Make any galvanometer dial with Galva: a whole program

Introduction

Despite the evolution of digital display techniques, galvanometers still have their interests, their users and their supporters.

The object here is not to see the advantages and disadvantages of the different systems, but to show concretely how to make galvanometer dials; and this is whether to restore a damaged dial of an old measuring instrument or to create a dial with new scales for a new galvanometer, or recovery one, to which you want to give a new life.

When restoring an existing galvanometer, the dial is sometimes in poor condition. When it is impossible to "recover" it, then it is necessary to consider recreating a new one, and to stay in the spirit of the restoration, the wish is often that the scales and the graphic are as identical as possible to the original. Conversely, when it is desired to use a galvanometer for a new use, it is necessary to create its own scales while respecting precisely the mechanical characteristics of the galvanometer.

There are a very large number of types of dials, and this especially according to the type of galvanometers. We can distinguish three major types of galvanometers:

1) those whose axis is vertical, parallel to the dial and whose needle moves horizontally (Fig. 1 and dial type 2 of Fig. 4). The scales are horizontal lines on a curved dial;

2) those whose axis is horizontal, parallel to the dial and whose needle moves vertically (Fig. 2 and dial type 1 of Fig. 4). Scales are vertical lines on a curved dial;

3) those whose axis is horizontal, perpendicular to the dial and whose needle has an angular displacement (Fig. 3). Several types

Fig. 1 - Type 1 galvanometer

of dials corespond to these galvanometers, according to the extent and the zone of deflection of the needle (dials 3 to 12 of Fig. 4). These are the most common galvanometers. The dials are planar and the scales are generally in arcs of circles, however, the type 12 of Fig. 4 is an example of a straight scale dial for a type 3 galvanometer.

For all devices, the zero can be placed anywhere on the needle deviation.

The shape of the dials is usually rectangular or circular.

Fig. 2 - Type 2 galvanometer

Note:

All the dials in Fig. 4 can also be made round or other shape. Fig. 5 gives an example for a dial version with inverted scales.

Each dial has one or more scales and there are an infinity of scales, and this without speaking of all possible combinations.
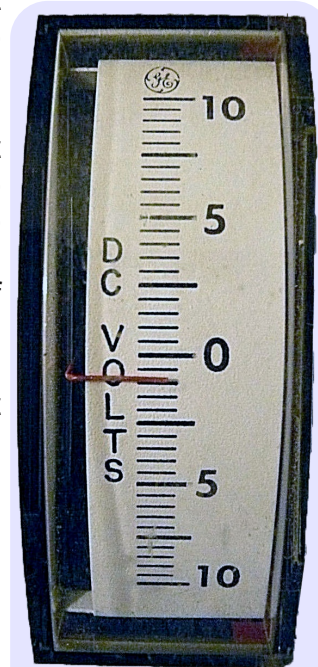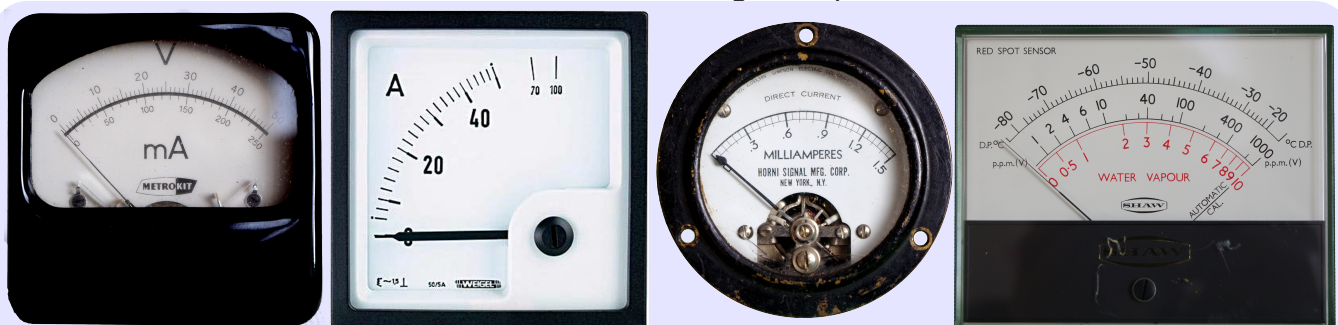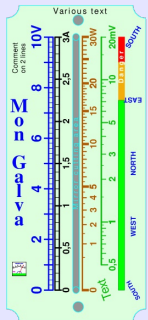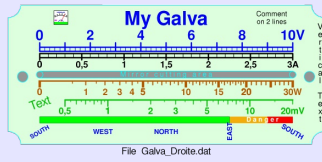

Fig. 3 - Type 3 galvanometers

Types of dials
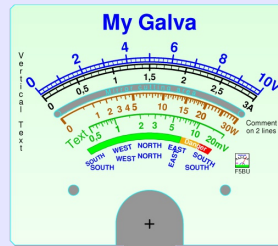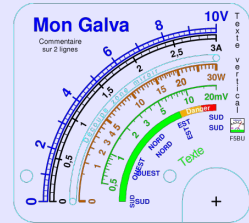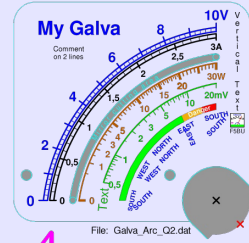
Fig. 4 - Different types of dials for type 3 galvanometers
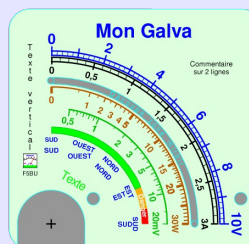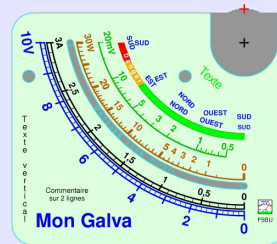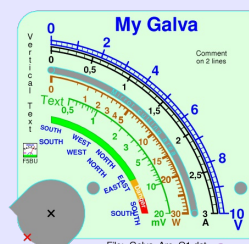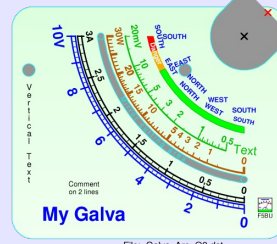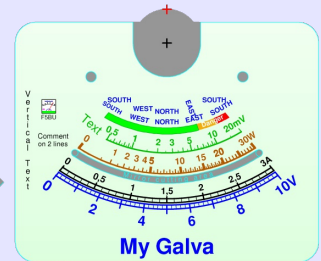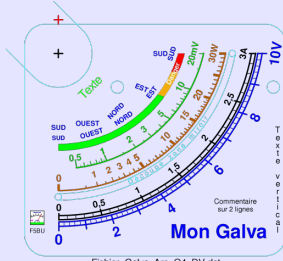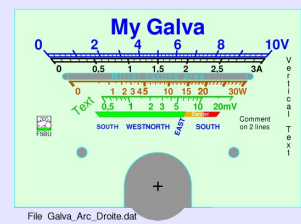
Fichier : Galva_Cmd_Tuto.dat

