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Summary. — *After having developped the corresponding analytical and sampling technics the Authors made in various public gathering places a survey of the respective concentrations in Nicotine, Carbon Monoxide and irritating Pollutants of possible smoke origin.*

Nicotine whose unquestionnable source is tobacco smoke, was never found in sufficient amount to be harmfull for non smokers. Otherwise the concentrations of Carbon monoxide and other non specific pollutants were always found lower than the usually allowed levels and may be considered as innocuous on the toxicological point of view.

However the nuisance which smoke means for non smokers and specially for allergic people and children justifies the restrictive measures usually taken in public places.

INTRODUCTION

While the general public is becoming more aware of the problems created by atmospheric pollution, numerous public health specialists have been investigating the effects of tobacco smoke on the health of nonsmokers and specifically on the health of children. This pollution by smoking, which is especially noticeable in certain poorly ventilated or crowded public places, has been observed sometimes even in private homes.

Certain authors have described the unfortunate nonsmokers who are obliged to live in an atmosphere polluted by smokers as "passive smokers", and have even issued staunch warnings by declaring that the situation is indisputably dangerous (Hess,1969 - Cole, 1973 - Dukelow, 1973 - Naumann, 1973 (12,4,15,17)). An important group study was published in 1974 under the direction of RYLANDER (18) (1974), which thoroughly examined the details of the question.

It should be noted, however, that not very much precise data on the actual significance of this pollution is available. The procedures used by most authors to determine the concentrations of pollutants created by smoking are subject to criticism: some authors have calculated the theoretical concentrations using the maximal concentrations found in tobacco smoke (HESS, NAUMANN) (12,17); others have worked with entirely artificial situations, such as the accelerated smoking of large quantities of cigarettes in an unventilated area (HARNSEN, 1957 (14), SCASSELATI, 1968 cited by DUKELOW (20), COLE, etc.). Still others have calculated concentrations using an element of a different nature to play the role of a tracer, but this is a risky procedure, at best (the particulate phase, for example, was calculated from the carbon monoxide level) (BRIDGE, 1972) (2). Although other serious studies have been carried out, they have mainly dealt with tests performed in the laboratory (HARKE (9,10), 1970 and 1972) and it might be difficult to extrapolate them to concrete real life situations.

An interesting study, with an assortment of samples, was carried out by the American Federal Aviation Administration during 26 airplane trips. Although measurements were only taken of carbon monoxide and the total particulate phase, we will examine the conclusions of this study in the discussion of our results.

We felt that it would be interesting to undertake a study on this topic by discreetly collecting samples in various locations where people smoke, such as cafes, train compartments, and automobiles, and afterwards, to measure the constituents of the pollution, probably originating from smoking, as thoroughly as possible. The first measurements were taken in 1974, but the difficulties which we encountered in using the technique, especially with nicotine, caused us to delay the publication. A relatively recent article by HINDS (1975) (13)revealed that this author has carried out a similar study in Boston, and we will discuss his results later on.

THE NATURE OF POLLUTION BY SMOKING

THE METHODOLOGICAL APPROACH

Tobacco smoke is a complex aerosol with a compostion which varies according to the stream under examination, whether it is the *mainstream* smoke, i.e. the portion which is inhaled by the mouth, or the *sidestream* smoke, i.e. the product of the spontaneous combustion of the cigarette in the air between puffs.

Atmospheric pollution caused by smoking is essentially due to sidestream smoke. In fact, most of the substances contained in inhaled smoke, which are important from the toxicological point of view, are retained by the organism.

Smoke contains a visible portion, *the particulate phase*, which is a dense aerosol containing approximately 10^4 particles per ml, between 0.1 and 0.8 microns in diameter (C. KEITH and J. DERRICK (16), 1960). The residual gas in air and the gases and vapors resulting from combustion form the *gas phase*. The complete separation of these two phases is a delicate procedure and, in practice, it is acceptable to consider the gas phase as the product of the filtration of smoke through the Cambridge filter (according to the CORESTA standards).

