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Letter-Report

Sir Charles Ellis, F.R.S.,
Westminster House,
7, Millbank,
L o n d o n , S.W.1,
England.

Dear Sir Charles,

PROJECT ARIEL

In this letter we report on the results of the work carried out in the period from April 1 to May 31, 1963. During this time the work on inorganic solid additives, i.e. point 3 of the programme, has been terminated. Besides, we have already started experiments with a view to determining the optimum size of the nucleation chamber required in the "Fig. 1 - device", i.e. part II of our schedule.

The experiments have shown that an inorganic solid is necessary in order to obtain the desired amount of nicotine transfer of 1 to 2 mg. The chemical nature and structure of the additive seem to be of secondary importance. Besides, the amount added is not very critical. In the case of silica we have varied the amount of additive between 5 and 50% and have found very good results. With only 25% of additive the nicotine transfer was somewhat lower.

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PART I3. Study of the effect of inorganic solid additives

The set-up for the experiments was essentially the same as that described in our letter-report of April 9. We used again rolled aluminium foils as central tubes, but instead of being connected to the Cambridge filter with a plastic tube, they were well inserted into the mouthpiece of the filter holder with the help of a stopper in order to avoid any loss of nicotine by deposition in the plastic tube.

As regards the heat input, we had made a small error in reading the instruments. May I apologize for that and ask you to make the following corrections in our report of April 9. Instead of 12.7 watts, read 10 watts; instead of 12.9, read 10.3; instead of 10.3, read 8; and instead of 16, read 11.5 watts.

The results of the experiments are compiled in the attached Table 1. This table shows that the nicotine transfer is improved by adding the powders of inorganic solids. Besides, the powder has the function of a carrier, and thus facilitates the preparation of the device. The chemical nature and structure of the added product appears to be of secondary importance. Nevertheless, silica appears to give the best results. The highest nicotine transfer achieved was 36.5%. For all these experiments, we used extract (c) which was prepared in different batches. We have noticed some variation in the behaviour of the extract from batch to batch as revealed by different values of transfer when tested without additive.

PART II

The work of this part concerns the "Fig.1 - device" of the provisional patent application. As regards the geometrical form of the device, two important design data have to be elaborated, i.e. the dimensions of the tube filled with tobacco, and the dimensions of the aerosol-forming chamber.

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At present we are experimenting with copper tubes which are 2.3 cm long, and have an inner diameter of 2.5 mm and a wall thickness of 0.1 mm. When the tubes are filled with tobacco and heated on one end with the electric furnace, the following temperatures are measured on the two extremities of the tube :

Heat input (watts)	T ₁ (°C)	T ₂ (°C)
5	120	120
7.5	158	158
10	190	171
12.5	211	194
15	256	221
17.5	267	243
20	276	261
22.5	292	271
25	308	285

The purpose of the aerosol-forming chamber is to transform the nicotine vapours emerging from the T₂-end of the tube into an aerosol. To find the optimum length of this chamber, we therefore have to find the distance from the end of the tube at which the vapour is transformed to smoke, i.e. we have to be able to distinguish between nicotine vapour and smoke. As our preliminary studies have revealed, and many experiments have confirmed, nicotine vapour, in contrast to smoke, cannot traverse a layer of tobacco. We are therefore carrying out the following experiments. The copper tube is filled with tobacco from W-428 cigarettes and fitted to a teflon tube 60 mm long and with a diameter of 5 mm. The teflon tube is in turn fitted to the mouthpiece of the Cambridge filter holder. In the teflon ^{tube} we place a layer of tobacco (10 mm long) at variable distances from the exit of the copper tube, the latter being heated on the other end with 7.5 watts. Unfortunately we can only pack about 60 to 70 mg of tobacco into the copper tube which corresponds to initial amounts of nicotine between 1.46 and 1.73 mg. We therefore have to take 60 puffs of

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2 seconds duration and at 7.5 seconds intervals in order to get a sufficient quantity of nicotine on the Cambridge filter. Accordingly, we are starting experiments in which the W-428 tobacco is enriched with the help of extract-(c) to an extent which permits about 10 mg of nicotine to be introduced into the copper tubes.

