1. TEMPERATURE MEASUREMENTS

Rates of Heating

(a) Smoulder. No difference of opinion here.

(b) Puff. Bell considers I.T. Co. interpretation to be unsound but his own arguments are perhaps no better. A temperature rise of 300 deg. C. is only very infrequently found for a given segment behind the coal during a 2 sec. puff. Also, during the puff a dynamic state exists and so instantaneous rates are the only really meaningful values. In the original experiments the electrical output of the thermocouples was fed to a UV chart recorder to give a record of temperature V. time. These records have been re-examined and the rate of heating determined from the temperature difference and time of passage in the temperature interval shown below. The calculated results of I.T. Co. and of Bell are given for comparison.

TABLE 1

Packing Density	Average Rate of Heating deg. C/sec.		
	Direct Measurement	I.T.Co. Calc.	Bell Calculation
1.0	240(200-500°C);100(530-700°C)	144(200-700°C)	104(200-700°C);146‡(200-500°C)
1.3	120+(300-500°C); 90(540-680°C)	157(200-700°C)	66(200-700°C); 92(200-500°C)
1.4	200(120-450°C); 95(550-700°C)	154(200-700°C)	57(200-700°C); 80(200-500°C)
1.5	110(290-500°C); 70(550-675°C)	95(200-700°C)	48(200-700°C); 67(200-500°C)

‡ Calculated from footnote (5) Table 1 Technical Report #3.

From the temperature profiles for puff and smoulder average rates of heating for the first 1.5 seconds of the puff have been calculated for the temperature ranges indicated below:

TABLE 2

Packing Density	Average Rate of Heating deg C/sec
1.0	200(200-500°C); 97(555-700°C)
1.3	120*(320-500°C);107(540-700°C)
1.4	220(170-500°C); 93(560-700°C)
1.5	97(400-500°C); 60(610-700°C)

*Low value because of unusually extended contours, attributed to the thermocouples being situated in the channel. Possibly also accounts for the low value marked † in Table 1.

These results indicate that cigarettes with packing densities 1.0, 1.3x and 1.4x probably have similar average rates of heating over a range 200-500°C. A similar pattern is found for the range 550-700°C, although the value is only about 50% of that found in the lower temperature region. The cigarette with packing density 1.5x has a lower average rate of heating in both temperature regions. This pattern of results, i.e. packing densities of 1.0, 1.3x and 1.4x giving similar but higher results than that for 1.5x, is similar to that found by I.T. Co. Their average rates of heating are calculated over a different temperature range and so agreement between us for the absolute values cannot be expected.

The calculated results of Bell show a steady decrease in the rate of heating with packing density. This is contrary to the pattern found by R. & D.E. by actual observation and by calculation of I.T. Co. from R. & D.E. results.

Temperature

Bell makes no comment on the fact that R. & D.E. obtained higher puff and smoulder temperatures with both increased packing density and with hole, rather than considerably reduced temperature, which was a specific claim in the patent. Bell's temperature measurements are at least 150°C. too low, as a result of using thermocouples 0.006" in diameter (cf. Touey and Mumpower).

2. LOWERING OF PHENOLS

Bell's argument does not follow. A wet C.A. filter is more efficient for phenol retention than wet tobacco. As a channel exists down the cigarette but not the filter, water will be retained in the filter in preference to the tobacco.

3. NICOTINE DELIVERY AND FILTRATION EFFICIENCY

Cigarette rods A, B and C are the same as cigarette rods E, F and G. Only the filters are different. Series 268 to 268C show similar filtration efficiencies - they are the same filter. Series 268D - 268G would be expected to be the same. The values for 268D and 268E are extraordinarily low, while 268G was wrongly calculated, and should be ~20%. The expected value for 15 mm C.A. 8.0/44000 would be about 15%, and it seems likely that series 268D - 268G really show no change.

If, indeed, the filtration efficiencies are constant, then the θ cannot be used to indicate changes in smoke composition. Possibly it would have helped if I.T. Co. (Canada) had measured the filtration efficiencies directly, as this would have given meaningful results, and eliminated the above uncertainties.

