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FUJI MICROCHIP OXYGEN SENSORS

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1. FOREWORD

About 21% of the atmosphere is oxygen. Oxygen is closely connected to us through breathing, combustion, and oxidation. For instance, if the oxygen concentration in the air was reduced about 5%, our pulse rate and respiration would increase and we would experience a headache, nausea, etc. Furthermore, half of our energy sources, up to the home cooking range, are related to combustion, a chemical reaction of oxygen. To extract energy, the oxygen concentration before and after reaction must be made suitable. There are also processes which dislike oxidation, such as the maintenance of the freshness of foodstuffs, growth of semiconductor crystals, etc.

The demand to know the oxygen concentration for safety, energy saving, etc. is strong and oxygen analyzer using various principles have been developed and practicalized. Fuji Electric manufactures, markets, and widely uses a paramagnetic analyzer developed in the late 1940's, luminous phenomene type oxygen analyzers which uses the light emitted when yellow phosphorus and oxygen react, and zirconia oxygen analyzer that uses zirconia solid electrolyte. However, since these analyzers are large and costly, they tend to be used in the process field.

Table 1 Comparison of features of oxygen sensors

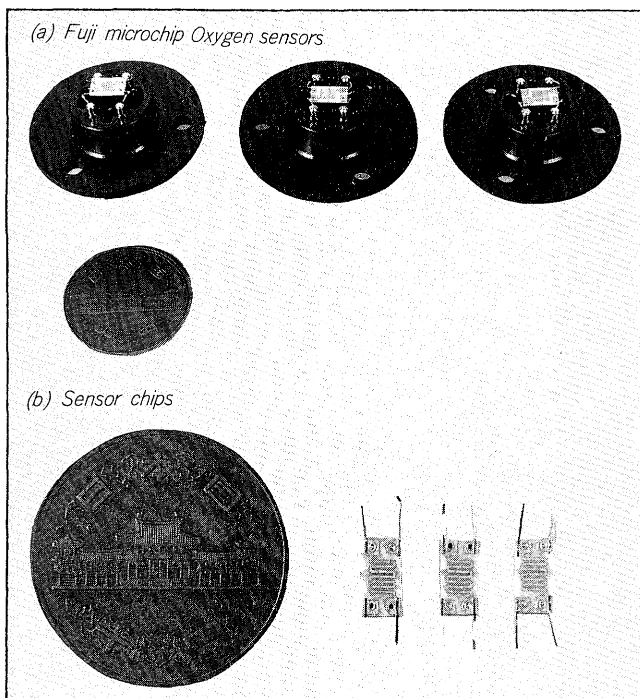
Item	Microchip oxygen sensor	Zirconia oxygen sensor	Magnetic oxygen sensor
Size	Miniature	Medium	Large
Stability	Good	Good	Calibration necessary
Output characteristic	Linear	Logarithmic	Almost linear
Response	Fast	Fast	Slow
Minute concentration measurement	Unsuitable	Suitable	Unsuitable
Interference of other gases	Combustible gas interference	Combustible gas interference	CO_2
Power consumption	Low	High	High
Portable type	YES	NO	NO

The Fuji microchip oxygen sensors introduced here were developed on years of experience and accumulated know-how, and have many features, such as miniature size, light weight, low power consumption, fast response, and low cost and meet a wide range of needs from process to consumer product use.

2. EXTERIOR VIEWS OF SENSORS

Exterior views of the sensor are shown in Fig. 1(a) and exterior views of the sensor chip are shown in Fig. 1(b). When the lead wire parts are removed, the sensor chip is a very small 7×3.5×0.5 (mm). It operates at a minute heater power of approximately 1W.

Fig. 1 Sensors and sensor chips



3. MANUFACTURING PROCESS

A sensor chip is obtained by green sheeting zirconia powder, screen printing the necessary electrodes, heater, etc., and obtaining a chip by cutting after layer integration, and baking. The oxygen sensor is completed by bonding platinum wires to this sensor chip and bonding these platinum wires to stems.

This process was made feasible by lowering the zirconia ceramic baking temperature to 1500°C by the recent micro-particlization of zirconia material and the development of electrode material and heater material which withstand heat treatment at this baking temperature.

The subminiature sensor previously mentioned was realized by using the previously described material and establishing know-how which obtains a green sheet with uniform minuteness after baking and reducing the electrode spacing.

