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Office for Research and Experiments of the International Union of Railways Oudenoord 60 3513 EV UTRECHT (Netherlands)

QUESTION C 149

Problems arising from the running of high speed trains in tunnels

Report No. 12

Aerodynamic measurements in the "DES BACHEES" tunnel

UTRECHT, September 1984

ORE QUESTION C 149
AERODYNAMIC MEASUREMENTS IN THE "DES BACHEES" TUNNEL
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English, French, German

This report describes the measurements taken with high-speed trains passing each other in the "DES BACHEES" tunnel. The tunnel is 426 m long and has a cross section of 41 m^2.

The programme involved tests which made it possible in particular to measure pressure variations at fixed points in the tunnel and on the trains.

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This report was prepared by the ORE Specialists Committee C 149 composed of:

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SUMMARY OF THE PROGRAMME OF WORK

1.	Theoretical prediction methods for calculating unsteady flows in railway tunnels	RP 1 (September 1980)
2.	Comparison of a mathematical method with the test results	RP 4 (April 1982) RP 6 (April 1983) RP 11 (September 1984)
2.1	In tunnels	RP 2 (September 1981) RP 7 (September 1983) RP 8 (September 1983)
2.2	In trains	RP 3 (September 1981) RP 12 (present report)
3.	Unfavourable effects on Staff	
3.1	Specifications of the effects which are caused by airstreams	RP 5 (September 1982)
3.2	Ascertaining the airstreams at various distances	RP 9 (April 1984)
4.	Unfavourable effects on passengers (specifications of the effects which pressure variations have on the human ear)	

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SUMMARY

This report describes the aerodynamic measurements taken in LES BACHEES tunnel with a gas-turbine train (RTG) passing either a TGV train (high-speed train) or a train composed of standard stock.

It contains a description of the tunnel, of the trains and of the measuring apparatus, and presents the results of the tests.

The experimental data obtained can be used to validate the theoretical models developed either for ORE or for the various railways.

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ABBREVIATIONS AND SYMBOLS USED IN THIS REPORT:

D_h (m)	hydraulic diameter: $4 \times \frac{S \text{ (cross section)}}{P \text{ (perimeter, wet)}}$
i (mm/m)	track gradient
LTR (m)	length of train
LTU (m)	length of tunnel
mm CE :	pressure in mm of water
PE (Pa)	static pressure outside the train
PI (Pa)	static pressure inside the train
P_{tu} (m)	perimeter of tunnel
S_{tu} (m^2)	cross section of tunnel
V (m/s or km/h)	speed of train
V_a (m/s)	air velocity

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1. PURPOSE OF THE MEASUREMENTS

The series of tests carried out in the RILLY-LA-MONTAGNE tunnel in October 1982 produced a considerable amount of data concerning the running of individual trains in tunnels.

The purpose of this latest series of tests, which took two weeks, was to obtain further information on non-steady aerodynamic phenomena when trains passed at high speed in a tunnel.

The chief aim was to provide the data necessary for validating computer programs with a view to evaluating the maximum variations of airflow characteristics which might be expected in future double-track tunnels traversed at high speed.

The tests in question were thus designed primarily to ascertain the air pressure field along the tunnel and in the vicinity of the trains.

The aim was not to fix limits which can be tolerated by human beings but rather to obtain measured values with a view to enabling a prediction to be made, using models, of the aerodynamic environment to which passengers, staff and trains will be exposed in tunnels.

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2. DESCRIPTION OF TUNNEL

LES BACHEES tunnel is 15 kilometres south of Poitiers on the PARIS to BORDEAUX line. It is a double-track tunnel faced along its whole length.

The chief characteristics are:

- length	LTU = 426 m
- cross section	S_{tu} = 41 m²
- perimeter	P_{tu} = 24 m
- hydraulic diameter	D_h = 6.8 m
- track layout	straight
- gradient	i = 0.0015 (rising in the Paris direction)
- distance between track centres	3.4 m

Figure 1 shows the longitudinal and cross sections of the tunnel, the Bordeaux end entrance of which is skewed by 45° to the longitudinal centreline of the tunnel.

The forms of the two portals are given in figure 2 (north end) and figure 3 (south end).

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3. DESCRIPTION OF TEST TRAINS

The trains used for the tests are described in figures 4 to 9. The principal features of the trains are: (train perimeter and cross section are defined in figure 7).

3.1 TGV train (test speed: 190 and 210 km/hour)

The train used for the tests was a high-speed electric multiple unit (figure 4) consisting of two power cars and eight trailer cars with the following characteristics:

- length of train — LTR = 200 m
- cross section of power car (and of the two end trailer cars R1 and R8) — S_1 = 10 m²
- perimeter of power car (and of the two end trailer cars R1 and R8) — P_1 = 10.8 m
- cross section of trailer cars — S_2 = 8 m²
- perimeter of trailer cars — P_2 = 9.7 m

3.2 Corail train (test speed: 180 and 200 km/h)

This was a train of normal stock consisting of a BB 22200 locomotive (figure 5) and nine Corail coaches (figure 6), the overall length being 255 metres.

Characteristics of stock:

	BB 22200	Corail coach
Length over buffers	17.5 m	26.4 m
Cross section (figure 7)	10.8 m²	9.8 m²
Perimeter (figure 7)	12 m	11 m

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3.3 RTG train (test speed: 100 to 190 km/h)

This was a gas turbine train (figures 8 and 9) which, for the tests, consisted of two power cars and two trailer cars.

Characteristics:

- length of train LTR = 103 m
- cross section S_3 = 10 m²
- perimeter P_3 = 11 m

4. DESCRIPTION OF MEASURING APPARATUS (Table 1)

During this series of tests air-pressure and air-velocity measurements were taken at fixed points in the tunnel. Of the trains only the RTG was equipped with air-pressure measuring points.

4.1 Measurements in the tunnel

Figure 10 shows the position of the measuring apparatus arranged at fixed points along the tunnel.

4.1.1 Air velocity (figures 10 and 11)

An orifice-plate flow anemometer, as shown in figure 11, was installed 213 metres from the north portal near the wall of the tunnel on track 2 side and 2.5 metres above rail level. The functioning principle is the same as with the Venturi tube: the air velocity is determined by measuring the difference in pressure between points 1 and 2. The chief advantage of this instrument is that the air velocity parallel to the tunnel centre-line can be measured regardless of the direction of movement.

4.1.2 Static air pressure (figures 10 and 12)

The static air pressure is measured along the tunnel, near the wall and 2.5 metres above rail level at the points indicated in figure 10.

4.1.3 Position of the test trains in the tunnel

As shown in figure 10, two light barriers were placed at each end of the tunnel to indicate track occupation by the amplitude of the signal:

5 mm when there is a train on track 1
10 mm when there is a train on track 2
15 mm when both tracks are occupied.

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4.2 Measurements on the trains

Figures 8 and 9 show the position of the measuring equipment installed on the RTG train. The position of the reflective strips on the TGV train and on the BB 22200 locomotive 5 metres from each end is shown in figures 4 and 5 respectively.

4.2.1 Static air pressure

The procedure for measuring the static air pressure from the RTG train was as follows (figures 8 and 9);

- 4 measuring points at the front of the train, Bordeaux end (A, B, B' and C);

- 2 measuring points outside the second vehicle 48 metres from the front of the train (F and F');

- 1 measuring point inside the third vehicle 65 metres from the front of the train (PI);

- 1 measuring point at the end of the train on the inside of the track when the RTG is on track 2.

The measurements were taken using differential transducers connected to a reference tank filled with air at the pressure prevailing in the tunnel.

4.2.2 Position of the RTG train in the tunnel (figure 9)

A photo-electric cell placed at each end of the train and directed towards the tunnel roof enabled an accurate indication to be obtained of the moment of entry and exit of the front and end of the RTG train.

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4.2.3 Recording of the moment of passing of the fronts of trains (Fig. 4, 5 and 8)

The exact time of passing of the trains was recorded by means of a photo-electric system placed on the RTG train and a reflective strip fitted on the IGV train or BB 22200 locomotive.

4.2.4 Speed of trains

The speed of the trains at the end of the tunnel was given by the signals from fixed light barriers and picked up on the measurement recordings in the tunnel.

The instruments detecting the passing of the front and the end of the RTG train at the ends of the tunnel provided additional information from which the speed could be calculated.

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5. RESULTS OF THE MEASUREMENTS TAKEN AT FIXED POINTS IN THE TUNNEL

5.1 Presentation of results

All the recordings of measurements taken at fixed points in the tunnel are presented as shown in figure 13. The signals provided by the light barriers arranged at the ends of the tunnel occur on either side of the curves and enable us to plot the trajectories of the front and the rear of the trains and the paths of the waves produced, with a view to interpreting the pressure changes and the air velocity.

5.2 Static air pressure

Figures 15 and 16 assemble the results of all the air pressure measurements taken at fixed points in the tunnel (points 11, 12, 21, 22, 31, 32, 41, 42 and 51).

Four quite different values of the air pressure are given in these tables, as defined in figure 14:

- $\Delta P+$: positive maximum amplitude
- $\Delta P-$: negative maximum amplitude
- $\frac{\Delta Pcc}{\Delta T}$: quotient of the overall "Peak to Peak" pressure variation by the duration of variation
- $\frac{\Delta P}{\Delta T}$: quotient of the largest scatter continuous pressure variation by the duration of variation (attempt to find a maximum gradient)

5.3 Air velocity

The results of the measurements of air velocity are provided in figures 15 and 16:

- V_a+ : positive maximum amplitude
- V_a- : negative maximum amplitude.

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The convention adopted for the sign of the air velocity is a plus sign (+) for the Paris to Bordeaux direction and a minus sign (-) for the opposite direction.

The instantaneous air velocities are determined by the pressure measured at transducer 102 and are such that:

$$V_a = 2 \cdot \sqrt{h}$$

in which:

V_a = air velocity in m/s (scale given in figure 13)

h = air pressure in mm CE.

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6. RESULTS OF THE MEASUREMENTS TAKEN ON THE RTG TRAIN

6.1 Presentation of results

All the air pressure variations measured from the RTG train are recorded and plotted as shown in figure 17. The information provided by the photo-electric systems installed on the train is given on the recordings and makes it possible to accurately locate the time the ends of the train pass the two portals and also the time that the fronts of the two trains pass each other.

Figure 17 interprets the pressure variations at transducer A, and this can be followed on the wave diagram in figure 18.

6.2 Results of measurements

In the same way as with the values of the pressure at fixed points in the tunnel, figures 19 and 20 show the results of the measurements of the air velocity on the RTG train at points A, B, B', C, F', F, B" and at the inside pressure point.

The aerodynamic phenomena in the tunnel set up when trains pass each other depend among other things on one important parameter, viz. the time elapsing between the moments of entry of the two trains into the tunnel. In view of the importance of this parameter, figures 21 and 22 give its value for the different tests and also the speed of the trains. For each train three indications of the speed are given:

- speed of entry and exit: calculated as a function of the length of the train using the "pips" indicating passage of the front and the rear of the train past the light barrier arranged at the portal in question:

- mean speed: calculated using the length of the tunnel (basic 430 m) and the "pips" indicating the passage of the front and the rear of the train past the two ends.

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7. REMARKS AND CONCLUSIONS

7.1 Static air pressure in the tunnel

The maximum variation of the air pressure was measured within the tunnel point 42: 8500 Pa peak-to-peak with the Corail train running at 197 km/h and passing the RTG train running at 178 km/h. During this test (run 333-5) the maximum pressure gradient was recorded at point No. 32 situated 260 m from the portal at the Paris end of the tunnel: 5700 Pa in one second.

With the TGV train the greatest pressure variation was measured during tests 326-4 (TGV train speed 187 km/h; RTG train speed 190 km/h) when a value of 7900 Pa was recorded with a gradient of 6000 Pa in one second.

7.2 Air velocity

The maximum air velocity occurred when the Corail train running at 200 km/h passed the RTG train running at 100 and 160 km/h: 21 m/s in the direction of running of the Corail train.

With the TGV train, this amplitude of the air velocity was 20 m/s during four test runs when the running speeds of the trains were not necessarily the highest (examples: TGV at 210 km/h and RTG at 130 km/h, and also TGV at 160 km/h and RTG at 100 km/h):

7.3 Static air pressure on the RTG train

The maximum variation of pressure on the RTG train (Point A) was 6400 Pa when it was running at 178 km/h and passed the Corail train running at 197 km/h. This variation of pressure peak-to-peak was accompanied by a gradient of 8600 Pa a second (6000 Pa in 0.7 s). During this same test the pressure inside the train was 5500 Pa and the gradient was 3300 per second.

When passing the TGV train (test 327-5) the maximum variation of the pressure was 6100 Pa outside at the front of the train, with a gradient of 5100 Pa per second. In this actual example, the wave diagram for which is given in

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figure 23, four consecutive pressure drops occurred within the space of one second:

- the reflection of the primary wave of the RTG train
- the wave caused by the entry of the end of the RTG train
- the wave caused by the entry of the end of the TGV train
- the passage of the front of the TGV train.

Particular mention should finally be made of the pressure variations inside the RTG train: figure 24 indicates that they are not affected by the front of the passing train. The pressure drop produced by the front of the passing train is felt only at the points outside the train on the six-foot way side. This drop in pressure is thus not constant in a given cross section of the tunnel and seems to be connected essentially with the dynamic pressure produced by the mass of air drawn along with the passing train.

7.4 Reproducibility of the measurements

It was observed during this series of tests that there was an extremely high degree of reproducibility of the recordings of the measured values, as illustrated by figure 25, the speeds of the two runs differing by only a few per cent.

7.5 Effect of the various parameters on the pressure variations

7.5.1 Influence of the type of trains

The pressure front due to the primary wave is greatly influenced by the type of train. Analysis of the results of measurements indicated that when the speed of entry into the tunnel was 185 km/h, the sudden pressure rise due to the primary wave was:

- 100 mm CE with the TGV train
- 120 mm CE with the RTG train
- 160 mm CE with the Corail train.