Here we will distinguish: linear scales of type $y = ax + b$, which means whose graduations (tick marks) are equidistant; scales of type $y = ax^z$; logarithmic of type $y = a * \log(x)$; as well as "manual" scales whose values have been measured and whose progression is not, in principle, consistent with any mathematical equation.
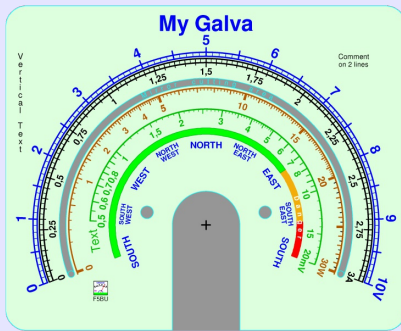
Note:

Any scale from know equation is feasible with Galva using the equation. See:
<u>"Making a scale of any known equation"</u>.

File Galva_Arc_reverse.dat
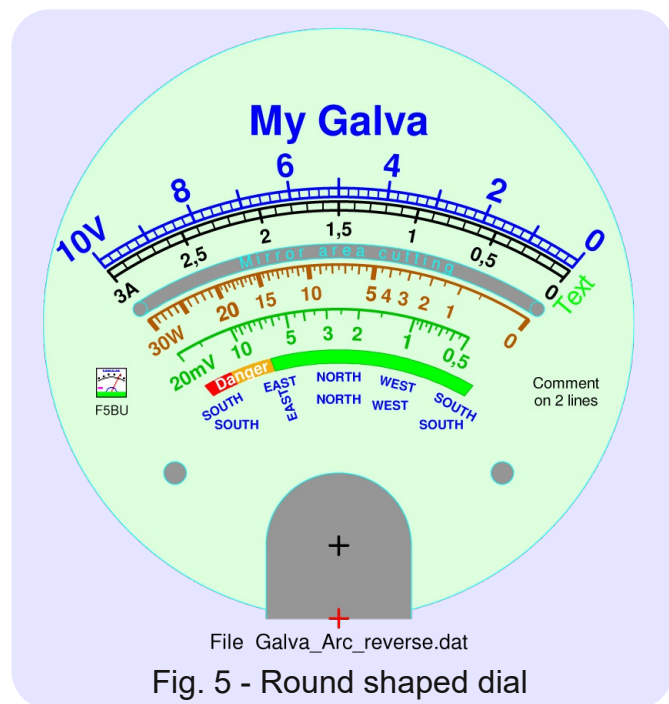
Fig. 5 - Round shaped dial

Realization of a dial

Whether it is to obtain a faithful reproduction in the case of a restoration, or to "stick" the best to the mechanical characteristics of a galvanometer, it is strongly recommended to start drawing a dial with a picture of the original dial in the background: then draw over the image, which is removed once the mechanical dimensions and the deviation of the needle match perfectly and no scale is to be "copied".

Note:

To make the job easier, it is often convenient to start drawing with a good visible color on the background image, and to replace that color with the appropriate colors only at the end of the job.

For this, it is important to have an image of the original dial of the best possible quality, well "horizontal" and deformed as little as possible. A line drawn horizontally above must be as parallel as possible to a horizontal line of the image and the height / width ratio respected. This is generally not a problem if the

image is obtained with a flatbed scanner, however, with a camera, it must be placed perpendicularly above the center of the dial and as far as possible of the dial to limit deformations. This image must then be placed in the background, and it is advisable to exactly respect the dimensions of the original, to not have to do a "Zoom Print" to obtain the right dimensions at the end of the work.

Quick presentation of Galva

Galva is a program that was initially developed specifically to draw accurately dials of galvanometers, potentiometers, variable capacitors, and so on.

The first version made available was in January 2004. Since then, several versions have succeeded and this program is today also very well adapted for many totally different applications ... In addition, many improvements, such as the **Input Masks**, the external commands, the rotations possibilities, ..., facilitate fundamentally the use, including for the realization of dials of galvanometers.

To get an idea of the possibilities of Galva, the best is to see the presentation on the site <u>f5bu.fr</u>, under the tab Galva / Presentation (availlable in French, English, German and Spanish), where many pdf files present concrete achievements. Do not hesitate to zoom, because the resolution of the screens is generally much lower than that of the printers.

The program runs under Windows, manages the mouse, the keyboard shortcuts, the colors, allows the insertion of Bézier curves, drawings made with the mouse and images. It can be used in French, English and German (and Spanish except for the input masks).

Galva is therefore particularly well suited for the realization of scales of all kinds, whose shapes can be curved or straight, and the graduations (tick marks) linear, functions of a power, logarithmic, manual, etc.

Notes

- It is a command interpreter, including graphical commands, not a software to draw everything directly using the mouse.

- As for many software, the possibilities are so numerous that a minimum of familiarization or learning is recommended, or necessary, according to the ease of each with a computer tool. For this there is a tutorial, an online help, input masks, a contextual help, very numerous files examples and specific tutorials like this one.

- Attempting to make drawings without a minimum knowledge of the program, does not allow to make the right choices and is, at best, a waste of time, at worst, a source of abandonment. It is therefore recommended to read at least the introduction of the help, to skim a little the description of the various commands and to do some tests for the sole purpose of understanding the "philosophy" of operation of the program before embarking on a true project.

Quick introduction to Galva

Galva is a command interpreter, that means that you have to write a kind of program that describes the graphic to be created. For this there are different commands or instructions.

For example:
Cercle = 20, 30, 10 [Cercle is Circle in French] will draw a circle whose center has the coordinates 20, 30 (the center is 20 mm to the right and 30 mm above the reference point, which defaults to the lower left corner of the screen or the sheet of paper) and 10 mm radius.

Other example:
Texte = 20, 40, blue, BC,My Text [Texte is Text in French] will write "My Text" in Blue, Bold and Centered in 20, 40.

You are not wild about writing commands with a sometimes large number of parameters! So, do not panic, the **Input Masks**, set up with the version 2.50, make the entry of the parameters of a command now easy. They give a description of the command and for each parameter, thus avoiding knowing the order of the parameters and their meaning. An example is given in Fig. 6 for the Image command, another in Fig. 9 for the external command GCE_E (mnemonic for GalvaCommandExternal_Echelle [Echelle is Scale in French]).

As for any programming, it requires logic and a little perseverance. Having already programmed, whatever the language that has been used, is obviously an advantage, but starting with Galva can also be a way to get "soft" to programming, because the result is visual and there is no risk of to experiment, quite the contrary.

