Title
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INTRODUCTION

The use of flammable gas detectors has been going on for many years. During this time their presence has prevented many possible explosions.

Through the efforts of industry, gas detectors have been made more sensitive and reliable and require less maintenance, thereby giving the user more confidence in the instrument.

TYPE OF DETECTORS

There are several types of detectors with the most prominent types being (1) the hot catalytic filament, (2) the hot filament with a catalyst deposited on a substrate which is bonded to the filament, and (3) the thermistor with the catalyst surrounding it. The operation is essentially the same in all cases.

USES OF DETECTORS

The most important and obvious use of gas detectors is of course to detect the otherwise unknown presence of a flammable gas. The prime reason for detection of the gas is to prevent an explosion. Once the gas has been detected, it is essential that the source of the gas be eliminated quickly.

In the field of particle accelerator laboratories and other research areas, gas detectors are used for detecting several types of gases. These gases are used in liquid gas bubble chambers and targets and pressurized gas targets and counters. Liquid gases typically used are hydrogen, propane, methane, and pentane. Gases used under pressure are those listed above plus ethane.

Another use for gas detectors is the continuous monitoring of the concentration of a flammable gas in a stream of what might be called a process. This is not a true process, but a by-product of highly energetic electrons from a particle accelerator being absorbed in water.

The most flagrant abuse of gas detectors is the use of an instrument designed and calibrated for one gas in an attempt to detect a different gas. Another abuse is the lack of maintenance and calibration. All manufacturers of this type of instrument state that their instruments should be given preventative maintenance and be calibrated within specific time intervals. This is most important because an instrument that is to be depended upon may fail at a most critical time because of the lack of maintenance and calibration.

PLACEMENT OF DETECTORS

A detector is of little use if it is located such that it cannot be in the stream of gas. An example of this is a detector placed on the floor of an enclosure that is to detect hydrogen. Obviously this is a very bad placement and care must be taken with each installation. If the particular area has forced ventilation, placement must be studied from a different viewpoint. Other conditions that must be considered are location of gas source with respect to forced ventilation, quantity of gas that may be released, the possibility of gas being in a liquid state when released, stratification, and others including geometrical arrangement of the area.

In my experience many gas leaks have been detected. Most of these have been from liquid hydrogen sources. The detection in several cases has prevented a potentially serious explosion. A case in point involved a liquid hydrogen storage dewar of 165 liter capacity and a small liquid hydrogen experimental apparatus. The experimenter transferred liquid from the dewar to the apparatus and almost immediately the gas detector sounded an alarm. The transfer was stopped. Had the operator not had a gas detector he could have well filled the room to an explosive level. There was a large leak in the transfer line that would not have been discovered by noise or other means.

THEORY OF OPERATION

The principle upon which all elements operate is the same in all cases. The catalyst is heated and upon coming in contact with a gas that can be oxidized, a reaction takes place in which heat is given off. This heat increases the temperature of the element thereby changing its resistance. This change of resistance is detected, sometimes amplified, and presented on a meter as some percentage of the lower explosive level of the gas detected.

DETECTOR SPECIFICATIONS AND OPERATING PARAMETERS

As previously described in the section on Theory of Operation, the detector element changes resistance. This resistance change is then detected. Most instruments use a bridge and use the bridge unbalance for the signal. This signal is some cases is amplified and linearized so that it may be presented on a linear scaled meter, generally indicating zero to one hundred percent of the lower explosive limit of the detected gas.

The hot platinum wire filament has the advantage of being relatively linear (Fig. 1) over the temperature range in which it operates and can be of a low enough source impedance to drive a meter directly. Its disadvantages are the high temperature at which it operates and relatively short life times. The high temperature at which it operates, i.e., 1100°F to 1400°F, is above the ignition temperature of most gases, therefore the element must be enclosed in a flash arrestor. The high temperature also causes the short life as the filament will evaporate faster as the temperature increases. The filament can also become insensitive if it comes in contact with silicon. It is presumed that molecular film of silicon dioxide is deposited on the filament when it comes in contact with silicon. When this happens the catalytic action can no longer take place.

The second type of element, the type with a catalyst deposited on a substrate, has the advantage of running at a lower temperature, i.e., 500°F to 700°F, thereby giving it longer life. This type is relatively linear (Fig. 2). The operating temperature is still above the ignition temperature of some gases and therefore must be placed in a flash arrestor. This type of element is also "poisoned" by silicon. Also this element is somewhat desensitized by continued immersion in an atmosphere of a 1% hydrogen-air mixture. The sensitivity drops about 5% per 24 hours. Tests were not made to reveal whether sensitivity would go to zero.