The experiments with the plain W-428 tobacco gave the following results :

Initial amount of nicotine (mg)	Distance of layer of tobacco from exit of copper tube (mm)	Nicotine found on Cambridge filter (mg)	Nicotine remaining in tobacco (mg)
1.48	no layer of tobacco	0.43	0.27
1.48	40	0.36	0.15
1.75	20	0.05	0.44
1.75	10	0.00	0.15

These first experiments seem to indicate that the aerosol-forming chamber should be about 40 mm long, but of course we have to be very careful in making any statements before we have any experiments with sufficient nicotine transfer, i.e. about 1 mg in ten puffs.

Programme for the coming research period

As regards the work on the "Fig.3-device", we see so far no reason to deviate from the fixed schedule, and we are now starting with point 4 of the programme, i.e. we are examining the behaviour of different materials for the central tube. The work on the "Fig.1-device" is directed towards an improvement of the nicotine transfer by the use of tobacco enriched with extract-(c) combined with the search for the best dimensions of the aerosol-nucleating chamber.

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We shall be very interested in your comments on our work,
especially with respect to the dimensioning of the aerosol-
nucleating chamber.

Yours sincerely,

Herbert Schachner
Herbert Schachner

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TABLE 1 - Results of nicotine analysis, "Fir. 4-de-ec"

Type of extract or tobacco	Type and amount of additive	Heat input (watts)	Max. temperature ($^{\circ}$ C)	Initial amount of nicotine (mg)	Nicotine collected on filters (mg)					Nicotine yield		Nicotine remaining in tube (mg) (%)	Nicotine found by analysis (%)	
					1+2	3+4	5+6	7+8	9+10	(mg)	(%)			
cigarette W-420					0.27	0.17	0.22	0.29	0.19	1.19				
cigarette W-428					0.12	0.10	0.12	0.10	0.17	0.61				
cigarette W-420					collected on one filter					1.11				
(c)	none	10	250	0.9	negligible					0.2	7.0	88	88	
(c)	none	10	226	18.4	negligible					0.2	15.0	86	86	
(c)	none	11.5	305	22.5	negligible					0.2	15.0	67	67	
(c)	none	10	240	5.6	0.12	0.12	0.07	0.07	0.12	0.5	9.0	3.6	64.4	73
(c)	alum. 300m ² /g. 50%	10.2	254	3.6	0.17	0.13	0.05	0.05	0.13	0.53	14.7	0.3	8.4	23
(c)	" 300m ² /g. 50%	10.2	246	11.1	0.03	0.05	0.10	0.15	0.66	0.99	8.9	3.3	30	39
(c)	" 1m ² /g. 50%	10	265	19.8	0.26	0.42	0.48	0.41	0.68	2.25	11.4	8.0	40.4	52
(c)	" 1m ² /g. 50%	10	265	10.2	0.19	0.17	0.15	0.35	0.56	1.42	13.9	3.6	35.4	49
(c)	" 1m ² /g. 50%	10	239	7.0	0.22	0.10	0.15	0.22	0.44	1.13	16.1	3.0	42.0	59
(c)	" 1m ² /g. 50%	10	236	6.4	0.12	0.10	0.22	0.61	0.12	1.17	18.3	2.2	34.4	53
(c)	magnesium silicate 50%	10	250	6.4	0.31	0.22	0.22	0.29	0.49	1.53	23.9	1.64	25.6	50
(c)	calcium carbonate 50%	10	270	7.7	0.20	0.12	0.33	0.42	0.65	1.72	22.3	2.64	34.3	57
(c)	silica													
(c)	175m ² /g. 25%	10	256	6.5	0.60	0.22	0.63	0.17	0.39	2.01	30.9	2.3	35.4	66
(c)	" 1m ² /g. 50%	10	256	6.7	0.22	0.12	0.16	0.24	0.41	1.15	17.2	2.8	41.8	59
(c)	" 155m ² /g. 50%	10	256	4.5	0.51	0.32	0.17	0.22	0.37	1.59	35.3	1.64	36.5	72
(c)	" 155m ² /g. 30%	10	236	10.9 ¹	0.39	0.29	0.12	0.44	0.68	1.92	17.6	5.2	47.6	65
(c)	" 155m ² /g. 10%	10	242	11.9	0.39	0.24	0.22	0.56	0.36	1.77	14.9	7.0	58.8	74
(c)	" 155m ² /g. 5%	10	256	10.8	0.39	0.24	0.15	0.32	0.51	1.61	14.9	5.6	51.9	67
(c)	" 155m ² /g. 25%	10	246	9.1	0.24	0.20	0.10	0.12	0.15	0.81	8.9	5.7	62.8	74

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