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NOTICE OF ENTITLEMENT

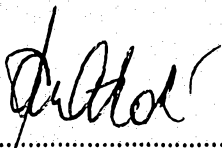
We, Reiner SZEPAN and Karl Stefan RIENER of Elektrastrasse 26a, D-8000 Munchen 81, Germany and Mullerviertel 20, A-4563 Micheldorf Austria, respectively, being the applicant in respect of Application No. 36900/89 state the following:-

The first Person nominated for the grant of the patent: Reiner SZEPAN, is the actual inventor, the second Person nominated for the grant of the patent Karl Stefan RIENER has entitlement to a share in the invention from the actual inventor by assignment.

Reiner SZEPAN is the applicant of the application listed in the declaration under Article 8 of the PCT.

The basic application listed on the request form is the first application made in a Convention country in respect of the invention.

By our Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS



.....
Ian A. Scott

Registered Patent Attorney

30 January 1991

.....
(Date)

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(54) Title
PROCESS AND DEVICE FOR SPECTROSCOPIC QUANTITATIVE DETERMINATION OF GASES IN GAS MIXTURES

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(56) Prior Art Documents
US 4441815
US 4410273
AU 496468 87586/75 G01J 3/42 G01M 15/00 G01N 21/61

(57) Claim

1. A method of quantitative analysis of the concentration of a gas component of a gas mixture, in which the gas mixture is periodically alternating impinged with light of at least two wavelengths each emitted from a monochromatic light source, the light of at least one wavelength being characteristic and the light of at least one other wavelength being uncharacteristic of the transmission of the gas to be determined, wherein the intensity of the radiation which exits the gas mixture is measured, characterised in that the intensity of at least one uneven Fourier component of the periodically alternating light will be measured, said measured intensity of the at least one uneven Fourier component being proportional to the concentration of the gas component in the gas mixture to be determined.

9. An apparatus for spectroscopic quantitative analysis of gases in gas mixtures, comprising a monochromatic light source which emits periodically alternating light of at least two wavelengths, the light of at least one wavelength being characteristic and the light of at least one other wavelength being uncharacteristic of the transmission of the gas to be determined;

a measuring section which contains the gas to be measured and an optical reference section for generating, during said transmission, electrical signals including

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harmonic components of at least one uneven Fourier frequency of an emission period the amplitude of which is proportional to the concentration of the gas to be determined in the gas mixture so as to determine electrical signals which are proportional to the concentration of the gas in the measuring section.

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(81) Bestimmungsstaaten: AT (europäisches Patent), AU, BE (europäisches Patent), BR, CH (europäisches Patent), DE (europäisches Patent), DK, FI, FR (europäisches Patent), GB (europäisches Patent), HU, IT (europäisches Patent), JP, KR, LU (europäisches Patent), NL (europäisches Patent), NO, RO, SE (europäisches Patent), SU, US.

Veröffentlicht

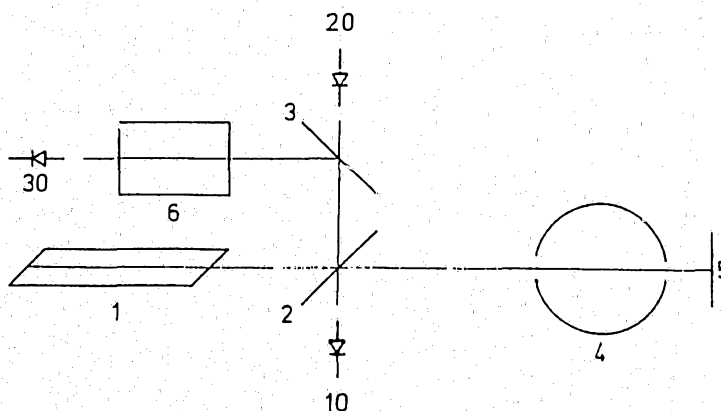
Mit internationalem Recherchenbericht.

(54) Title: PROCESS AND DEVICE FOR SPECTROSCOPIC QUANTITATIVE DETERMINATION OF GASES IN GAS MIXTURES

(54) Bezeichnung: VERFAHREN UND VORRICHTUNG ZUR SPEKTROSKOPISCHEN MENGENBESTIMMUNG VON GASEN IN GASGEMISCHEN

(57) Abstract

The invention concerns a process and a device for the spectroscopic quantitative determination of gases (4) in gas mixtures, in which periodically alternating monochromatic light (1) of at least two wavelengths is used. The light (1) of at least one wavelength is characteristic, and the light (1) of at least one other wavelength is uncharacteristic, of the transmission of the gas to be determined. This transmission generates electrical signals containing harmonic components of at least one nonlinear Fourier frequency of an emission period, the amplitude of which is proportional to the concentration of the gas (4) to be determined in the gas mixture, and decreased as the concentration increases.



(57) Zusammenfassung

Die Erfindung betrifft ein Verfahren sowie eine Vorrichtung zur spektroskopischen Mengenbestimmung von Gasen (4) in Gasgemischen, bei dem periodisch alternierend monochromatisches Licht (1) wenigstens zweier Wellenlängen benutzt wird, wobei das Licht (1) wenigstens einer Wellenlänge charakteristisch, und das Licht (1) wenigstens einer anderen Wellenlänge uncharakteristisch für die Transmission des zu bestimmenden Gases ist, wobei diese Transmission elektrische Signale erzeugt, welche harmonische Anteile mindestens einer ungeraden Fourier-Frequenz einer Emissionsperiode beinhalten, deren Amplitude proportional der Konzentration des zu bestimmenden Gases (4) im Gasgemisch ist, und mit der Konzentration verschwindet.