The thermistor type element has the advantage of running at somewhat lower temperatures than the other mentioned elements. These elements operate at temperature from 250°F to 450°F. Linearity of these elements are shown in Fig. 3. The thermistor type element also suffers from silicon poisoning. It also will be desensitized in a mixture of 1% hydrogen-air mixture. The sensitivity will go to zero in a matter of hours. It is noted that the element can be brought back to its normal sensitivity by immersing it into a hydrogen-air mixture greater than the lower-explosive level. (See Fig. 4.)

Zero drift of all the above type instruments is shown in Fig. 5. Some of the drift is in the element and some is in the electronics. The amount of each has not been ascertained at this time.

CONCLUSION

In my opinion all of the instruments of which I have knowledge are good, reliable devices. There can be improvements made to overcome various deficiencies in each type and I am sure that industry is striving to do just that.

The use of flammable gas in all areas of research is increasing and it is mandatory for those who are concerned with safety to be aware and knowledgable of all advances and new developments in this field.

ACKNOWLEDGMENTS

I wish to thank Luther Lucas and Deiter Walz of SLAC for their effort in determining the linearity and zero drift of gas detectors. I also would like to thank Pat Cookson for her typing of this manuscript.

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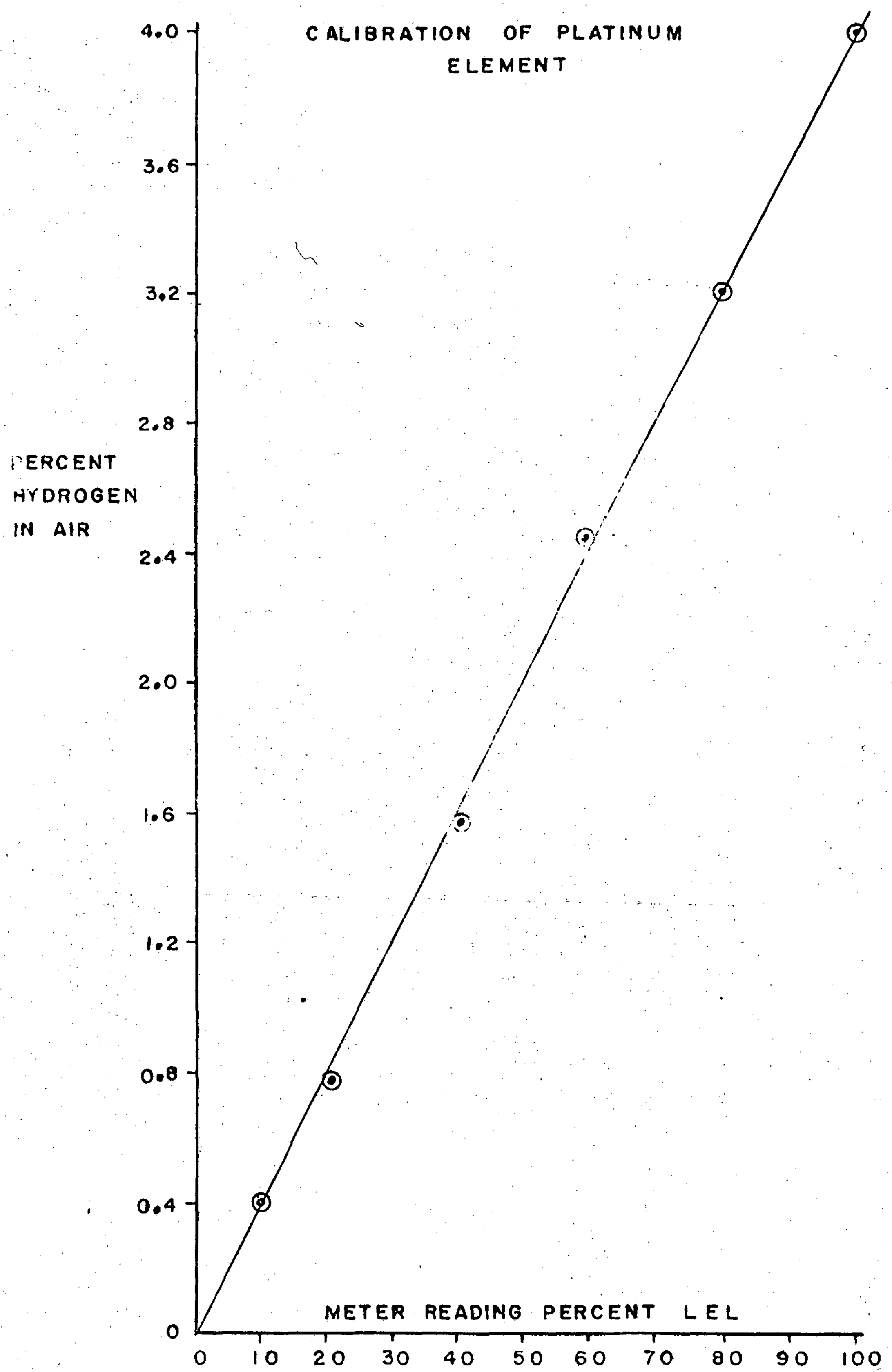