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It is certain that, other parameters being equal, this characteristic of the front of the Corail train to generate a higher in the tunnel amplitude of the primary wave, will lead to correspondingly greater pressure variations. Nevertheless, it must be emphasised that, for equal speeds, there will not necessarily be greater pressure variations with the Corail train, because of the effect of the other parameters such as the difference in entry time of the trains into the tunnel and the length of the trains.

7.5.2 Influence of the difference in entry time of two trains into the tunnel

The pressure variations are greatly influenced by the time difference between the entry of the two trains into the tunnel. This difference, an apparently very important parameter, affects in particular the risk of superpositioning of the waves causing very high pressure amplitudes and gradients. Figure 23 clearly indicates that during tests 327-5 the pressure variation of 6100 Pa due to the simultaneous occurrence of four low-pressure waves would not have been reached if the time difference of entry of the two trains had been zero or between 3 and 6 seconds.

Two examples, shown by figures 26 to 29, clearly reveal the important effect of this parameter on the form and the amplitude of the pressure variations occurring when trains pass in the tunnel. Figures 26 and 27 relate to crossings of RTG and TGV trains running at speeds of 130 km/h and 190 km/h respectively, but in which the difference in the time of entry of the trains into the tunnel was not the same (0.2 s for test 328-2 and 2 seconds for tests 328-4). Figures 28 and 29 show instances of the RTG train (125 km/h) passing the Corail train (195 km/h) with time differences of entry into the tunnel of 7 and 11 seconds: these figures also exemplify the importance of this parameter.

These two pairs of figures plainly reveal the considerable change in the signal characterising the changes in both the form and the amplitude of the pressure when the only parameter which varies is the difference in time between the entry of the trains into the tunnel.

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7.5.3 Influence of train speed

It was noted that the speed of the trains has a twofold effect:

- it modifies the intensity of the waves due to the entry of the front and the rear of the train into the tunnel;
- it affects the times of entry of the rear of the trains and the instants at which the expansion waves are generated, this influences the manner in which a wave superpose of one another.

Tests 328-1 and 328-5 which involved passing the TGV train, show that when the speed of the passing train rises from 160 to 210 km/h there is a 50% increase in the pressure variation in the tunnel (the ΔPcc increasing from 3800 Pa to 5700 Pa) and one of 75% on the RTG train (the ΔPcc increasing from 2700 Pa to 4700 Pa). During these two tests, the time differences between entry of the trains into the tunnel were equal and the speed of the RTG train varied by 27 km/h. This difference in speed of the RTG train has very little effect on the above pressure variations. The values are taken from peak to peak and are spread out over 3 to 5 seconds.

7.6 Conclusions

The aerodynamic phenomena encountered when trains pass in a tunnel are governed by a number of parameters, viz:

- the length and the section of the tunnel
- the speed and the length of the trains
- the difference in time of entry of the two trains into the tunnel
- the type of trains involved (which covers the parameters front and rear shape, section and length).

The purpose of these tests was to provide the data required for validating the computer programs but they did nevertheless also show that the difference

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in time of entry of the two trains and the running speed of the passing train have a considerable influence on the air pressure variations in the tunnel and on the train.

Since the maximum pressure variations are combinations of several waves and therefore also depend on the simultaneous occurrence and the intensity of these waves, it is difficult to resolve these problems encountered when trains pass, (a) because of the large number of parameters involved and (b) owing to the fact that certain of these parameters such as the speed of the trains and the type of train have an effect both on the intensity of the component waves and on the relationship between these waves.

1. MEASUREMENTS IN THE TUNNEL

1.1 Measurement of air velocity (figure 11)

- orifice-plate flow anemometer made by SNCF, and VALIDYNE differential pressure transducers type DP7 and DP15

1.2 Measurement of static air pressure (figure 12)

- VALIDYNE differential transducers type DP7 and DP15

1.3 Position and speed of test trains in tunnel

- reflective light barrier

2. MEASUREMENT ON THE TRAINS

2.1 Measurement of static air pressure on the RTG trains (figure 12)

- VALIDYNE differential transducers type DP7 and DP15

2.2 Position and speed of RTG train in tunnel

- photo-electric cell

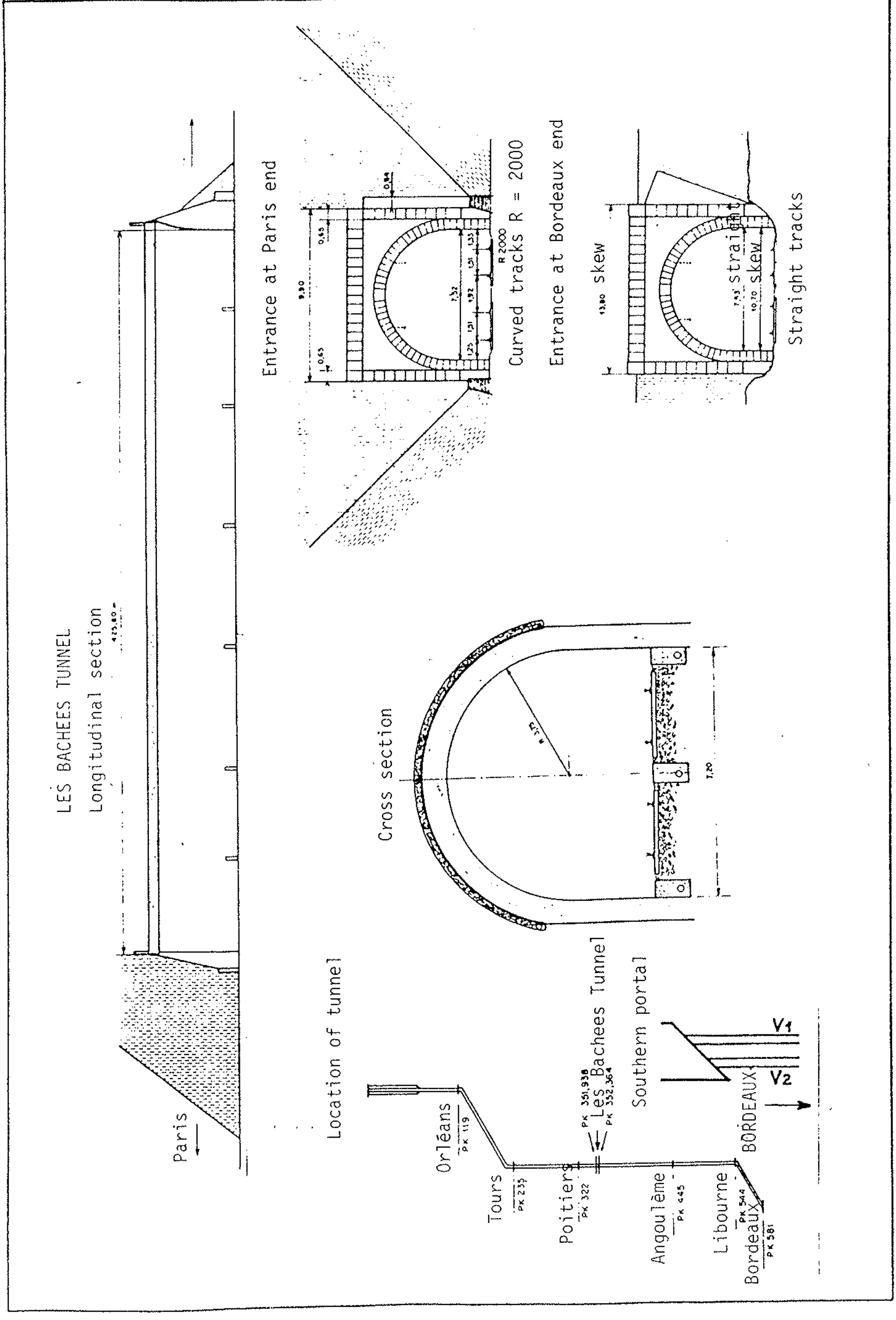
2.3 Recording of the moment at which the fronts of the trains pass each other

- reflective light barrier

3. RECORDINGS OF MEASURED VALUES

All the recordings were made with UV and memory oscillographs.

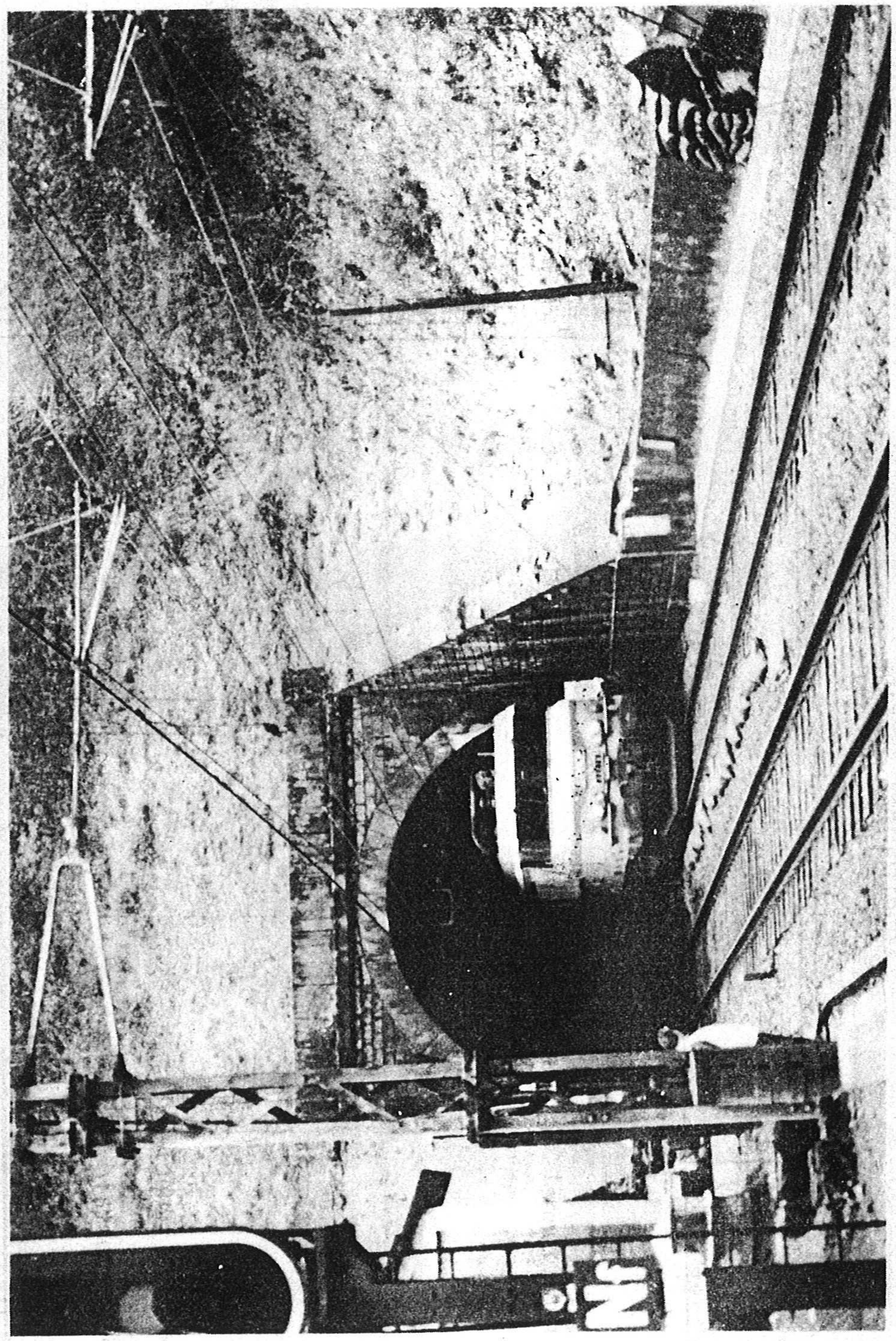
ORE C149/RP12	LONGITUDINAL AND CROSS SECTIONS OF TUNNEL	Fig. 1



