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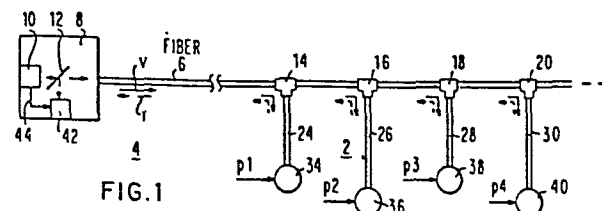
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(54) **Fiber optical sensor system, preferably for measuring physical parameters.**

(57) The system contains a fiber optical transmission line (6), a first light source (10) for emitting a first light beam into a first end of the transmission line (6), and at least one first light sensitive element (46) for receiving light from a second end of the transmission line (6). An energy storage device (56) such as a capacitor is connected to the first light sensitive element (46) for energizing various components. The system further contains a second light source (82) for emitting a second light beam into the second end of the transmission line (6). This source (82) is controlled in dependence upon information to be transmitted, preferably in dependence of a physical parameter (p1,p2,p3,p4). The system finally contains a second receiver element (90) for receiving light from the first end of the transmission line (6). This element generates an electric output signal which is in accordance with the transmitted information. The system preferably has a large number of transducer units (60) or measuring elements associated with various second ends of the transmission line (6) for transmitting information of various nature and/or from various locations.



CROSS REFERENCE TO RELATED APPLICATIONS

This application relates to the same technical field as the application of Georg Sichling, entitled "Fiber Optical Sensor System, Preferably for Use in Automotive Equipment", Serial No. , also assigned to Siemens Corporation, filed on the same day as this application.

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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention in general relates to a fiber optical system for transmission of information from one location to another. In particular, this invention relates to a system for measuring one or more physical parameters or data and transmission thereof to evaluation circuitry, which circuitry is located remote from the location of the measurement. Still more particularly, this invention relates to an optical sensor system using at least one transducer for measuring a physical parameter, preferably a multitude of transducers for measuring various physical parameters, and fiber optical means for optical transmission of the sensed parameters to an evaluation circuitry. Such optical sensor system may be applied, for instance, in industrial facilities such as power plants or chemical plants, or in automobiles for the measurement and/or control of various functions.

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2. Description of the Prior Art

In "Control Engineering", February 1979, pages 30-33, fiber optical sensors and transducers for measurement of physical parameters are disclosed. These transducers generate digital signals in accordance with the physical parameter being measured without using analog to digital (A/D) converters. The transducers require only light in order to become energized. The aforementioned sensors may be applied for measuring temperature, pressure, flow rate, and similar physical parameters. They are included in fiber optical transmission systems. When multimode fibers are used in these systems, the transmission schemes can be digital intensity modulation (binary, pulse width, frequency, etc.), wave length or color modulation, and color multiplexing.

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- 1 In the measurement of physical parameters, it is generally desirable that the transducer directly produce digital signals, rather than require an electric A/D converter. Further, the transducer should require power only in the
- 5 form of optical power. In addition, the design of the transducer and the optical transmission line should be such that the system can withstand hostile environments, including electromagnetic interference.
- 10 In "Control Engineering", supra, page 32, third column, and page 33, lower figures, a fiber optical sensor system is disclosed which works as a luminescent temperature transducer. The system includes a pulsed light source which emits light pulses into the first end of a fiber
- 15 optical cable. The remote sensor is simply the expanded second end of the fiber optical cable, which end is coated with or is embedded in a phosphorescent material. Phosphorescence of this material occurs after each light pulse which has been received from the light source. A
- 20 response or return light signal is emitted from the phosphorescent material in backward direction through the fiber optical cable. By means of a light coupler associated with the first end of the optical cable, the response signal is coupled to a photodetector. The electric
- 25 output signal of the photodetector, that is the post-excitation return signal, is fed into a sample-hold or time-constant measurement device. Here, the decay time constant of the phosphorescent process is measured. The temperature sensor system provides a pulse width which is
- 30 proportional to the decay time constant, and therefore, proportional to the temperature to which the phosphorescent material is exposed. --This fiber optical sensor system is based on the measurement of a decreasing analog signal and therefore subject to disturbing influences.
- 35 In addition, the costs for such a system may be high.

1 Thus, there is a need for a fiber optical sensor system
which is not only precise and reliable, but which is al-
so inexpensive to manufacture. Such a system should
have some sort of energy source on the measurement side
5 so that active electric devices, such as transistors, may
be energized. The system should derive the required pow-
er from optical signals transmitted through a fiber op-
tical transmission line, and it should not require any
additional sources of electric power at the location(s)
10 of measurement.

A fiber optical sensor system of the kind just described
appears to be particularly suited for use in automobiles.
In conventional automotive applications, more than a doz-
15 en parameters are sensed at the automobile engine alone,
and more than a dozen other parameters are measured at
other locations of the automobile. A sensor system ap-
plied in a car should require only a minimum of cabling,
should be extremely reliable, even under extreme environ-
20 mental conditions like heat, cold, humidity, vibration,
chemical and mechanical stress, and also under the usual
wear and tear to which an automobile is subjected. A
fiber optical transmission cable by nature would be lit-
tle effected by all these factors and would exhibit the
25 additional advantage that it is not subject to electro-
magnetic interference, which may be generated by the ig-
nition system of the car and by other devices. There-
fore, in automobile applications an electro-optical sen-
sor system may be used widely, if such a system could be
30 manufactured inexpensively and if the accuracy required
for the sensors can be obtained. This is not only true
for automobile applications, but also for other applica-
tions with similar requirements, such as industrial appli-
cations.

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SUMMARY OF THE INVENTION

1. Objects

It is an object of this invention to provide a fiber optical sensor system for transmission of information from one location to another, whereby an independent power source, such as a battery, a power line or an electric outlet, is not available on said one location.

10 It is another object of this invention to provide a fiber optical sensor system for transmission of information from one location to another through a fiber optical transmission line, wherein power is optically transmitted to said one location from the other location through the very same
15 fiber optical transmission line.

It is still another object of this invention to provide a fiber optical sensor system having a measurement side and an evaluation side, wherein an electric power source is
20 provided on the evaluation side, and wherein an additional power source is not required on the measurement side.

It is still another object of this invention to provide a fiber optical sensor system having a measurement side and
25 an evaluation side, wherein various measurement signals delivered by a plurality of transducers may be transmitted as optical signals via a single fiber optical transmission line or cable from the measurement side to the evaluation side.

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It is still another object of this invention to provide a fiber optical sensor system which allows for the measurement of a multitude of physical parameters under rough environmental conditions.

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1 It is still another object of this invention to provide
a fiber optical sensor system which allows for the measure-
ment of a multitude of physical parameters and which none-
theless requires only a comparatively small expenditure.

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It is still another object of this invention to provide
a fiber optical sensor system in which all different
kinds of physical parameters can be transmitted and meas-
ured, such as temperature, pressure and mass flow.

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It is still another object of this invention to provide
a fiber optical sensor system which includes a compara-
tively high number of transducers, for instance, twenty
or more.

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It is still another object of this invention to provide
a fiber optical sensor system which requires only a sin-
gle light source on the first side of a fiber optical
cable for addressing and energizing a plurality of trans-
ducers on the second side of said fiber optical cable.

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It is still another object of this invention to provide
a fiber optical sensor system having only low power re-
quirements, such that the power can be taken, for in-
stance, out of a car battery.

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It is still another object of this invention to provide
a fiber optical sensor system which can withstand hostile
environmental conditions, such as humidity, oil, acid and
vibrations.

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It is still another object of this invention to provide
a fiber optical sensor system for transmission of a phys-
ical parameter from a location of measurement to a loca-
tion of evaluation, wherein electromagnetic disturbances

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1 at the location of the measurement do not have any im-
pact on the measurement results.

It is still another object of this invention to provide
5 a fiber optical sensor system in which external distur-
bances, such as electromagnetic interference (emi), do
not have an impact on the measurement results, that is
to provide such a system wherein the transmission of in-
formation is immune against disturbances from outside the
10 system.

It is still another object of this invention to provide
a fiber optical sensor system for measurement of various
physical parameters which provides the capability of sys-
15 tem expansion, if additional parameters are to be meas-
ured.

It is still another object of this invention to provide
a fiber optical sensor system which can be manufactured
20 relatively simply and inexpensively.