Specification

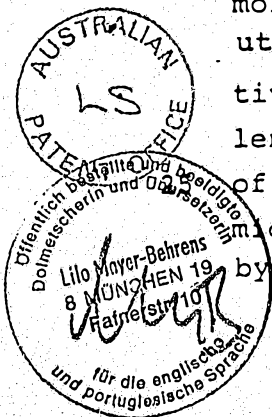
Process and Device for Spectroscopic Quantitative Determination of Gases in Gas Mixtures

The invention relates to a method according to the characteristic features of the preamble of claim 1 and to an apparatus according to the characteristic features of claim 6.

- 5 The quantitative analysis of gases in gas mixtures is made on the basis of the absorption of radiation having a wavelength which is characteristic of the gas in question. Molecular gases dispose in particular of a pronounced characteristic for that purpose in the far infrared region.
- 10 Spectral distinction of the characteristic absorption by the gas to be analyzed from background radiation or from the uncharacteristic radiation damping along the transmission path is obtained by periodically sequencing the emission from a suitable source of radiation according to conventional analytical procedures at a wavelength which is
- 15 characteristic of the particular gas and at a respective adjacent unspecific wavelength, with respective interruptions.

Lasers offer themselves as radiation sources; a dye laser

20 is suitable for use in the visible region and a suitable molecular gas laser in the infrared region. The latter utilize the vibrational-rotational transitions of the respective gases. The molecular gas laser is set to the wavelengths of the respective desired emission lines by means of a resonator mirror or optical grating supported by a micropositioning means. The microposition can be controlled by electrical signals for generating the periodic emission



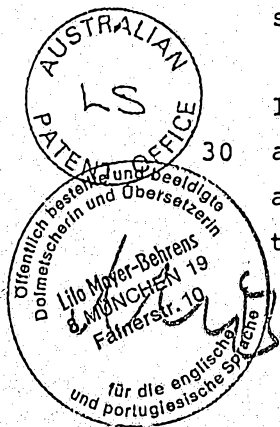
sequence at different wavelengths.

In this context the quantitative analysis of ammonia in flue gases is of industrial-scale importance. Flue gases are produced with every atmospheric combustion and together with them necessarily also nitrogen oxides NO_x . The latter, on the one hand, can be reduced to products which are free of noxious components by feed ammonia. On the other hand, the so-called "slip", in other words a noticeable excess of ammonia is undesired.

10 By law of nature one line each of the vibration-rotation bands of ammonia and $^{13}\text{C}^{16}\text{O}_2$ coincide at wavelength $9.89 \mu\text{m}$ within the line widths at normal or operating conditions of a furnace. Therefore, the absorption of the radiation of a tuned $^{13}\text{C}^{16}\text{O}_2$ laser in a gas mixture in-
15 forms about the content of ammonia.

If the gas to be analyzed - in the instant case ammonia in flue gas - is present in traces, the specific and un-specific absorptions in the laser emission sequence differ only little so that the transmission signals of the sequence are only little different from one another and, in addition, contain incoherent signal noise contributions from the laser emission, the noise in the measuring section and in the detector means. These circumstances make it necessary to apply long signal integration times in
20 order to obtain the signal reliability as required, for instance, in industrial applications. That, on the other hand, means that the arrangement must meet high operational stability requirements.

It is the object of the invention to develop a method and an apparatus of the generic kind in question such that
30 a certain porportion of gas in a gas mixture can be determined better.



1 The object is met, as far as the method is concerned, by the characterizing features of claim 1 and, as far as the apparatus is concerned, by the characterizing features of claim 6.

5 In an advantageous embodiment of the method according to the invention the harmonic signal components of at least one uneven Fourier frequency and those of an even Fourier frequency are related to each other and the relationship thus established is a measure of the characteristic absorption.

10 With another advantageous embodiment of the method according to the invention the second Fourier component of the electrical signal becomes the maximum.

15 With another advantageous embodiment of the method according to the invention the emission of the radiation pulses used is effected each at constant energy, and the pulse center spacing corresponds to half the emission period.

20 With another advantageous embodiment of the method according to the invention the emissions of both transmissions producing the different wavelengths are of the same duration and are separated by phases of the same duration which are free of emissions.

25 In the case of another advantageous embodiment of the method according to the invention the respective emission phases and the emission-free phases are of equal duration.

30 With an advantageous embodiment of the apparatus according to the invention the gas is ammonia and the light source is a laser, especially a $^{13}\text{C}^{16}\text{O}_2$ laser which emits periodically alternating radiation of the quantum mechanical P8II transition of the vibration-rotation spectrum and of an adjacent transition (e.g. P6II or P10II).

Another advantageous embodiment of the apparatus according to the invention comprises a circuit means for adapting the electrical signal to one another.



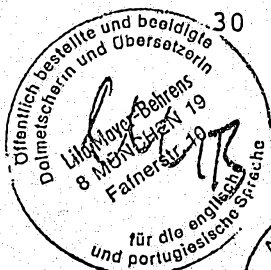
In the case of another advantageous modification of the apparatus according to the invention the duration of emission of the higher energy of laser 1 is decreased or increased, centered about the middle.

- 5 Another advantageous embodiment of the apparatus according to the invention includes an infrared detector comprising signal amplitudes which originate from the wavelength sequenced laser emission and from the transmission of a gas containing ammonia, respectively. And a symmetry
10 try mixing circuit is provided which is linked with a signal of the second Fourier frequency of the emission period.

- With another advantageous embodiment of the apparatus according to the invention the above mentioned mixed products, having been filtered in a device, are subjected to
15 synchronous rectification which is controlled by a signal of the first Fourier frequency of the emission period.

- Another advantageous modification of the apparatus according to the invention comprises a quotient circuit by means
20 of the signal ratios of which a magnitude which is independent of the emission intensity of the light source and of the non-spectral transmission reductions is produced from the filtered rectifier products and from the equal share of the mixed product.