It is a sequential programming, which means that the commands are executed in the order they appear in the code (program). If a command draws a large white rectangle, everything that was previously drawn there will be hidden by it. The Stop and ListVar commands

make it easy to detect such problems. In addition, by putting an apostrophe "'" in front of a command line it is transformed into a comment, which makes it easy to see its effect.

Make a dial with Galva

To make a dial with Galva, it is of course always possible to directly write your own code, to start from one of the numerous examples provided by looking for the name of the file to use in one of the GalvCmdEx.pdf, GalvCmdEdEv.pdf, ..., files and/or to use the GCE_E_Auto command allowing an automatic plotting of simple scales (see file GCE_E_Auto_Demo.dat). In any case, it is recommended to read the quick tutorial Galva_Tutorial.pdf, which may be sufficient for the realization of a very simple dial.

However, the purpose of this tutorial is to present an approach using one of the new example files (Galva_Arc_*.Dat, Galva_Droite.dat or Galva_DroiteV.dat) depending on the type of dial to realize. Fig. 4 or the Galva_cmd.pdf file show the different types that can be made with, under each example, the name of the corresponding example file. These files, made from the base file Galva_Arc.dat are very similar, but are each time specifically adapted to a type of dial.

In order to allow an easy adaptation to a personal realization, these files do not correspond to realistic dials, but integrate each one the following possibilities:
- display an original dial image in the background of the screen;
- draw a rectangular or circular plate / frame with holes for fixing and cutting for the axis of the galvanometer, and this whatever the shape of the plate presented as an example (Other forms of plates are achievable by writing a corresponding code),
- define the deviation of the needle,
- draw two linear scales (the most common case),
- draw a cutout for the galvanometers with a no parallax error mirror,
- draw a nonlinear scale of type $y = x^2$,
- draw a "manual" scale,
- draw a logarithmic scale with an offseted origin or not,
- draw colored sectors,
- draw two scales with texts, showing different possible orientations for the texts,
- add a title, texts and images,
- do a rotation of all the scales.

In order to facilitate the realization of customized dials, incorporating any combination of these different possibilities, the files are constituted of blocks that can easily be ignored or duplicated with other values, as needed.

Main steps to make a dial

Become a little familiar with Galva

As mentioned before, read at least the introduction of the help, skim over the description of the main commands and perform some tests for the sole purpose of understanding the "philosophy" of operation of the Galva program before embarking on a real project.

Reminders:

• pressing the **F1 key opens the help**.

• with the cursor on a command line, pressing **F2 opens the Input Mask** describing the command and explaining each parameter.

• *The words of the commands are in blue once the line is validated by changing line or* viewing the result by F4.

• *a line beginning with an apostrophe " ' " is considered a comment by the program and becomes green in color. By placing an apostrophe at the beginning of a line of code it is not interpreted, which makes it easy to see its effect.*

• *a line ending by " _" (space underscore) continues in the next line.*

• *the decimal separator in the Galva code is the point (". ").*

• *the dimensions are in mm and the angles in degrees.*

• *a Stop or an exclamation point " ! "command stops the execution of the program, which makes it possible to see if a drawing is before or after this place.*

• *a ListVar command displays the contents of all the variables at this point of the code.*

• *an AngRot command allows to rotate around the 0,0 point everything that follows.*

Structure of the example programs

The example programs are structured in two parts: the first concerns the definition of the characteristics of the plate, the second concerns the characteristics of the scales.

Each part is structured in blocks, each block having a precise function like the drawing of a type of scale. Each block, easily identifiable, begins with a label (example E2:) and ends with a line containing Stop or 'Stop. The second line of a block contains Goto or 'Goto. If this line starts with an apostrophe, then it is a comment line, the command is not executed, and the lines of the block are. If there is no apostrophe at the beginning of the line, the Goto command is executed and the block code is ignored. The third line generally describes the action of the block.

At the end of the block, the line containing Stop or 'Stop is managed in a similar way to that containing Goto or 'Goto. If it begins with an apostrophe, no command is executed, and the program continues sequentially; if it does not start with an apostrophe, the program stops there, which is often useful during the time to work on a block.

Block example:

```
E2:
'Goto E21    ' Put / remove the apostrophe to draw the scale or not
' Drawing of a second linear scale (3A)
' -------------------------------------------
Inversion              ' reverse the side of the graduations and values
EpaisT = %e_Arc mm
%2_Arc== -%2_Arc
%r_Arc==%r_Arc-.5        ' new radius
%C_Arc = black     ' new color
' Put an apostrophe at the beginning of the following line for only 1 arc
Arc =90-%AD1,90+%AD2,%r_Arc+%2_Arc,%C_Arc ' 2th Arc
Arc =90-%AD1,90+%AD2,%r_Arc,%C_Arc
GCE_E =,,6§30,1.5§1,.3mm§.15mm,%C_Arc§%C_Arc,6,0,3,3,A,%C_Arc,Arial,.8 g,,,,%DR,%VRA
Inversion              ' reverse the side of the graduations and values
'Stop
```

Since each block must be able to execute independently of the others, a large number of commands are redundant. As, in addition, there are many blocks, the files may seem a bit long at first glance.

Create an image of the original dial

Unless you have precisely all the mechanical features of the dial to replace or to achieve, even if it is new, it is advisable to scan the dial in order to put the picture in the background of the screen. If necessary, rotate the picture with a photo editing software so that it is perfectly "horizontal". Otherwise, it is possible to use the possibilities of Galva scale rotation, but this complicates a little things: During the step of determining the edges of the frame and the deviation of the scales, it is then advisable to use the %RA variable (which is used in particular by the AngRot command) to obtain a rotation equal to the angle of inclination of what should be "horizontal".

Note

Attention: to remove a galvanometer dial, remember that a galvanometer contains a very strong magnet, so it is recommended to work on a clear space with no parts that can be attracted by this magnet during disassembly, and ... attention do not twist the needle when removing the dial!

Select the dial type

* * * * V2 main novelties * * * *

This new version of the tutorial is valid for the new Galva_Arc*, Galva_Droite and Galva_DroiteV files, which include improvements, notably thanks to the possibilities introduced with version 2.8 of Galva. One of the most important is the ability to easily perform scale rotations around the origin point of coordinates 0,0, just by using the new AngRot command or by changing a new parameter in the Arc, Droite or DroiteV commands. Straight or curved scales of any inclinations can so easily be made for charts or other needs.