BASIS FOR COMPARISON OF CIGARETTE PERFORMANCE

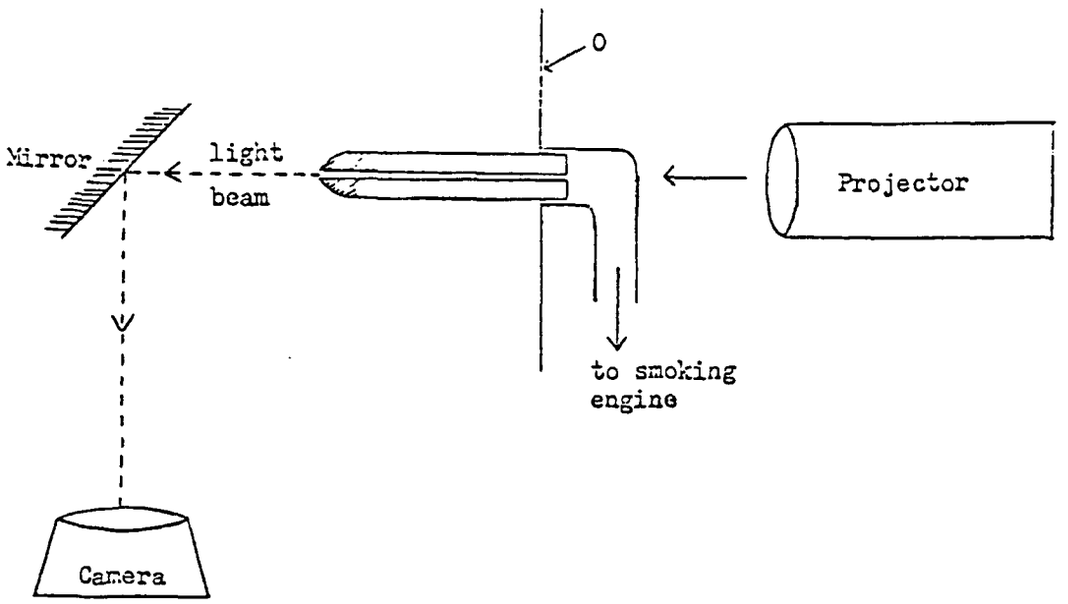
Ideally the best way of looking at changes is when constant weights of tobacco in rod are burned in the same number of puffs and the tobacco filtration coefficient remains constant. For the present cigarette the latter is unlikely to be constant and the calculation of weight of tobacco burned is of doubtful reliability for cigarettes with large increases in packing density and with a hole down the rod.

The use of D.P.M. may be difficult to justify but it is to Bell's advantage not to use it. However, this is a conventional method of comparing cigarettes, i.e. normalising on the basis of unit weight of condensate.

"Changes found on a per puff basis" is obviously the comparison most advantageous to Bell. However, if nicotine is the yardstick used, the device of Bell, Jones and Laing is only better for phenols and formaldehyde (and coloured h.c.s.). Conventional filters (with additives) can achieve results better than this.

In the conclusion Bell says ".... the only fair and meaningful basis for comparison .... is that which uses the "per puff" approach - providing that no dilution of the smoke occurs."

Some experimental work has been done to check on this point. A standard 35 mm. slide projector was used to project a beam of light down a Bell and Laing cigarette without its filter. The cigarette was smoked at one 35 ml puff of 2 secs. duration each minute. The beam of light was reflected through 90° using a small mirror placed on the axis of the cigarette and at 45° to it. The cigarette was photographed with a Polaroid camera, both along its axis in the mirror and sideways at the coal:-



The accompanying photographs show that the hole persists through the coal during the puff, and from this fact it follows that air dilution is occurring through this hole in the coal.

In a further experiment, cigarettes were extinguished in carbon dioxide and measurements were made of the pressure drops of the coals. The coals from the Bell and Laing cigarettes had pressure drops that were on average 25% lower than those from unmodified cigarettes.

Thus considerable air dilution is occurring during a puff and comparison on the basis of delivery per puff has very doubtful validity.

It would have been useful if cigarettes with high packing density without the hole had been examined by I.T. Co., as it is very difficult to differentiate the effects of the hole and of the packing density from their analytical data.