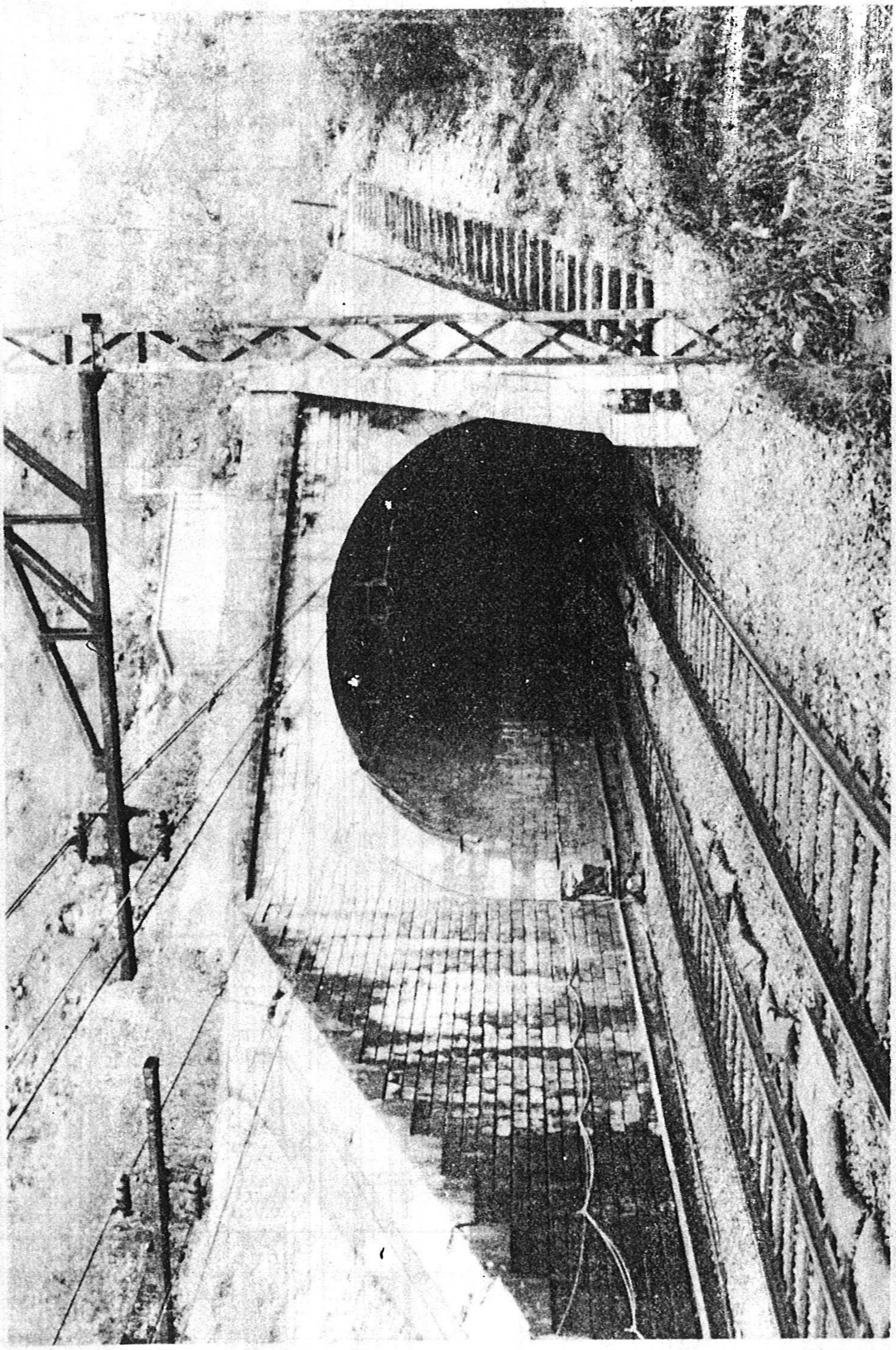
ORE C 149 /RP 12

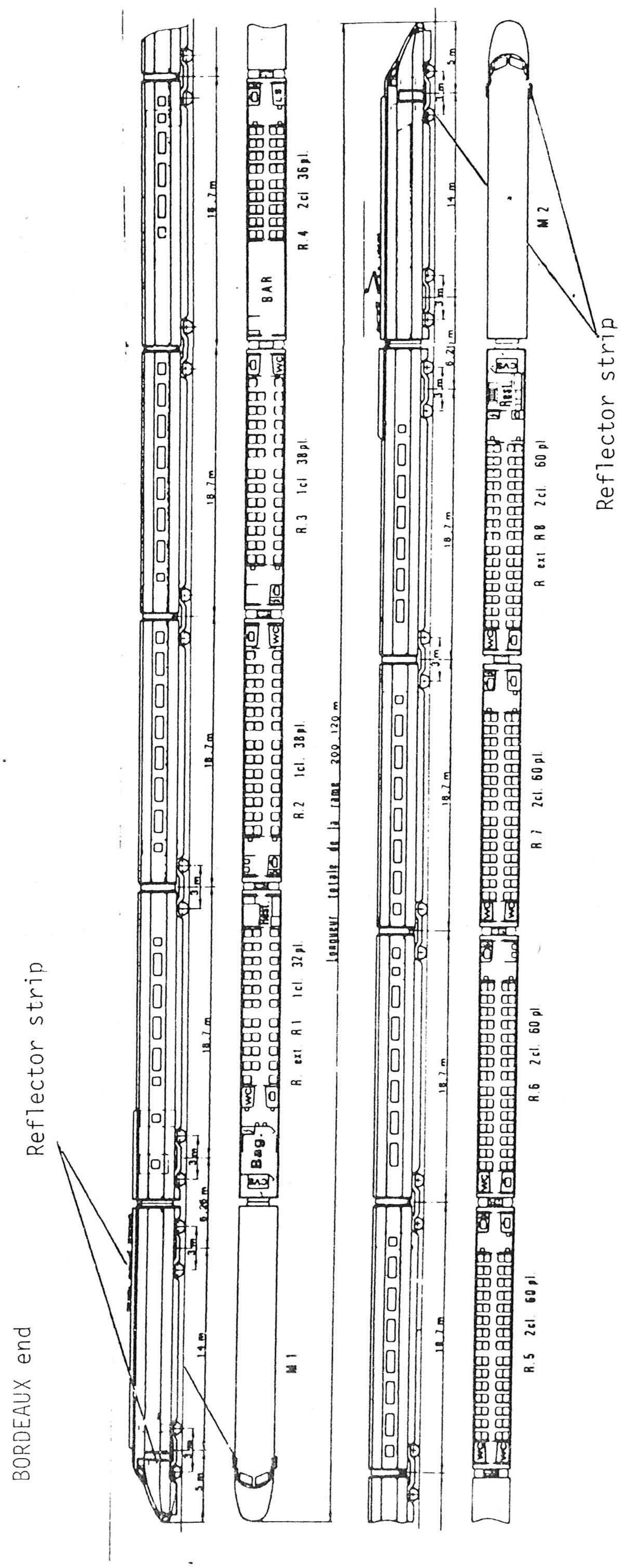
PORTAIL NORD
NORDPORTAL
NORTHERN PORTAL
(PARIS)

Fig. 2

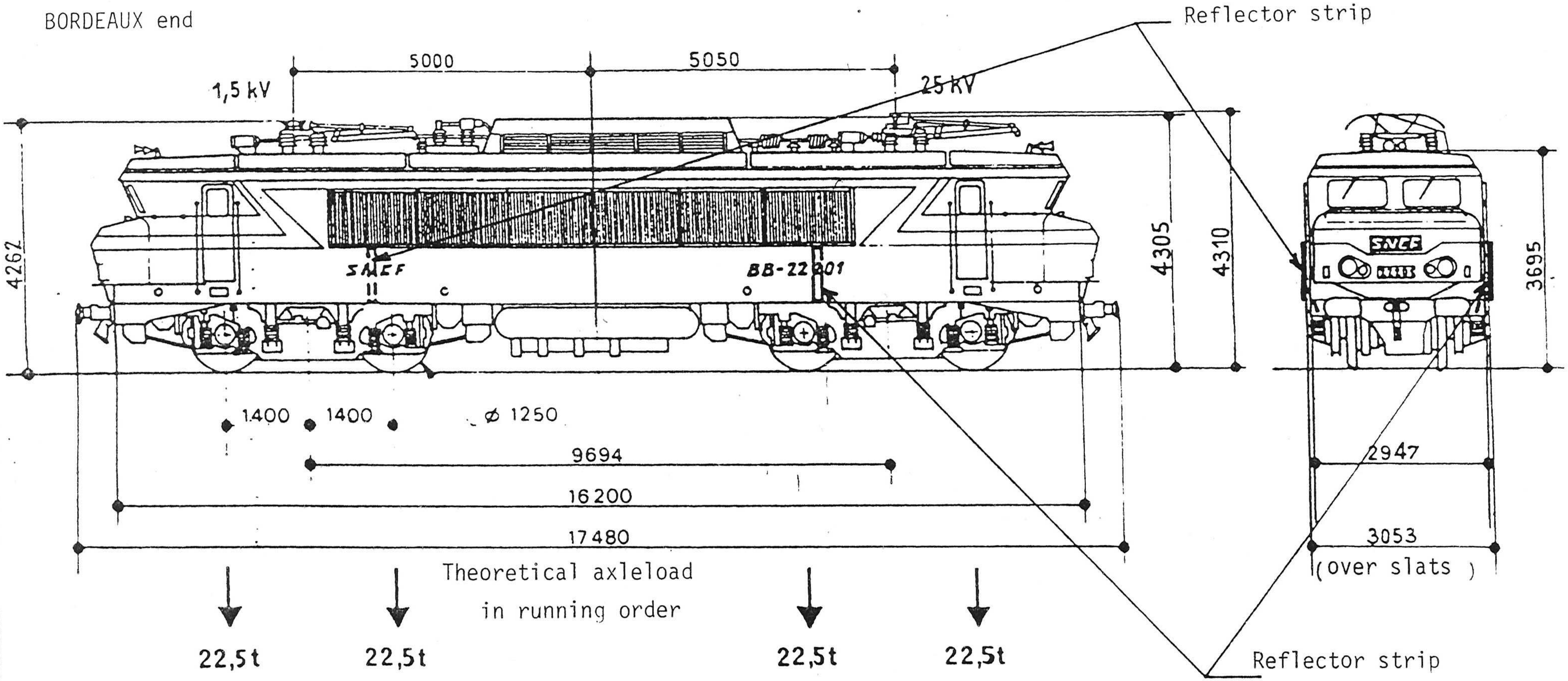


PORTAIL SUD
SUDPORTAL
SOUTHERN PORTAL
(BORDEAUX)





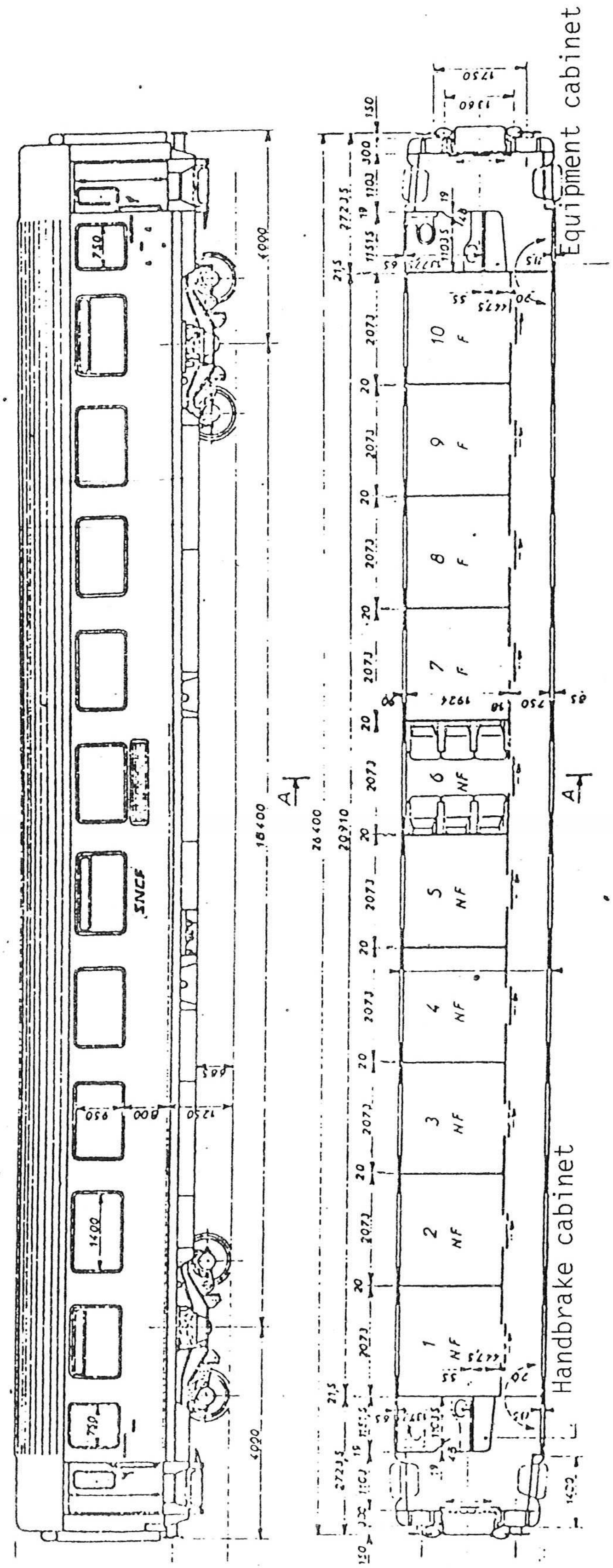
BORDEAUX end
Reflector strip
M 1
R. ext R1 1cl 32pl
R 2 1cl 38pl
R 3 1cl 38pl
R 4 2cl 36pl
BAR
longueur totale de la rame 200 120 m
R 5 2cl 60pl
R 6 2cl 60pl
R 7 2cl 60pl
R ext R8 2cl 60pl
M 2
Reflector strip



Theoretical weight in running order	90	t
Theoretical adhesive weight	90	t
Weight per unit metre between buffers	5.1	t
Weight per unit metre between end axles	7.2	t
Theoretical tare weight	89	t
Minimum radius for curve negotiation	100	m