Four new variables have been added in the sample files:
- %RA defines the rotation angle of the scales,
- %VRA the absolute or relative rotation angle of the values,
- %PRA the rotation angle of the plate and
- %DR which defines the orientation of the

scale values according to the offseted center by "D" or the center of the needle by "R", when there is a non-zero offset of the center of the scales and that %VRA defined a relative angle.
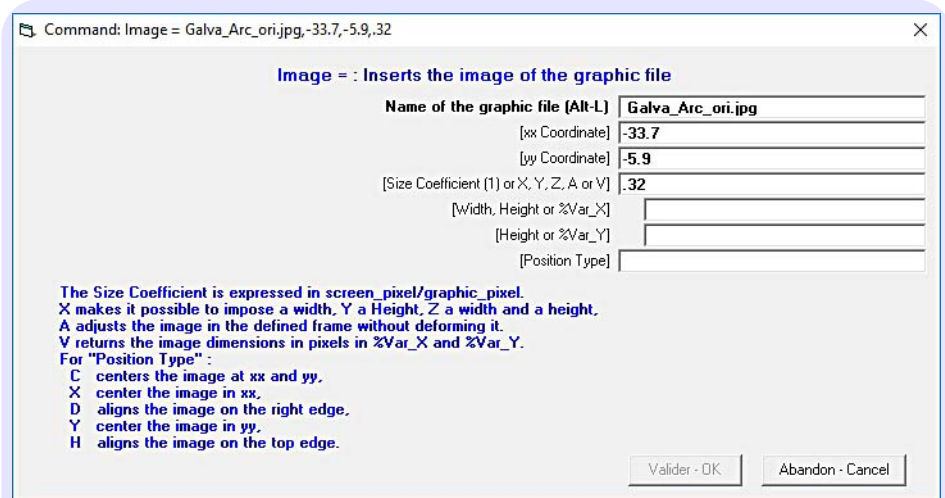
Fig. 6 - Input mask for the Image command

Thus, the main differences existing now between the files are the values of these variables and the positioning of the texts (block E7: and E8:) and the image (Galva icon, block E9:).

When there are two dials (dials types 4, 6, 7, 9, 10 and 11) for the same type of dials, the one whose name ends with VO corresponds to the old file, which allows only a Vertical Offset of the scales axis, while the new file is set for an offset along an axis of symmetry of the scales. Other values being possible by modifying the parameters. In old files, the dial type was only defined by the %AD1 and %AD2 variables, whereas in the new examples the %AR variable plays an important role.

The values of the graduations can be oriented relative to the offset center, relative to the center of the needle or in absolute angle. As noted above, the choice is made by putting the letter D or the letter R for the variable %DR, or by putting a value for %VRA not preceded by the letter "R".

The example of the type 12 dial is given for scales in quadrants 1 and 2, but all the other examples with curved scales can be made with straight scales by setting a value equal to -10000 for %Decal_Arc.

* * * *   * * * *

- Find on Fig. 4 or on the Galva_cmd.pdf file (better quality) the type of dial and open, with Galva, the file whose name is the one of the example.

- Save this file under a custom name (File Menu, Save As) so that you can go back to the original file if necessary.

Place the picture in background of the screen

- At the beginning of the programs, about line 72 according to the file (the number of the cursor line is displayed in the small window on the right at the bottom right of the graphic screen), you find the following two blocks (too long lines continue with continuation lines):

```
C0:
Goto C1      ' Put / remove the apostrophe to draw _
the image or not
' --------------------------------------------
' Eventual original image in the background
' --------------------------------------------
%C_Back= N
%C_Arc = magenta
%e_CT = .05
Image = Galva_Arc_ori.jpg,33.7, 5.9,.32
Trait           =         0,0,90+%AD1+%RA           °,
80, ,magenta
Trait = 0,0,90-%AD2+%RA °,80,,magenta
Arc =90-%AD1,90+%AD2§%RA,%r_Arc,%C_Arc
CadreA     =    -%X1,-%Y1§%RA,
%Plate_Width  r,%Plate_Heigth  r,
%R_Plate,%C_Plate,,§0
Stop

C1:
'Goto  C2     ' Put / remove the
apostrophe to draw _
the plate or not
' Plate drawing
' -----------------
Goto Trace_Cadre
L1:
' Back here after the plate drawing
'Stop
```

- place an apostrophe " ' " before the command Goto C1, as recalled in comment,
- delete the apostrophe at the beginning of the line containing 'Stop, at the end of the first block (after the CadreA = ... command),
- place the cursor in the line of the Image command,
- press **F2** to open the **Input Mask** of this command (see Fig. 6),
- replace Galva_Arc_ori.jpg

with the picture file name of your original dial and validate,
- **press F4** or click on the Visualize menu to see the result (beware, forgetting this point is a common mistake!),
- by performing successive tests, and using each time the input mask, modify the "Size Coefficient" so that the dimensions on the picture are exactly those measured on the original. Use the "Zoom (F7)" menu to have an image large enough to correctly measure on the screen while taking into account the zoom level or use the displayed coordinates of the mouse.

Notes

• *The Cartesian coordinates of the mouse are displayed in the small middle window at the bottom right of the graphics screen.*

• *Modify the Size Coefficient by making rules of three. Example: if with the coefficient .32 you get 74.2 mm while you should have 50, then 0.32 * 50 / 74.2 = 0.216 is the new coefficient to try. Do this until you have the right result. For security, a print can confirm the result.*

- If necessary, reposition the image where you want it by modifying the values of the %X0
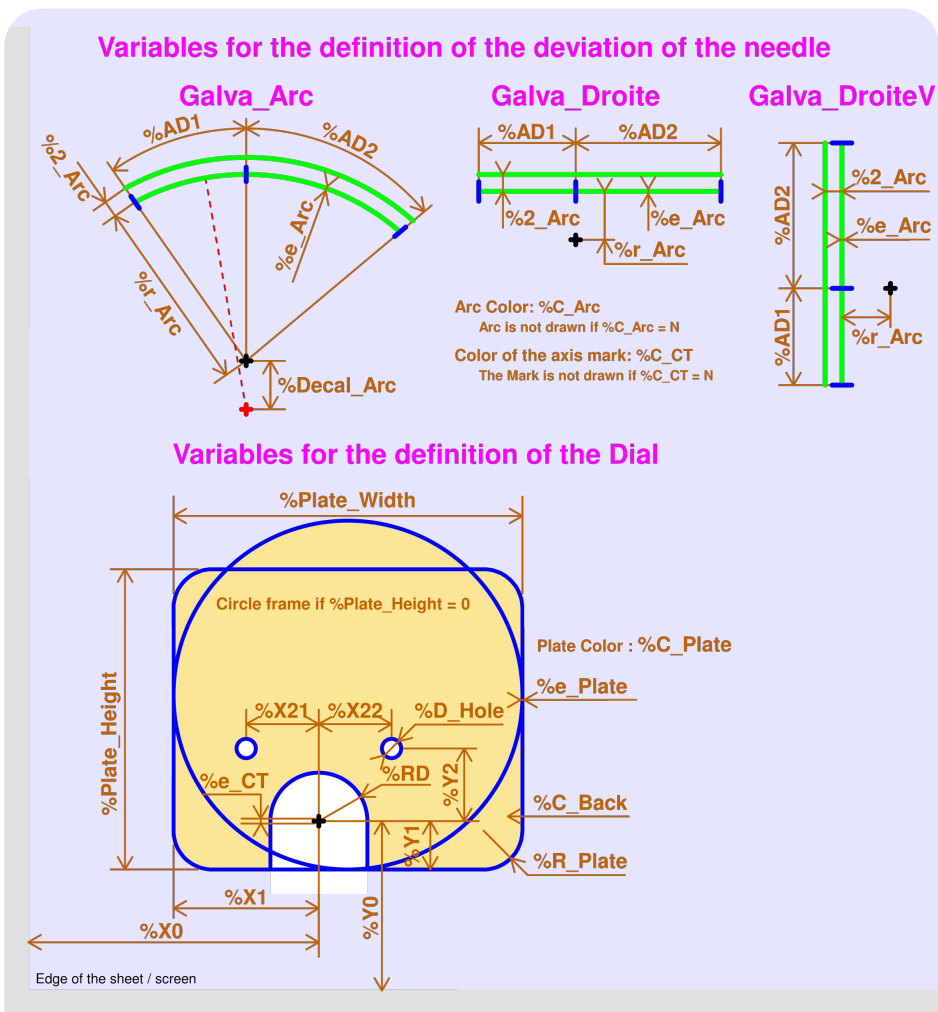

