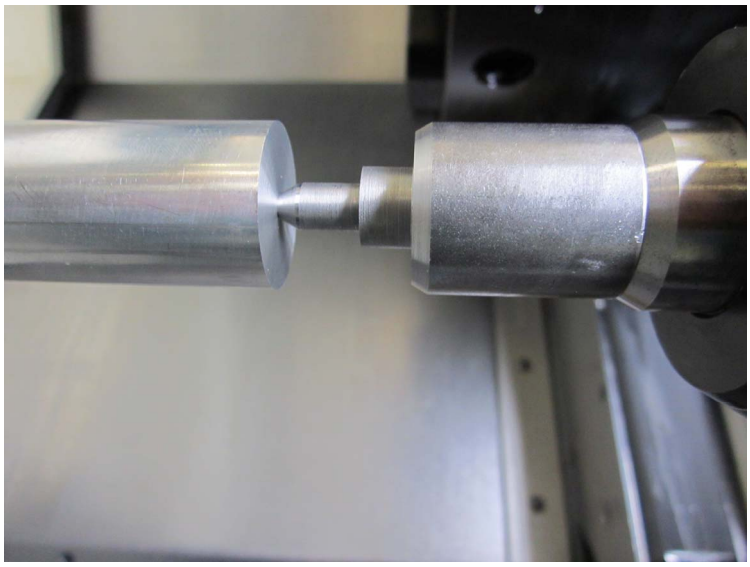
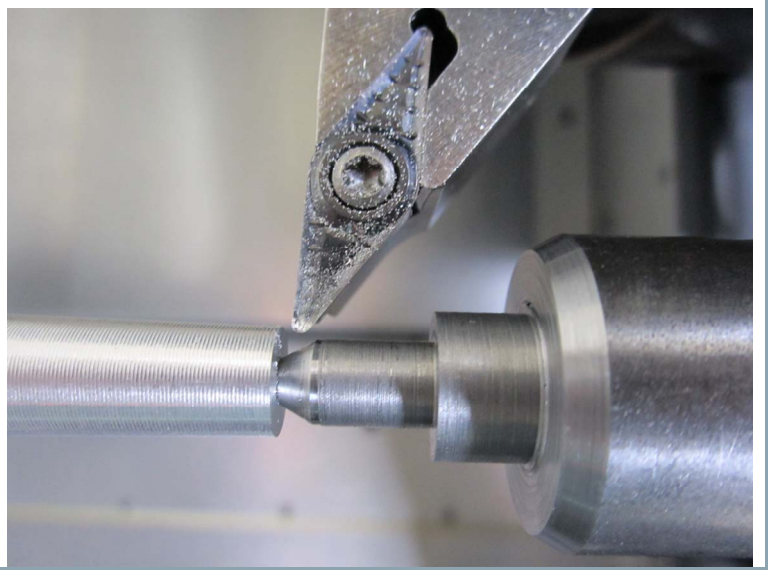
The tower is manufactured on a CNC turning machine.
The unmachined part is approx. 176.5 mm long and can be clamped in the collet chuck only to a length of 20 mm. For this reason, the machining is performed with a tailstock center as tailstock.
The small diameter of the sphere is 8 mm. To prevent the turning tool traveling to the tip while manufacturing the contour, a customized "adapter tip" is manufactured. It is clamped between the tailstock center and the unmachined part.
Finally, a 3 mm wide groove with a diameter of 6.5 mm is grooved. This means the material has a wall thickness of only 0.25 mm here and so can be broken off without problem after the contour has been manufactured.
The resulting burr at the end of the 6 mm hole is removed and deburred by hand.

The cut-to-size unmachined part is clamped securely (collet chuck recommended).

Machining steps on the turning machine

1. Approach the reference point of the machine
2. Import the programs
3. Enter the measured tools in the tool list
4. Insert the tools in the magazine
5. Set the workpiece zero point by scratching
6. Perform the simulation
7. Start the manufacturing, execute the machining plan

Tower clamping jig and tool

Description	Clamping situation
Produce the tailstock with a customized tailstock tip	 

8. Manufacturing the television tower sphere/dome

Two zero points were used for the machining.
Because the television tower sphere is very complex, two programs must be used. One program to drill the 1 mm holes in which the fiber-optic conductors are glued and the second program to manufacture the sphere.
Difficulties for the first side can occur when drilling the 1 mm holes. The very small cores and the poor chip removal of the drill because of the soft material mean tool breakages can occur. To avoid damage to the workpiece during a cut-off, a recess with 4 mm diameter is produced. As consequence, the wall thickness is only 0.5 mm and the sphere can be broken off and deburred by hand.