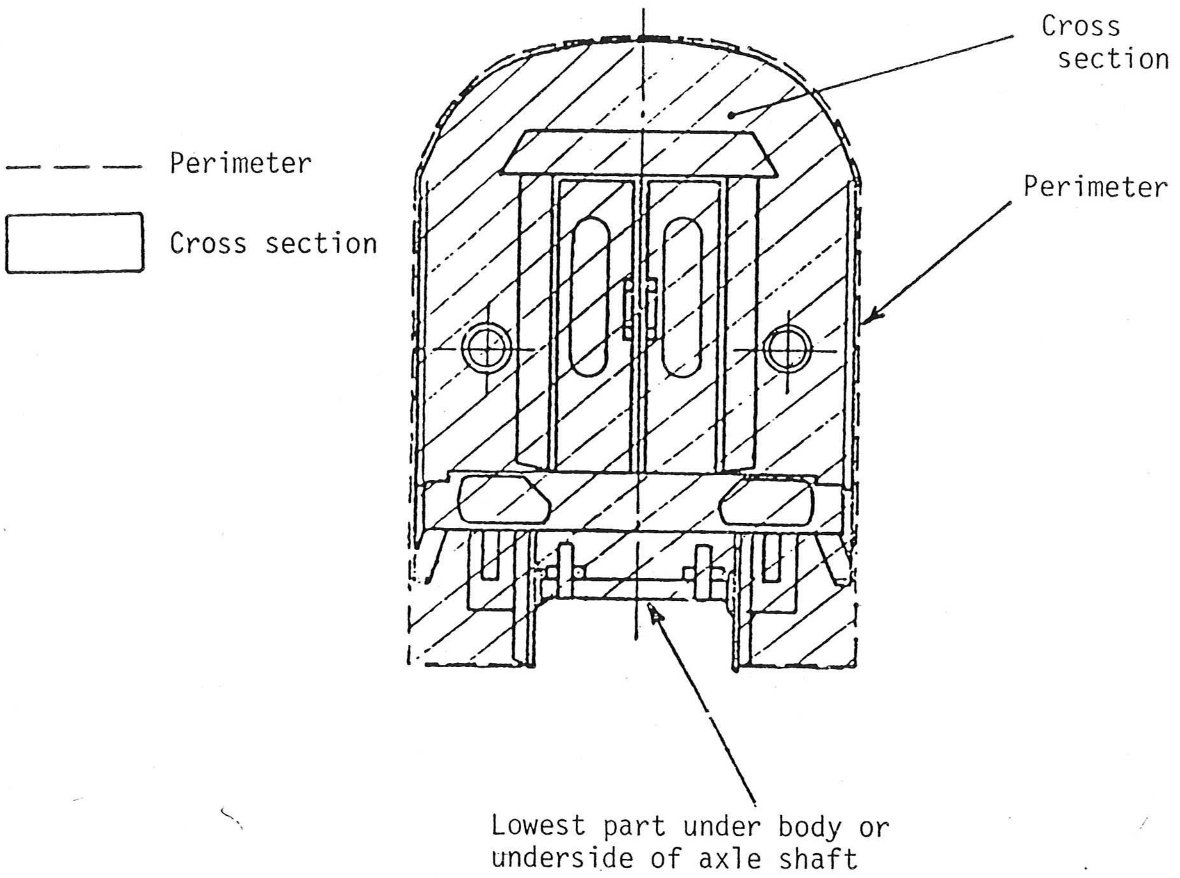
Maximum speed	180 km/h
Maximum operating speed	160 km/h
Continuous power under nominal line voltage	
- At maximum operating speed	4000 kW
- At 65% of maximum operating speed	3800 kW

