LAMP ROBOT WITH MEMORY METAL DRIVES

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Abstract.
A lamp robot that obeys verbal orders. The principle of the lamp
is basically a combination of two new technologies: speech recog-
nition and memory metal.
The lamp can move in six directions, and the movements can be
generated by extremely small memory metal elements with a total
mass of about 3 grams. The temperature of the memory elements and
thus also their shape can be remote controlled by a system which
exists of a Personal Computer with a speech recognition card and a
microphone, an interface with D/A and A/D-converter and amplifier
and the lamp robot itself.
Heating of the memory metal is achieved by direct resistance
heating pulses from the interface. The position of each drive
system is recorded continiously by miniature precision potentiome-
ters and any desired intermediate position can be reached and kept
by spoken commands. A fast transformation of the TiNi-elements and
so short response times is achieved by the use of very thin flat
rolled wire of 0.2 * 1.7 mm, produced by Memory Metal Holland in
Enschede.
This flat wire combines high recovery forces with much higher
cooling rates than round wire.
The lamp robot has been developed for and installed in "The House
of the Future" in Rosmalen, The Netherlands, which gives a perma-
nent exhibition of possible applications of new technologies in
houses.
A possible application is for use by disabled persons.

Introduction.

There were two reasons to develop a Lamp-robot.
The first reason was to show the possibilities of memory metal.
Therefore a permanent demonstration in The House of the Future, where
more than half a million visitors come yearly seemed to be a good
promotion.
Another significance of the robot lamp is that it demonstrates that for
many categories of handicapped technological solutions for the opera-
tion of many objects are being offered.
The same principle can be used to open curtains, to switch on the oven,

to open the door, etc.
The National Rehabilitation Fund and the Organisation for Fund Raising
Activities in The Netherlands also recognized this major significance
for the handicapped.
These two organisations have paid the development costs of the robot
lamp.

Realisation.

This project has been realised by the following persons.
The idea, integration of speech recognition and memory metal (for which
patent was applied) is from Ing. N.W. Buys, De Meern. The lamp has been
designed by Ton van Roermund and Ir. Peter Besselink. Ton van Roermund
(IPS,Amsterdam) is an industrial designer. He designed the lamp model
and the mechanism of the swing arm. Peter Besselink (Memory Metal
Holland, Enschede)is specialist in the development and manufacturing
of memory metal and applications.
He designed the rotation mechanisms and built the lamprobot.
The software and interface which made the control of the robot by means
of speech recognition possible have been developed by Ir. P.Kurver (BMA
in De Meern) and his team of coworkers.

The complete system (see fig.1) consists
of a PC, a speech recognition card , an
interface and the lamp itself.
Speech recognition means that through an
inserted card the computer is capable of
understanding spoken commands.
This speech recognition is speaker depen-
dant,i.e. that the PC only listens to per-
sons whose voices he has come to know
through a short training programme. A user
has to complete such a training programme
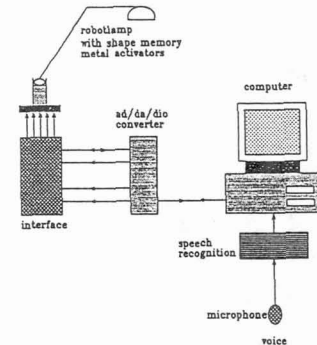(which takes two minutes) only once.

Fig.1 Scheme of the system.

Functions of the lamp.

The lamp can move in six directions. The movements are generated by
extremely small memory metal elements with a total mass of about 3
grams. These memory metal elements are made from a Titanium-Nickel-
Copper alloy, which was supplied by GST in Essen, Germany as 8 mm rod.
The wire drawing, strip rolling and production of springs were done by
MMH.
The As-temperature of the memory metal elements is 58 degrees Celsius.
Using memory metal offers the possibility to make the very simple drive
systems which are used in this lamp.
In this construction the memory metal is used to imitate muscle func-
tions, where the necessary temperature rise is obtained by conducting
electric current directly through the memory wire.
The temperature of the memory elements and thus also their shape can be
remote controlled, and the lamp robot can listen to the spoken commands
"on","out","dim","clear","left","right","up","down","forward","back-
ward","stop" and "object".
With this last command several functions of the lamp are combined and
it moves to a predefined position where it lights a painting on the
wall, for instance.
All mechanisms can be fixed in any desired intermediate position with
the command "stop".