Although numerous studies have been carried out on the composition of the mainstream, less is known about the sidestream. However, the published studies all agree on one point: qualitatively speaking, the composition of the sidestream is analogous to that of the mainstream. Consequently, the factors considered to be harmful from the toxicological point of view are identical. There is general agreement on the fact that four groups are involved (GUILLERM, 1969, GUILLERM, BADRE et al., 1972) (7,8):

1) the alkaloid group, which is esentially nicotine;

2) carbon monoxide which interferes with oxygen transport to tissues;

3) the group of substances which irritates the respiratory mucosa, is found in the particulate phase as well as in the gas phase, and is essentially composed of aldehydes, ketones, and acids, all of which are water soluble;

4) the group of polycyclic hydrocarbons and various substances which are known to be carcinogenic in industrial toxicology.

In the case of atmospheric pollution caused by tobacco smoke, the first three chemical groups are the most relevant:

Nicotine, because of the specific character of its origin, should be a good indicator of pollution from smoking.

Carbon monoxide, which is found in urban pollution, is also important, but it is only a good indicator when other sources are not present.

Irritating substances found in the gas phase, particularly the aldehydes and acrolein, are important, and it is possible to measure them.

As for the *polycyclic hydrocarbons*, since their infinitesimal levels are already difficult to analyze in the laboratory under optimal conditions, analysis in the field is not very feasible.

Because of the reasons mentioned earlier, we have used the following substances as indicators of atmopsheric pollution caused by smoking: nicotine, carbon monoxide, and the principal irritating agents of the gas phase.

THE ANALYTICAL METHODS

1. The Sample Collection Apparatus

In order to perform our study in the various public places chosen, it was necessary to create an inconspicuous sampling system , which could be contained in a plain valise and could be started easily without having to open the valise. Samples of nicotine, gas needed to measure the carbon monoxide, and traces of pollutants were simultaneously collected on a suitable trap.

a) The sampling device for *nicotine* was basically composed of "Cambridge" filters placed over the intake of a pump with a known flow rate. Usually, when smoke is aspirated, all of the nicotine, which is almost totally in the particulate phase, can be collected on a "Cambridge" filter. Thus,we thought that we could use these filters to measure the amount of nicotine in smoke present in the air. The low values we obtained, even in a very smoke-filled area, quickly cast doubts on the validity of this technique.

In examining the physical properties of nicotine, we found that its volatile properties were far from being negligible(vapor pressure of pure nicotine at an ambient temperature is close to 0.1 torr, which in saturated vapor corresponds to 1 mg per liter of air). To confirm the risks of loss via this mechanism , we did the following: we impregnated each of two identical Cambridge filters with an equal volume of tobacco smoke condensate solution containing 130 μg of nicotine. We then passed 200 liters of air through one of the filters under the same conditions as for the smoke sampling, i.e. at a rate of 4 l/min. The nicotine was then extracted with cold ethyl acetate and was measured by chromatography. We recovered 107μg from the control filter and 19 μg from the other filter, thus noting an 80% loss of nicotine. These results confirmed that, although retention of the particulate phase was total, a portion of the nicotine vaporized from the passage of air aspired through the filter, and also, that a large portion of the nicotine from the particulate phase entered the gas phase when the smoke was dispersed into the air (which further depleted the particulate phase). Thus, it was necessary to find another sampling method which would assure the retention of nicotine in a nonvolatile form, whether it was in the particulate phase or in the vapor phase. We started by employing

a technique we had used earlier with CANO (3) (1970), which required water acidified with sulfuric acid, but after a series of tests, we substituted the water for a solution of 1% oxalic acid in 95% ethyl alcohol, since the alcohol promoted the destruction of the smoke aerosol (the principle of the water pipe illustrates the stability of this aerosol when bubbled through water). Under these conditions, after placing three similar scrubbers in a series and passing 200 liters of smoke-filled air through them, we recovered 77% of the total nicotine in the first, 13% in the second, and 10% in the third.