It is still another object of this invention to provide
a fiber optical sensor system which can be used for auto-
motive applications.

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It is still another object of this invention to provide
a fiber optical sensor system which has an overall ac-
curacy sufficient for an application in an automobile.

30 2. Summary

According to this invention, a fiber optical sensor sys-
tem for transmission of information from one location to
another contains a fiber optical transmission line or ca-
ble. This transmission line has a first end and a second
35 end for transmitting light therebetween. The system also

1 contains a first light source for emitting a first light
beam into the first end of the transmission line. At the
second end of the transmission line is arranged at least
one first receiver element which is sensitive to the light
5 of the first light source. This first receiver element
is provided for receiving light of the first light source
from the second end of the transmission line and for gen-
erating a first electric output signal in accordance with
the light received. An electrical energy storage device
10 is connected to the first receiver element. It will re-
ceive the first electric output signal. This device will
store energy in accordance with the optical energy trans-
mitted through the transmission line. At the second end
of the transmission line is also arranged a second light
15 source. This second light source is provided for emitting
a second light beam into the second end of the transmis-
sion line. The second light source is energized from the
electrical energy storage device, and it is controlled
according to the information to be transmitted. There is
20 also provided a second receiver element sensitive to the
light of the second light source. The second receiver
element will receive light of the second light source
from the transmission line. This second receiver element
is provided for generating a second electric output sig-
25 nal in accordance with the light received. This signal
is in accordance with the transmitted information.

The energy storage device preferably may comprise a stor-
age capacitor which is connected to the first receiver
30 element. The capacitor will derive an electrical charge
from the receiver element when the first light source
emits the first light beam. The capacitor is the energy
source used for energizing the second light source.

35 The system is applicable for transmission of various phys-

- 1 ical parameters. These parameters may be sensed by any
kind of sensor, such as an electromechanical or photo-
electric sensor.
- 5 The fiber optical sensor system may be designed such
that besides the second light source, further electronic
components are connected to be energized from the energy
storage device.
- 10 According to this invention, a preferred embodiment of
the fiber optical sensor system for measuring at least
one physical parameter may comprise:
 - a) a first light source for emitting a first light
pulse;
 - 15 b) at least one first receiver element which is
sensitive to the light of the first light pulse;
 - c) a fiber optical transmission line having two
sides, whereby the first light pulse is trans-
mitted from the first light source arranged on th
20 first side of the transmission line, to the
first receiver element arranged on a second side
of the transmission line;
 - d) a sensor element containing a resistor-capacitor
combination, the time constant of which combina-
25 tion is dependent on the physical parameter to
be measured;
 - e) a device for changing the charge of the capacitor
in accordance with the time constant of the re-
sistor-capacitor combination, whereby such a
30 change will be initiated when the first receiver
element detects the first light pulse;
 - f) a sensing device for sensing the voltage of the
capacitor and for determining the point of time
when the voltage of the capacitor has reached a
35 predetermined value;

- 1 g) a second light source arranged on the second side
 of the transmission line for emitting a second
 light pulse or response pulse when the capacitor
5 voltage has reached the predetermined value, where-
 by the second light pulse is transmitted from the
 second side to the first side of the transmission
 line;
- h) a second receiver element sensitive to the light
 of the second light pulse, the second receiver
10 element being arranged on the first side of the
 transmission line; and
- i) a measuring device for measuring the time differ-
 ence between the first and the second pulse, where-
 by this time difference is a function of the phys-
15 ical parameter to be measured.

The term "information" as used herein is intended to be
applied in its most general form and comprises all sort
of information, such as data, signals, physical para-
20 meters, measurement results, communication signals and
 code words.

The foregoing and other objects, features and advantages
of the invention will be apparent from the following more
25 particular description of preferred embodiments of the in-
 vention, as illustrated in the accompanying drawings.

1 BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

- 5 Fig. 1 is a schematic view of a fiber optical sensor system having on its measurement side various measurement elements including transducers which are exposed to various physical parameters, and on its evaluation side a primary light source and an evaluation circuit;
- 10 Fig. 2 is a detailed view of a branching element which can be used in the sensor system of Fig. 1;
- 15 Fig. 3 is an opto-electrical circuitry which can be used on the measuring side of the sensor system of Fig. 1, wherein a resistor is applied as the sensor element;
- 20 Fig. 4 is a partial view of an opto-electrical circuitry similar to Fig. 3, wherein a capacitor is applied as the sensor element;
- 25 Fig. 5 is a more detailed embodiment of the evaluation circuitry shown in Fig. 1;
- 30 Fig. 6 is a time diagram showing light pulses (charge pulses and encoded identification pulses) transmitted to the measuring side of the sensor system of Fig. 1;
- 35 Fig. 7 is a time diagram showing the voltage of a capacitor which is charged and discharged in response to a physical parameter, the capacitor being a component of the circuitry of Fig. 3;
- Fig. 8 is a time diagram showing light return pulses which are emitted from the measuring side to the evaluation side of the sensor system in Fig. 1;

Fig. 9 is a cross section of a mechanical design of one of the transducers shown in Fig. 1;

Fig. 10 is a cross section of a measuring element incorporating a housing having a cavity in the form of an ellipsoid; and

Fig. 11 is an opto-electrical circuitry which includes a pulse width modulator and which can be used on the measuring side of the fiber optical sensor system of Fig. 1.

1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

 In Fig. 1 a fiber optical sensor system for transmission
of physical parameters $p_1, p_2, p_3, p_4 \dots$ from a location
5 of measurement or measuring side 2 to a remote location
of application or control and evaluation side 4 is illus-
trated. The sensor system is preferably applicable in
the control and/or testing of automobiles. This design
does not depend on the amplitude of an optical beam and
10 does not exhibit any specific problems of accuracy.

 The system includes a fiber optical transmission line or
transmission cable 6 for transmission of light in either
direction. On its control and evaluation side 4, the
15 transmission line 6 is operatively connected to an emit-
ter and receiver device 8. The device 8 includes a first
light source 10 for emitting a first light beam through
a beam splitter 12 into the left end of the fiber optical
transmission line 6. The light source 10 may be a light
20 emitting diode (LED), a laser or a GaAs light emitter.
The transmission line 6 leads to the measuring side 2.
Here, the fiber optical transmission line 6 passes var-
ious coupling elements 14, 16, 18 and 20, four of which
are illustrated. There may be provided more than four
25 coupling elements 14, 15, 18 and 20. The coupling ele-
ment 14-20 may be, for instance, T-couplers or branching
elements, such as disclosed in "Applied Optics", Vol. 16,
No. 8, August 1977, pages 2195-2197. The four coupling
elements 14-20 serve to distribute the first light beam
30 among four fiber optical branches 24, 26, 28 and 30, re-
spectively. At the end of these branches 34-40, there
are provided measuring elements 34, 36, 38 and 40, re-
spectively, which measure the physical parameters p_1-p_4 ,
respectively, of the automobile. The parameters p_1-p_4
35 may be, for instance, pressure, temperature, gas flow and
speed.

1 As will become apparent later, the measuring elements 34-
40 each contain a first receiver element which is sensi-
2 tive to the light of the first light source 10. The first
3 receiver elements generate first electric output signals
4 in accordance with the light which they receive. The meas-
5 uring elements 34-40 each also contain an electrical ener-
6 gy storage device which is supplied by the first electric
7 output signal and which will store the energy contained
8 in such signal. Each of the measuring elements 34-40
9 further contains a second light source for emitting a
10 second light beam back into the branches 24-30, respec-
11 tively. From here, the second light beam passes through
12 the respective coupling elements 14-20 into the left end
13 of the fiber optical transmission line 6 on the control
14 and evaluation side 4. From this end, the second light
15 beam is transmitted into the device 8. Each of the se-
16 cond light sources within the individual measuring ele-
17 ments 34-40 is energized from the associated electrical
18 energy storage device. These light sources which all
19 have the same characteristics are controlled in a depend-
20 ence of the physical parameters p1-p4, respectively.
21 Thereby, the information represented by the physical
22 parameters p1-p4 is optically transmitted from the meas-
23 uring side 2 to the control and evaluation side 4. Trans-
24 mission of the parameters p1-p4 is performed one after
25 another.