A   rotation body
B   potmeter cover

M 1   memory metal spring
M 2   memory metal strips
M 3   memory metal springs

C 1   spiral spring
C 2   spring
C 3   springs

P 1-2-3   potmeters

a   steel wire
b   pin connected to C 1
c   guide wheel
d   frame

DESIGN : TON VAN ROERMUND & Ir. PETER BESSELINK (Memory Metal Holland)
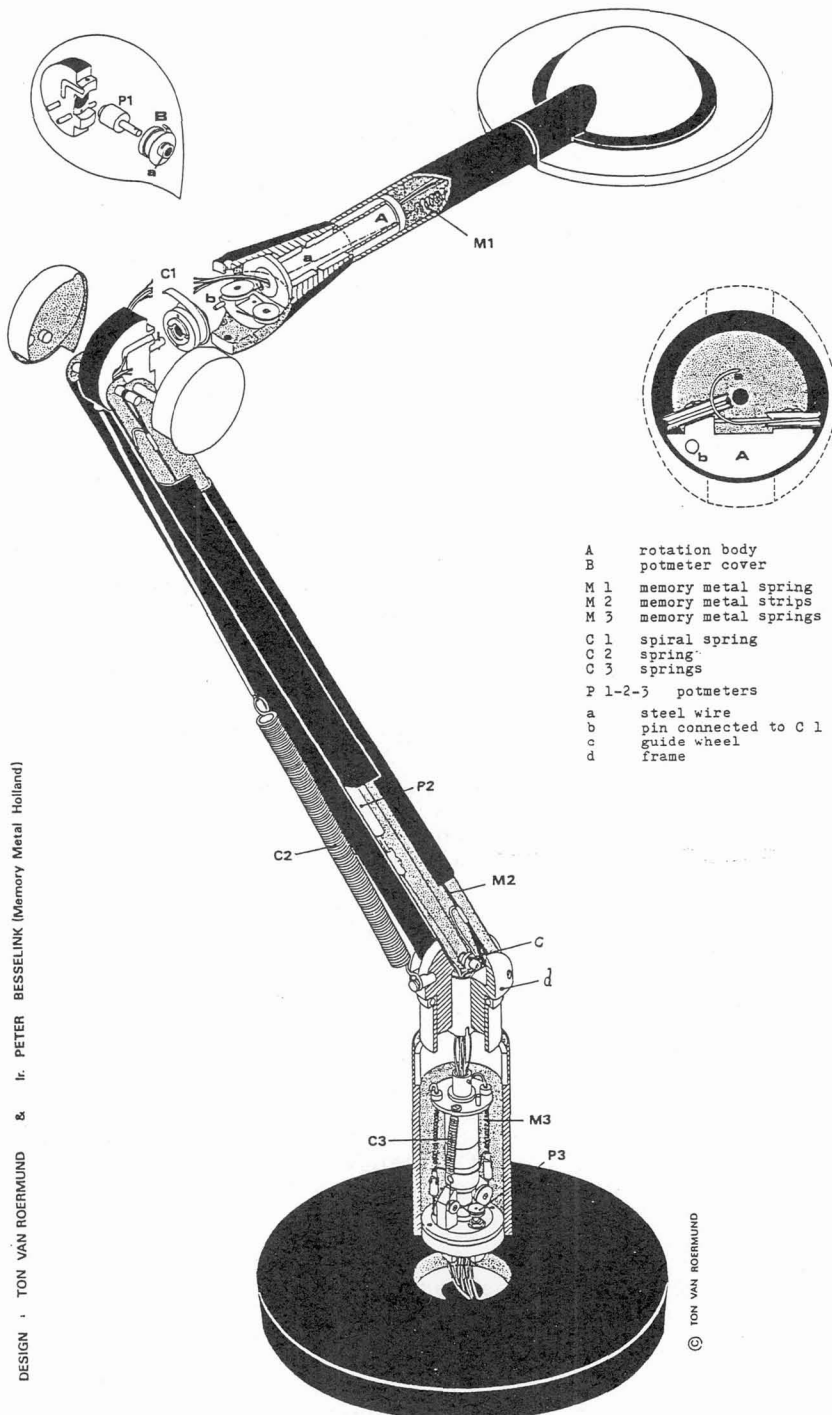
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Fig. 2 The lamp robot

The position at that moment is monitored by 3 miniature precision
potentiometers for respectively the upper arm with the light, the swing
arm and the foot rotation.
These positions are maintained because the computer continiously sends
digital information to the interface which converts this information
into electrical pulses that are amplified to the correct heating energy
for the memory elements. By the interface the konstant control voltage
for the potentiometers is also supplied.
The temperature of the memory elements can be controlled very accura-
tely and any deviation of the position is corrigated immedetially by
the computer.

Construction of the lamp.