In another test, we added 200 µg of nicotine to the acidic alcohol of the 1st scrubber, passed 400 liters of air through all scrubbers, and measured the nicotine content of each scrubber. We found 171 µg, 4.8 µg, and 1.4 µg, respectively. These results confirmed the presence of a mechanical drive caused by high intensity bubbling, and have enabled us to estimate a maximum of a 5% error in our samples due to a more modest flow rate of 4 l/min. Thus, the final apparatus contained a series of three scrubbers, each containing 15 ml of an acidic alcohol solution, through which 200 liters of air was pumped in 50 minutes (an activated charcoal filter was placed over the exhaust to prevent air pollution by alcohol vapors).

b) The *pollutants* were also collected by a technique which was developed by us and which we are using at present. It entailed aspirating 100 ml of air through a glass tube filled with a chromatographic adsorbant, Porapak Q, using a syringe whose piston was operated by an electrical motor. The pollutants collected from the volume of air were eluted in the laboratory and were analyzed by gas phase chromatography (BOURDIN, BADRE and DUMAS: 1975) (1).

c) The samples for *carbon monoxide* analysis were collected by using a pump which filled a 5 liter balloon in 20 minutes (it was previously determined that the balloon was practically impervious to CO for a storage period of less than 24 hours).

2. Analytical Techniques

a) *Carbon monoxide measurement.* The simplest procedure, which is currently used in the area of air pollution, is infrared analysis by the nondispersive method. CO is known to have a specific band which is quite distinct from the CO_2 band. The only element which could interfere in the appropriate zone of sensitivity is water vapor. This interference could be eliminated by drying the gas, or, preferably, by specially arranging receiving chambers to considerably improve the selectivity ("UNOR" apparatus of the Society MAHIAK). We used the apparatus employing the latter method (a scale of 0 to 100 ppm, the limit of detection is on the order of 1 ppm). A sample of a few deciliters was sufficient, and the analysis was instantaneous. The apparatus was recalibrated before testing each sample using a standard mixture of CO in nitrogen

b) *Measurement of the irritating pollutants.* The sample tube was eluted in the laboratory with heat under a stream of nitrogen. The eluted products, collected in a loop immersed in liquid nitrogen, were reheated and injected into the chromatograph only once. This method produced a concentration factor of 100, which enabled us to obtain a great sensitivity. We have already described the methods of operation elsewhere (BOURDIN, BADRE, DUMAS, 1975).

c) *Measurement of nicotine.* This was carried out by gas phase chromatography using a technique derived from the one described by CANO (3) (1970), except the flame ionization detector was replaced by a thermoionic detector (*). The separation was performed on a 1/8" column, 1.3 m in length, with the phase being composed of "GASCHROM Q" impregnated with "UCON POLAR 50 HB" 3.2%, and 6% KOH.

The chromatograph was a "Hewlett-Packard" 5750 model with a thermoionic detector specific for nitrogen molecules under the following conditions of operation:

Helium vector gas flow 30 ml/min.
Hydrogen flow 28 ml/min air 140 ml/min.
Column temperature 110°C.
Detector temperature 400°C.

The acidic alcohol solution from the scrubbers was completely evaporated at a moderate temperature, rediluted in 1N NaOH and extracted twice in 2 ml of ethyl acetate. The extracts were dried on anhydrous Na_2SO_4 and were collected in a calibrated, stoppered flask, which enabled calculation of the solvent volume from its mass, since it was so volatile. We then injected 1 to 2 µl into the chromatograph, and calculated the concentration.

RESULTS OBTAINED

The results are summarized in table I.

Carbon monoxide. The values found were generally very low. In the case of cafe L.R., we found that the inside measured value (23 ppm) was on the same order as the value measured outside on the sidewalk (obvious automobile pollution).

(*) This provided a significant improvement, since we were able to avoid concentrating the samples because of the sensitivity which was clearly greater to that of the flame ionization. Also, the specificity assured better separation and minimized the solvent "lag".