CALIBRATION OF PLATINUM
ELEMENT
PERCENT
HYDROGEN
IN AIR
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
METER READING PERCENT LEL
0
10
20
30
40
50
60
70
80
90
100

FIG 1

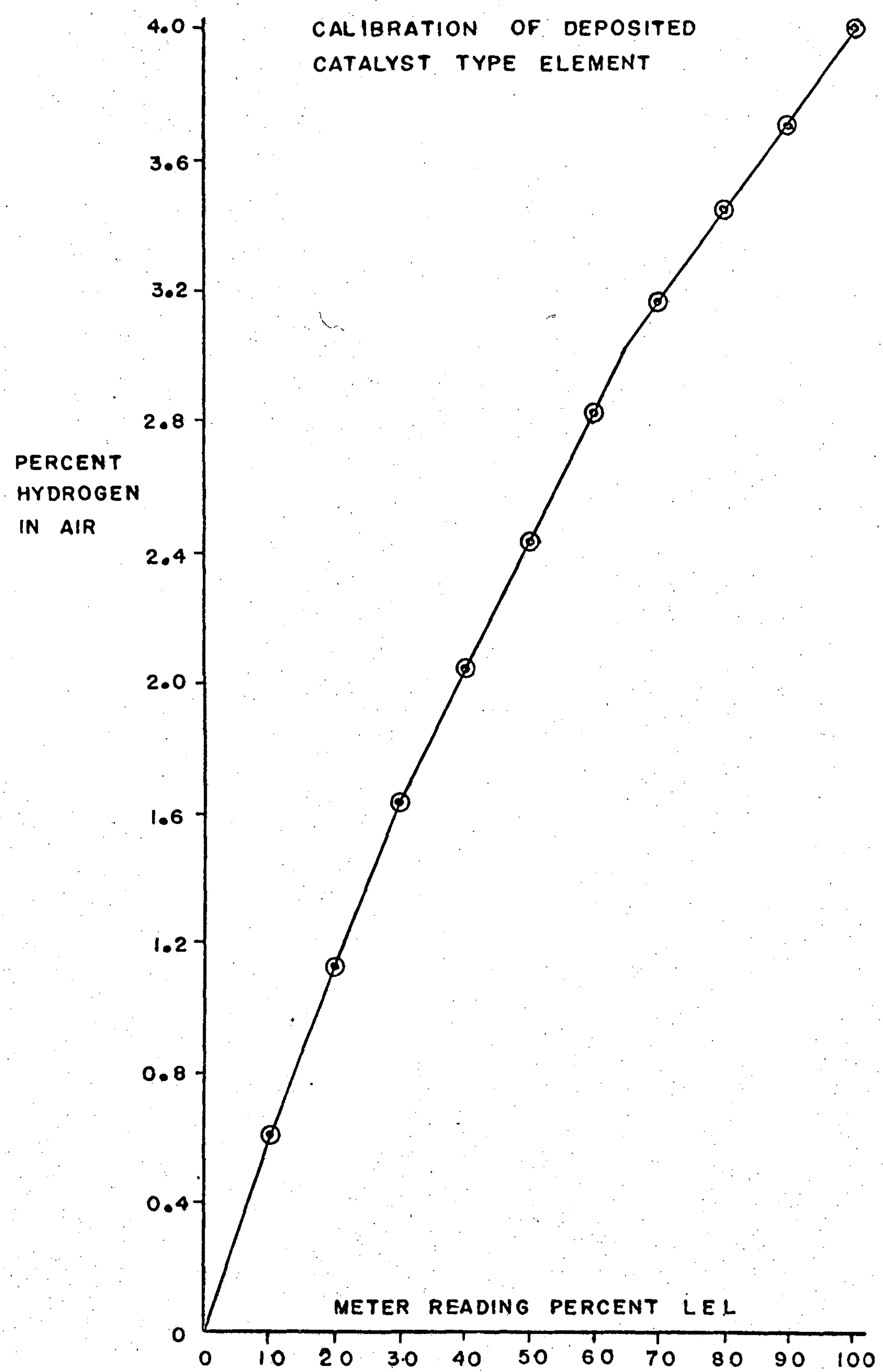

CALIBRATION OF DEPOSITED
CATALYST TYPE ELEMENT
PERCENT
HYDROGEN
IN AIR
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
METER READING PERCENT LEL
0
10
20
30
40
50
60
70
80
90
100