- 25 With another advantageous modification of the apparatus according to the invention the signal amplitudes of an infrared detector originating from the wavelength sequenced emission of the light source are applied, as the error signal, to a proportional control loop which adjusts the sequential amplification of the signal of the infrared
30 detector or the duration of emission.



1 In the case of another advantageous embodiment of the
apparatus according to the invention an optical resonator
of the laser is modulated periodically as to wavelength,
and the resulting modulation
5 frequency signal components of an infrared detector, as a
consequence of the laser emission variation, serve as er-
ror magnitude in an integral control loop to maximize the
respective emissions.

10 Another advantageous modification of the apparatus accord-
ing to the invention comprises a reference cuvette through
which the wavelength sequenced emission of the laser ra-
diates, an operational characteristic magnitude being pro-
duced which is proportional to the reference gas quantity.

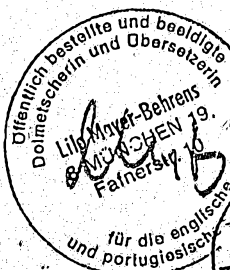
15 The invention will be described further, by way of example,
with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic presentation of the optical ar-
rangement according to the invention;
20 Fig. 2 is a diagrammatic circuit arrangement for the quan-
titative gas analysis;
Fig. 3 is a diagrammatic circuit arrangement for signal
conditioning;
Fig. 4 is a diagrammatic circuit arrangement for gauging;
25 Fig. 5 shows electronic signal patterns.

Fig. 1 shows a laser 1 radiating a gas 4 to be analyzed
through an analysis space. The laser generates a periodic
sequence of two emissions 40, 41 separated by pauses or at
30 least by attenuation phases 42 and each having a respec-
tive associated wavelength, as illustrated in fig. 5. This
period is referred to below as the emission period and
the reciprocal value of integer partial ratios of the emission
period is designated Fourier frequency of the order correspond-
ing to the partial ratio.

35

It is advantageous to determine the quantity of ammonia
gas, for instance, in flue gases by the emission of the
quantum mechanical transition P8II of the vibration-rotation
spectrum of a $^{13}\text{C}^{16}\text{O}$ laser, as the characteristic

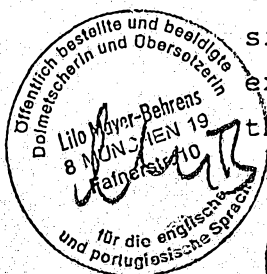


proof, because of the selective properties and the efficiency thereof.

The narrow-band coherent signal process methods of the instant invention are used in addition to the dominant emission level of the laser 1 and the noise signal superpositioning for the technical signal process domination of the variation in transmission which is differentially small and appears because of the absorption of the gas 4 to be analyzed in an optical measuring section (beam splitter 2, analysis space containing gas 4, retroreflector 5, radiation detector 10). Accordingly, an alternating electrical signal is generated which has the frequency of an uneven Fourier component of the emission period, the amplitude thereof being proportional to the laser emission energy and the transmission losses, resulting from the characteristic absorption, and disappearing with the characteristic transmission losses. Moreover, an electrical signal is generated which has the frequency of an even Fourier component of the emission period, the amplitude thereof being proportional to the energy of at least one emission pulse. That requires conditioning of the emission or of the electrical signals which are obtained by suitable radiation detectors 10,20,30 including amplifiers, as the receivers of the emission.

25 This signal conditioning is accomplished in two ways by control arrangements such as shown in fig. 3, for example, resorting to a separate optical section 2,20 which contains no shares of the gas 4 to be found and to a separate electrical signal section 20...29.

30 As shown in fig. 5, the centers of two radiation pulses 40,41 of constant energy each are spaced by half the emission period. The radiation pulse 40 of higher energy is extended or shortened, centered about the middle, such that the first Fourier component of the emission period



disappears at the detector 30. Component parts 11,12,13, 21,22,23 31,32,33 which will be explained in greater detail below do not apply here.

The spacing between centers of the two radiation pulses
5 40,41 of constant energy each corresponds to half the emission period. A summing amplifier 23 takes care of an adaptive rise of the gain of the weaker pulse 41 at the detector 20 and of an adaptive attenuation of the stronger pulse by switching on (22) or off an electronic potentiometer 21 in the associated emission phase 7 so that the
10 first Fourier component 44 and 43, respectively, of the emission period will disappear at the output of the amplifier 23.

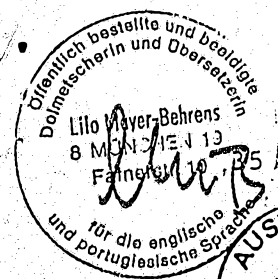
The conditioned signal mixture at the input of the symmetry mixing circuit 24 is mixed in the same with a signal
15 8 of the second Fourier frequency of the emission period. The signal components of this particular frequency disappear or are attenuated so that all that is available beyond the filter circuit and an optional amplifier circuit 25 is signal components of the first Fourier frequency of the emission period which components originate from detuning of the signal conditioning according to fig. 3. The magnitude and sign of such signal components are given by the output signal 28 of the synchronous rectifier 26
20 which is switched by a signal of the first Fourier frequency 9 of the emission period. The rectifier signals 24, 26 are smoothed in low pass filter circuits 27,28, the sum group delay time of the filters 25,28 corresponding to the group delay time of the filter 27. A quotient circuit 29 supplies a control error which is independent
30 of the radiation intensity and influences the adjusting members (micropositioning or potentiometer 43) by way of a control circuit 45 such that the first Fourier component disappears at the mixer input 24.