TABLE I. RESULTS OF VARIOUS SAMPLES

	15 mars Autorail (A)	Compart. train 18 mars (B)	Café G. 26 mars (18 h) (C)	Café L.R. 2 avril 17 h 55 (D)	Café Rv 4 avril 18 h 30 (E)	Café Rg 16 avril 17 h 15 (F)	Café S.A 6 mai 18 h 1 (G)	Hall gare 10 mai 13 h 14 (H)	Café M 15 mai 20 h (I)	Foyer hôpital 15 mai (J)	Compart. train 16 mai (K)	Wagon Pulmann 20 mai (L)	Automobile 30 mai vitre entrouverte (M)	Automob. 30 mai vitre ouverte (N)	Automob. vitres fermées (O)	Chambre étanche (P)
mg/m³	(1) 0,392	3,06	0,64	0,02	0,09	0,48	0,17	3,08	0,14	0,03	0,01	0,34	0	0		
	(2) 0,065	1,01	0,49	0,48	0,17	0,63	2,32	1,41	0,54	0,29	0,38	0,70	0,48	0,26	2,50	1,64
	(3) 0,073	0,12	0,05	0,10	0,02	0,15	0,27	0,15	0,07	0,01	0,04	0,10	0,04	0,01	1,00	0,58
	(4) 0,07	0,12	0,05	0,07		0,09	0,10	0,04	0,03	0,02	0,02	0,07	0,02	0,03	0,30	0,185
	(5) 2,17	0,75	1,12	0,91	5,88	1,31	0,91	0,77	1,40	1,16	0,36	0,67	0,40	0,32	1,20	0,510
	(6) 0,46	4,64	2,51	2,07	1,33	3,56	1,41	0,93	1,05	0,82	0,21	1,39	0,14	0,43	1,00	0,40
	(7) 0,085	0,10	0,10	0,08	0,15	0,10	0,12	0,05	0,05		0,02	3,17	0,02	0,04	0,15	0,109
	(8) 0,119	0,18	0,16	0,15		0,21	0,18	0,09	0,21	0,24	0,09	0,19	0,03	0,03	0,50	0,30
	(9) 1,213	2,46	0,69	0,42	0,30	0,54	0,54	0,47	0,37	0,30	0,24	1,03	0,20	0,22	0,30	
	(10) 1,44	6,55	5,31	3,00	1,64	2,17	1,2[illegible]	1,27	0,88	0,73	0,17	1,10	0,34	0,30		
	(11) 0,95	0,19	0,38	0,12		0,28										
	(12) 0,74	1,87	0,93	0,17	0,04	1,04						4,61			0,50	0,218
	(13) 2,77	5,83	1,28	0,16	0,07	2,59	2,15	3,43	0,42	0,33	0,18	1,71	0,05	0,07	20	
ppm	(14) 1	5	11	23	5	14	2	2	7	5	4	2	18	14	0	50
	(15)			15	0	7	0	0					0	0		0
mg/m³	(16) 43	50	25	40	30	50	30	20	52	37	36	45	180	65	1010	500
	(17) 10/15	2/3	5/16	30/100	10/30	20/60	5/19	20/50	2/8	12/30	2/3	10/20	3/3	3/3	2	18

KEY: (A)= March 15, Rail car
(B)= March 18, Train Compart.
(C)= March 28 (6P.M.) Cafe G
(D)= April 2 (5:55P.M.) Cafe LR
(E)= April 4 (6:30 P.M.) Cafe Rv
(F)= April 16(5:15 P.M.) Cafe Rg
(G)= May 6 (6:15 P.M.) Cafe SA
(H)= May 10 (1:45 P.M.) Train Sta.
(I)= May 15 (8P.M.) Cafe M
(J)= May 15 Hospital entrance
(K)= May 16 Train compart.
(L)= May 20 Pullman wagon
(M)= May 30 Auto. window partly open
(N)= May 30 Auto. window open
(O) Auto. windows closed
(P) Airtight room