On the control and evaluation side 4, the light from the
second light source is transmitted through the beam split-
26 ter 12 to an evaluation circuitry 42. The evaluation
27 circuitry 42 contains a second receiver element which is
28 sensitive to the light of all second light sources. It
29 generates a second electrical output signal in accordance
30 with the light received and thereby in accordance with
31 the physical parameter p1, p2, p3 or p4 transmitted.
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34
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1 In Fig. 1 the light paths from the emitter and receiver
device 8 to the individual measuring elements 34-40 are
indicated by straight arrows, whereas the light paths
from the measuring elements 34-40 back to the device 8
5 are indicated by broken arrows.

In the emitter and receiver device 8, there is also pro-
vided an address line 44 which leads from the light con-
trol circuitry for the light source 10 to the evaluation
10 circuitry 42. Through this address line 44, information
is transmitted indicating the measuring element 34, 36,
38 or 40 which is being addressed by the control circuit-
ry: Therefore, in the circuitry 42 the received signal
can be assigned to the measuring element 34-40 which has
15 responded.

In Fig. 2, an embodiment of the coupling element 14 is
illustrated. The coupling element 14 is here designed as
a well-known branching element. A small fiber line 24a
20 branches off the main fiber optical transmission line 6.
The coupling elements 16-20 may be designed in a similar
way.

In Fig. 3 an embodiment of one of the measuring elements
25 34-40 is illustrated. This embodiment may be, for in-
stance, the measuring element 34.

It will be noted that the end of the fiber optical branch
24 which emits the first light beam 45 is arranged close
30 to a first receiver element 46. This first receiver ele-
ment 46 may be a small photo diode or an arrangement of various
photo diodes. The element 46 receives the first light
beam 45 from the branch 24 and generates an output volt-
age in accordance with the light received. Between the
35 end of the branch 24 and the first receiver element 46,

1 there may be arranged optical means for concentrating the
radiation on the light sensitive area of the element 46.
The first receiver element 46 is connected in series with
a diode 48 for generating a supply voltage between a sup-
5 ply voltage bus 50 and ground 52. The connection point
between the element 46 and the diode 48 is designated as
54. The series connection 46, 48 is coupled to an energy
storage device 56. The storage device 56 is designed as
a storage capacitor. A Zener diode 58 is connected par-
10 allel to the storage capacitor 56. This Zener diode 58
serves to keep the voltage of the storage capacitor 56
constant. The storage capacitor 56 derives electrical
charges from the first receiving element 46 when the
first light source 10 emits the first light beam 45. It
15 stores these charges and energizes various electronic
components in the measuring element 34, as will be dis-
cussed below.

The measuring element 34 further contains a transducer
20 unit 60 for transforming the physical parameter p1 to be
measured into a corresponding electrical quantity and
subsequently into an optical signal. For this purpose,
the transducer unit 60 contains an RC combination formed
by a resistor 62 and a capacitor 64 which are connected
25 in series. The components forming the RC combination 62,
64 are selected such that the time constant of the RC
combination 62, 64 is dependent on the physical parameter
p1 to be measured. In the embodiment illustrated in Fig.
3, the resistor 62 is exposed to the parameter p1, and
30 the resistance of the resistor 62 is directly dependent
on the parameter p1, whereas the capacitance of the ca-
pacitor 64 remains constant. The resistance may vary,
for instance, in accordance with temperature or pressure.
Thus, the resistor 62 may be considered as the sensor
35 proper of the measuring element 34 of the fiber optical

1 sensor system.

The transducer unit 60 contains a voltage divider formed by the series connection of a first resistor 66 and a
5 second resistor 68. This voltage divider 66, 68 is connected between the supply voltage bus 50 and ground 52. The first resistor 66 represents a first voltage source of a fairly constant first supply voltage, and the second resistor may be considered as a second voltage
10 source of a second supply voltage that is also fairly constant.

The series connection consisting of the sensor resistor 62 and the capacitor 64 is coupled through a first switching
15 element 70 to a supply voltage source. This supply voltage source is the first voltage source represented by the first resistor 66. The first switching element 70 preferably is an electronic switch, such as a FET. It is controlled by an initiation signal which is derived
20 from a control device, specifically from an address decoder 72.

The address decoder 72, which is energized from the supply voltage bus 50, decodes an input signal arriving on
25 its input line 73. The input line 73 is connected to the connection point 54. Whenever the decoded input signal indicates that the address decoder 72 has been addressed by the first light beam 45, an output pulse is issued as an initiating signal i. The instant when this pulse appears at the output of the address decoder 72 will be
30 termed the first point of time. The control line between the address decoder 72 and the first switching element 70 is shown in Fig. 3 as a broken line.

35 The first switching element 70 in combination with the

1 first voltage source (resistor 66) may be considered as
a device for changing the charge of the capacitor 64 in
accordance with the time constant of the RC combination
62, 64. Particularly, the first voltage source (resistor
5 66) is determined to charge the capacitor 64 through the
resistor 62. Therefore, the initiation signal i issued
to close the first switching element 70, may be considered
as a "start charge" signal. In the ON position of the
first switching element 70, the capacitor 64 will be
10 charged to obtain a voltage U_c of the polarity indicated
in Fig. 3.

The transducer unit 60 also includes a device for dis-
charging the capacitor 64 after it has been charged. This
15 device basically includes the second voltage source as re-
presented by the second resistor 68, a second switching
element 74, and a delay circuit 76. The second switching
element 74 which may be a transistor such as a FET, is
connected parallel to the series connection of the capac-
20 itor 64 and the second resistor 68. It is actuated by
the delay circuit 76, which in turn is supplied with the
initiation signal i from the address decoder 72. The de-
lay circuit 76 has a delay time T_0 which is fixed. The
delay circuit 76 may be designed, for instance, as a
25 counter which issues an output pulse after the initiation
signal has been received. The output pulse is delayed by
the delay time T_0 with respect to the initiation signal i .
The second voltage source (resistor 68) has a reverse
polarity with respect to the charged capacitor 64. As
30 soon as the second switching element 74 is closed (ON po-
sition), the voltage of the second voltage source (resis-
tor 68) counteracts the capacitor voltage U_c , so that the
capacitor 64 is discharged.

35 The transducer unit 60 also contains a device 78 for

- 1 sensing the voltage of the capacitor 64 and for deter-
mining a second point of time, which is precisely the
instant when the capacitor voltage U_c has reached a
predetermined value. In particular, this predetermined
5 value may be zero volts.

The voltage sensing device 78 may be formed by a com-
parator such as a flip-flop. The voltage sensing de-
vice 78 is a control unit. It is part of an electro-op-
10 tical device for emitting a second light beam which is
directed into the face end of the fiber optical branch
24. In particular, the device 78 generates a return or
response light pulse 80. Part of the electro-optical
emitting device is also a second light source 82. This
light source 82 may be a light emitting diode (LED) or
15 a laser, preferably a GaAs light emitter. It should be
mentioned that the wavelength characteristics of the se-
cond light source 82 may be different from the wavelength
characteristics of the first light source 10 (shown in
Figs. 1 and 5). The second light source 82 is connected
20 in series with a third switching element 84 between the
supply voltage bus 50 and ground 52. The third switch-
ing element 84 may be a transistor such as a FET. It is
actuated by the output of the voltage sensing device 78,
as indicated by a broken control line. When the third
25 switching element 84 is brought into its closed position
(ON position), the energy storage capacitor 56 will sup-
ply the second light source 82 with electric energy for
emission of the return pulse 80.

30 From the preceding description of the voltage device 78
it has become apparent that the second light source 82
will emit the return pulse 80 when the voltage of the
capacitor 64 has reached the predetermined voltage value
at the second point of time. Since the time difference
35 between the second and the first point of time is an in-

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1 dication of the value of the parameter p_1 , the occurrence
of the return pulse 80 with respect to the first point of
time will be determined on the control and evaluation side
4. Therefore, the return pulse 80 is transmitted from the
5 second light source 82 through the branch 24 to the left
end of the fiber optical transmission line 6 (Fig. 1) and
from there to the evaluation circuitry (Fig. 1). During
the emission of the return pulse 80, the storage capacitor
56 will be discharged. Since this measuring method is
10 based on the measurement of pulses, it can be termed pulse
code modulation.

Thus, it is obvious that the storage capacitor ⁵⁶~~52~~ energizes
the address decoder 72 and the voltage sensing device 78...
15 It also serves as an energy source for charging and dis-
charging the capacitor 64 and for activation of the se-
cond light source 82 which sends out the response pulse
80.