ORE C149/RP12	CORAIL COACH	Fig. 6

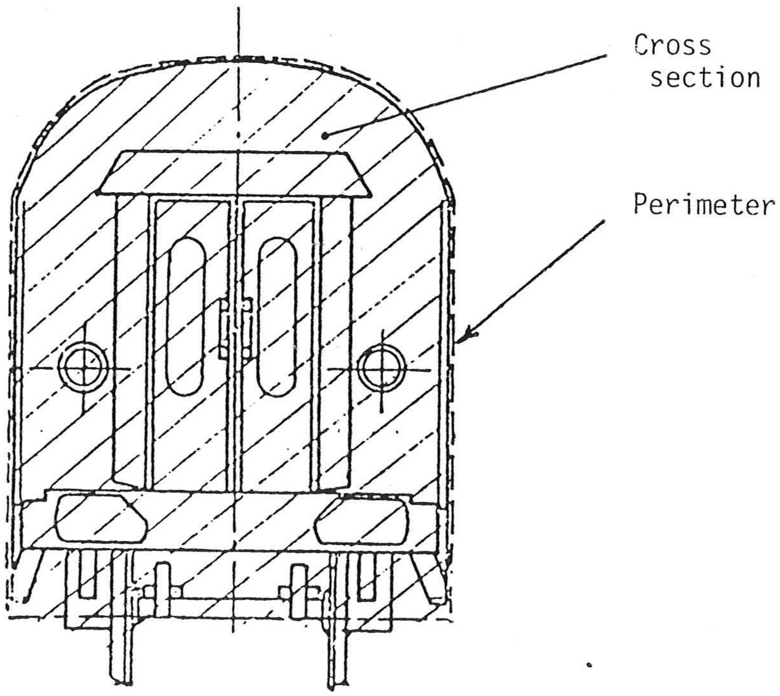


ORE C149/RP12	PERIMETER AND CROSS SECTION OF STOCK	Fig. 7

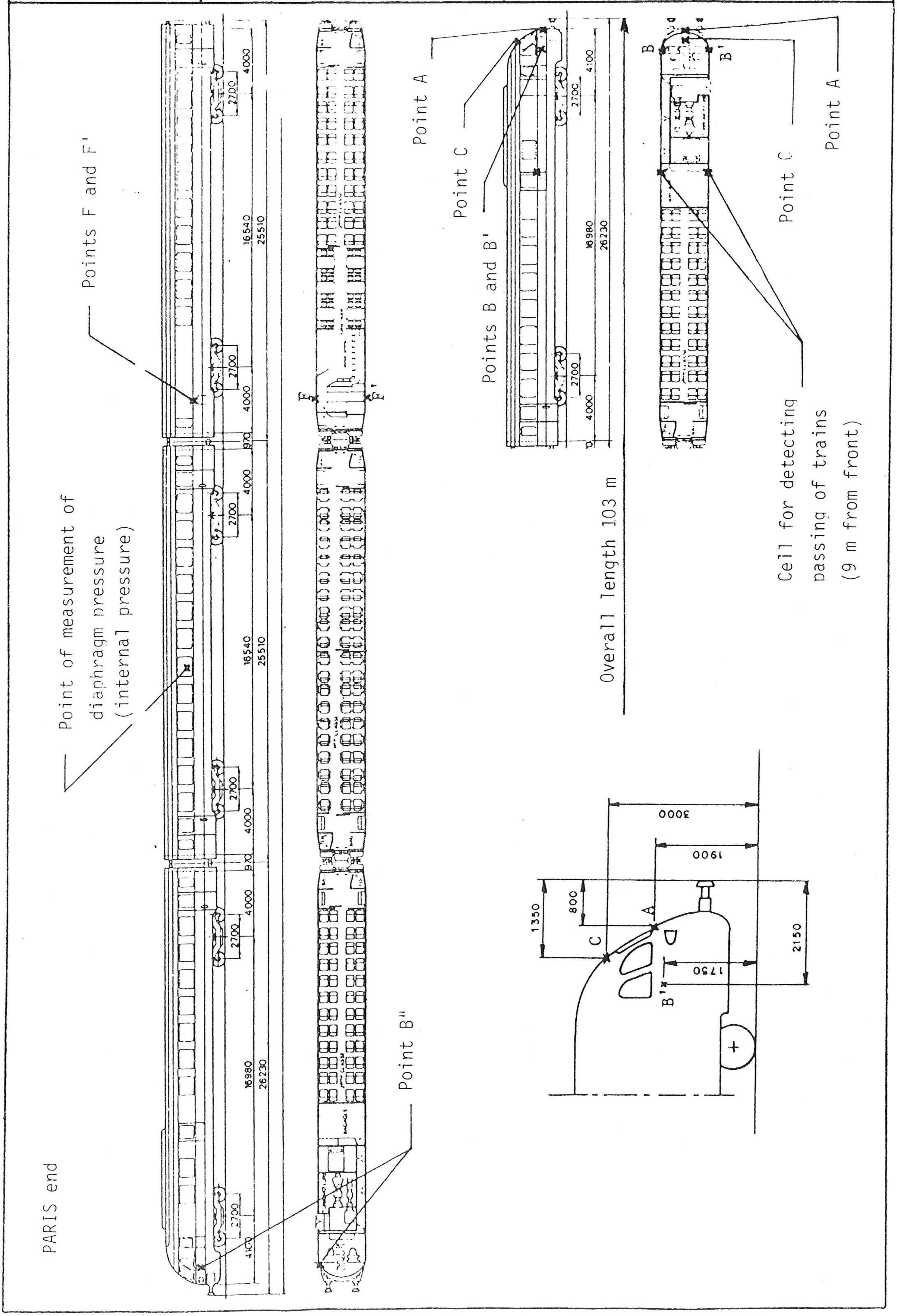
SNCF definitions used in this report



Definitions used by BR

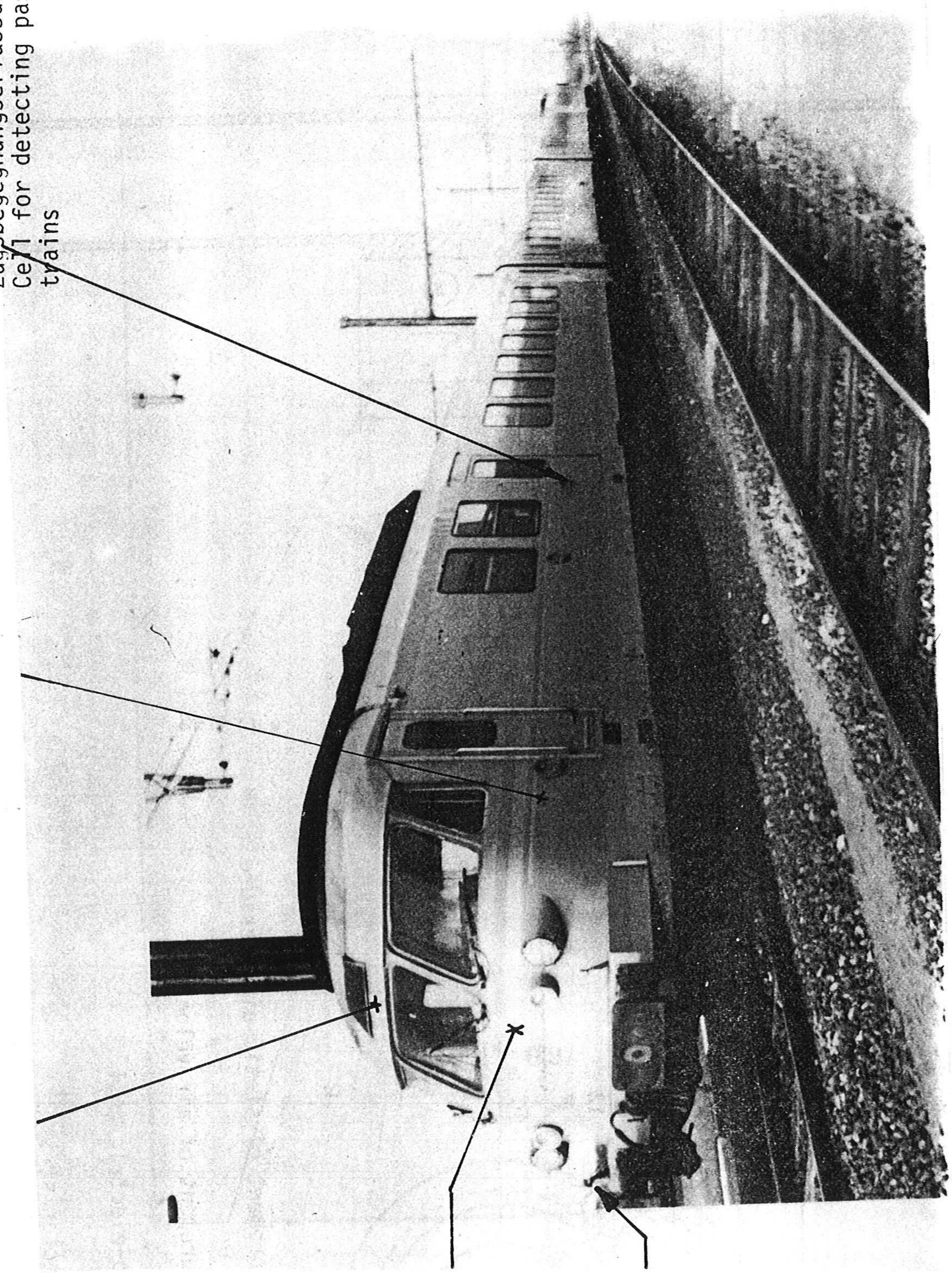


ORE C149/RP12	RTG TRAIN	Fig. 8

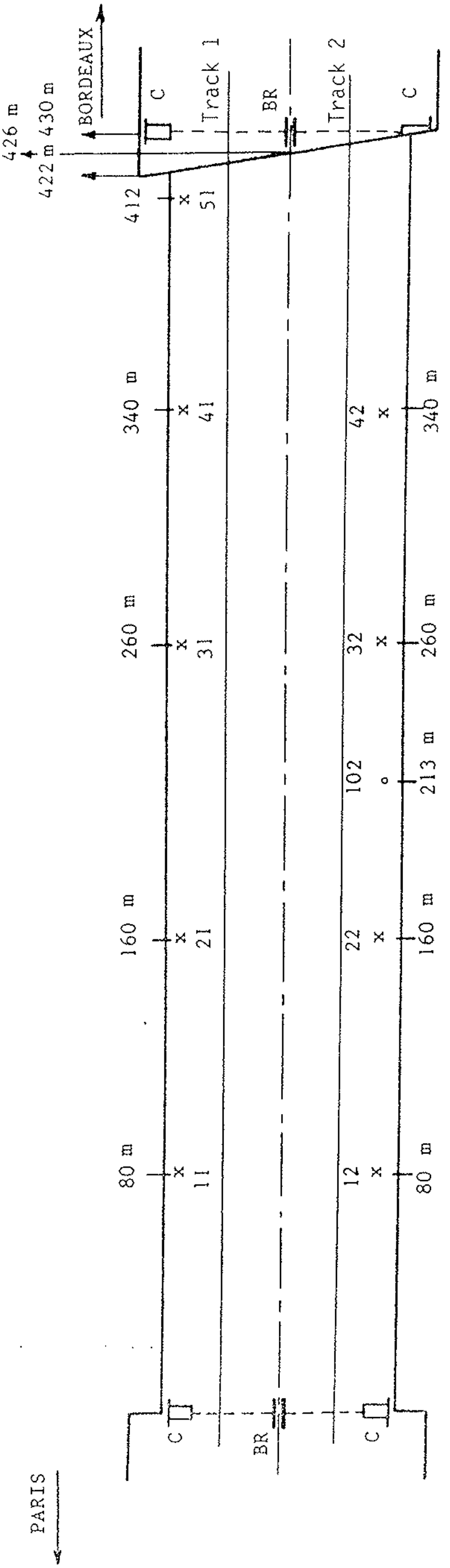


RAME RTG
RTG-ZUG
RTG TRAIN

Fig. 9



ORE C 149/RP12	MEASURING POINTS ALONG THE TUNNEL	Fig. 10



x Measurement of static air pressure

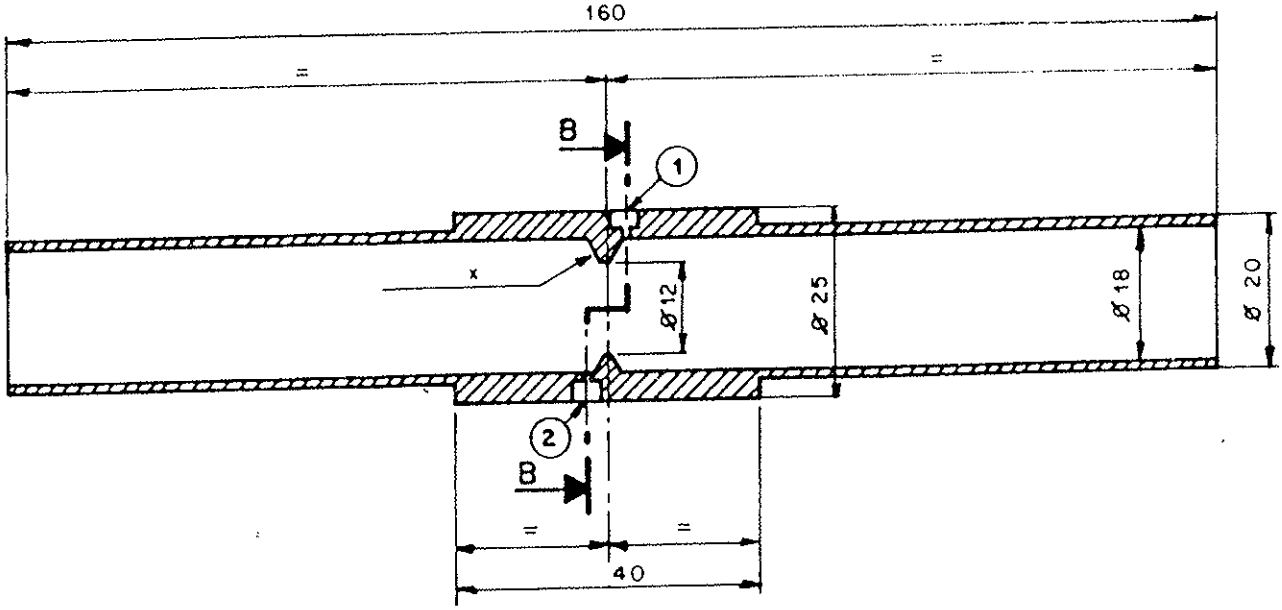
∘ Measurement of air velocity

C Photo-electric cell

BR Reflector strip

ORE C149/RP12	DIAPHRAGM ANEMOMETER	Fig.11

SECTION AA



Detail x

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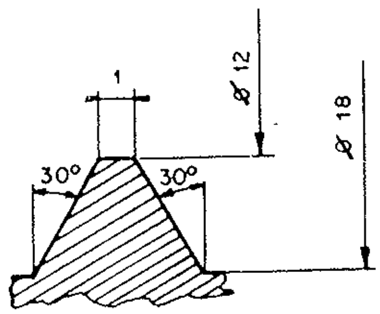
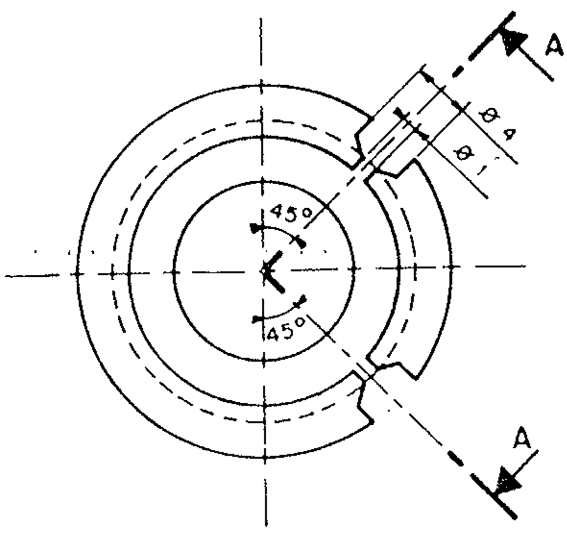


SECTION BB



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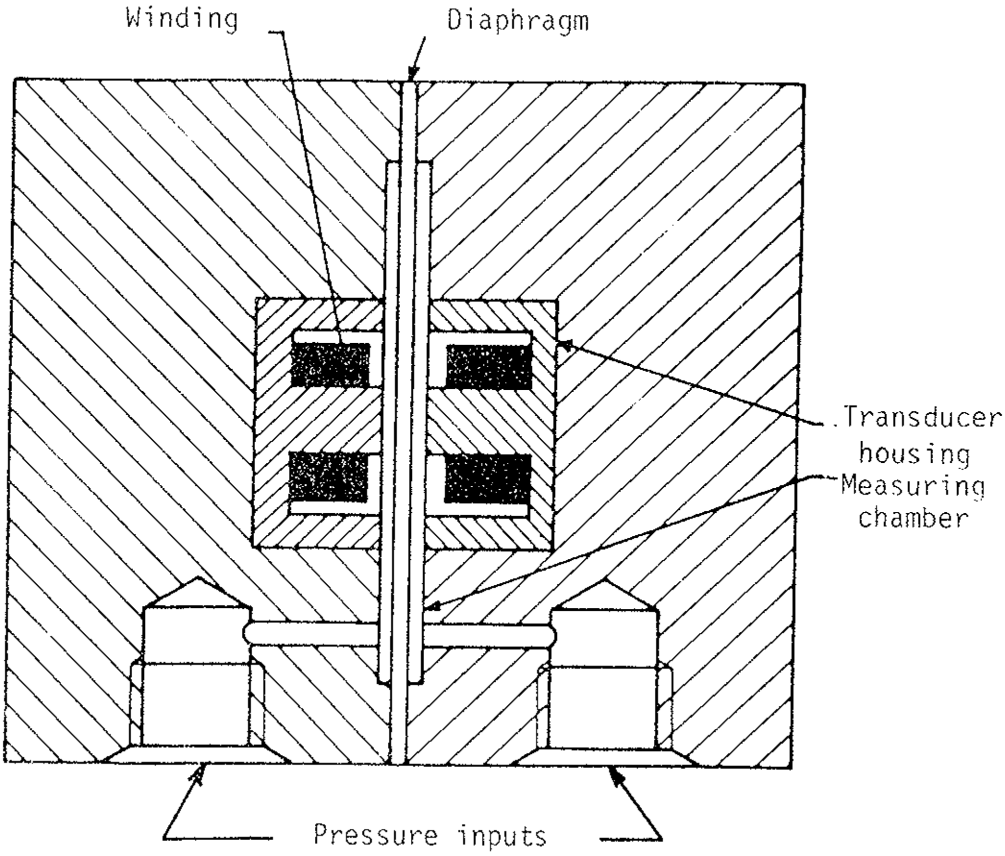
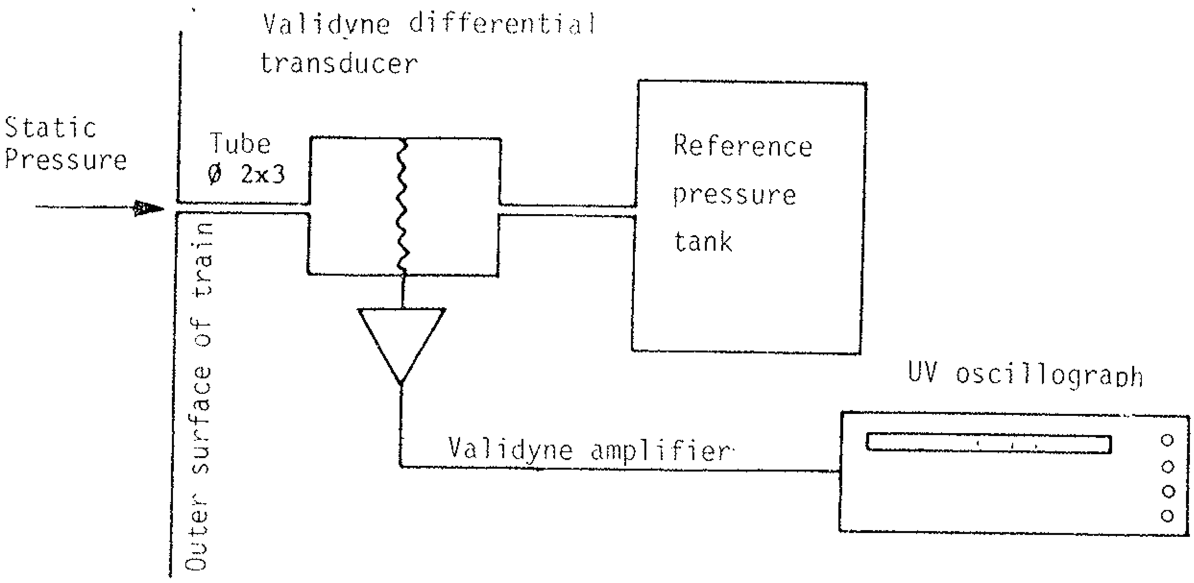
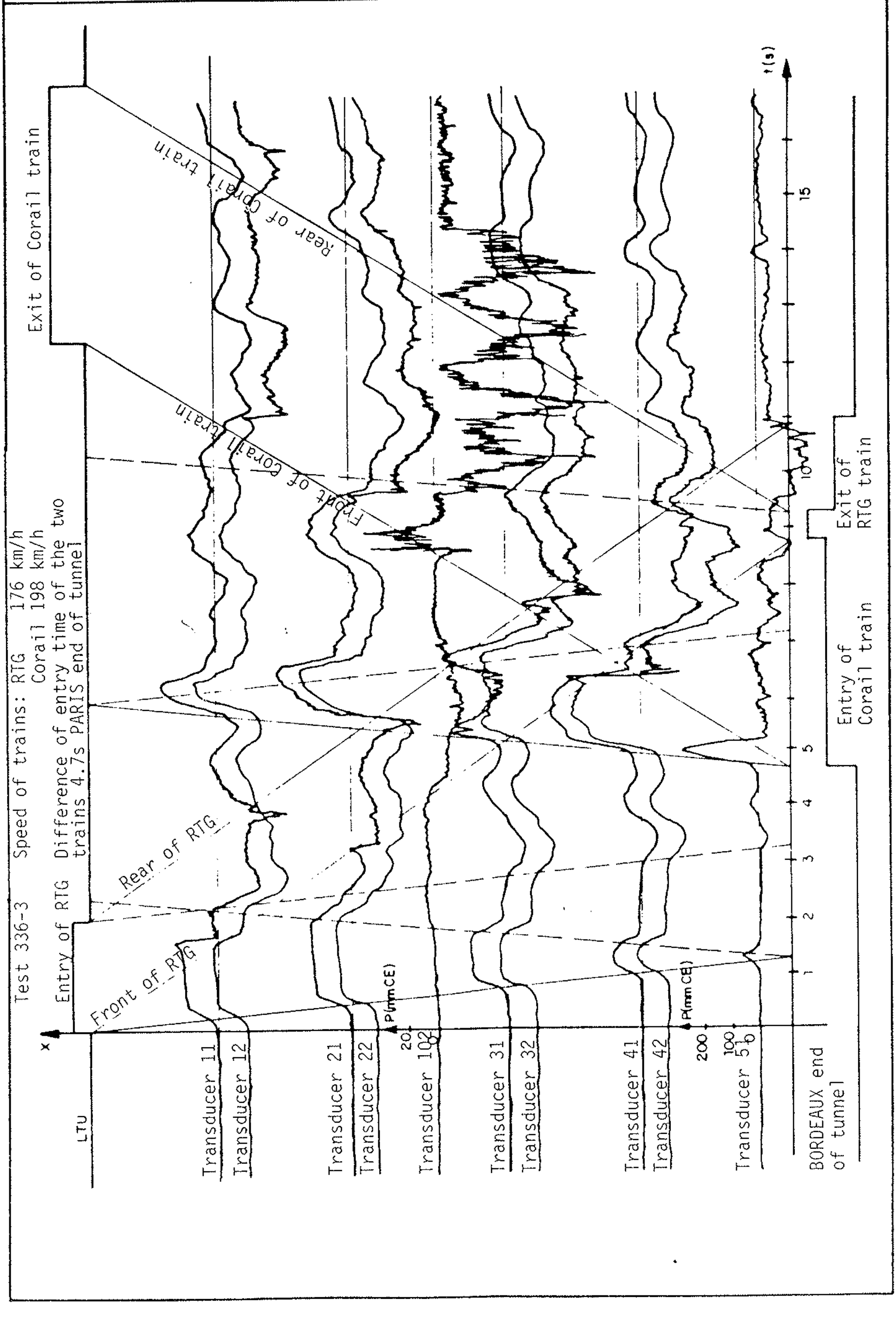
VALIDYNE TRANSDUCER