(1) Cyclohexane
(2) Ethanal
(3) Propanal
(4) Acrolein
(5) Acetone
(6) Ethyl acetate
(7) Benzene
(8) Isopropanol
(9) Ethanol
(10) Methylethyl ketone
(11) Methyl methacrylate
(12) Toluene
(13) 2-Pentanone
(14) CO ppm
(15) CO exterior
(16) Nicotine
(17) Number of smokers

Various pollutants. It was difficult to find a correlation between their abundance and the assumed pollution by smoking. They could certainly originate from a great many sources (cooking, heating gas, etc.). Overall, however, the concentrations were very low and were much lower than the maximal allowable concentrations (M.A.C.).

Nicotine. The concentrations found, except in two exceptional cases of an airtight room and a completely closed automobile (*), were most often lower than or close to 50 $\mu g/m^3$ (this theoretically corresponds to the smoke from one cigarette dispersed in a 20 m^3 room).

DISCUSSION

The results obtained for *carbon monoxide* and for *trace pollutants* can only be used as indicators because of the nonspecific character of these substances and the diversity of the possible sources. Nevertheless, we can conclude that the concentrations measured at the various test points were considerably lower than the allowable levels (**). Based on these results, which seem to correlate well with the nicotine measurements, it could be stated that the compounds originating from smoking only contribute a small amount to the general air pollution. Especially for carbon monoxide, in cases where the source is essentially smoking (no other sources - exterior pollution low), the concentration usually does not reach the allowable value for a continuous stay in confinement (25 ppm for the 90-day MAC), nor even the lowest value of 8.7 ppm determined by the E.P.A. (Environmental Protection Agency).

As for *nicotine*, the values found were clearly lower than those determined by authors using theoretical studies or laboratory measurements. On the other hand, they were higher than the values found by HINDS(1975) (13), who measured material trapped on a filter. We have seen that this method contains a basic error, and we have verified, for example, that in the same smoke-filled atmosphere, 215 $\mu g/m^3$ was collected by our method of sampling, as opposed to 14 μg with the "Cambridge" filter (32%) and only 5.5 μg (13%) with the "AA Millipore" filter used by HINDS.

(*) Where the air was almost not breathable.

(**) N.B.: The allowable concentrations in this case are not the allowable values of industrial hygiene for work locations, but much lower concentrations, authorized either by organizations fighting pollution (Environmental Protection Agency) or for a long duration confinement (90-day MAC in a submarine on patrol).

This further corresponds to the relationship between our results and the results of Hinds, whose values ranged between 1 and 10.8 $\mu g/m^3$.

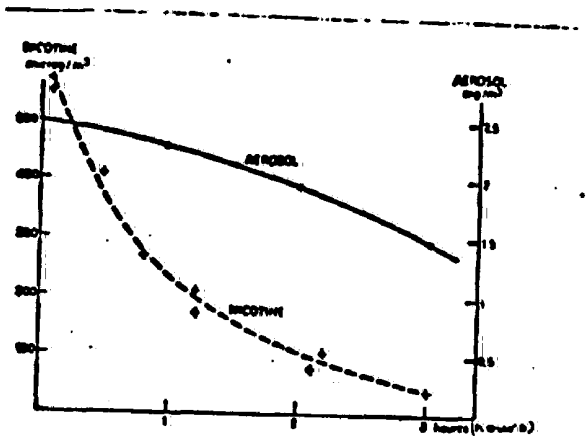

Fig.1. Simultaneous changes of photometric density of smoke and the concentration of total nicotine.