The gas-characteristic attenuation of transmission along the measuring section 2,4,5,10 is a measure of the concentration of the gas 4 to be analyzed. In accordance with the invention this magnitude is represented, after the
5 signal conditioning 20...29,45, as an electrical signal of an uneven - preferably the first - Fourier frequency of the emission period. The structure of the measuring signal section 10...19 shown in fig. 2 corresponds identically to that of the conditioning section 20...29.

10 The radiation detector 10 measures the wavelength specific transmission of the gas 4 to be examined and amplifies it, if desired. As the emission energies of the pulses 40,41 differ, at the wavelengths applied, a pulse width correction is effected by the conditioning, or the summing amplifier 13 carries out an adaptive raising of the amplification of the weaker emission signal or an adaptative
15 weakening of the stronger emission signal by switching on 12 or off an electronic potentiometer 11 in the associated emission phase 7 which potentiometer is synchronized with potentiometer 21.
20

The existence of signal components of the first Fourier frequency in the mixed products 15 is due solely to the specific radiation absorption of the gas 4 to be analyzed once the conditioning 20...29,45 has been completed. Their
25 magnitude is proportional to the concentration of the gas 4 to be analyzed. In applying this coherent analytical procedure it becomes possible by the invention to isolate a very weak signal specific of a gas, apart from the dominant emission signal. The signal of the first Fourier
30 frequency of the emission period is separated by a filter 15 from the mixed products and amplified, if desired. Finally, the gas-specific useful signal is applied to the synchronous rectifier 16 which is switched by the first Fourier frequency and which thus reflects the intensity
of the useful signal characteristic of the gas. The quo-

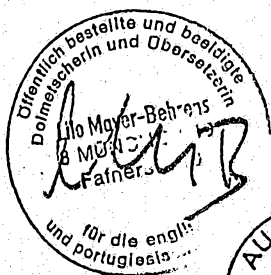


tient 19 of the filtered signals 17,18 represents a process magnitude which is independent of the intensity, proportional to the concentration of the gas 4 to be analyzed and also highly resolved, thanks to the coherent signal processing technique. The contributions from incoherent signal noise components are reduced by this method and apparatus for the selective spectroscopic quantitative analysis of gases in gas mixtures so that rapid, reliable data sequences 19 are available which are needed for industrial application.

A problem of apparatus stability crops up when using lasers 1 as the source of radiation involving the centering of the optical resonator or filter to the respective emission maxima. The micropositioning means carrying the resonator or filter and being driven electrically carries out swinging motion which causes the alternating emission of radiation of at least two wavelengths. A periodic small slower motion is superposed over that swinging motion. The spectral signal component of the frequency of this scanning motion in the error signal 29 of the proportional control circuit 45 for conditioning, furthermore, represents an error signal of the integral control for micropositioning to obtain the maximum emission.

Another problem of apparatus stability is involved in the start-up of the process and apparatus for the selective spectroscopic quantitative analysis of gases 4 in gas mixtures. This problem is solved in accordance with the invention by a reference section 1,2,3,6,30. This solution of the problem is of the greatest significance when setting into operation redundant systems with operational tasks.

A beam splitter 3 couples a part out of the laser radiation emitted and this part impinges on the beam detector 30 after having passed through a cuvette 6 which contains



the gas to be analyzed. The signal processing 30...39 corresponds to that of the useful signal section 10...19 or conditioning section 20...29. The circuit arrangement generates a signal 39 which is coordinated within given
5 tolerance limits with a calibration quantity in the cuvette 6.

The maladjustment of the laser arrangement essentially is due to the aging of component parts and to thermal influences. Upon switch-on a search run is started which may
10 be processor controlled, if desired, and which searches the range of the wavelength-harmonizing micropositioning means of the laser 1 for the reference condition in the reference section 3, 6, 30 and effects the operational positioning.

The arrangement 2...45 may be designed such that the
15 emission of another laser is coupled into the arrangement if the operational laser 1 should fail.

The determination of the absolute quantity of the ammonia contained in the gas 4 to be analyzed is calculated in a signal process computer based on the process measuring
20 data 29, the emission width of the laser 1, the absorption width of the ammonia vapor, and the line shift of the laser emission and the ammonia absorption.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of quantitative analysis of the concentration of a gas component of a gas mixture, in which the gas mixture is periodically alternating impinged with light of at least two wavelengths each emitted from a monochromatic light source, the light of at least one wavelength being characteristic and the light of at least one other wavelength being uncharacteristic of the transmission of the gas to be determined, wherein the intensity of the radiation which exits the gas mixture is measured, characterised in that the intensity of at least one uneven Fourier component of the periodically alternating light will be measured, said measured intensity of the at least one uneven Fourier component being proportional to the concentration of the gas component in the gas mixture to be determined.
2. The method as claimed in claim 1, wherein a ratio is established between the harmonic signal components of at least one uneven Fourier component and those of an even Fourier component, said ratio being a measure of absorption by the gas component of radiation of said characteristic wavelength.
3. The method as claimed in claim 2, wherein the even Fourier component becomes the maximum.
4. The method as claimed in any one of claims 1 to 3, wherein the emission of the periodically alternating light is pulsed and said pulses are emitted at a constant rate.
5. The method as claimed in claim 4, wherein the pulse centres of said pulses are spaced by half the emission period.
6. The method as claimed in any one of the preceding claims, wherein the emissions of both transitions which produce the light of at least two wavelengths are each of the same duration and are each separated by emission-free phases of equal duration.
7. The method as claimed in any one of the preceding claims, wherein the gas component is ammonia.
8. The method as claimed in any one of the preceding claims, wherein the monochromatic light source is a $^{13}\text{C}^{16}\text{O}_2$ laser which periodically alternatingly emits



radiation of the quantum mechanical P8II transition of the vibration-rotation spectrum and of an adjacent transition.