The drawing of the lamp mechanism makes clear how it works (see fig.2)
There are memory metal elements M1,M2 and M3, counteracting steel
springs C1,C2 and C3 and precision potentiometers P1,P2 and P3 for
upper arm, swing arm and foot rotation respectively.
Upper arm.
The rotation of the upper arm is caused by the two counteracting-
springs : memory spring M1 and spiral spring C1. The memory spring is
connected to a steel wire (a), that runs through the tube of the rota-
tion body (A) and over two guide weels.
The end is attached to the cylindrical part of the potmeter cover (B),
which is made clear in the detail at right.
When the memory spring is heated it contracts and the upper arm turns
counter-clockwise (see detail above left). The reverse movement is
caused by spring C1, that is wrapped around the middle section of the
potmeter cover (B) and mounted on pin b on the rotation body.
Potmeter P1 is connected to the rotation body A, so the rotation is
directly monitored.
When the electric current is interrupted, the memory spring cools down,
becomes weak and thus looses its tractive force. The tractive force of
the spiral spring becomes greater than the tractive force of the memory
spring and the upper arm turns back clockwise.
Foot rotation.
The same principle goes for the footrotation-mechanism,which contains
two memory metal springs (M3) and two counteracting steel springs (C3).
All springs are connected to steel wires, that run over small guide
weels to the hollow axle of the rotation mechanism: these wires are
connected tangentially to this axle and they are attached in such a way
that the foot rotates counterclockwise by heating and clockwise by
cooling.
Potmeter P3 is driven by the axle by means of a rubber belt.
This mechanism has been designed to transform a liniar movement of
contracting memory metal elements into a rotation of the tube, where it
is connected with. Parallel with the length axis of the memory elements
lies the rotation axis, which makes it possible to construct a long,
thin, stand-alone rotating actuator that can be put into a cylindrical
place.
When the same movement had to be made with a memory metal torsion
element, it would take a much heavier element to reach the same torque
and then the drive current and the cooling time would be much longer.
Swing-arm.
The swing-arm is a special double parallelogram construction of four U-
profiles fitting into each other two by two, which makes a perfect
horizontal movement of the upper arm possible during rotation of the
swing-arm.

It works with two counteractive tractive systems, that pull the arm to
a certain angle: The two memory metal strips M2 pull the arm forward
and the steel spring C2 pulls the arm backward during cooling.
It only takes a contraction of 1% of the length of the memory metal
strips to get a rotation of 25 degrees of the swing-arm.
Using thin, flat rolled strip brings the advantage of the combination
of high recovery forces and short temperature cycling times, compared
to normal round wire or springs.
A liniar potentiometer P2 is connected to a steel wire that is partly
wrapped around a small wheel c below and connected to the frame at d.
When the swing-arm moves forward, the steel wire rolls partly over the
wheel c and moves the potentiometer rod.
This rod is pulled back by a miniature pseudoelastic spring which is
placed above P2 in the u-profile (not visible).

The reach angle of this lamp robot is about 180 degrees for the upper
arm, 70 degrees for the swing-arm and 100 degrees for the foot.

Results.

In figure 3 the position of the
swing-arm mechanism is given (in
degrees) as a function of time
(upper part).The lower part gives
the drive signals as voltage le-
vels marked with *.These voltage
levels are compared with the de-
sired potentiometer output of the
swing-arm position control.
At moment t1 a maximum output le-
vel is given (during a movement
forward) until the measured posi-
tion equals the desired value and
than a minimum signal is given at
time t2 to compensate the over-
shoot. Then, after t3 the hold
current is given as pulses with a
frequency of 18 Hz.
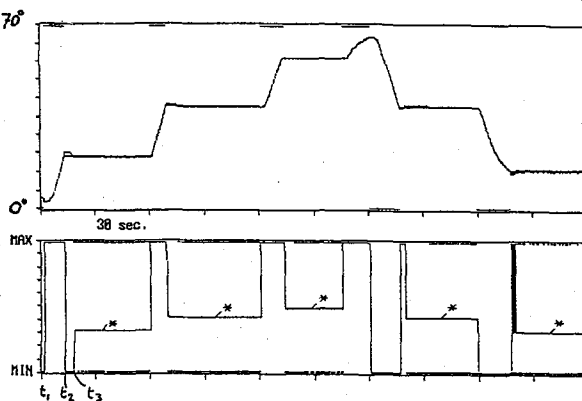It is an on/off control system
which works very simple and accurate.

Fig. 3. Swing-arm position (upper) and drive signals(lower) as function
of time.

Conclusion.

The lamp-robot, based on three different drive systems has been reali-
sed to be used as a demonstration object to show some important possi-
bilities by the use of memory metal, in combination with speech recog-
nition.
The performance of the lamp makes that this goal is realised very well.