20 In Fig. 4 is illustrated another embodiment of the meas-
uring element 34, whereby only a section of the electric
circuit is shown. Further components and connections may
be chosen as in Fig. 3. In this embodiment the capaci-
tance of the capacitor 64 may vary in accordance with the
25 physical parameter p_1 , whereas the resistance of the re-
sistor 62 is constant. Since the charging time and the
discharging time of the capacitor 64 is dependent on the
capacitance, the time difference between the second and
the first point of time is again a function of the physi-
30 cal parameter p_1 .

It should be mentioned that RC combinations other than
those illustrated in Figs. 3 and 4 may be chosen. For
instance, it may be sufficient to use the wiring resis-
35 tance as a resistor 62 of constant value.

1 In Fig. 5 an embodiment of the emitter and receiver device 8 is illustrated. The first light source 10 is controlled by a control unit 86. This control unit 86 provides for the emission of charge light pulses which are
5 used for energizing the measuring elements 34-40. The first light source 10 is not only a source for transmitting energy on the measuring side 2. It is also used as a signal source. For this purpose an encoder 88 is provided. The encoder 88 controls the first light source
10 10 as to emit a series y of coded light pulse patterns. Each of these coded light pulse patterns addresses a particular address decoder 72 in one of the measuring elements 34-40. With each individual address decoder 72 a predetermined and individualized pulse pattern is associated.
15 sociated. Each of the decoders 72 on the measuring side 2 issues an initiation signal i when the transmitted coded light pulse pattern corresponds to the predetermined pulse pattern contained or stored therein.

20 According to Fig. 5, the evaluation circuitry comprises a second receiver element 90 which is sensitive to the light of any of the second light sources 82 on the measuring side 2. This second receiver element 90 preferably may be a photo diode. It is connected in series with a
25 resistor 92 to a voltage source. The second light source 90 receives the return light pulse r from the transmission line 6 and generates a second electric signal in accordance with the light received. In other words, whenever one of the second light sources 82 of the measuring
30 elements 34-40 emits a return light pulse 80, an electric pulse is generated by the element 90. This pulse is conducted to a time measuring stage 94. The stage 94 measures the difference between the second and the first point of time, whereby this time difference is a function of
35 the physical parameter to be measured, and issues an out-

1 put signal a accordingly. The stage 94, for instance,
may be a counter which is started from the control unit
86 by a start signal that coincides with the initiation
signal used on the measuring side 2. The counter is
5 stopped by the pulse from the light sensitive element 90.
The time lapse between "start" and "stop" is a function
of the physical parameter to be measured.

In Figs. 6 through 8 diagrams referring to the operation
10 of the fiber optical sensor system are illustrated.

In Fig. 6 the sequence y of light pulses emitted from the
first light source 10 is shown. First a primary optical
pulse or charge pulse no. 1 is generated by the first
15 light source 10. This charge pulse no. 1 passes the beam
splitter 12 and enters the optical fiber cable 6. Light
which passes the coupling elements 14-20 and exits from
the branches 24-30 hits the photo diode 46 in each of the
measuring elements 34-40, respectively. The photo diode
20 46 converts the light into an electric voltage which
charges the storage capacitor 56. The capacitor 56 feeds
the transducer unit 60, the address decoder 72 and the
comparator 78 through the supply voltage bus 50. Thus,
the charge pulse no. 1 serves to charge all capacitors 56
25 of the measuring elements 34-40. From the trailing edge
of the charge pulse no. 1 the decoder 72 determines that
the charge pulse no. 1 is terminated. For instance, a
flip-flop may be activated by the trailing edge. However,
it is also possible to start a counter with the leading
30 edge which delivers a termination pulse after a given
period of time.

Subsequently, at a point of time t_1 , first address code
pulses are generated. These pulses may be of smaller am-
35 plitude than the charge pulse no. 1. These first address

1 code pulses are assigned to the first measuring element
to be addressed, for instance the measuring element 34.
Corresponding electrical pulses are generated and fed to
the address decoder 72 for address recognition and de-
5 coding.

Subsequently, a start pulse p_1 is generated by the light
source 10. This pulse p_1 may have a higher amplitude
than the first address code pulses.

10

The recognition of the address code in the first measuring
element 34 causes the generation of the initiation signal
 i which initiates charging and discharging of the capaci-
tor 64. In the present embodiment, the electrical pulse
15 corresponding to the start pulse p_1 is simply passed
through the decoder 72 onto the first switch 70. After
the fixed delay time T_0 , this pulse will also actuate
the second switch 74. The trailing edge of the start
pulse p_1 determines the first point of time t_{l1} , that is
20 the instant when the first switch 70 is closed. At the
point of time $(t_{l1} + T_0)$, the second switch 74 is closed,
whereas the first switch 70 may be opened.

As can be seen in Fig. 7, the capacitor voltage U_c will
25 rise from the first point of time t_{l1} on and decrease
after the delay time T_0 has elapsed. At the second point
of time t_{l2} the capacitor voltage U_c will have arrived at
the predetermined value of zero volts. In Fig. 7 can be
seen that this second point of time t_{l2} is shifted on the
30 time axis t when the value of the parameter p_1 is changed.
A voltage curve corresponding to a second value of the
parameter p_1 is shown in broken lines.

The output signal of the comparator 78 is generated at the
35 second point of time t_{l2} . This output pulse closes the
third switching element 84 which thereupon discharges the

1 load of the storage capacitor 56 across the second light
emitting element 82. The stored energy is converted in-
to a return light pulse 80 which is transmitted back in-
to the fiber optical cable 6. In Fig. 8 is shown the re-
5 turn light pulse $\underline{r}$ which is emitted toward the evaluation
circuitry 42 at the second point of time t_{12} . In Fig. 8
is also shown in broken lines a return pulse $\underline{r}$ which
would be created if the capacitor 64 would be charged and
discharged according to a capacitor voltage U_c following
10 the broken lines in Fig. 7.

The time interval between the return pulse (time t_{12}) and
the start signal (time t_{11}) is a measure of the value of
the time constant of the RC element 62, 64 which in turn
15 is a measure of the physical parameter p_1 to be measured.
This time interval ($t_{12}-t_{11}$) is measured by the counter
94 (see Fig. 5). In other words, the measurement of the
parameter p_1 is performed as a measurement of a time in-
terval.

20

After the return signal $\underline{r}$ from the first measuring element
34 has been received and after a short pause, the next
measuring element 36 is addressed by second address code
pulses at a point of time t_2 (see Fig. 6). As will be
25 noted in Fig. 6, the second address code is different
from the first address code. Therefore, only address
decoder 72 of the second measuring element 36 will now
be activated to pass along the following start pulse p_2 .
After a certain period of time, at a second point of time
30 t_{22} , the measuring element 36 sends back a return light
pulse $\underline{r}$ which can be seen in Fig. 8. The time difference
($t_{22}-t_{21}$) between the return pulse (see Fig. 8) and the
start pulse (see Fig. 6) is again a measure of the physi-
cal parameter p_2 to which the transducer unit 60 in the
35 second measuring element 36 is exposed.

1 The measurement of the parameters p3 and p4 is performed
in the same way. After this has been accomplished, a new
measurement cycle is started by emitting a charge pulse
no. 2 determined to energize the measuring elements 34-40
5 again. Subsequently, the first pulse pattern is emitted
again. This first pattern is again addressed to the first
measuring element 34 which in turn will send out again
a return pulse 80. Thus, a change of the parameter p1
between this and the preceding measurement cycle can be
10 determined.

In Fig. 9 is illustrated the mechanical design of a meas-
uring element 34 which is connected through a fiber opti-
cal cable 24 and a fiber optical branching element 14 to
15 the main fiber optical cable 6. This measuring element
34 is part of a fiber optical sensor system which may have
various applications. For instance, it may be applied in
an automobile control device or in a process or industri-
al control device. Such a system can also be used for
20 data transmission, for supervision and control in power
plants, for instance in nuclear plants, and for tests in
aerospace.

The measuring element 34 contains a housing which is
25 formed by a container 100 and a cap 102. The container
100 basically has the shape of a cylindrical pot. It
is made of a metal. The cap 102 forms the top of the
housing. It is also made of a metal and has the shape
of a cone.