9. An apparatus for spectroscopic quantitative analysis of gases in gas mixtures, comprising a monochromatic light source which emits periodically alternating light of at least two wavelengths, the light of at least one wavelength being characteristic and the light of at least one other wavelength being uncharacteristic of the transmission of the gas to be determined;

a measuring section which contains the gas to be measured and an optical reference section for generating, during said transmission, electrical signals including harmonic components of at least one uneven Fourier frequency of an emission period the amplitude of which is proportional to the concentration of the gas to be determined in the gas mixture so as to determine electrical signals which are proportional to the concentration of the gas in the measuring section.

10. The apparatus as claimed in claim 9, wherein the gas is ammonia and the light source is a $^{13}\text{C}^{16}\text{O}_2$ laser which periodically alternately emits radiation of the quantum mechanical P8II transition of the vibration-rotation spectrum and of an adjacent transition.

11. The apparatus as claimed in claim 9, wherein a circuit means is provided by which the electrical signals are adapted to one another.

12. The apparatus as claimed in claim 10, wherein the duration of emission of the higher energy of the laser is decreased.

13. The apparatus as claimed in claim 10, wherein an infrared detector is measuring signal amplitudes which result from the wavelength sequenced laser emission or the transmission of a gas containing ammonia, and a symmetry mixing circuit is provided which is linked with a signal of an even Fourier frequency of the emission period.

14. The apparatus as claimed in claim 10, further comprising a filter device and a synchronous rectifier, wherein mixed electrical signals, produced when the light impinges on a detector, are filtered in the filter device and are subjected to synchronous rectification in said rectifier, said rectifier being controlled by a signal of the uneven Fourier frequency of the emission period.



15. The apparatus as claimed in claim 14, further comprising a quotient circuit, by means of the signal ratios of which a magnitude, which is independent of the emission intensity of the light source and of the non-spectral transmission reductions, is produced from filtered rectifier products and from the equal share of the mixed electrical signals.

16. The apparatus as claimed in claim 9, further comprising an infrared detector for supplying the signal amplitudes resulting from the wavelength sequenced emission of the light source, as an error signal, to a proportional control loop which adjusts a sequential amplification of the signal from the infrared detector.

17. The apparatus as claimed in claim 10, wherein an optical resonator of the laser is modulated periodically as a wavelength, and further comprising an infrared detector, wherein the resulting modulation frequency signal components of the infrared detector due to the laser emission variation serve as an error magnitude in an integral control loop to maximise the respective emissions.

18. The apparatus as claimed in claim 10, wherein a reference cuvette is provided through which the wavelength sequenced emission of the laser radiates to produce an operational characteristic magnitude which is proportional to the reference gas quantity.

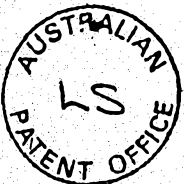
19. The apparatus as claimed in claim 10, wherein the duration of emission of the higher energy of the laser is increased.

20. An apparatus for spectroscopic quantitative analysis of gases in gas mixtures, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 18th day of November, 1991

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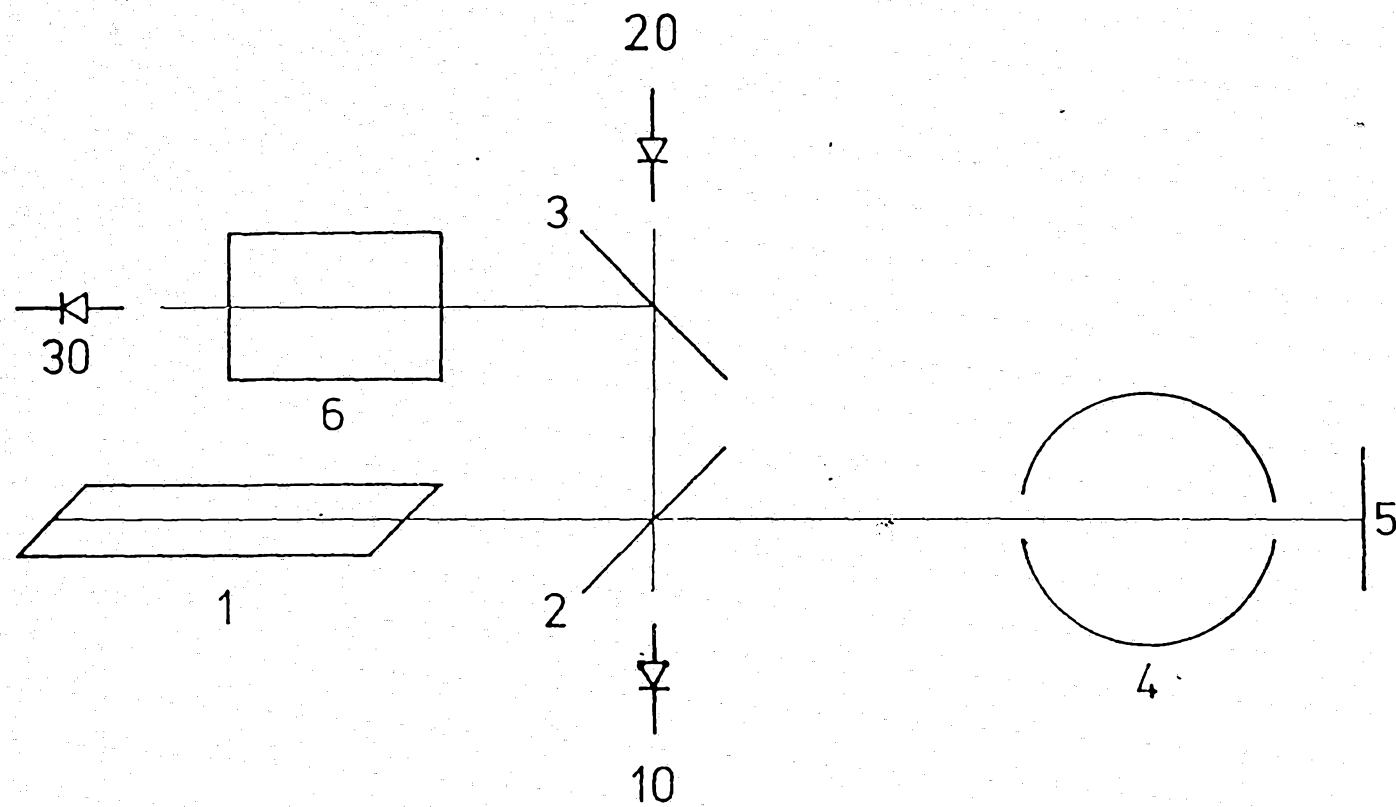