The cut-to-size unmachined part is clamped securely (collet chuck recommended).

Machining steps on the turning machine

1. Approach the reference point of the machine
2. Import the programs
3. Enter the measured tools in the tool list
4. Insert the tools in the magazine
5. Set the workpiece zero point by scratching
6. Perform the simulation
7. Start the manufacturing, execute the machining plan

9. Manufacturing the tower tip

To prevent chatter marks, an R0.2 rather than an R0.4 finishing insert is used. Small infeeds (0.05 mm) are used for the machining because otherwise the tip would push away. The fit size 3r6 was manufactured conventionally from the second side.

The cut-to-size unmachined part is clamped securely (collet chuck recommended).

Machining steps on the turning machine

1. Approach the reference point of the machine
2. Import the programs
3. Enter the measured tools in the tool list
4. Insert the tools in the magazine
5. Set the workpiece zero point by scratching
6. Perform the simulation
7. Start the manufacturing, execute the machining plan

10. Assembly guide

(Numbered figures for the visualization are shown on the following pages)

1. Fit the battery holder

- Bend the contacts
- Remove the spacers

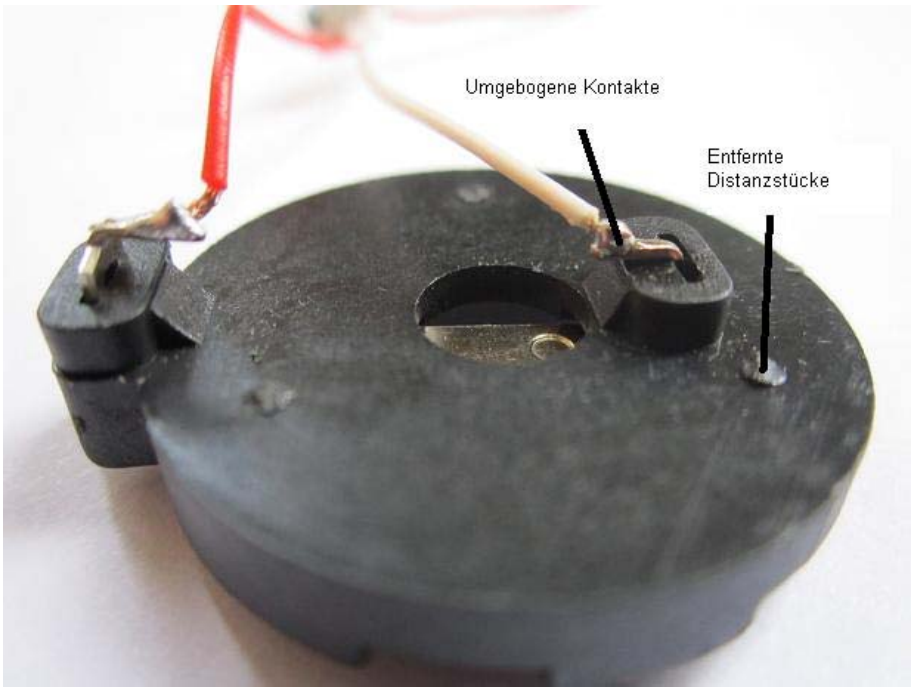
2. Solder the cables to the battery holder and the microswitch
3. Remove a contact on the microswitch to prevent short-circuits
4. Glue on insulation tape to prevent short-circuits
5. Press the microswitch into the base recess
6. Feed the cable through the hole in the base
7. Glue the battery holder into the pocket recess in the base
8. Feed the loose cable ends through the tower
9. Press the tower into the guide in the base
10. Solder the LEDs

- Shorten the contacts of the LEDs (see figure)
- Cut off the cables from the tower approx. 5-7 mm above the tower
- Remove the insulation and then tin-coat
- Cut off the shrink tubing to approx. 7 mm length and push over each cable (it must not cover the soldering point (approx. 2-3 mm space)
- Solder the red cable to the anode (the cathode (-) is in the LED, shown as cup)
- Pull the shrink tubing over the cable to the LED and shrink with a hot-air fan
- Insert the LED with a marked 2 mm thick wire into the hole in the sphere as far as the marking and so ensure the separation to the LEDs.