Fig. 2 Stability in atmosphere

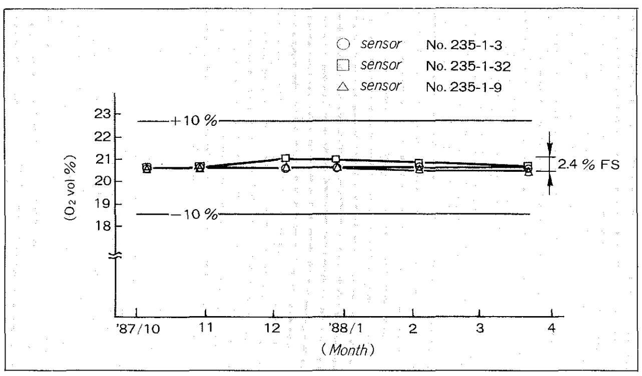
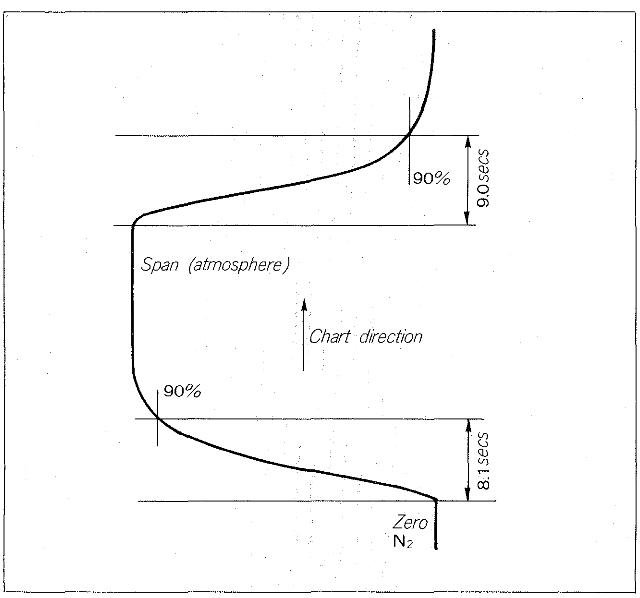


Fig. 3 O_2 controller response



4. CHARACTERISTICS

This stability, response, reproducibility, and temperature characteristics and shown in Figs. 2, 3, 4, and 5 as typical characteristics.

Regarding the long-term stability of the characteristics, acceleration tests were conducted and an estimated life of five years or longer in the actual usage state was obtained.

5. APPLICATION

The miniature size, good stability, and other features of the microchip oxygen sensor are utilized and the sensor has the following applications:

(1) Application as atmospheric oxygen sensor controller

Fig. 4 O_2 controller reproducibility

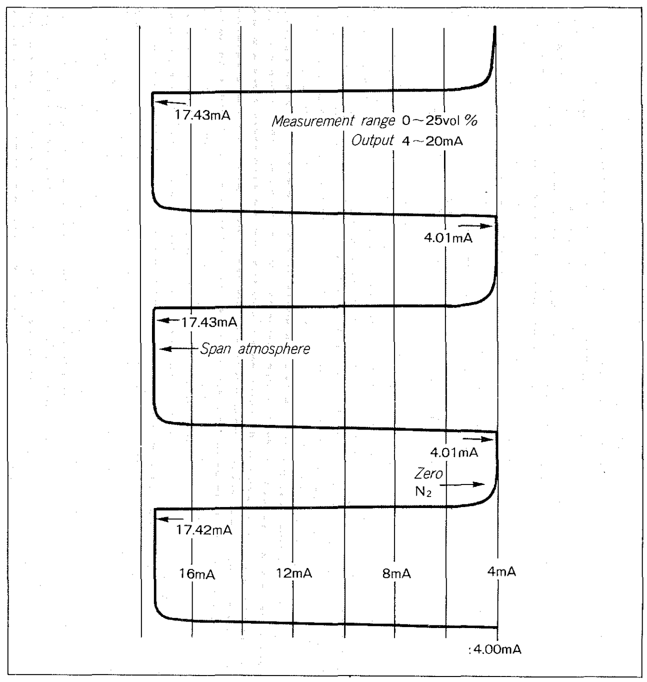


Fig. 5 Ambient temperature characteristic

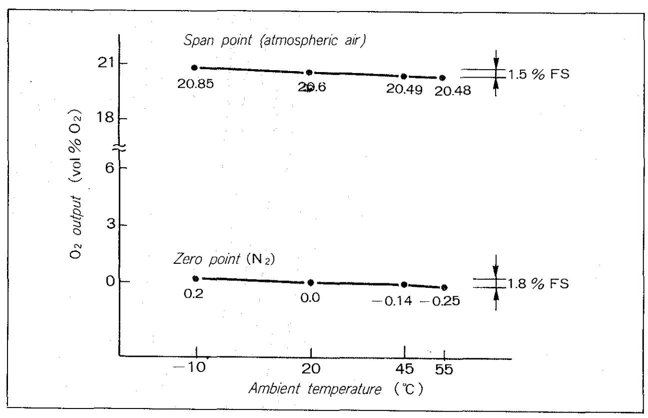


Fig. 6 Microchip O_2 sensor module outline dimensions

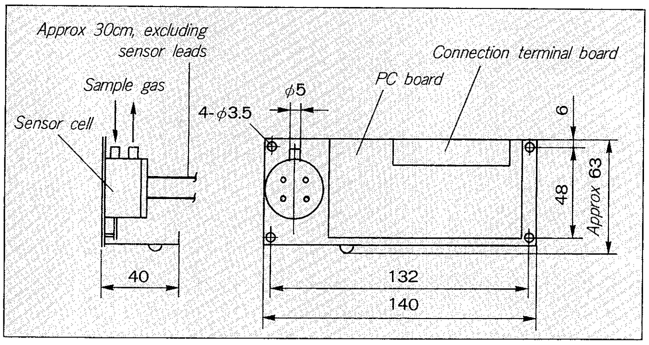
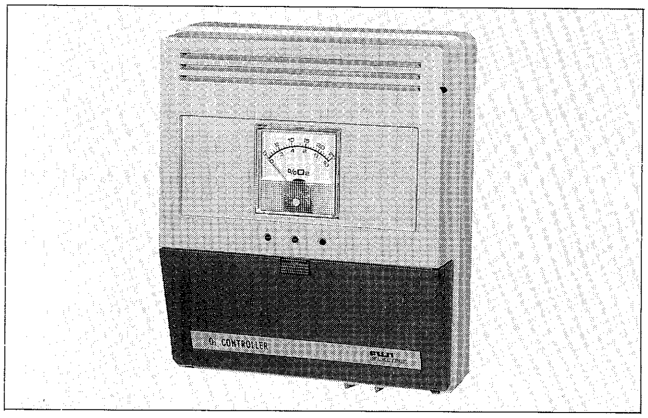


Fig. 7 Exterior view of O_2 controller



for CA storage, shipping container, cultivation tank, greenhouse, and other foodstuff ripening, freshness maintenance, and organizm fermentation and cultivation.

(2) Prevention of oxygen defficiency in subway, underground facilities (parking lot, warehouse, etc.), ship's hold, and other enclosed spaces.

(3) Application as operating room, central treatment room, nursing equipment, oxygen concentrator, and other medical treatment.

(4) Application as oxygen sensor for general processes.

6. APPLICATION PRODUCTS

6.1 Microchip O_2 sensor module

This module consists of a power supply which drives a cell incorporating the previously described sensor chip and an electronic circuit which amplifies the sensor output and meets the need for incorporation into various machinery.

Specifications

(1) Measured gas : Oxygen in the atmosphere
(2) Measurement range : 0~25% O_2
(3) Reproducibility : ±0.5% F.S.
(4) Linearity : ±2.5% F.S.
(5) Response speed : Approx. 10 secs/90%
(6) Sample gas flow : Standard 0.51/min (constant flow at 0.2~1.01/min)
(7) Sample gas temperature : 0~50°C
(8) Coexistence gas conditions : No combustible, corrosive, or other gases which have an adverse affect on the sensor, no dust or water drips in the gas
(9) Output : 0~1V (zero point offset; +50mV or less)
(10) Power requirement : DC 5V, 1.3A
(11) Installation site conditions
Temperature : 0~45°C
Humidity : 90% RH or less
(12) Wiring connection : M3 terminal
(13) Piping connection port : 5mm dia hose end
(14) Gas contact part material : Brass, PPS resin

6.2 O_2 controller

As sample gas suction pump, filter, indicator, etc. are integrated and housed in a case, in addition to the basic type of O_2 sensor unit and practicability is raised by using a commercial AC power supply as the power source and providing upper and lower limit alarm contact outputs as the control output.

Specifications

(1) Measured gas : Oxygen in the atmosphere
(2) Measurement range : 0~10/25vol%
(3) Reproducibility : ±1% FS
(4) Stability : ±10% FS/6 months
(5) Output : DC 4~20mA or DC 1~5V
(6) Linearity : ±2.5% FS
(7) Alarm output : Upper, lower each 1c contact output (AC250V, 3A resistance load)
(8) Response : 90% response approx 10 secs
(9) Power requirement : AC100, 115, 220, 240V ±10% 50/60Hz
(10) Power consumption : Approx 20VA
(11) Warm-up time : 30 mins
(12) Ambient conditions : Temperature 0~45°C, Humidity 90% RH or less
(13) Sampling : Pump and filter built-in
(14) Dimensions : 257 x 220 x 85 (mm) (height x width x depth)
(15) Weight : Approx 3kg

7. CONCLUSION

The microchip oxygen sensor, O_2 sensor unit, and O_2 controller were described above. This sensor is expected to extend the market of the oxygen sensor, which was limited to process use in the past, up to consumer products because of its ease of use, performance, and economy. We will advance development of application products and meet the diverse needs of each field in the future.