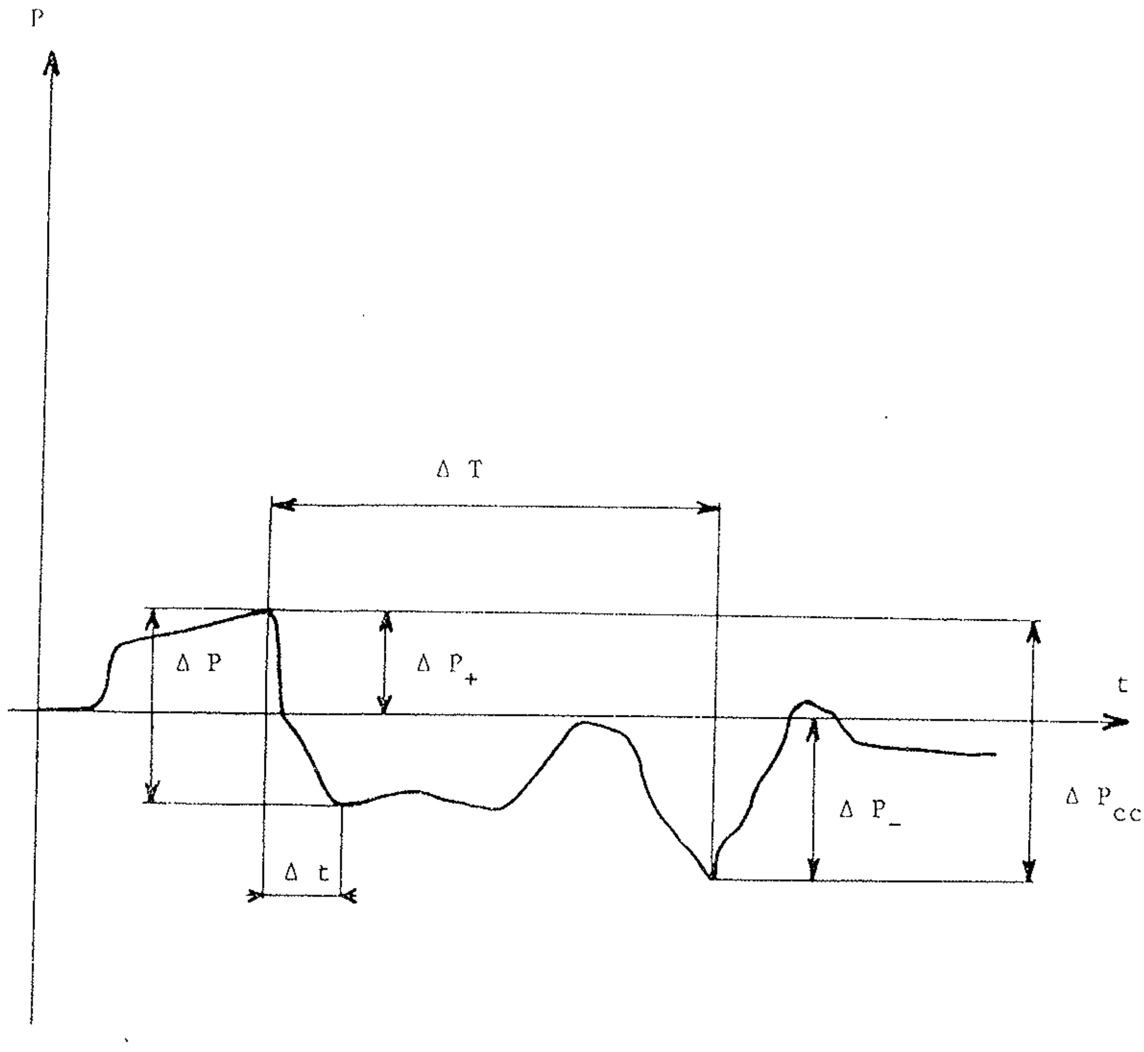
MEASURING ASSEMBLY



ORE C149/RP 12	STATIC PRESSURE AND AIR VELOCITY IN THE TUNNEL	Fig. 13



ORE C149/RP12	DEFINITION OF PRESSURE VARIATIONS	Fig.14



ORE C149/RP12

STATIC PRESSURE AND VELOCITY OF AIR IN THE TUNNEL

Fig.15

Speed of trains (km/h) TGV	RTG	Test No.	N°11 ΔP_+	N°11 ΔP_-	N°11 $\frac{\Delta P_{cc}}{\Delta T}$	N°11 $\frac{\Delta P}{\Delta t}$	N°12 ΔP_+	N°12 ΔP_-	N°12 $\frac{\Delta P_{cc}}{\Delta T}$	N°12 $\frac{\Delta P}{\Delta t}$	N°21 ΔP_+	N°21 ΔP_-	N°21 $\frac{\Delta P_{cc}}{\Delta T}$	N°21 $\frac{\Delta P}{\Delta t}$	N°22 ΔP_+	N°22 ΔP_-	N°22 $\frac{\Delta P_{cc}}{\Delta T}$	N°22 $\frac{\Delta P}{\Delta t}$
210	180	326-1	150	150	300/3	280/0.1	130	140	270/4	240/1	180	200	380/1.5	340/1	210	180	390/6	260/0.4
"	180	326-5	190	170	360/8	300/0.1	/	/	/	/	270	290	560/4	300/0.5	280	210	490/6	340/0.5
"	160	327-1	120	170	230/7	130/0.05	80	160	240/8	160/0.1	230	300	530/3.5	210/0.05	240	250	490/6	170/0.3
"	160	327-3	130	170	300/8	140/0.05	100	160	260/7	170/0.05	260	280	540/7	140/0.05	230	250	480/7	270/0.4
"	160	327-5	250	190	440/1.5	230/0.05	180	180	360/1.5	280/0.8	290	300	590/4	430/0.6	320	330	650/4	400/0.5
"	130	328-1	130	160	290/5	110/0.05	120	150	270/6	160/0.1	150	260	410/6.5	200/0.2	150	220	370/3.5	300/0.4
105	130	328-3	150	140	290/3	170/0.1	140	110	250/4	150/0.4	120	110	230/4	/	130	130	260/4	/
160	100	328-5	50	100	150/8	/	50	90	140/7	10/0.05	130	130	260/5	/	110	130	240/5	80/0.05
210	100	329-1	120	110	230/11.5	130/0.3	120	130	250/11.5	120/0.1	/	/	/	/	/	/	/	/
210	100	329-3	120	160	280/6	140/0.5	110	170	280/6	160/0.1	/	/	/	/	170	230	400/6.5	300/0.8
190	160	325-2	130	280	410/4	150/0.1	/	/	/	/	220	280	500/4.5	130/0.05	200	200	400/4.5	160/0.1
"	190	326-2	150	240	390/3	130/0.05	/	/	/	/	200	270	470/5	370/1	230	270	500/5	380/1
"	190	326-4	110	220	360/1	360/1	/	/	/	/	170	260	430/5	370/1	170	250	420/5	400/1
"	160	326-6	190	240	430/8	190/0.1	190	180	370/8	170/0.1	230	280	510/7	270/0.8	230	230	460/5	270/0.8
"	160	327-2	210	240	450/7	180/0.1	200	170	370/8	150/0.1	270	290	560/7	160/0.1	260	270	530/4.5	/
"	160	327-4	160	260	420/4	130/0.1	120	160	280/7	190/0.1	280	280	560/7	160/0.05	280	240	520/7	230/1
"	130	327-6	170	180	350/4	180/0.1	110	170	310/4	230/1	160	200	360/3.5	210/1	180	180	360/4	160/0.5
"	130	328-2	200	170	370/4	200/0.1	190	150	340/4	190/0.5	220	210	430/6	160/0.1	230	160	390/4.5	/
"	130	328-4	200	200	400/4	190/0.1	170	150	320/4	200/1	210	240	450/4	160/0.1	240	250	490/7	240/1
"	100	328-6	180	150	330/4	180/0.1	110	140	250/4	/	200	180	380/4	150/0.1	210	160	370/4	/
"	100	329-2	200	180	380/4	200/0.2	170	160	330/4	230/1	/	/	/	/	200	180	380/7	170/0.5

Test No.	N°31 ΔP_+	N°31 ΔP_-	N°31 $\frac{\Delta P_{cc}}{\Delta T}$	N°31 $\frac{\Delta P}{\Delta t}$	N°32 ΔP_+	N°32 ΔP_-	N°32 $\frac{\Delta P_{cc}}{\Delta T}$	N°32 $\frac{\Delta P}{\Delta t}$	N°41 ΔP_+	N°41 ΔP_-	N°41 $\frac{\Delta P_{cc}}{\Delta T}$	N°41 $\frac{\Delta P}{\Delta t}$	N°42 ΔP_+	N°42 ΔP_-	N°42 $\frac{\Delta P_{cc}}{\Delta T}$	N°42 $\frac{\Delta P}{\Delta t}$	N°51 ΔP_+	N°51 ΔP_-	N°51 $\frac{\Delta P_{cc}}{\Delta T}$	N°51 $\frac{\Delta P}{\Delta t}$	Air velocity (m/s) V_a+	V_a-
326-1	/	/	/	/	140	190	320/1	200/0.2	220	220	440/2	320/1	300	250	550/2.5	280/0.1	180	270	450/5	220/0.2	10.5	17.5
326-5	320	240	560/1	250/0.3	320	240	560/4	520/1	210	160	370/1.5	250/0.5	300	200	500/4	260/0.2	90	150	240/3	100/0.1	11.5	18
327-1	280	270	550/4	190/0.3	270	330	600/5	250/0.2	210	220	430/7	200/0.1	270	280	550/7	260/0.1	160	210	370/8	250/0.1	0	17.5
327-3	340	300	640/3.5	410/1	340	350	690/3.5	250/0.1	200	230	430/6	140/0.05	280	310	590/4	230/0.1	170	200	370/7	250/0.1	0	17.5
327-5	190	240	430/3	230/0.1	220	290	510/5	200/0.1	170	150	320/3.5	180/0.1	200	220	420/3.5	30/0.1	140	150	290/11	150/0.05	12.5	19.5
328-1	270	280	550/4	220/0.2	260	310	570/3.5	250/0.2	200	170	370/4.5	160/0.1	260	230	490/4	340/0.1	160	150	310/3.5	180/0.1	0	20
328-3	80	90	170/7	120/0.1	80	110	190/7	100/0.2	50	110	160/10	100/0.05	50	100	150/10	/	30	70	100/11	90/0.05	2.5	15
328-5	140	160	300/6.5	/	150	230	380/6.5	110/0.05	140	100	240/4	/	160	170	330/4.5	140/0.1	100	90	190/11	100/0.1	0	20
329-1	160	190	350/4	260/1	160	200	360/4	260/1	170	130	300/3.5	260/1	150	110	260/3.5	250/1	130	90	220/3.5	160/0.5	9	20
329-3	240	240	480/4	300/1	220	280	500/4	200/0.1	210	160	370/3.5	340/1.5	270	170	440/3.5	350/1	140	120	260/3.5	190/0.5	0	17
325-2	/	/	/	/	240	310	550/5	420/1	190	180	360/2	110/0.2	250	170	420/2	230/0.1	140	150	290/7	140/0.1	0	18.5
326-2	/	/	/	/	250	260	510/1	430/1	170	280	450/1.5	380/1	180	260	440/1	440/1	220	150	370/2	300/0.4	12.5	19.5
326-4	220	300	520/2	460/1	200	340	510/2	460/1	280	320	600/1	600/1	360	430	790/1.5	600/1	200	180	380/3	250/0.2	12	20
326-6	240	220	460/5	180/0.3	240	330	570/4	230/0.1	140	150	290/8	120/0.1	180	170	350/8	150/0.1	110	160	270/9	160/0.1	12.5	17.5
327-2	300	290	590/4	300/1	300	370	670/4	210/0.05	240	180	420/7	340/1	300	190	490/7	380/1	100	160	260/8	160/0.3	4	18
327-4	260	240	500/7	360/1	260	280	540/7	410/1	230	180	410/8	300/1	240	220	460/3.5	220/0.1	110	150	260/7	180/0.1	0	12.5
327-6	170	190	360/4	310/1	160	180	340/4	230/1	130	120	250/7	/	140	130	270/7	/	70	110	180/7	110/0.1	4.5	13
328-2	240	240	480/7	380/1	240	250	490/7	400/1	210	150	360/7	/	220	170	390/7	160/0.1	60	140	200/7	160/0.1	0	17.5
328-4	220	240	460/4	290/1	210	240	450/4	310/1	100	180	280/7	120/0.1	110	220	330/2	260/0.5	60	150	210/10	170/0.3	13	9
328-6	190	210	400/7	270/1	180	220	400/7	300/1	160	150	310/7	140/0.1	180	140	320/7	150/0.3	60	120	180/7	140/0.1	0	12
329-2	190	220	410/7	360/1	190	210	400/7	330/1	170	150	320/7	/	180	140	320/7	100/0.1	60	120	180/6.5	130/0.1	8	18.5