Fig.1

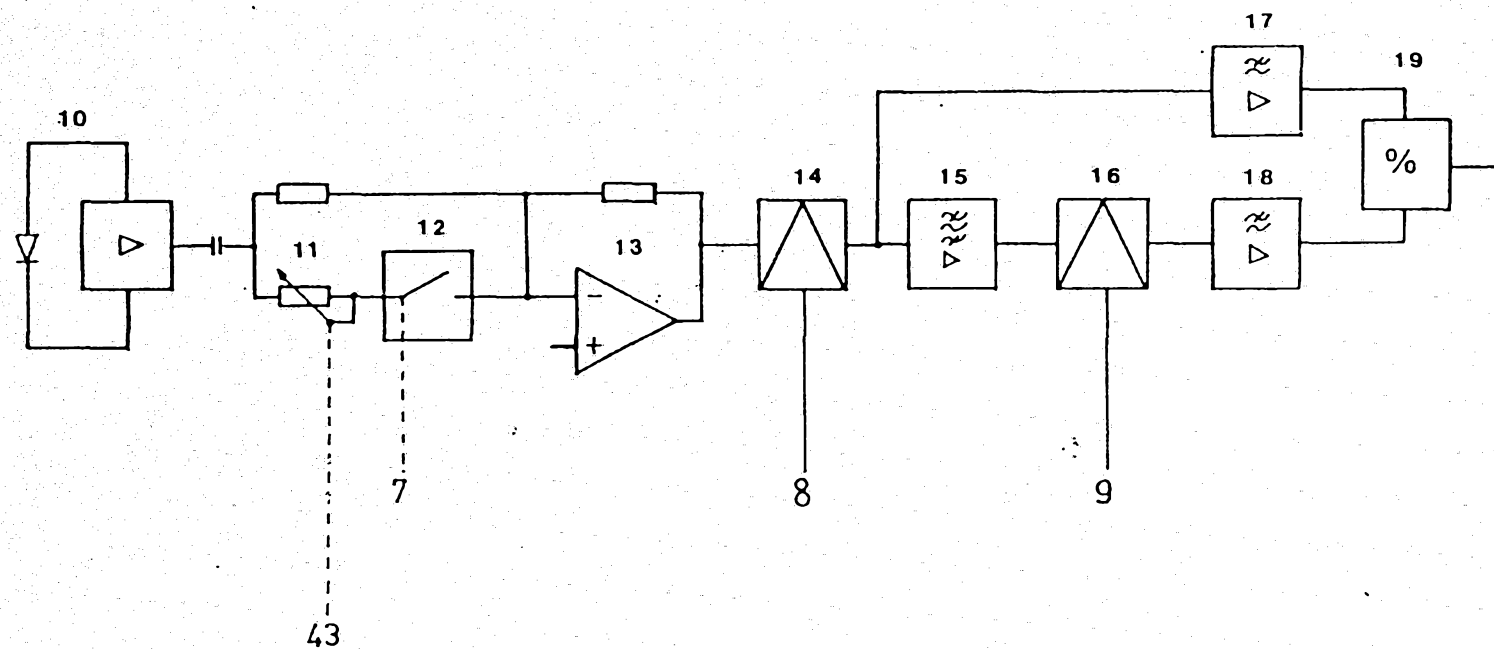


Fig. 2

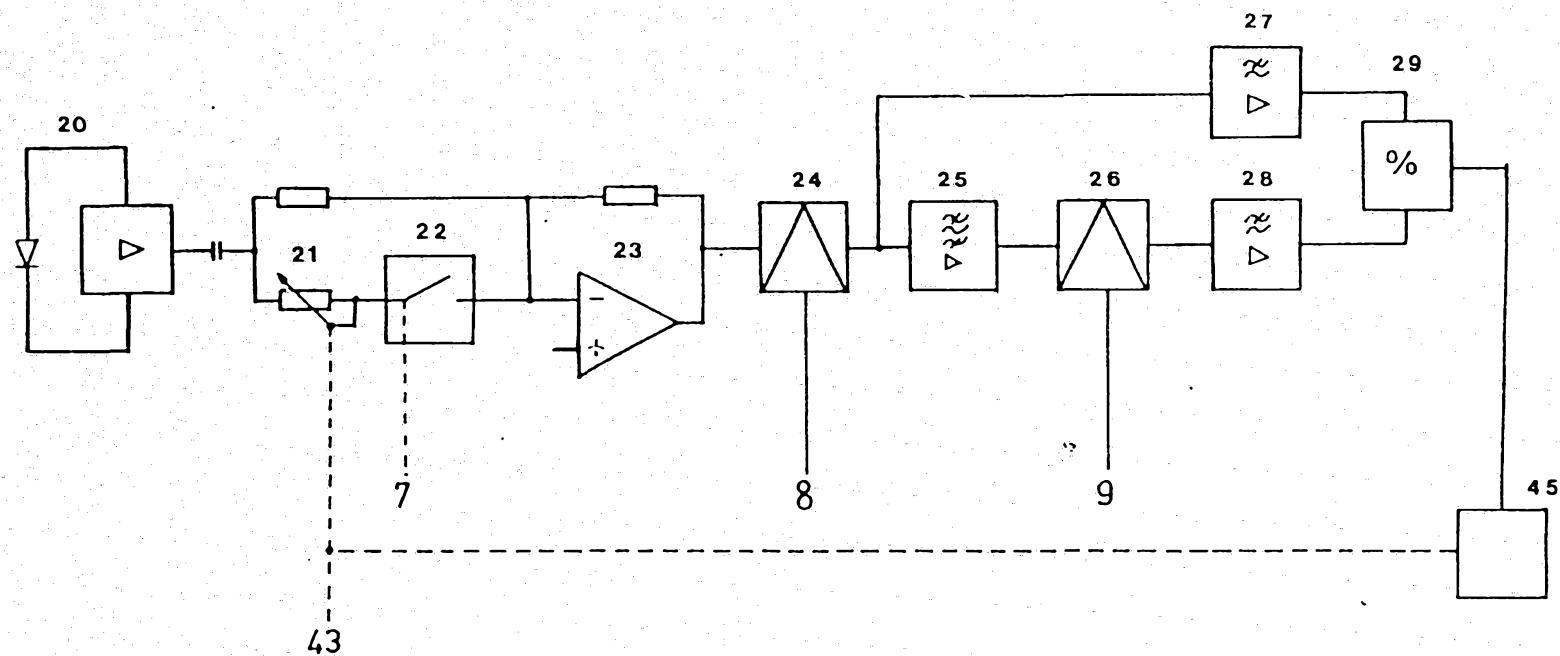


Fig. 3

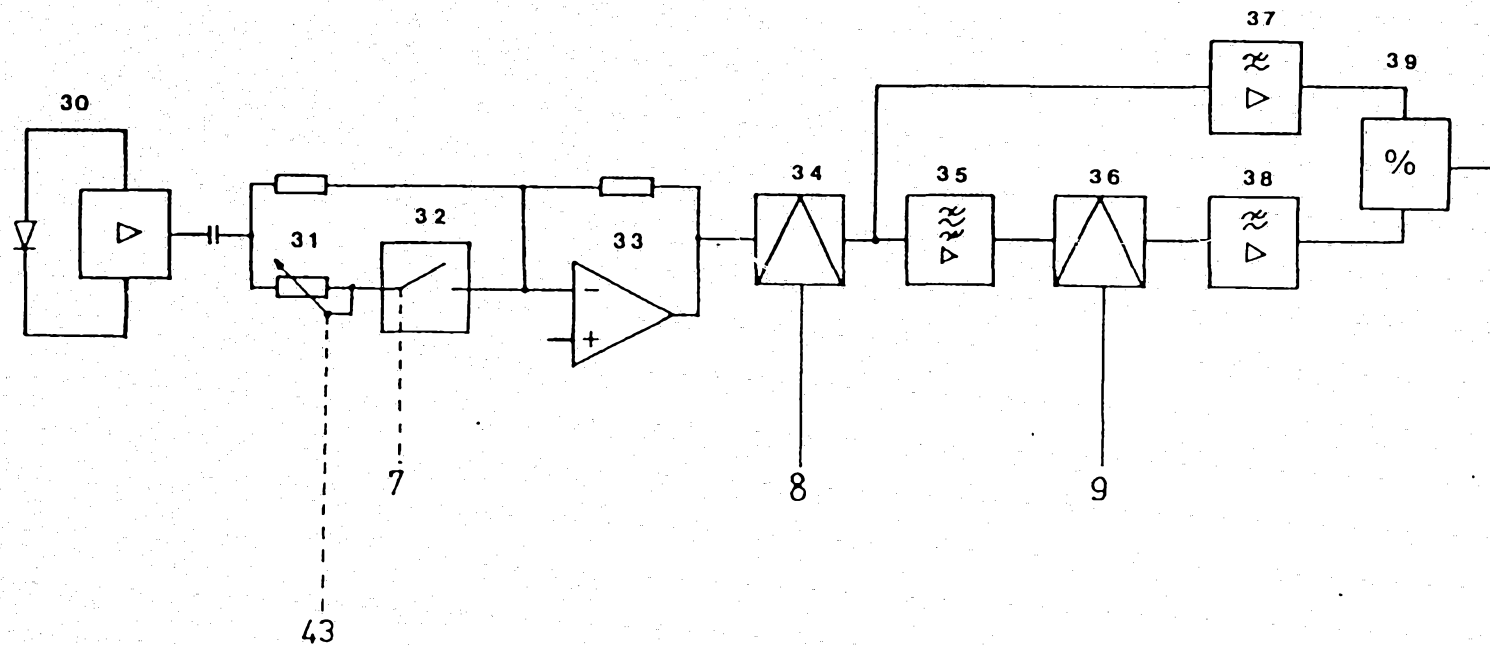


Fig. 4

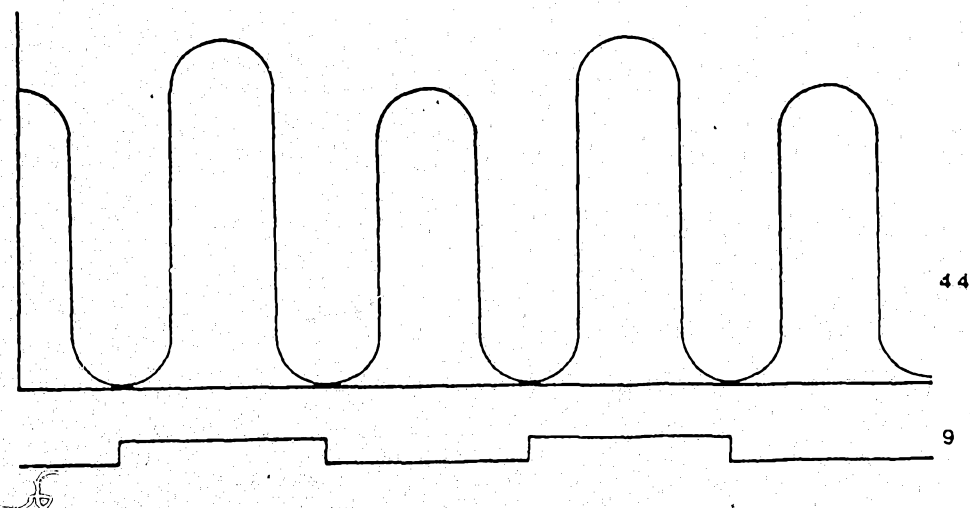
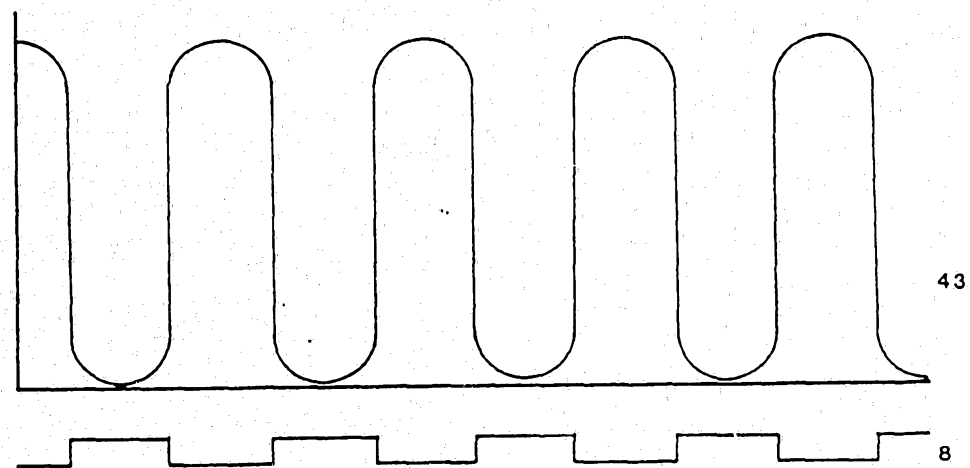
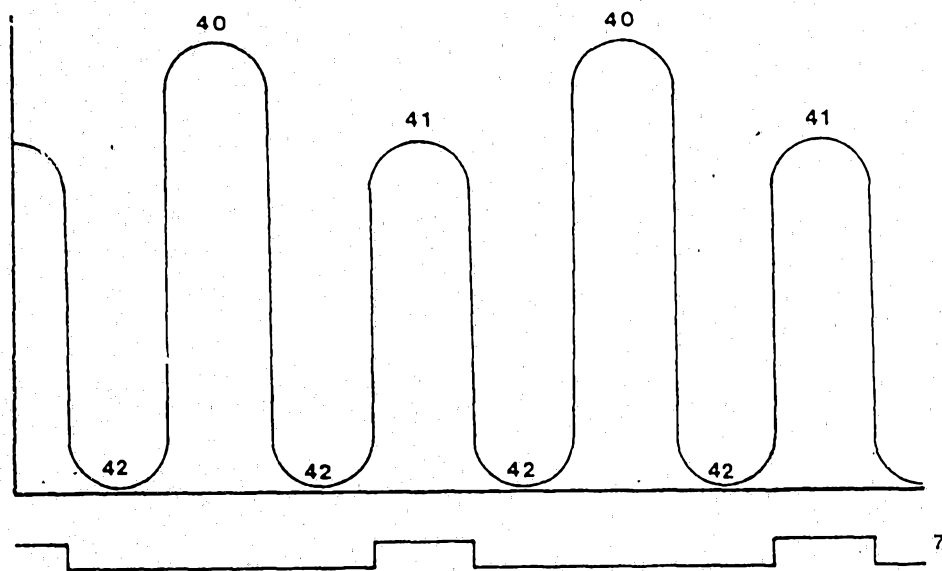


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 89/00596

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. ⁴ : G 01 N 21/39		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. ⁴	G 01 N 21/39, G 01 N 21/31, G 01 J 3/433	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	Review of Scientific Instruments, Vol.54, No.6, June 1983, American Institute of Physics, (New York US), W.Olsowski et al.: "Filter correlation photo- meter", pages 722-727, see part 1: 1. "Apparatus"; pages 722-723	1,7
A	US, A, 4410273 (A.W.MANTZ et al.) 18 October 1983, see column 3, lines 31-68; column 4; column 5, lines 39-63	1,7
A	US, A, 4441815 (T.IZUMI) 10 April 1984, see column 1, lines 26-68; column 2, lines 1-18, 58-68; column 3, lines 1-22	1,7
A	Applied Optics, Vol.24, No.17, 01 September 1985, Optical Society of America, (New York, US), A.P.Force et al.: "Laser remote sensing of atmosphe- ric ammonia using a CO ₂ lidar system", pages 2837- 2841, see page 2837-2838, part II: "Experimental Apparatus"	1,7
⁹ Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
22 August 1989 (22.08.89)	21 September 1989 (21.09.89)	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE		

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

EP 8900596

SA 28726

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 13/09/89
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4410273	18-10-83	None	
US-A- 4441815	10-04-84	JP-A- 57161518	05-10-82