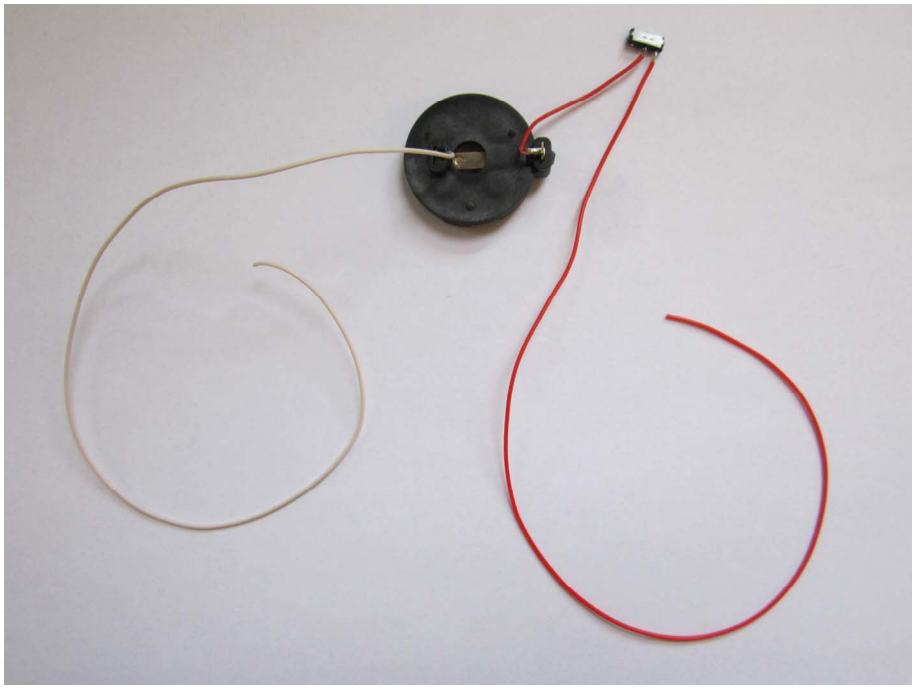
11. Press the sphere into the tower
12. Press the tip into the sphere


Figures for the assembly guide

1.



2. + 3.



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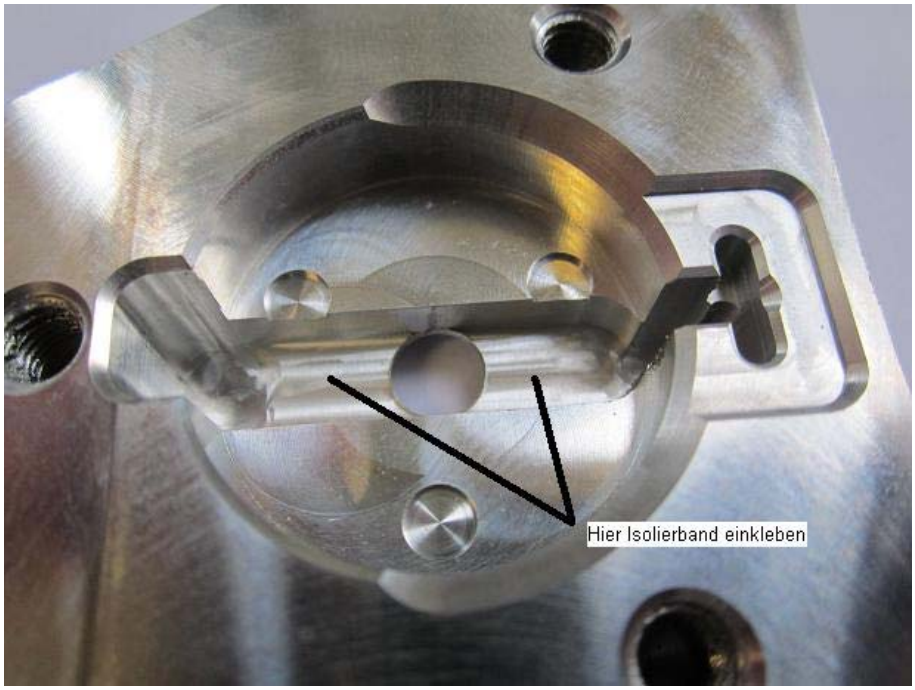
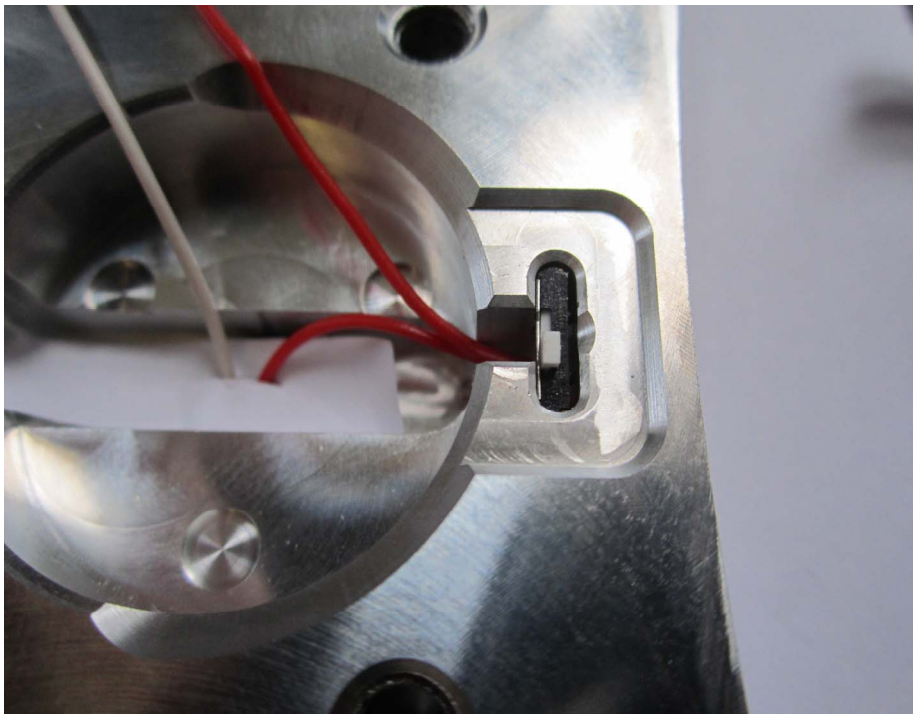