NB: The pressure variations are given in mm CE

ORE C149/RP12

STATIC PRESSURE AND VELOCITY OF AIR IN THE TUNNEL

Fig.16

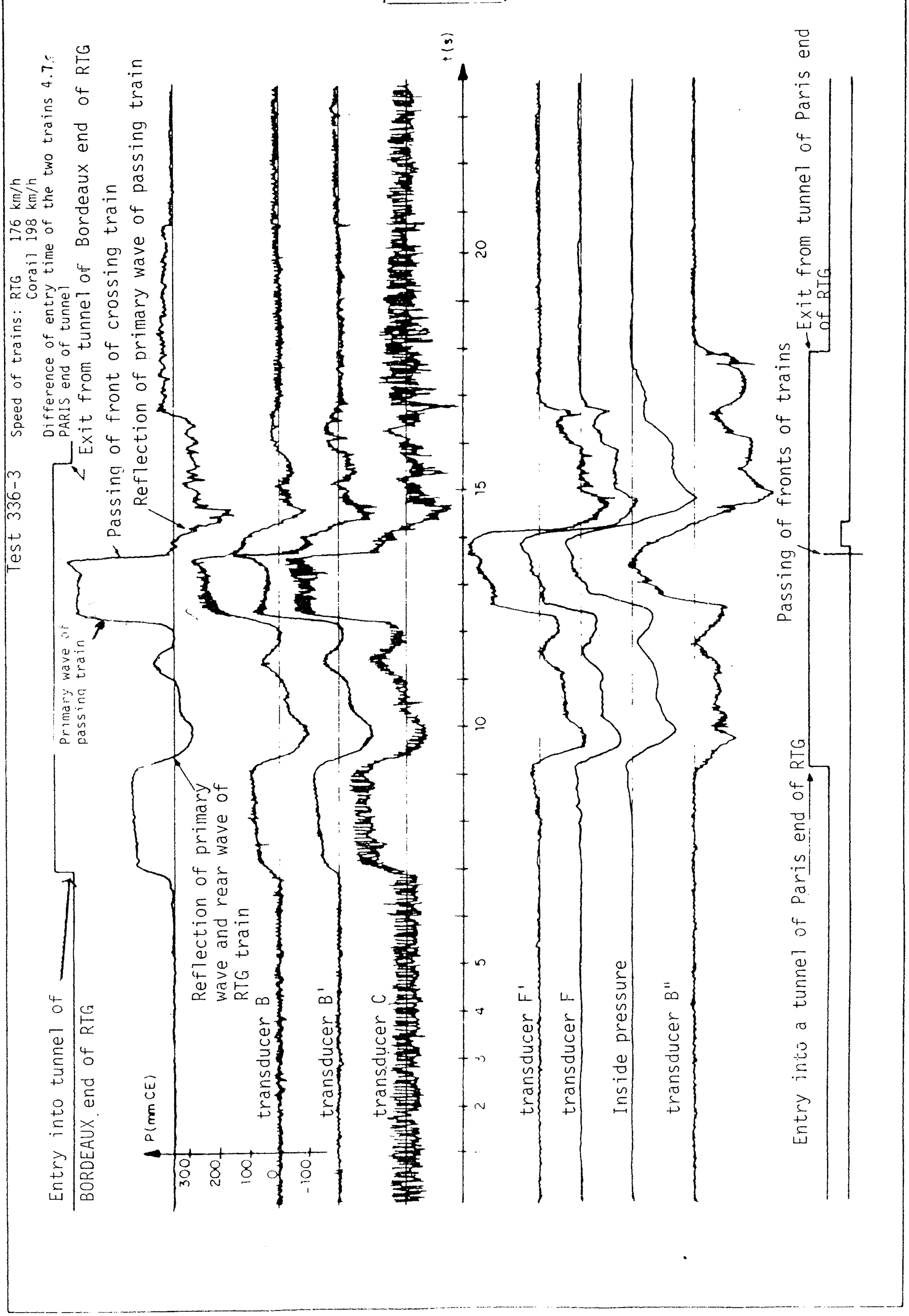
Speed of trains (km/h) CORAIL	Speed of trains (km/h) RTG	Test No.	N°11 ΔP_+	N°11 ΔP_-	N°11 $\frac{\Delta P_{cc}}{\Delta T}$	N°11 $\frac{\Delta P}{\Delta t}$	N°12 ΔP_+	N°12 ΔP_-	N°12 $\frac{\Delta P_{cc}}{\Delta T}$	N°12 $\frac{\Delta P}{\Delta t}$	N°21 ΔP_+	N°21 ΔP_-	N°21 $\frac{\Delta P_{cc}}{\Delta T}$	N°21 $\frac{\Delta P}{\Delta t}$
200	160	333-3	310	170	480/3	260/0.1	310	200	510/6.5	310/1	340	300	640/4.5	260/0.05
"	180	333-5	190	170	360/2	340/1	180	190	370/2	300/1	/	/	/	/
"	160	334-3	150	180	330/7.5	160/0.05	120	190	310/7.5	230/1	320	240	560/5	390/1
"	130	335-1	200	110	310/7	200/0.5	190	130	320/7	180/0.5	260	200	460/5	280/1
"	130	335-3	200	110	310/5	170/0.5	190	120	310/5	160/0.5	240	200	440/4.5	200/0.5
"	100	335-5	160	130	290/6.5	240/0.5	150	160	310/5	270/0.2	250	230	480/5	250/0.5
"	100	336-1	150	120	270/5	180/0.5	140	140	280/5	180/0.5	280	230	510/4.5	290/0.8
"	180	336-3	200	210	410/2.5	280/0.8	190	140	330/3.5	250/0.8	260	240	500/1	500/1
180	190	333-4	200	270	470/8	320/0.8	170	270	440/6.5	320/0.2	360	300	660/4	270/0.5
"	190	333-6	180	240	430/10.5	330/1	150	190	340/9	280/0.2	/	/	/	/
"	160	334-2	210	200	410/7	220/0.05	170	210	380/7	250/0.2	260	300	560/5.5	250/0.5
"	160	334-4	310	320	630/4	320/0.05	270	290	560/4	350/1	280	250	530/5	350/1
"	130	334-6	180	160	350/6	330/1	160	130	290/9	280/1	210	190	400/9	160/0.05
"	100	335-2	240	230	470/4	340/1	200	150	350/4	270/1	230	260	490/4	270/1
"	130	335-4	250	190	440/7	250/0.05	200	180	380/7	210/0.2	230	290	520/6.5	200/0.05
"	100	335-6	250	160	410/8	350/1	200	110	310/6.5	270/1	240	250	490/7	290/1.5

Test No.	N°22 ΔP_+	N°22 ΔP_-	N°22 $\frac{\Delta P_{cc}}{\Delta T}$	N°22 $\frac{\Delta P}{\Delta t}$	N°31 ΔP_+	N°31 ΔP_-	N°31 $\frac{\Delta P_{cc}}{\Delta T}$	N°31 $\frac{\Delta P}{\Delta t}$	N°32 ΔP_+	N°32 ΔP_-	N°32 $\frac{\Delta P_{cc}}{\Delta T}$	N°32 $\frac{\Delta P}{\Delta t}$
333-3	350	330	680/4.5	300/1	370	290	660/6.5	260/1	370	370	740/6.5	340/1
333-5	200	260	460/7	370/1	400	300	700/5	500/1	400	350	750/4	570/1
334-3	/	/	/	/	310	300	610/4	330/1	340	370	710/4	370/1
335-1	270	220	490/5	300/1	220	230	450/4	320/1	220	250	470/4	360/1
335-3	260	230	490/4.5	300/1	300	200	500/4	340/1	300	250	550/4	470/1
335-5	240	240	480/5	230/0.5	320	250	570/3.5	320/1	330	310	640/6.5	460/1
336-1	280	240	520/4.5	260/0.8	310	240	550/4	380/1	320	300	620/4	460/1
336-3	260	240	500/5	410/1	220	270	490/1	490/1	200	230	430/1	430/1
333-4	320	330	650/4.5	310/1	360	270	630/3	410/1	370	350	720/3	490/1
333-6	180	240	420/5	370/1.5	360	280	640/2	450/1.5	330	400	730/4	420/1.5
334-2	270	250	520/5.5	/	260	300	560/5	390/1	270	400	670/5	320/0.05
334-4	300	260	560/5	340/0.5	130	170	300/5.5	210/0.5	150	170	320/5.5	230/0.5
334-6	180	240	420/6	230/0.1	290	280	570/5	280/1	300	240	540/5	260/1
335-2	240	220	460/4	280/0.7	150	190	340/7.5	180/0.05	170	180	350/7.5	270/1
335-4	250	260	510/7.5	/	240	220	460/5	/	240	220	460/5	190/0.1
335-6	260	210	470/7	270/1.5	220	200	420/8	180/0.6	250	170	420/7.5	230/0.6

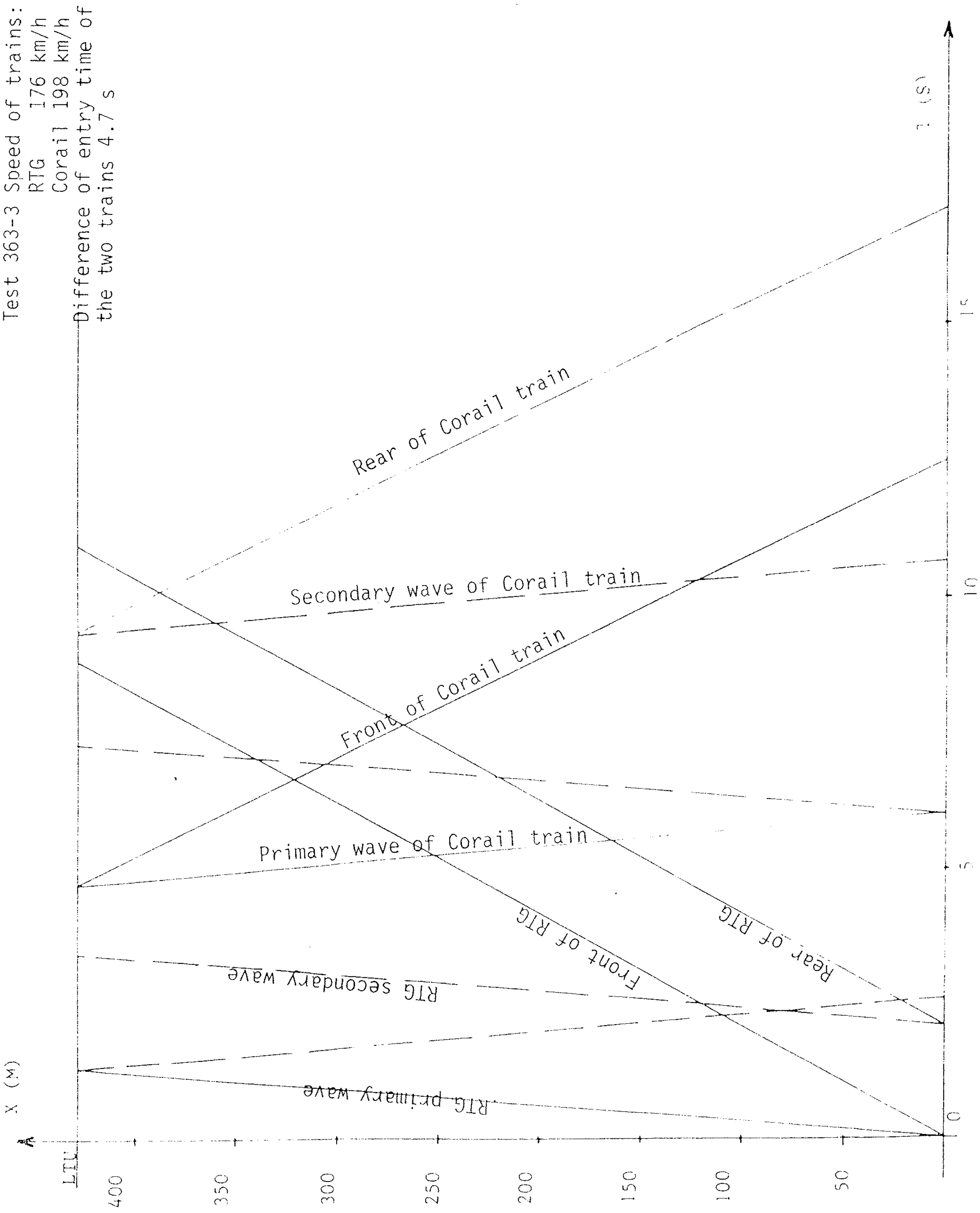
Test No.	N°41 ΔP_+	N°41 ΔP_-	N°41 $\frac{\Delta P_{cc}}{\Delta T}$	N°41 $\frac{\Delta P}{\Delta t}$	N°42 ΔP_+	N°42 ΔP_-	N°42 $\frac{\Delta P_{cc}}{\Delta T}$	N°42 $\frac{\Delta P}{\Delta t}$	N°51 ΔP_+	N°51 ΔP_-	N°51 $\frac{\Delta P_{cc}}{\Delta T}$	N°51 $\frac{\Delta P}{\Delta t}$	Air velocity (m/s) V_a+	Air velocity (m/s) V_a-
333-3	300	230	530/6.5	350/1	340	200	540/6.5	390/1	170	190	360/9.5	240/0.1	11	21
333-5	350	400	750/4	430/1	400	450	850/4	500/1	220	300	520/7	240/0.2	4	19
334-3	260	270	530/7	370/1	320	320	640/5	370/1	240	230	470/8	250/0.1	0	20
335-1	290	270	560/4	380/1	350	250	600/4	500/1	240	290	530/7	260/0.2	10	19
335-3	240	200	440/4.5	380/1	260	180	440/4.5	400/1	240	140	380/4.5	250/0.2	9	20
335-5	250	170	420/4	360/1	330	210	540/4	430/1	220	130	350/10	250/0.2	0	21
336-1	250	180	430/4	320/1	340	190	530/4	430/1	240	100	340/5	250/0.2	0	21
336-3	320	230	550/2	400/1	360	270	630/1.5	500/1	270	200	470/6	320/0.2	10	20
333-4	240	200	440/2	280/0.6	290	220	510/2	280/0.05	180	200	380/6.5	240/0.05	8	20
333-6	340	300	640/1.5	580/1	340	210	550/1	550/1	210	210	420/2	250/0.2	6.5	19
334-2	240	130	430/6.5	200/0.5	230	170	400/4	230/0.05	210	160	370/7	250/0.3	5	18
334-4	150	120	270/2	260/1	140	140	280/2.5	260/0.7	110	110	220/2.5	140/0.1	12	19.5
334-6	260	170	430/5	280/1	270	230	500/3.5	300/0.6	100	150	250/6	170/0.05	7	19
335-2	150	150	300/5.5	120/0.2	160	140	300/5.5	130/0.2	100	120	320/7	140/0.1	11	15.5
335-4	210	130	340/7.5	180/0.5	260	140	410/7.5	220/0.5	70	150	220/9	180/0.05	8	13.5
335-6	100	130	230/7.5	160/0.5	130	130	260/7.5	160/0.5	90	120	210/7	130/0.05	13.5	17