30

The cap 102 contains a central cavity or light channel
104. The fiber optical cable 24 merges into the top of
this light channel 104. The cap 102 is attached to the
inner walls of the container by means of a lead screw 106

35

- 1 in the upper part thereof. The interior of the housing is shielded against electromagnetic interference since the container 100 and the cap 102 are made of metal.
- 5 The interior of the housing contains a supporting plate or board 108 which has the shape of a disc. This plate or board 108 may be a circuit board carrying various electronic components. Preferably it is a silicon chip which contains or incorporates a plurality of components
- 10 and integrated circuits that form receiver and emitter circuits. Preferably, the integrated circuits may be so-called large scale IC. The supporting plate 108 is attached to the inner walls of the container by a ring (not shown) or by any other suitable means.
- 15 As illustrated in Fig. 9, the supporting board 108 supports the first light receiving element 46. This element may be a light sensitive diode, for instance, working on a silicon basis. The light receiving element 46
- 20 has the shape of a disc. It is centered on the supporting plate 108 opposite the end of the fiber optical cable 24. Its diameter approximately corresponds to the width of the light channel 104.
- 25 Supported by the first light receiving element 46 is a second light source or light emitter 82. This second light source 82 may be a light emitting diode (LED) or a laser, in particular a GaAs light emitter. The second light source 82 is the return signal generator, which
- 30 emits the return pulse 80. It is arranged on the central axis of the container so that it is positioned just opposite to the face end of the fiber optical cable 24.

The upper end face of the supporting plate 108 may also

35 support electrical components which are designated as

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1 110. These components may form the address decoder 72
and other circuits. The lower end face of the supporting
plate carries an energy storage device such as a supply
or storage capacitor 56.

5

The side wall of the container contains a hole. Through
this hole a lever 112 extends into the interior of the
housing. The lever 112 is pivotly attached to the hous-
ing by means of a pivot 114 which is located in the hole
10 itself or close thereto. The inner portion of the lever
112 has a protrusion 116 on its upper side. This protru-
sion 116 engages a sensor capacitor 64, the capacitance
of which is variable in accordance with Fig. 4. The sen-
sor capacitor 64 is firmly attached to the lower end face
15 of the supporting plate 108. The capacitor 64 is made
of two plates between which an electrolytical fluid is
arranged. By means of the lever 112, the parameter p1
is transferred into a change of the capacitance of the
capacitor 64 and thereby into an electrical quantity.

20

The sensor capacitor 64 shown in Fig. 9 is sensitive to
the force exerted by the protrusion 116 of the lever 112.
Thus, the sensing element 34 is a force or pressure sen-
sitive element. The capacitance and consequently the
25 voltage of the capacitor 64 vary in accordance with the
parameter p1. A change of this parameter p1 may be, for
instance, caused by a change of temperature, pressure,
or flow.

30 Instead of the force sensitive capacitor 64 shown in Fig.
9, various other sensors may be applied. For instance,
there may be applied an element which changes the dis-
tance in dependence on the temperature, or which changes
the dielectric constant in dependence on the temperature.
35 There may also be a temperature sensitive resistor 62

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1 which is implemented on the silicon chip 46 or on the
GaAs chip 82, and in this case heat transfer to the re-
sistor 62 may occur directly through the housing. It is
also possible to connect external resistor strips to the
5 sensor element. Similar designs are possible with pres-
sure sensitive actuators.

In Fig. 10 the cross section of a housing 120 is illus-
trated which contains a cavity 122 in the form of an
10 ellipsoid. This cavity 122 is provided with reflecting
walls. That is, the walls reflect very well the wave-
length of the light which is transmitted into the cavity.
The walls may be coated with silver. The cavity 122 is
sealed from the outside to preserve good optical proper-
15 ties.

The ellipsoidal cavity 122 is characterized by its focal
points F_1 and F_2 . A second light source 82 is located
in the first focal point F_1 . This light source 82 is
20 supplied with power from the exterior. For instance,
this light source 82 may be a GaAs laser. The light
emitted from the second light source 82 will be collected
in the second focal point F_2 . In this focal point F_2 ,
there is arranged the end face of a fiber optical cable
25 24 which leads out of the cavity 122. Light emitted from
the first light source will enter the cavity through the
end face of the fiber optical cable 24. This light will
be collected by the first optical receiver or photo diode
46 which is arranged around the first focal point F_1 .

30

The reflection on the ellipsoidal side walls provides for
a high power coupling.

In Fig. 11 is illustrated the basic design of another
35 embodiment of the measuring element 34. As indicated

1 earlier, the transmission of information according to
Fig. 3 is pulse code modulated (PCM). In contrast
thereto, the transmission according to Fig. 11 is pulse
width modulated (PWM). The energy transmission and
5 storage device may be the same as in Fig. 3.

According to Fig. 11, the transducer 60 is energized
again from the main supply voltage bus 50. This trans-
ducer 60 contains a sensor 130. The sensor 130 is ex-
10 posed to a change of a physical parameter p , for instance,
a change of a distance or temperature, and it delivers
at its electrical output a control signal c . This con-
trol signal c is supplied to a pulse width modulator 132
which issues pulses the length of which corresponds to
15 the control signal c . It will be noted that the output
signal of the modulator 132 is used for activating the
third switching element 84, which in turn causes the se-
cond light source 82 to emit a return light pulse 80.
The duration of the light pulse 80 is a function of the
20 physical parameter p . The light pulse 80 is directed to
the end face of the fiber optical cable 24 and forwarded
to the evaluation circuitry 42.

While the forms of the fiber optical sensor system herein
25 described constitute preferred embodiments of the inven-
tion, it is to be understood that the invention is not
limited to these precise forms of assembly, and that a
variety of changes may be made therein without departing
from the scope of the invention.

WHAT IS CLAIMED IS:

- 1 1. A fiber optical sensor system for transmission
2 of information from one location to another, comprising
3 in combination:
- 4 a) a fiber optical transmission⁽⁶⁾ line having
5 a first end and at least one second end for
6 transmitting light therebetween,
- 7
8 b) a first light source⁽¹⁰⁾ for emitting a first
9 light beam into said first end of said trans-
10 mission line;⁽⁶⁾
- 11
12 c) at least one first receiver element⁽⁴⁶⁾ sensi-
13 tive to the light of said first light source (10)
14 for receiving light of said first light source (10)
15 from said second end of said transmission line (6)
16 and for generating a first electric output sig-
17 nal in accordance with the light received;
- 18
19 d) electrical energy storage means⁽⁵⁶⁾ connected
20 to said first receiver element⁽⁴⁶⁾ for receiving
21 said first electric output signal and for stor-
22 ing energy in accordance therewith;
- 23
24 e) a second light source⁽⁸²⁾ for emitting a second
25 light beam into said second end of said trans-
26 mission line,⁽⁶⁾ said second light source⁽⁸²⁾ being
27 energized from said electrical energy storage
28 means⁽⁵⁶⁾ and being controlled in dependence upon
29 information to be transmitted; and
- 30
31 f) a second receiver element⁽⁹⁰⁾ sensitive to the
32 light of said second light source⁽⁸²⁾ for receiving
33 light of said second light source⁽⁸²⁾ from said
34 transmission line⁽⁶⁾ and for generating a second
35 electric output signal in accordance with the

36 light received and thereby in accordance with
37 the transmitted information.

1 2. The fiber optical sensor system according to
2 claim 1, ~~characterised in that~~ ⁽¹⁰⁾ wherein said first light source is operative to
3 emit repeatedly charge pulses, said charge pulses being
4 received by said first receiving element ⁽⁴⁶⁾ for supplying
5 said energy storage means ⁽⁵⁶⁾ with electrical power.

1 3. The fiber optical sensor system according to
2 claim 1, ~~characterised by~~ ⁽⁸²⁾ at least one electronic com-
3 ponent in addition to said second light source ⁽⁵⁶⁾, connected
4 to be energized from said energy storage means.

1 4. The fiber optical sensor system according to
2 claim 1, ~~characterised in that~~ ⁽⁵⁶⁾ wherein said energy storage means comprises a
3 storage capacitor connected to said first receiver ele-
4 ment ⁽⁴⁶⁾ for deriving electrical charges from said first re-
5 ceiving element ⁽⁴⁶⁾ and for storing said charges when said
6 first light source ⁽¹⁰⁾ emits said first light beam.