Fig. 7 - Definition of the "Plate" and "needle deviation" variables

and %Y0 variables, which reposition all the new drawings. If the position of the axis of the galvanometer is visible on the original picture, it must coincide with the black + sign of the mark of the new position of the axis. Otherwise, it is necessary to make coincide, as well as possible, the elements of the plate dependent of the axis position: cutting around the axis, edges of the plate, beginning, end and arc of scale, ... If necessary, use the %RA variable to rotate the drawing.

Define the plate and needle deviation

The first part of the example files concerns the definition of the plate and the deviation of the needle. This part is entirely managed by variables described in Fig. 7.

- put an apostrophe at the beginning of the line of the Stop command at the end of the block C0: (after the command CadreA = ...),
- delete the apostrophe at the beginning of the line containing 'Stop at the end of the second block after the line L1:, to draw the new plate,
- give each variable (lines about 20 to 60) the appropriate value for your wish,
- press F4 or click on the Visualize menu to see the result (do not forget it!),
- Depending on the value given to the variable %R_Cadre, the corners of the plate can be rounded (positive values), curved inward (negative values) or cut by a straight line (when the value is followed by "§D").
- If you want the radius of the scales not to be counted from the axis of the galvanometer (usually to have a larger radius, thus a smaller curvature of the arcs of scales) use a value other than zero for the %Decal_Arc variable. An absolute value greater than or equal to 10,000 generates straight lines instead of arcs. If the axis offset for the scales should not be vertical, use the %RA variable to rotate the scales. For example in Galva_Arc_Q2, %RA = 45. In FIG. 4, the axes of the galvanometers are marked with a black + sign, while the axes of the scales are marked with a red + sign if they are different from the axis of the galvanometer.

Note

To enter numeric values, arithmetic operations, functions and the use of previously defined variables are allowed. However, to assign the result of a calculation to a variable, 2 equal signs must be used to specify that it is the numerical result to be used and not the expression. Examples:
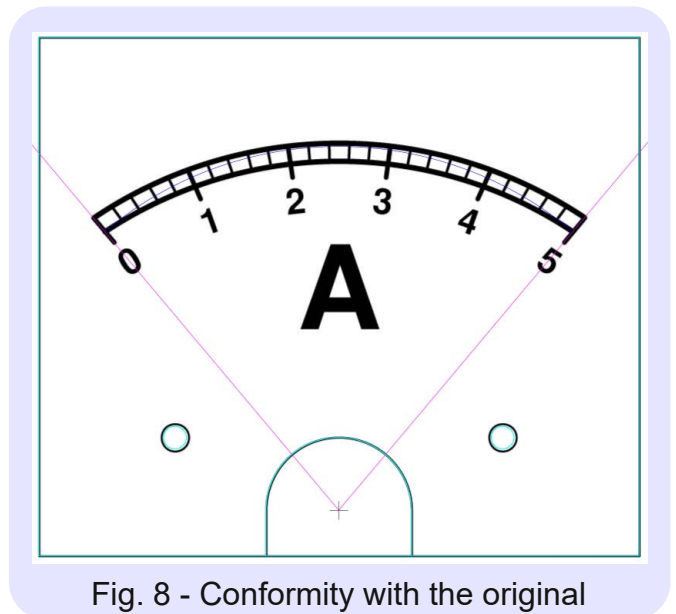%X1== %Plate_Width/2 ; %AD1== 180-40

Fig. 8 - Conformity with the original

For the Galva_Arc.dat example file, the result is given by Fig. 8. The new outline of the plate, in cyan, and the deviation of the needle, in magenta, must be perfectly superimposed on the picture of your original dial. The scales of the example file may be totally different from the desired scales, including their curvature radii. Use the Zoom menu (F7) to perform the operation with maximum precision.

Notes
• *For the other example files, the dimensions of the plate and / or the deviation of the needle are generally not respected, the original picture being always the same!*
• *Press F6 (or double-click the mouse) to center the mouse position on the graphical part of the screen and Ctrl-F6 to return to the default position. Ctrl-F7 returns to the default Zoom, defined by the last ZoomIni command executed.*

- Once the result is satisfactory, put an apostrophe before the Stop command after L1: and delete the apostrophe at the beginning of the line 'Goto after C0: and ... (press F4!).

The new scales must now match the <u>mechanical</u> characteristics of your galvanometer.

Realize a first scale

The second part of the programs concerns the realization of the scales, and there, the possibilities are so numerous that it is not possible to manage everything just by variables without being extremely reducing in terms of possibilities or having to manage an incredible number of variables. A log scale or a mirror cutout can not be managed as a linear scale because the characteristics are totally different.

So here, they are essentially the commands input masks which allow to enter directly the right parameters in the commands.

For starters, it is advisable to first perform a linear scale, before moving on to other scales, even if you plan to erase it later.

- Find in the program the line 'Stop at the end of the E1: block, just before the label E2: (around the line 122 depending on the file) and delete the apostrophe before 'Stop to stop the execution of the program after this E1: block which draws a first linear scale.

- press F4 or click on the Visualize menu (yes!),

- the predefined scale appears with 2 arcs plotted.

- To have only one arc, put an apostrophe at the beginning of the first Arc = line, as indicated in the comment line above.

- Move the mouse cursor a little further down to the line starting with GCE_E = and press F2 to open the input mask.

You have to get something like Fig. 9.