Another confirmation of nicotine depletion in the particulate phase was made by a study, in an enclosed area, of the simultaneous changes in the smoke density (aerosol photometry) and the concentration in total nicotine (fig.1). It was found that the latter decreased much more rapidly, probably through condensation on the walls and ground, which could be demonstrated by measuring, as we did, the nicotine deposited on glass plates in these areas. For example, in 50 minutes, the nicotine level decreased by 50% (half-life), whereas the density of the aerosol decreased by less than 50% in 3 hours. These results were similar to the ones mentioned by MORTON CORN (18) (RYLANDER, ed., 1975) according to which the half-life of the particulate phase was 43 minutes in an airtight room with circulation (curiously, he mentioned 84 minutes for carbon monoxide, which indicates that the room was not airtight for this gas). In the same study, RYLANDER referred to our earlier results with CANO (3) (1970) by noting that the respective levels of nicotine (32 $\mu g/m^3$) and CO (40 ppm) which we had measured were very different from those of ANDERSON and DALHAMN(1973) who found 0.377 mg/m^3 and 5 ppm, and from those of HARKE (10)(1972) who found 0.51 mg/m^3 and 64 ppm.

It should be noted that we obtained concentrations of 0.517 mg/m^3 of nicotine and 50 ppm of CO in our measurements in an airtight room after the smoking of 18 cigarettes per 40 m^3, and 0.05 mg/m^3 and 5.6 ppm in an ordinary, closed, unventilated

room, which confirms the results of Harke and, in general, the values found in *short duration tests*. In our earlier tests with CANO, we were dealing with very *long duration tests* (several days). According to other data on the spontaneous decrease in nicotine concentration, it was normal for the *mean* level to remain permanently quite low while the CO was accumulating (it was even periodically necessary to use a catalytic absorber).

The fact that only low levels of nicotine enter through the airways of "passive smokers" has been confirmed by the determination of nicotine quantities excreted in the urine. In our earlier study with CANO (1970), we demonstrated that non-smoking subjects spending 24 continuous hours in an environment polluted by smokers, with a mean air level of 30 to 40 $\mu g/m^3$ of nicotine, eliminated approximately 30 μg of nicotine in urine per 24 hours, while smokers eliminated approximately 1 mg per day. The results have been confirmed by a recent study by RUSSEL and FEYERABEND (19) (1975), which found that urinary levels were approximately 200 times lower in passive smokers as compared to those of smokers.

There seems to be adequate evidence, according to the studies reviewed by RYLANDER (1974), that the respiratory effects of smoke do not lead to significant differences in the rate of respiratory infections in normal nonsmokers. With respect to children, COLLEY (22)(1974) has reported the results of an epidemiological study carried out in over two thousand schoolchildren and their parents. At first, the frequency of a cough in the children appeared to be associated with the smoking habits of their parents. A direct correlation existed between the respiratory symptoms of the parents and those of the children, and when the respiratory symptoms of the parents were taken into consideration, the exposure of the children to cigarette smoke produced by their parents had little effect on the children's symptoms. Thus, the association between the smoking habits of the parents and the respiratory effects in the children that have been reported by other authors and have been interpreted as linked to pollution by smoking, are, in fact, mostly connected with the respiratory diseases of the parents. It is obvious, however, that persons who care for young children, must be dissuaded from smoking in rooms where the children are present.

On the other hand, we cannot deny that certain hypersensitive subjects are inconvenienced by smoke. It has not been possible to clearly demonstrate the allergenic effects of smoke (RYLANDER, 1974). However, there is no doubt that a large proportion of nonsmokers exposed to smoke experiences eye irritation, at least, and a study dealing with this matter was carried out in 1971 during air travel by the

Federal Aviation Administration and the N.I.O.S.M. in the U.S.A. (6). The questionnaire, given to 3,296 passengers, showed that, despite the low level of pollution indicated by the CO measurements, 60% of the nonsmokers, and even 20% of the smokers, were annoyed by the smoking of other passengers. Finally, it should be noted that numerous asthmatics are bothered by smoke-filled environments, through a mechanism which requires more thorough investigation; it is not caused by an allergenic type of mechanism, but by an increase in the nonspecific sensitivity of the bronchial receptors to the irritants in smoke or by a psychosomatic phenomenon.

CONCLUSION

The measurements, which we performed under realistic conditions, showed that the concentrations of carbon monoxide and the nonspecific compounds of tobacco smoke in the air of places where there was smoking were not increased sufficiently to create a toxicological risk for nonsmokers sharing areas with smokers.