1 5. The fiber optical sensor system according to
2 claim 4, ~~characterised in that~~ ⁽⁴⁸⁾ wherein a diode is connected between said stor-
3 age capacitor and said first receiver element ⁽⁴⁶⁾.

1 6. The fiber optical sensor system according to
2 claim 1, ~~characterised by~~ ⁽⁶⁰⁾ ~~wherein~~ a transducer unit containing
3 a sensor element for receiving said information to be
4 transmitted and for supplying an electric sensor output
5 signal in accordance therewith, said transducer unit ⁽⁶⁰⁾ be-
6 ing connected to and controlling said second light source ⁽⁸²⁾.

1 7. The fiber optical sensor system according to
2 claim 1, ~~characterised in that~~ ^(p1-p4) wherein said information to be transmitted is
3 information about a physical parameter to be measured.

1 8. The fiber optical sensor system according to
characterised in that (60)
2 claim 7, wherein said transducer unit comprises an RC
(62) (64)
3 combination containing a resistor and a capacitor, the
4 time constant of said RC combination being dependent on
5 said physical parameter to be measured.

1 9. The fiber optical sensor system according to
characterised in that (60)
2 claim 8, wherein said transducer unit further comprises:
3 1) means (64) for changing the charge of said
4 capacitor in accordance with said time constant,
5 said means being actuated by an initiation sig-
6 nal (1) issued at a first point of time;
7 2) means (78) (64) for sensing the voltage of said
8 capacitor and for determining a second point
9 of time, said second point of time being the
10 point of time when said capacitor voltage has
11 reached a predetermined value; and
12 3) means (82) for actuating said second light source, (82)
13 said second light source emitting a light pulse
14 when said capacitor voltage has reached said
15 predetermined value and said light pulse being
16 transmitted from said second end to said first
17 end of said optical transmission line;
18 and wherein said fiber optical sensor system further com-
19 prises:
20 means connected to said second receiver ele-
21 ment for measuring the difference between said
22 first and said second point of time, said time
23 difference being a function of said physical
24 parameter to be measured.

1 10. The fiber optical sensor system according to
characterised in that
2 claim 9, wherein said means for changing the charge of
(64)
3 said capacitor of said RC combination comprises a volt-
4 age source (64) for charging said capacitor through said re-
(62)
5 sistor of said RC combination.

1 11. The fiber optical sensor system according to
 2 characterised in that
 3 claim 10, ~~wherein~~ said means for changing the charge of
 4 said capacitor⁽⁶⁴⁾ additionally comprises means for discharging
 5 said capacitor⁽⁶⁴⁾.

1 12. The fiber optical sensor system according to
 2 characterised in that⁽⁶⁰⁾
 3 claim 8, ~~wherein~~ said transducer unit contains said re-
 4 sistor and said capacitor in a series connection, where-
 5 in said series connection is coupled to a supply voltage
 6 source through first switching means⁽⁷⁰⁾, and wherein control
 7 means are provided for controlling said first switching
 8 means⁽⁷⁰⁾ in dependence on an initiation signal⁽¹⁾.

1 13. The fiber optical sensor system according to
 2 characterised in that⁽⁶²⁾
 3 claim 8, ~~wherein~~ said resistor in said RC combination has
 4 a resistance which is dependent on said physical parameter.

1 14. The fiber optical sensor system according to
 2 characterised in that⁽⁶⁴⁾
 3 claim 8, ~~wherein~~ said capacitor in said RC combination
 4 has a capacitance which is dependent on said physical
 5 parameter.

1 15. The fiber optical sensor system according to
 2 characterised in that
 3 claim 10, ~~wherein~~ said voltage source for charging said
 4 capacitor⁽⁶⁴⁾ is formed by said energy storage means⁽⁵⁶⁾.

1 16. The fiber optical sensor system according to
 2 characterised in that
 3 claim 1, ~~wherein~~ at least one of said receiver elements
 4 is a photo diode.

1 17. The fiber optical sensor system according to
 2 characterised in that
 3 claim 1, ~~wherein~~ at least one of said light sources is
 4 a light emitting diode.

1 18. The fiber optical sensor system according to
 2 characterised in that
 3 claim 11, ~~wherein~~ said means for changing the charge of
 4 said capacitor⁽⁶⁴⁾ comprises a first voltage source of a

4 predetermined polarity for charging said capacitor and
5 a second voltage source of reverse polarity for subse-
6 quently discharging said capacitor. (64)

1 19. The fiber optical sensor system according to
2 characterised in that (66,68)
3 claim 18, ~~wherein~~ two resistors are connected across a
4 supply voltage source to form a voltage divider, and
5 wherein one of said resistors is connected to form said
6 first voltage source and the other one of said resistors
7 is connected to form said second voltage source.

1 20. The fiber optical sensor system according to
2 characterised in that (74)
3 claim 18, ~~wherein~~ second switch means are connected be-
4 tween said second voltage source and said capacitor of (64)
5 said RC combination.

1 21. The fiber optical sensor system according to
2 characterised in that (76)
3 claim 20, ~~wherein~~ a delay member is provided for con-
4 trolling said second switch means (74) such as to apply said
5 voltage of reverse polarity to said capacitor at a pre- (64)
6 determined period of time after said initiating signal (1)
7 was issued.

1 22. The fiber optical sensor system according to
2 characterised in that (56)
3 claim 1, ~~wherein~~ said energy storage means is connected
4 to said second light source through third switch means, (82) (84)
5 whereby said energy storage means supplies said second
6 light source with electric energy for emission of said (56)
7 second light beam when said third switch means is in an (84)
8 ON position.

1 23. The fiber optical sensor system according to
2 characterised in that (56)
3 claim 9, ~~wherein~~ said energy storage means is connected
4 to said second light source through third switch means, (82) (84)
5 whereby said energy storage means supplies said second
6 light source with electric energy for emission of said (56)
7 light beam when said third switch means is in an (84)
8 ON position.

6 second light beam when said third switch means⁽⁸⁴⁾ is in an
7 ON position, and wherein said third switch means⁽⁸⁴⁾ is actu-
8 ated by said voltage sensing means⁽⁷⁸⁾.

1 24. The fiber optical sensor system according to
2 characterised in that ~~for the purpose of~~ output means for delivering
3 an output signal in dependence on said time difference
4 and thereby in dependence on said physical parameter.

1 25. The fiber optical sensor system according to
2 characterised in that ~~wherein~~ ⁽⁸⁸⁾ an encoder is provided for controlling
3 said first light source ⁽¹⁰⁾ as to emit a series of coded
4 light pulse patterns, wherein a plurality of receiver
5 elements ⁽⁴⁶⁾ is optically connected to said fiber optical
6 transmission line ⁽⁶⁾, wherein an individual decoder ⁽⁷²⁾ is con-
7 nected to each of said receiver elements ⁽⁴⁶⁾, whereby a pre-
8 determined and individualized pulse pattern is associated
9 with each individual decoder ⁽⁷²⁾, each of said decoders ⁽⁷²⁾ de-
10 coding said coded pulse patterns and issuing an initia-
11 tion signal ⁽¹⁾ to said means for changing the charge when
12 the coded pulse pattern received equals its predetermined
13 and individualized pattern.

1 26. The fiber optical sensor system according to
2 characterised in that ~~wherein~~ ⁽⁸⁸⁾ said encoder is connected to control
3 said first light source ⁽¹⁰⁾ such that at first a storage
4 pulse and subsequently said series of coded light pulse
5 patterns are emitted from said first light source ⁽¹⁰⁾.

1 27. The fiber optical sensor system according to
2 characterised in that ~~wherein~~ at least said first receiver element ⁽⁴⁶⁾
3 and said second light source ⁽⁸²⁾ are arranged in a metal
4 housing ⁽¹²⁰⁾.

1 28. The fiber optical sensor system according to
2 characterised in that ~~wherein~~ ⁽⁸²⁾ said second light source is mounted on
3 said first receiver element ⁽⁴⁶⁾.