- Like any input mask, it describes the command and all its parameters. As indicated, the command GCE_E (mnemonic for GalvaControlExternal_Echelle [Echelle is Scale in French]) draws a scale with up to 3 levels of graduations (tick marks) and values. To have more levels of graduations, it is easy, if necessary, to execute the command twice with different parameters or to use, alone or in addition, the Grad* and Val* commands.

- Attention, instead of "Number of graduations" and "Number of values" to plot, it would be more accurate to say number of intervals, because there is always one graduation / value more than the number of intervals. Example: for 5 intervals there are 6 values: 0, 1, 2, 3, 4, 5.

- The following should not be a problem. For each parameter, the default value is indicated in parentheses. Remember that screen reso-
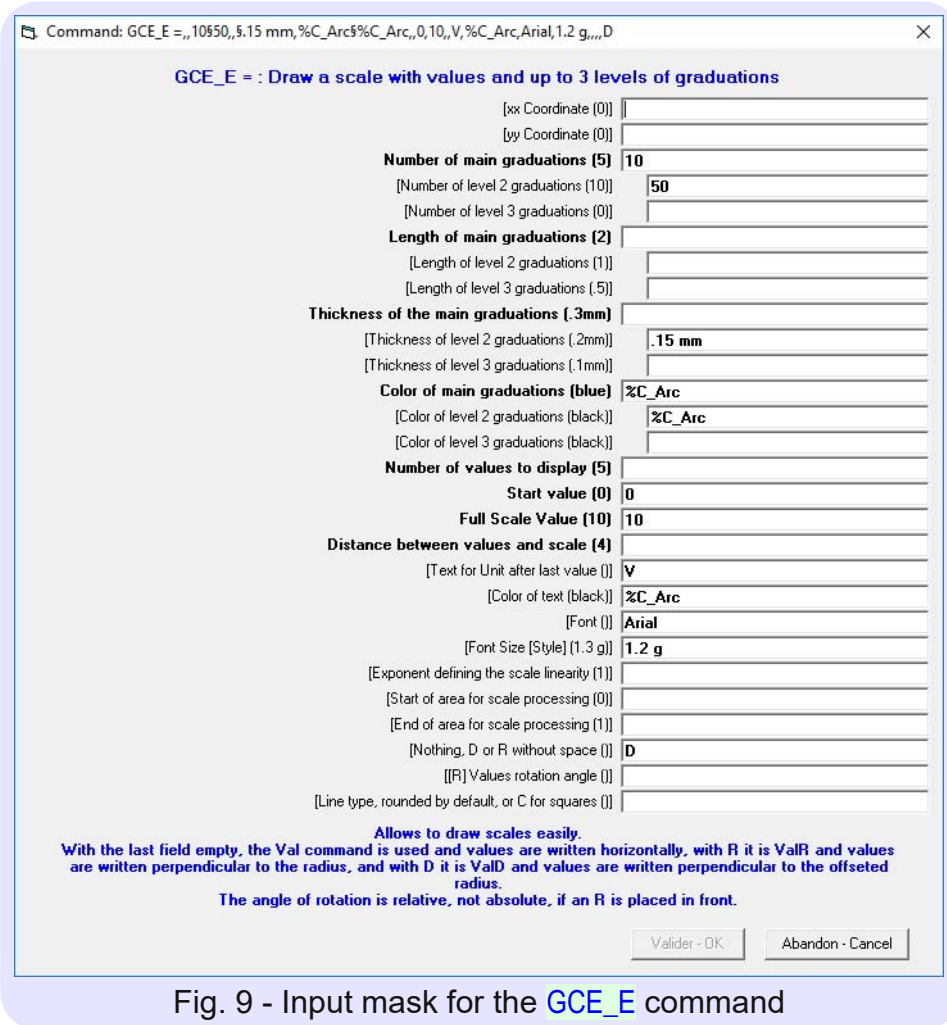
Fig. 9 - Input mask for the GCE_E command

lution is usually much worse than printing and you need to use a large zoom to distinguish differences in line thickness and so on.

- The start and Full Scale values to be displayed must be chosen such that (Full Scale Value) - (Start Value) is divisible by the number of intervals (values) to be displayed. Example: values from 0 to 2000 for 10 intervals; counter-example: values from 0 to 5 for 3 values, because the displayed values would be: 0, 1.6667, 3.3333, 5, which is not usually desired.

- To have a central zero, just take as starting value a value equal to minus the Full Scale value. Example -10 and 10.

- The starting value can be greater than the Full Scale value. Example, 100 and 0 (the zero is then on the right). To invert all scales, it is also possible to exchange the values of %AD1 and %AD2 and to change their signs (see examples Galva_Arc_Reverse.dat, Galva_Arc_Q14, ...). Attention: %AD1 defines the deviation from the left until the position of midday, and %AD2 defines the deviation from the position of midday to the right, whereas for the Arc command, it is about the "absolute" angles. In

addition, %AD1 and %AD2 are defined for a rotation angle (%RA) of zero.

- Depending on the D or R value given to the %DR variable, the values are written perpendicular to the offset radius or radius passing through the galvanometer axis. By putting a D or R in place of %DR this choice can be changed command by command.

- A text for the unit of measure of the scale can be placed behind the last value displayed by the parameter "Text for unit after last value" of the GCE_E command. A command Val1D (or Val1R), present in comment, makes it possible to place a text anywhere on the scale. It is also possible to use a Text or TextC command.

- At the beginning of each block, there is a line with Inversion. If the line does not begin with an apostrophe, the Inversion command reverses the side where the graduations and values are placed. A second line with Inversion is present at the end of the block, and it is advisable to manage the two lines in the same way (no inversion or two inversions) so that a block has no effect on the rest of the code.

- To continue, remember to place an apostrophe in front of the Stop command located before the E2: label.

Realize another linear scale

- To draw a second linear scale, delete the apostrophe at the beginning of the line 'Stop at the end of block E2: (before E21:), then proceed as for the first scale.

- To have a third or nth linear scale, select the lines from the line describing the block (after 'Goto E21 '...) down to the empty line after 'Stop, then copy them, by Ctrl-C, and paste them, by Ctrl-V, after the empty line after 'Stop; delete the apostrophe from the line 'Stop at the end of the block and modify the value of %r_Arc, of the new radius, to the desired value (different from the previous one, otherwise the new scale will be strictly superimposed on the previous one and therefore not visible), as well as the other parameters of the scale. Code example of a green scale from -12 to 12:

```
'Inversion           ' reverse the side of the the the _
graduations and values
'Stop

' Drawing of a third linear scale (-12 to 12)
' -----------------------------------------------
Inversion           ' reverse the side of the _
graduations and values
```

```
EpaisT = %e_Arc mm
'%2_Arc=-%2_Arc
%r_Arc==34 ' new radius
%C_Arc = green     ' new color
' Put an apostrophe at the beginning of the following _
line for only 1 arc
Arc = 90-%AD1,90+%AD2,%r_Arc+%2_Arc,%C_Arc
    ' 2th Arc
Arc =90-%AD1,90+%AD2,%r_Arc,%C_Arc
GCE_E =,,6§30,1.5§1,.3mm§.15mm, _
%C_Arc§%C_Arc,6,-12,12,3,,%C_Arc,Arial,.8  g,,,,%DR,
%VRA
Inversion             ' reverse the side of the _
graduations and values
'Stop

E21:
Goto E3      ' Put / remove the apostrophe to draw _
the scale or not
```

Realize a nonlinear scale

- If necessary, place an apostrophe in front of the Stop commands before the block to use; remove the apostrophes from the 'Goto lines preceding the unwanted blocks.