FIG 2

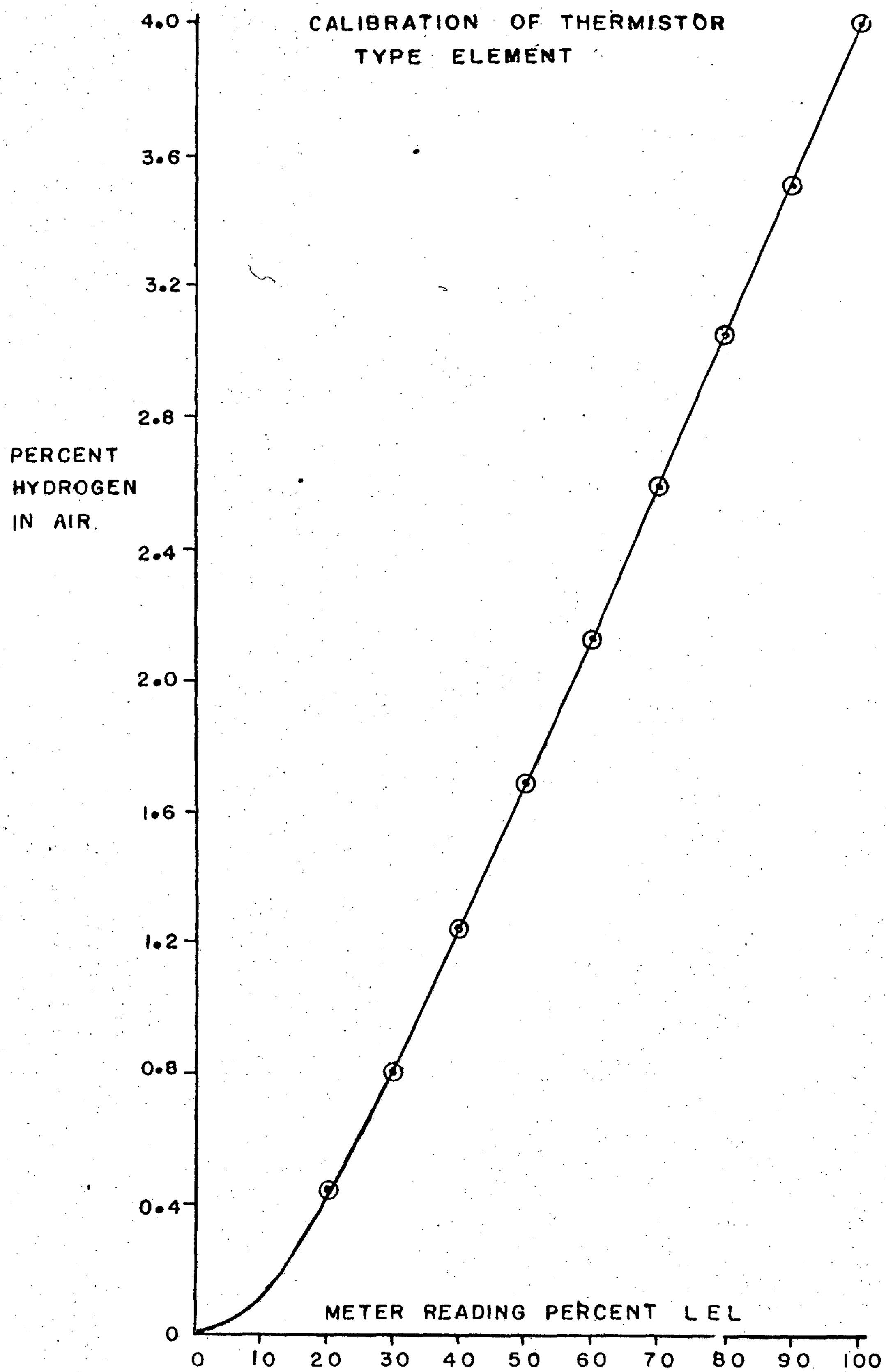
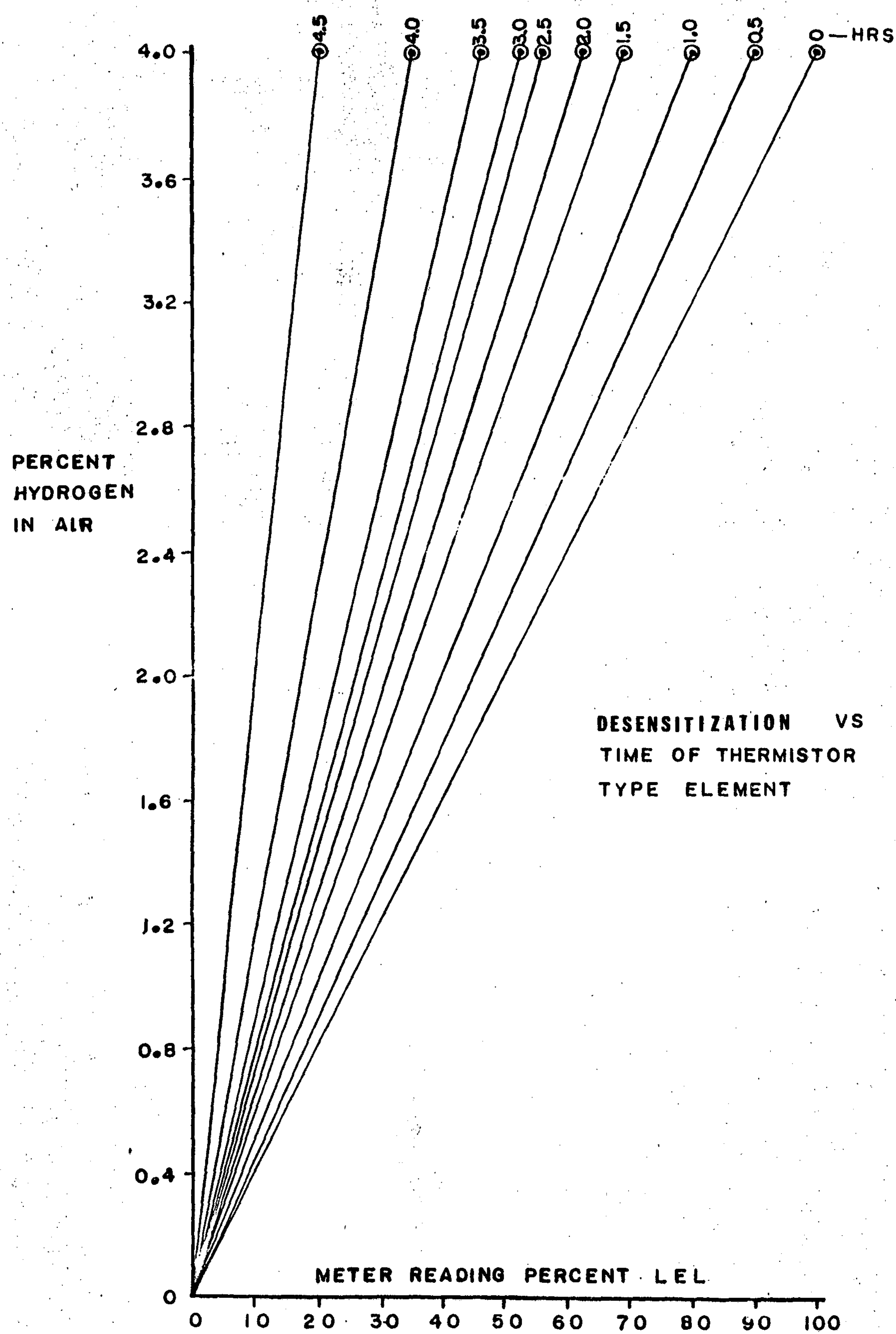

CALIBRATION OF THERMISTOR
TYPE ELEMENT
PERCENT
HYDROGEN
IN AIR.
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
METER READING PERCENT LEL
0
10
20
30
40
50
60
70
80
90
100