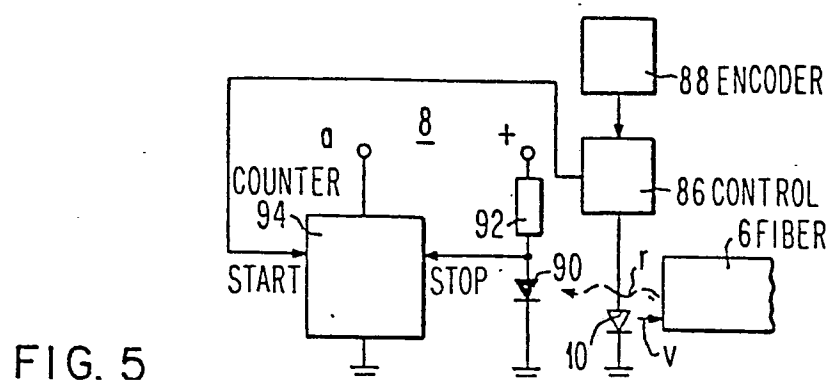
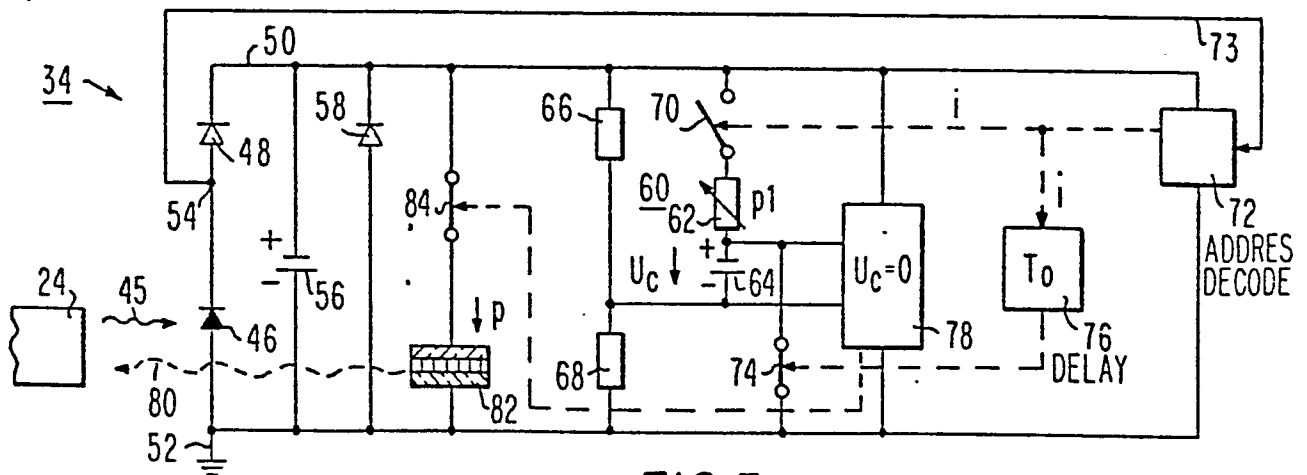
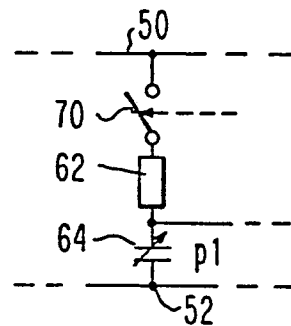
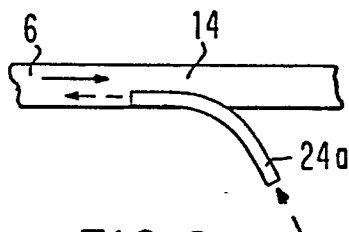
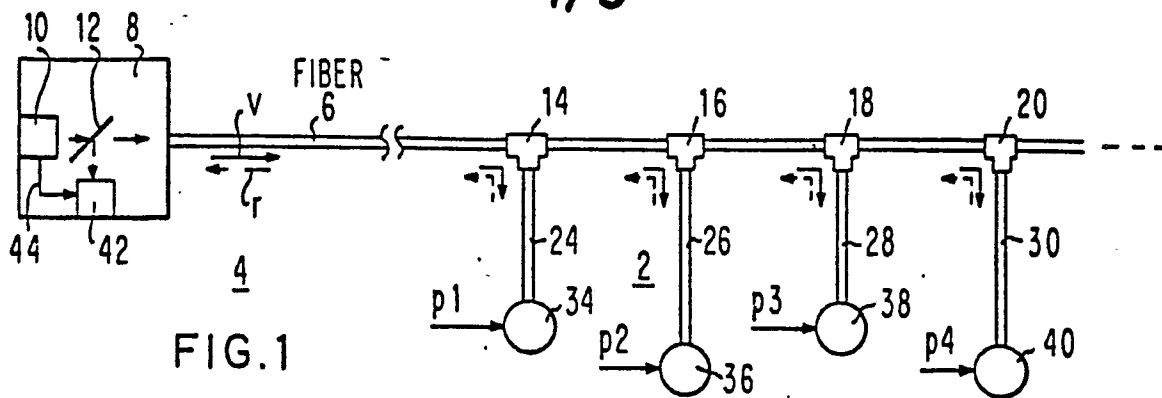
1 29. The fiber optical sensor system according to
characterised in that (90)
2 claim 1, ~~wherein~~ said second receiver element is arranged
3 for receiving light from said first end of said trans-
4 mission line (6).

1 30. The fiber optical sensor system according to
characterised in that (60)
2 claim 1, ~~wherein~~ said transducer unit is connected to
3 transform said information into a corresponding electrical
4 quantity, and wherein said second light source is connected (82)
5 to transform said electrical quantity into an optical quan-
6 tity.

1 31. The fiber optical sensor system according to
characterised by (132)
2 claim 1, ~~comprising~~ a pulse width modulator con- (130)
3 nected between said sensor and said second light source (82)
4 for supplying control pulses for controlling said second
5 light source, the width of said control pulses being de- (82)
6 termined by said information to be transmitted.

1 32. The fiber optical sensor system according to
characterised in that (60)
2 claim 1, ~~wherein~~ said transducer unit is determined to
3 measure a physical parameter in an automobile.