5. + 6.



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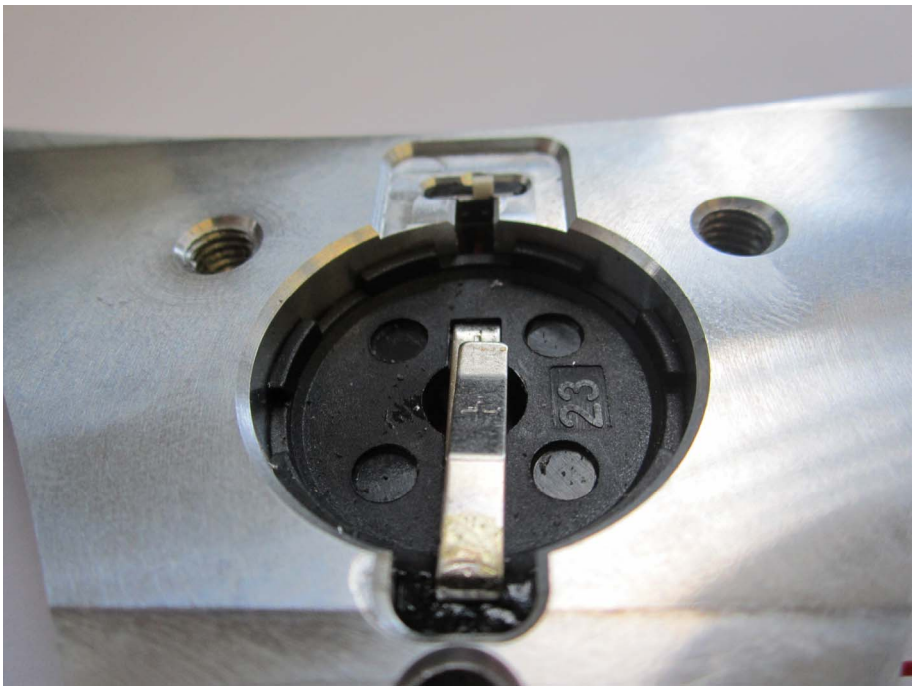