- Consider here the block E4: of the nonlinear scale (30W).

- Delete the apostrophe at the beginning of the line 'Stop at the end of the block.

- For nonlinear scales, depending on the value of the exponent, the number of graduations and especially the number of values to display, the result is not always pleasant if the same parameters are used for the whole scale. Also, after having filled in the parameter "Exponent defining the scale linearity" of the GCE_E command and having made some tests, 3 zones or sectors of parameters were retained: from 0 to 10, from 10 to 20 and from 20 to 30 for the values and 2 zones for the graduations: 0 to 20 and 20 to 30. To arrive at this result, 3 GCE_E commands are used with each time different parameters. With the input masks (F2), a little bit logic and some tests, all this is relatively easy. In practice, to arrive at this result, start with a GCE_E command for the whole scale and a large number of graduations and values, then reduce its action to the area where the result is good by entering the parameter "End of area for scale processing". Enter then another command with fewer graduations and / or values and apply it from the end of effect of the previous command. And so on until the whole scale is processed.

- For information, the same result would be obtained with the following native commands:

```
EpaisT=%e_Arc mm§c
Grad =60,.6,,40,.12mm,%C_Arc
Grad =30,1,,,.18mm,%C_Arc
Grad =6,1.4,,,.5mm,%C_Arc
TailleP = *.8 g
ValD =%VRA,30,0,30,3.5,,5,%C_Arc
ValD =%VRA,6,0,30,3.5,,4,%C_Arc
ValD =%VRA,6,0,30§W,3.5,6,,%C_Arc
```

The Grad commands draws a single level graduations on a sector and the Val, ValD or ValR commands write values on a sector. There are fewer parameters per command, but more commands are needed: everyone has to choose "his" solution. An example is given in the Galva_Arc_2W.dat file at E41:.

Realize a "manual" scale

Such scales can be realized using a large number of Grad1 and Val1, Val1D or Val1R commands, however, to avoid to have to use a large number of commands, rather use the possibility of these commands to put a variable containing a list of values in place of a value.

An example of a "manual" scale realization is given by the block E21:, intended to replace the E2 : block.

- Remove the apostrophe at the beginning of the line 'Goto E21 after the line E2:,
- Place an apostrophe in front of the command Goto E3, after line E21:,
- Remove the apostrophe at the beginning of the line 'Stop at the end of the block,
- Press F4 or click on the Visualize menu to see the result, ☺
- The black 3A scale is now a "manual" scale, which, in the example, conforms to a nonlinear scale of exponent = 1.2, which served as a model.
- To achieve this scale, the following code has been entered:
```
'GCE_E =,,6§30,1.5§1,.3mm§.15mm, _
%C_Arc§%C_Arc,6,0,3,3.2,A,%C_Arc,Arial,.8 g, _
1.2,,,DR,%VRA
'Couleur = magenta
%G=
Grad1 =%G§%G,1,.15mm
%G=0
Grad1 =%G§%G,2,.3mm
%V=0,0.5,1,1.5,2,2.5,3A
Val1D =%VRA,%G§%G,%V§txt,3.2,magenta
```
- The first two lines of this code are present in the example, and you just have to remove the apostrophes that were added to the beginning of the lines; In the last line, replace the %C_Arc color with magenta,

- Pressing F4 then shows, in black, the scale that served as a template (as if it were an original dial), and in magenta the values and graduations for which the values has already been entered. Initially, only the value 0 was entered for the large graduations (second Grad1 command) and the values (Val1D command).
- In the graphical part of the screen, double click on the black graduation of value 0.5, then press F7 to put the zoom between 6 and 10 (according to the resolution of the screen),
- Enter the estimated value 2 in the first line %G =, which becomes %G = 2, ... and press F4,
- A graduation in magenta appears between 0 and the first small black graduation, on the side of 0. It is therefore necessary to increase the value. Replace 2 by 6,
- The result is almost good, but we went a little past the first small black graduation. Replace 6 by 5.9, the result is satisfactory (provided you press F4!), and proceed the next small graduation in the same way.
- The first line %G = becomes:
%G =5.9,10.5,14.7,18.65

Note

Instead of entering percentage values of the scale for %G, it is also possible to enter angles for type 3 galvanometers and mm for type 1 and 2, provided you set %RA = 0.

To do this, double click on the small window on the left at the bottom right of the graphical screen, which displays the polar coordinates of the mouse. The letter T indicates that this is the angle for a Trait [Trait is line in French] command, an A is the angle for an Arc command. After double clicking, you must have the letter A. Place the mouse on the first small black graduation and copy the angle (54.7°) you read as a value of %G. Pressing F4 shows that it is the good value. Do the same for the other values without forgetting the ° sign which specifies that it is an angle and not a percentage. With a sufficient zoom level, we have the angle directly to the nearest tenth of a degree. After adjustments of hundredths of degrees where it is useful, the line becomes %G = 54.7°,58.4°,61.74°,64.92°.

In degrees, these are absolute positions that remain the same when the needle full scale deviation is modified. It's up to you, according to everyone's tastes! As very often in computer science, there are several solutions to a problem.

For type 1 and 2 dials, read the values in mm from the x (or y) positions and also follow them with the ° symbol.

- Now a value (in percentage or in degrees because the two techniques may be mixed) for the large graduation and value 0.5 must be entered. Proceed as before, but this time, the value must be added to the second %G = line which will become %G = 0, 22.55 (or %G = 0,68 °),
- And so on ... It's easy, but longer to do than for a known equation scale.

Note

As shown in the input mask and explained in the help, the first %G in the Grad1 = *command represents a formula function of a variable that is specified by the second %G. I concede that this is probably not easy to understand at first glance, but what must be remembered is that this way of writing allows to specify at the command to use one after the other all the values contained in the %G variable.*

For those who like to understand, another example may be more telling. If we had written: Grad1 = 2 * Sin(%G) §%G, 1, .15mm *that are twice the sine of each value of %G that would have been used: 2 * Sin(%G) is a formula, which may contain several variables, in which %G is successively replaced by the values of %G.*

Realize a scale of any known equation

The possibility of using a formula with a "list of values" variable, as explained in the previous note, makes it easy to perform any scale of known equation. Code example for some points of a scale of equation $y = x^{1.2}$ (like that of block E21:):

%G = 0,.5,1,1.5,2,2.5,3
%B==1/1.2
%A==100/(3^%B)
Grad1 =%A*%G^%B§%G,2
Val1 =%A*%G^%B§%G,%G,4

%G contains the list of values and also serves here as the list of texts to display. %A and %B are parameters of the equation.