1/3



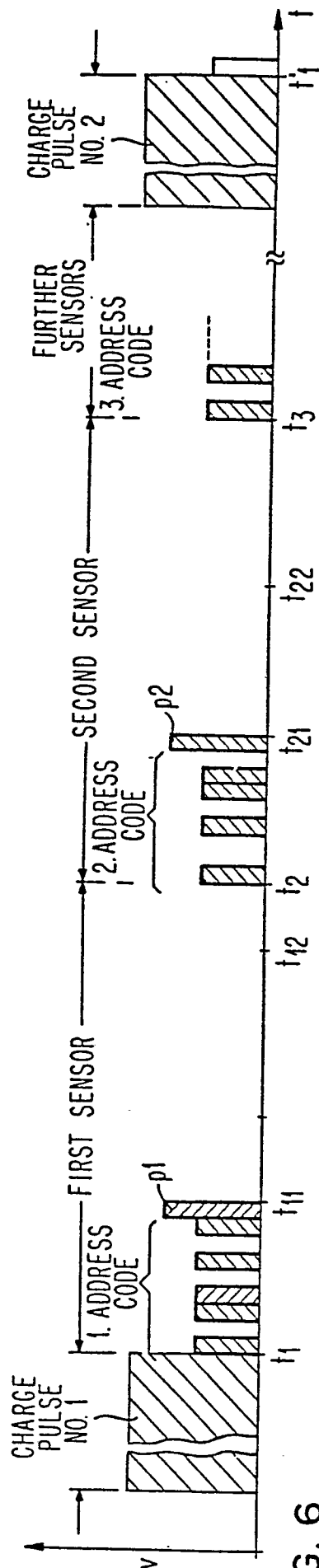


FIG. 6

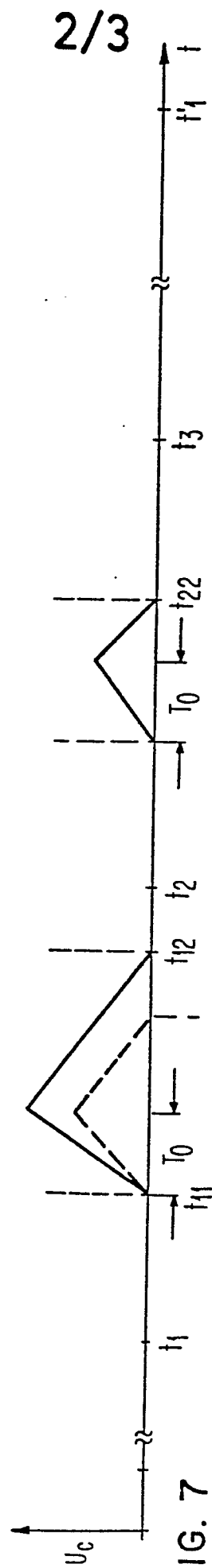


FIG. 7

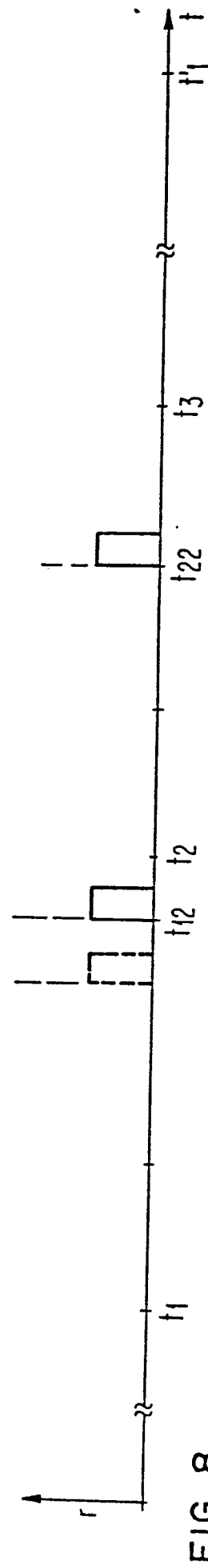


FIG. 8

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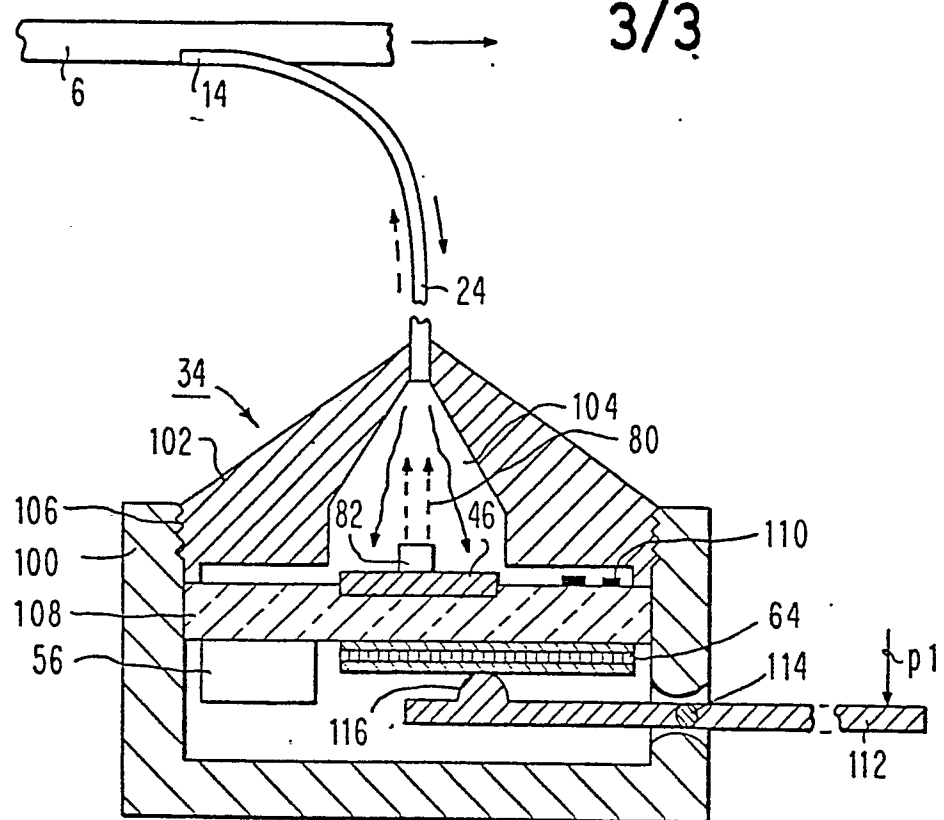


FIG. 9

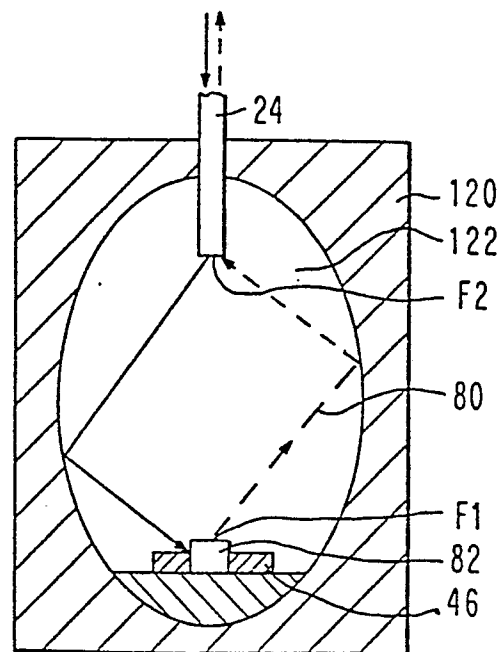
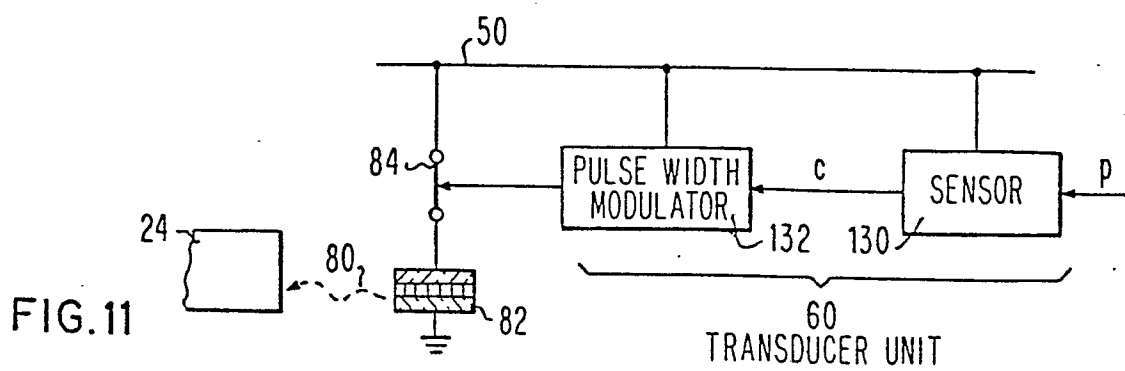


FIG. 10





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EUROPÄISCHER RECHERCHENBERICHT

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Nummer der Anmeldung

EP 81 11 0054

EINSCHLÄGIGE DOKUMENTE			KLASSIFIKATION DER ANMELDUNG (Int. Cl.)
Kategorie	Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	betrifft Anspruch	
X	THE BELL SYSTEM JOURNAL, Band 58, Nr. 7, September 1979, Seiten 1735-1741 New York, U.S.A. R.C. MILLER et al.: "Optically powered speech communication over a fiber lightguide"	1,3,4, 6,16, 17,29-31	H 04 B 9/00 12/00 B 60 R 16/04
Y	* Seite 1735, Zeile 19 - Seite 1737, Zeile 22; Seite 1739, Zeile 11 - Seite 1740, Zeile 15; Seite 1740, Zeile 40 - Seite 1741, Zeile 1; Figuren 1,2 *	2	
--			RECHERCHIERTE SACHGEBIETE (Int. Cl.)
Y	LASER FOCUS, Band 15, Nr. 1, Januar 1979, Seiten 48-50 Newton	2	H 04 B 9/00 G 08 C 23/00 G 01 R 15/07 H 04 Q 9/14 B 60 R 16/04 H 04 B 12/00
A	"Bell Labs builds a light-powered phone around efficient photocell and ringer" * Seite 49, Zeilen 6-11; Seite 49, Zeilen 24-37 *	1,16, 17,24, 26	
--			
A	DE - A - 2 839 127 (BBC) * Seite 4, Zeile 31 - Seite 6, Zeile 11 *	1,32	
--			KATEGORIE DER GENANNTEN DOKUMENTE
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EUROPÄISCHER RECHERCHENBERICHT

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