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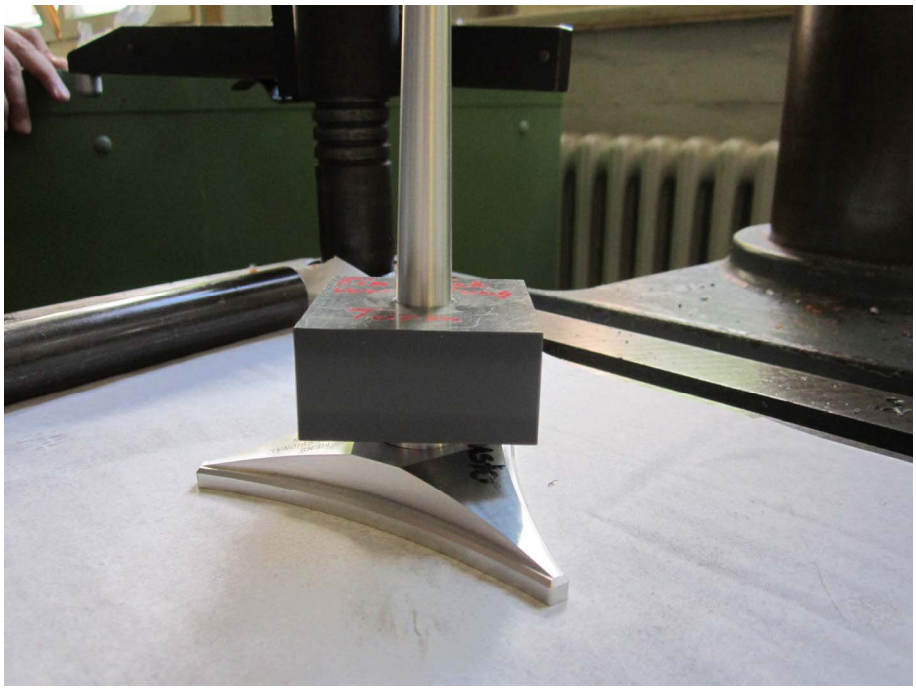