As for nicotine, the total concentration in air polluted by tobacco smoke was often low and was usually below 50 $\mu g/m^3$. If we were to assume, for example, that the nonsmoker spent 10 hours per day (work and travel) in 50 $\mu g/m^3$ smoke-filled air, he would inhale 400 µg of nicotine, of which he would retain 80%, at most, or 320 µg. When compared with what the smoker inhales on the average, i.e. around 1 mg/cigarette it would be the equivalent of the nonsmoker smoking only 40% of one cigarette, while the smoker smoked about twenty. Strictly from the toxicological point of view, we could thus say that smoking does not present a risk to nonsmokers.

Statements which depict the "passive smoker" as a victim whose health is being threatened by his neighbor's smoking habit are truly irrational, particularly because of the psychosomatic incidents, which are especially evident is asthmatics, and have also been known to occur with many nonsmokers. It is equally irresponsible to overlook the fact that smokers will satisfy their tobacco habits anytime and anyplace ignoring the fact that they are annoying a large proportion of the population, as was thoroughly demonstrated by the F.A.A. study. Thus, we are supporting those activities which will reinforce and complement the already existing measures that have been effective but are now being neglected, especially the mass transportation regulations which reserve compartments for nonsmokers.

BIBLIOGRAPHY

[1] Bourdin (M.), Badre (R.) et Dumas (Cl.). *Analusis*, 1975, *3*, p. 34-38.
[2] Bridge (D.P.) et Corn (M.). *Environmental Research*, 1972, *5*, p. 192-209.
[3] Cano (J.P.), Catalin (J.), Badre (R.), Dumas (C.), Viala (A.) et Guillerm (R.). *Ann. pharm. fr.*, 1970, *28*, p. 561-565.
[4] Cole (P.V.) et Brown (E.). *Lancet*, 1973, *1*, p. 576-579.
[5] Dunlow (D.A.). *J.A.M.A.*, 1973, *223*, p. 336-337.
[6] Federal Aviation Administration (anonyme) (1971). Health aspects of smoking in transport aircraft. Report U.S. Public Health Service Depart' of Health, Education and Welfare.
[7] Guillerm (R.). *Les Cahiers Sandoz*, 1969, *15*, p. 29-47.
[8] Guillerm (R.), Badre (R.), Hee (J.) et Masurel (G.). *Revue de Tuberculose et de Pneumologie*, 1972, *36*, p. 187-208.
[9] Harke (H.P.). *Münch. Med. Woschr.*, 1970, *112*, n° 51, p. 2328-2334.
[10] Harke (H.P.) et coll. *Int. Arch. Arbeitsmed.*, 1972, *29*, p. 323-339.
[11] Hermsen (H.) et Effensberger (E.). *Arch. Hyg.*, 1957, *141*, p. 383.
[12] Hess (M.). *Literator Eildiients*, Roche, 1959, *37*, p. 49.
[13] Hinds (W.C.) et Firts (M.W.). *New England J. Med.*, 1975, p. 844-845.
[14] Horning (E.C.) et coll. *Life Sciences*, 1973, *13*, p. 1331-1346.
[15] Huber (G.) *New England Journal Med.*, 1975, p. 858-859.
[16] Keit (C.), Derrick (J.). *J. Coll. Sc.*, 1960, *15*, 340-356.
[17] Naumann (R.J.). *Sciences*, 1973, *182*, n° 4110, p. 334-336.
[18] Rylander (R.). *Scandinavian Journal of Resp. Diseases*, 1974, Supplem. n° 91.
[19] Russel (M.A.) et Feyerabend (C.). *Lancet*, 1975, *1*, p. 79-181.
[20] Scassellati et coll. *Riv. ital. Igiene*, 1968, *28*, p. 43-55.
[21] Taylor (G.). *Scand. J. Resp. Dis.*, 1974, Suppl. n° 91, p. 50-55.
[22] Colley (J.R.T.). *Brit. med. Journal*, 1974, *2*, p. 201-205.