FIG 3


4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
—HRS
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
PERCENT
HYDROGEN
IN AIR
DESENSITIZATION VS
TIME OF THERMISTOR
TYPE ELEMENT
METER READING PERCENT LEL
0 10 20 30 40 50 60 70 80 90 100
FIG 4

ELECTRONIC CONTROLS AND ELEMENTS

ZERO DRIFT VS TEMPERATURE

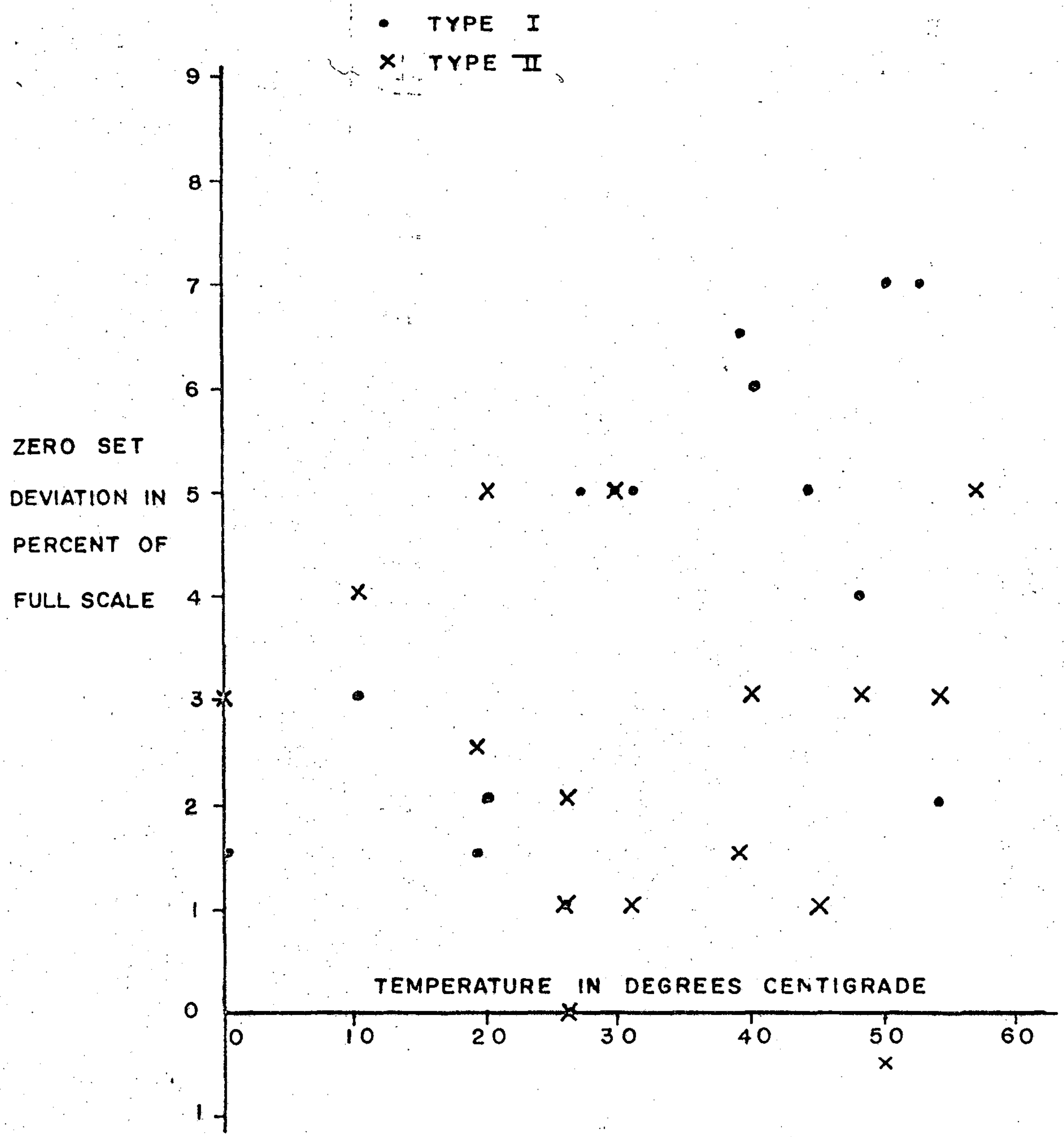


FIG 5