Another example is given in the new Galva_Arc_Ohm.dat file, by the realization of an ohmmeter scale of theoretical equation: I = 1.5 / (R + 15000), corresponding to the use of an1.5 V voltage source and a 100 μA full-scale galvanometer with an internal resistance of 15 kΩ.

Realize a logarithmic scale

The logarithmic scales are very different from the other scales, because the intervals between the graduations are even less constant; but they reproduce identically for each decade: the interval between 1 and 2 is the same as between 10 and 20 or 100 and 200, etc. Also, when defining a logarithmic scale with the Exponent command, the parameters of the commands Grad[1], Val[1], Val[1]D and Val[1]R are interpreted differently. Number of Values and Number of Graduations are interpreted as the interval, within a decade from 1 to 10, between two Values or Graduations. A value of 10 will display the graduations or values "1" in all decades (so ..., 0.1, 1, 10, 100, ...); a value of 5 values of 1 and 5 in every decade, etc.

The block concerned in the sample files is the block starting with the label E5:.

The beginning of this scale is offseted compared to the other scales. This is to show how to proceed, but just put %R1 = 0 to cancel this effect.

Note

The beginning or the end of any scale can be shifted by using, at the beginning of the block, an Arc *command (*Droite *or* DroiteV*) with a starting Angle (Start coordinate) or an end value modified relative to the other scales.*

For logarithmic scales, the Grad, Val, ValD and ValR commands allows to specify the range of application of the rules within each decade. Thus, the first command ValD displays the values in steps of 1 from 1 to 3, and the second command values 1 and 5. That means in all 1, 2, 3 and 5, ... in each decade. For the graduations, three Grad commands give three levels of graduations.

Note

The commands for the smallest number of values and graduations have to be placed after those with larger numbers, so that they are drawn on top of the others in case they are of different color or thickness.

Realize a scale with Texts

The E7: block gives examples of "text" values scales. Like the values, the texts can be oriented in absolute or in relative (parameter "[R] Rotation Angle of the text") with respect to the axis of the galvanometer (commands Val[1]R) or to the shifted axis (commands Val[1]D).

Realize a drawing for a mirror cutout

All sample files include a block drawing a cutout area for a no parallax error mirror, which is usually found on precision instruments. It is the block starting with the label E3:.

There are two methods for drawing these areas. When %Decal_Arc is different from 0, the active one, which draws an area with the ends in an arc is slightly more difficult to implement than the second. The second simply traces sectors. It is activated by deleting the apostrophes at the beginning of 4 lines as indicated in comment.

To find the right parameters to use to draw the circles at the end of the zone for the active solution when %Decal_Arc is not 0, proceed as follows:

- give the correct values to %r_Arc and %R1, which represents the half width of the area,
- place a "?" at the end of the Arc command (5th parameter).
Example :
Arc = 90-%AD1,90+%AD2,%r_arc,n   'Cercle = 0, -8., 40.46, 57.3, 122.7 should give:
Arc = 90-%AD1,90+%AD2,%r_arc,n,?
- press F4 or click on the Visualize menu,
- as comment, appears then, at the end of the command, a command equivalent to the drawing of the Arc (or Trait) command. This command contains the values of the "offset" radius and the start and end angles to be used to position the circles at the ends of the zone. The values have just to be copied at the right places in the Cercle commands that take into account the rotation defined by %RA, used in a AngRot command.

A TextC command shows how to write text in an arc using the offset radius value commented after the Arc command, then adjusting a little if necessary.

Draw colored sectors

Block E6: shows how to plot "full" colored sectors and an unfilled one which marks the outline of a "full" colored sector.

A TextC command shows how to write text in an arc.

Add a title and texts

Block E8: gives some examples of text additions. Since version 2.8 of Galva, the Texte command now allows to change the character spacing of a text of any orientation, as well as vertically written text.

Most of the sample files have been written in such a way that these texts rotate with the scales or the dial. For a specific dial, a zero angle of rotation around the 0,0 point can be specified to cancel the rotation defined by a RotAng command.

Add one or more images

Block C0: contains an example of adding an image (the original image of a dial).
 Note: the position of an image can rotate, but not the image itself.

Add personal code

It is, of course, possible to add personal code, not only at the indicated place (after E9:), but anywhere throughout the program.

Print and set up the new dial

It is possible to make the final print on glossy photo paper, which has an excellent definition, or on a self-adhesive label, to make the cut, then to glue the new dial on the support. In fact, a difficulty is often to stick the label exactly in the right place! The use of a glue allowing repositioning for a few moments greatly facilitates the operation.

Access to files

All files involved here are provided with version 2.8 of Galva. English versions of these files are bundled in the compressed Galva_Dat_en.zip file.
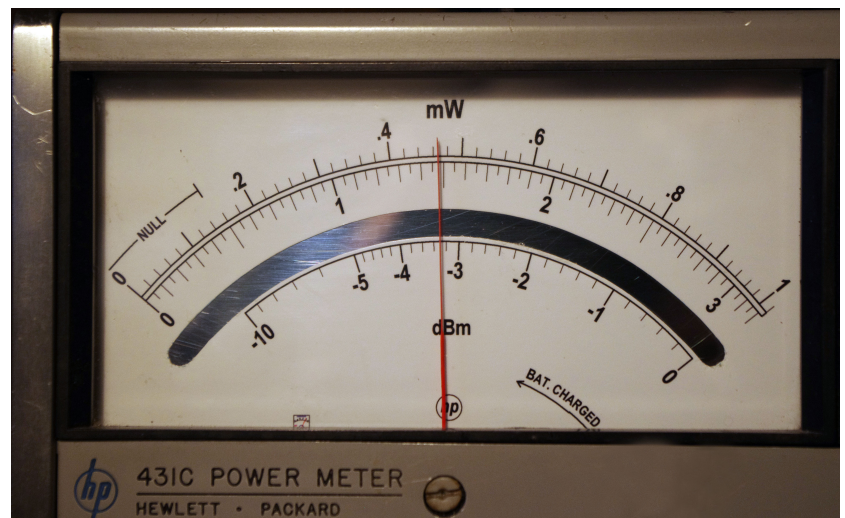
Jean-Paul Gendner, F5BU
author of the Galva program
Site : f5bu.fr

Fig. - 10 Example of realization
(file Galva_Arc_HP431.dat)