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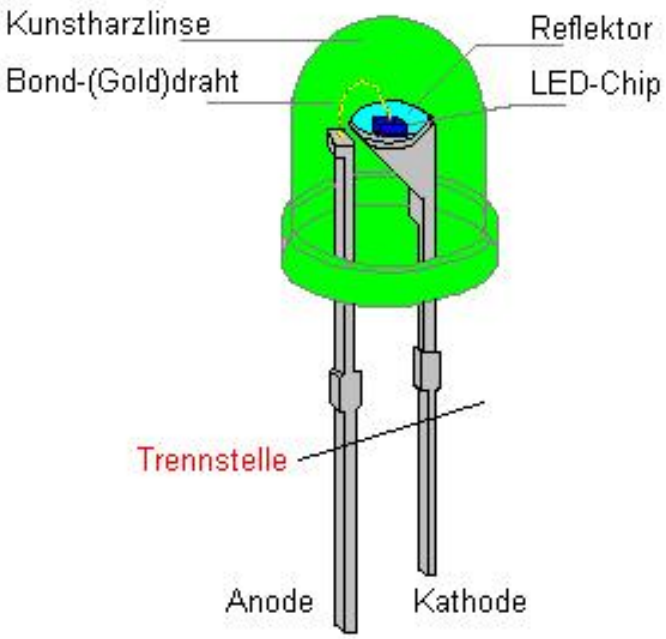
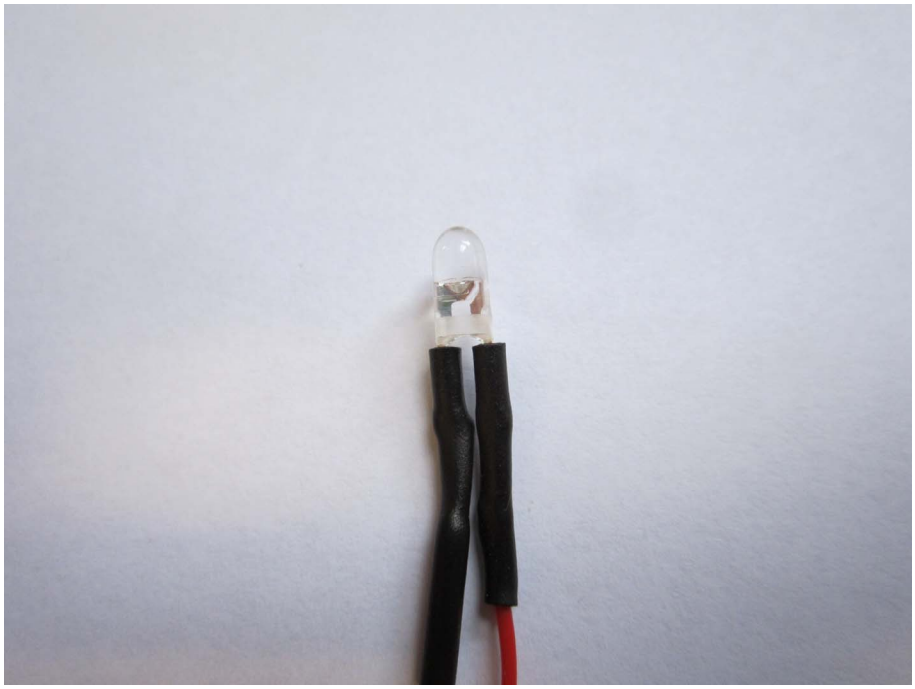
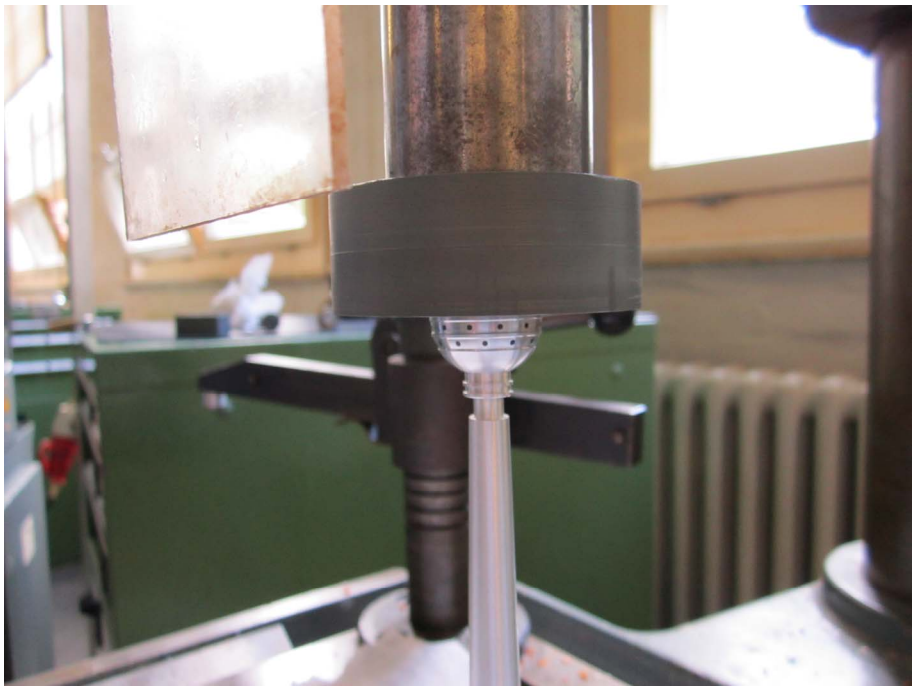

Kunstharzlinse
Reflektor
Bond-(Gold)draht
LED-Chip
Trennstelle
Anode
Kathode

10.



11.



12

11. Information in the Internet

**Design of the parts, creation of the drawings,
development of the machining plans and programs for the machining**

SIEMENS Professional Education SPE
Nonnendammallee 104
13629 Berlin, Germany

Details of the machine tool to be used

Gildemeister Aktiengesellschaft,
Gildemeisterstraße 60,
33689 Bielefeld, Germany
In the Internet: www.gildemeister.com

Manuals and information from Siemens AG

Manuals and detailed information about our products can be found at www.siemens.de/sinumerik -> Index or search: DOConWEB -> SINUMERIK

- "Simple Turning with ShopTurn" Training Documents
  -> Info/Training -> "Simple Turning with ShopTurn" training documents
- ShopTurn Product Brief
  -> 840D/840Di/810D Users -> ShopTurn 840D/810D product brief
- ShopTurn Operation/Programming
  840D/840Di/810D Users -> ShopTurn operation and programming
- "Simple milling with ShopMill" training document
  -> Info/Training -> "Simple milling with ShopMill" training document
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  -> 840D/840Di/810D users -> ShopMill operating and programming

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- You can restrict the search by clicking "A-Z"
  (-> a search is now performed below this point in the index)
- Or click the zoom
  (-> a full text search is now performed below this point

11. Figures

Television tower

Engraving