NB: The pressure variations are given in mm CE

ORE C149/RP 12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig.17



ORE C149/RP12	WAVE DIAGRAM	Fig. 18



ORE C149/RP12

VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN

Fig.19

Speed of trains (km/h)		Test No.	A				B				B'				C			
TGV	RTG		ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$	ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$	ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$	ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$
210	180	326-1	290	200	490/2	350/0.3	190	130	320/3.5	290/1.2	270	140	410/2	350/1.2	300	110	410/2	390/1.2
"	180	326-5	140	130	270/6.5	250/0.1	80	100	180/1	130/0.2	190	110	300/5.5	180/0.1	150	80	230/1	180/0.1
"	160	327-1	260	300	560/4	500/2	190	230	420/4	300/2	180	240	420/4	340/2	270	250	520/4	420/2
"	160	327-3	280	240	520/3	270/0.2	200	160	360/4	100/0.1	200	160	360/4	150/0.1	280	170	450/4	230/0.2
"	160	327-5	380	230	610/1.2	610/1.2	210	200	410/1.2	410/1.2	170	220	390/1.2	390/1.2	340	210	550/1.2	550/1.2
"	130	328-1	270	200	470/3	260/0.3	240	130	370/4	140/0.3	220	150	370/4	150/0.2	270	190	460/3.5	210/0.2
105	130	328-3	170	100	270/4	170/0.6	100	80	180/4	100/0.6	60	80	140/4	/	150	90	240/4	140/0.6
160	100	328-5	140	130	270/4	120/0.2	130	110	240/4	120/0.4	110	100	210/4	70/0.1	140	110	250/4	100/0.1
210	100	329-1	160	100	260/2	100/0.1	120	120	240/2	200/1	100	130	230/2	180/1	120	110	230/2	210/1
"	100	329-3	240	250	490/3.5	150/0.1	220	210	430/4	200/0.4	200	220	420/4	90/0.1	240	220	460/4	130/0.1
190	160	325-2	200	265	465/1.6	465/1.6	/	/	/	/	170	130	300/1.6	300/1.6	/	/	/	/
"	190	326-2	30	250	280/1.2	280/1.2	0	250	250/1.2	250/1.2	40	300	340/2.1	270/0.8	30	260	290/1.1	290/1.1
"	190	326-4	0	310	310/1.2	310/1.2	0	350	350/1.2	350/1.2	0	300	300/1.2	300/1.2	0	320	320/1.2	320/1.2
"	160	326-6	0	250	250/1.5	250/1.5	0	270	270/1.5	270/1.5	0	270	270/1.5	270/1.5	0	260	260/1.5	260/1.5
"	160	327-2	0	280	280/1	280/1	0	310	310/1	310/1	0	270	270/1	270/1	0	280	280/1	280/1
"	160	327-4	0	290	290/5	/	0	290	290/5	/	0	290	290/5	/	30	280	310/5	/
"	130	328-2	30	270	300/4.5	160/1	50	280	330/4.5	170/1	40	270	310/4.5	160/1	40	270	310/4.5	160/1
"	130	328-4	50	220	270/4	250/1	30	240	270/4	260/1	50	230	280/4	260/1	50	220	270/4	260/1
"	100	328-6	40	210	250/4.5	150/0.8	30	230	260/4.5	150/0.8	20	220	240/4.5	120/0.8	30	230	260/4.5	150/0.3
"	100	329-2	70	180	250/4	190/1.2	70	190	260/4	210/1.2	70	190	260/4	200/1.2	70	180	250/4	210/1.2

Speed of trains (km/h)		Test No.	F'				F				PI				B''			
TGV	RTG		ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$	ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$	ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$	ΔP_+	ΔP_-	$\Delta P_{cc}/\Delta T$	$\Delta P/\Delta t$
210	180	326-1	210	230	440/1.5	420/0.8	220	220	440/1.5	420/0.8	180	200	380/2	360/1	200	240	440/2	420/1
"	180	326-5	160	170	330/6	180/0.1	170	180	350/6	180/0.1	130	150	280/6	100/0.2	190	160	350/3.5	170/0.3
"	160	327-1	70	310	380/4	360/1.5	80	290	370/4	330/1.5	60	280	340/4	300/1.5	0	320	320/1.5	320/1.5
"	160	327-3	140	320	460/4	100/0.1	140	320	460/4	230/1	160	280	440/4	280/1	100	320	420/5	190/0.3
"	160	327-5	130	250	380/4	100/0.1	140	270	410/4	240/0.5	100	240	340/4	270/1	50	310	360/4	180/0.8
"	130	328-1	170	300	470/4	110/0.1	170	300	470/4	200/0.4	160	260	420/4	240/1	140	270	410/4	230/0.5
105	130	328-3	10	120	130/3	60/0.3	20	130	150/3	60/0.3	30	120	150/3	50/0.3	0	130	130/3	/
160	100	328-5	80	150	230/4	70/0.1	80	150	230/4	120/0.4	80	140	220/4	120/0.7	50	160	210/4	100/0.5
210	100	329-1	90	140	230/2	100/0.1	90	140	230/2	120/0.5	60	120	180/2	120/0.8	10	120	130/4.5	110/0.5
"	100	329-3	170	240	410/4	100/0.1	170	240	410/4	170/0.3	160	230	390/4	160/0.5	150	240	390/4	220/0.5
190	160	325-2	70	250	320/3.8	/	70	250	320/3.8	/	50	250	300/4.2	230/2	/	/	/	/
"	190	326-2	40	260	300/0.9	300/0.9	40	290	330/0.9	330/0.9	40	260	300/4.2	270/0.9	160	220	380/4.2	360/1
"	190	326-4	90	320	410/0.9	410/0.9	80	340	420/0.9	420/0.9	70	330	400/1	400/1	210	290	500/1.4	460/1
"	160	326-6	110	240	350/4.4	270/1.5	110	250	360/4.4	270/1.5	80	240	320/4.4	240/1.5	170	170	340/4.4	180/1.5
"	160	327-2	110	270	380/4.2	330/1.2	110	280	390/4.2	330/1.2	80	270	350/4.2	300/1.2	210	200	410/4.2	340/1.5
"	160	327-4	60	200	260/2.5	160/0.5	60	220	280/2.5	160/0.5	60	190	250/2.5	130/0.5	150	170	320/4	220/0.6
"	130	328-2	30	210	240/3.5	230/1.3	40	220	260/3.5	230/1.2	40	170	210/4	200/1.2	180	170	350/4	290/1.2
"	130	328-4	120	220	340/4	310/1	120	220	340/4	320/1	100	230	330/4	280/1	170	190	360/4	340/1.5
"	100	328-6	100	180	280/6.5	/	110	190	300/6.5	/	80	150	230/4.5	/	170	160	330/4.5	280/1.2
"	100	329-2	70	210	280/4.5	220/0.7	70	210	280/4.5	220/0.7	60	190	250/4.5	220/1.3	140	170	310/6.5	220/1.2

NB: The pressure variations are given in mm CE

Speed of trains (km/h) CORAIL	RTG	Test No.	A ΔP_+	A ΔP_-	A $\frac{\Delta P_{cc}}{\Delta T}$	A $\frac{\Delta P}{\Delta t}$	B ΔP_+	B ΔP_-	B $\frac{\Delta P_{cc}}{\Delta T}$	B $\frac{\Delta P}{\Delta t}$	B' ΔP_+	B' ΔP_-	B' $\frac{\Delta P_{cc}}{\Delta T}$	B' $\frac{\Delta P}{\Delta t}$	C ΔP_+	C ΔP_-	C $\frac{\Delta P_{cc}}{\Delta T}$	C $\frac{\Delta P}{\Delta t}$
200	160	333-3	340	130	520/4.5	300/0.3	150	180	330/5.5	/	230	190	420/5.5	160/0.2	320	190	510/5	240/0.1
"	180	333-5	390	250	640/1.5	600/0.7	310	160	470/1.5	450/1	300	170	470/1.5	450/1	380	180	560/1.5	500/0.7
"	160	334-3	310	210	520/4	270/0.1	260	210	470/4.5	160/0.2	230	210	440/4.5	130/0.1	300	210	510/4.5	200/0.2
"	160	334-5	380	200	580/4.5	240/0.1	250	200	450/4.5	140/0.5	270	210	480/4.5	140/0.1	360	200	560/4.5	170/0.1
"	130	335-1	320	170	490/0.8	300/0.1	280	100	380/0.8	200/0.2	360	110	470/0.9	250/0.1	340	140	410/1	260/0.1
"	130	335-3	270	310	580/0.6	400/0.2	240	250	490/0.6	450/0.3	270	200	470/0.6	340/0.2	310	260	570/0.6	500/0.3
"	100	335-5	320	220	540/4	200/0.1	280	200	480/4	80/0.1	260	220	480/4	170/0.1	310	230	540/4	180/0.1
"	100	336-1	310	230	540/4	220/0.1	270	210	480/4	80/0.1	270	230	500/4	180/0.05	310	230	540/4	170/0.1
"	180	336-3	370	190	560/1	370/0.1	290	100	330/1	170/0.1	360	120	480/1	220/0.5	390	120	510/1	300/0.1
180	190	333-4	0	310	310/4	/	0	330	330/4	/	0	350	350/4	/	0	310	310/4	/
"	190	333-6	0	280	280/3.5	/	0	300	300/3.5	/	0	300	300/3.5	/	0	290	290/2.5	/
"	160	334-2	0	270	270/5.5	150/0.3	0	290	290/5.5	/	0	300	300/5.5	/	0	270	270/5.5	/
"	160	334-4	110	260	370/4.5	170/0.4	110	210	340/4.5	180/0.7	130	280	410/4.5	180/0.4	120	270	390/4.5	100/0.1
"	130	334-6	0	230	230/4.5	100/0.1	0	270	270/4.5	100/0.1	0	250	250/4.5	/	0	240	240/4.5	80/0.1
"	100	335-2	160	200	360/4.5	170/0.4	150	230	380/4.5	120/0.1	160	210	370/4.5	170/0.4	150	200	350/4.5	170/0.5
"	100	335-6	140	210	350/7	170/0.3	130	220	350/7	130/0.1	130	210	340/7	160/0.3	130	210	340/7	160/0.3

Speed of trains (km/h) CORAIL	RTG	Test No.	F' ΔP_+	F' ΔP_-	F' $\frac{\Delta P_{cc}}{\Delta T}$	F' $\frac{\Delta P}{\Delta t}$	F ΔP_+	F ΔP_-	F $\frac{\Delta P_{cc}}{\Delta T}$	F $\frac{\Delta P}{\Delta t}$	PI ΔP_+	PI ΔP_-	PI $\frac{\Delta P_{cc}}{\Delta T}$	PI $\frac{\Delta P}{\Delta t}$	B'' ΔP_+	B'' ΔP_-	B'' $\frac{\Delta P_{cc}}{\Delta T}$	B'' $\frac{\Delta P}{\Delta t}$
200	160	333-3	50	270	320/4	150/0.3	50	260	310/4	150/0.3	70	250	320/4	150/0.6	0	290	290/4	170/0.6
"	180	333-5	230	330	560/4	140/0.1	200	270	470/4	230/0.5	250	300	550/4	200/0.6	200	410	610/4	300/0.7
"	160	334-3	120	300	420/4.5	120/0.1	100	250	350/4.5	/	100	290	390/4.5	/	0	330	330/2.5	160/0.5
"	160	334-5	150	280	430/5	100/0.1	130	230	360/5	/	100	270	370/4.5	100/0.4	0	310	310/4.5	100/0.4
"	130	335-1	250	200	450/0.7	400/0.3	180	150	330/0.5	270/0.3	240	170	410/1	200/0.3	240	200	440/1.5	100/0.1
"	130	335-3	250	160	410/2	250/0.05	210	120	330/2	180/0.2	200	140	340/2	160/0.4	240	230	470/1	160/0.1
"	100	335-5	240	260	500/4.5	130/0.05	200	220	420/4.5	70/0.1	220	250	470/4	160/0.4	190	260	450/4.5	160/0.3
"	100	336-1	220	280	500/4	120/0.05	180	230	410/4	80/0.1	200	260	460/4.5	170/0.5	170	270	440/4.5	180/0.4
"	180	336-3	240	240	480/1	320/0.1	210	200	410/1	410/1	240	230	470/1	470/1	230	270	500/1.5	170/0.3
180	190	333-4	60	310	370/4	160/0.4	60	290	350/4	140/0.3	80	300	380/4	160/0.5	270	220	490/4	200/0.3
"	190	333-6	80	310	390/1	300/0.5	40	320	360/0.5	300/0.4	70	280	350/1	330/0.8	160	250	410/1	400/0.8
"	160	334-2	50	260	310/5	/	50	210	260/5	/	50	240	290/4.5	/	120	150	270/5	/
"	160	334-4	160	230	390/5	180/0.3	140	200	340/5	100/0.1	150	210	360/4.5	160/0.5	230	140	370/4.5	160/0.1
"	130	334-6	50	230	280/4.5	/	40	200	240/4.5	/	50	220	270/4.5	/	190	180	370/5	/
"	100	335-2	190	190	380/4	160/0.3	150	170	320/4	90/0.1	190	170	360/4	170/0.5	210	140	350/4	130/0.1
"	100	335-6	160	170	330/4.5	150/0.3	140	160	300/4.5	100/0.1	160	170	330/4.5	130/0.4	210	140	350/4.5	120/0.1

NB: The pressure variations are given in mm CE

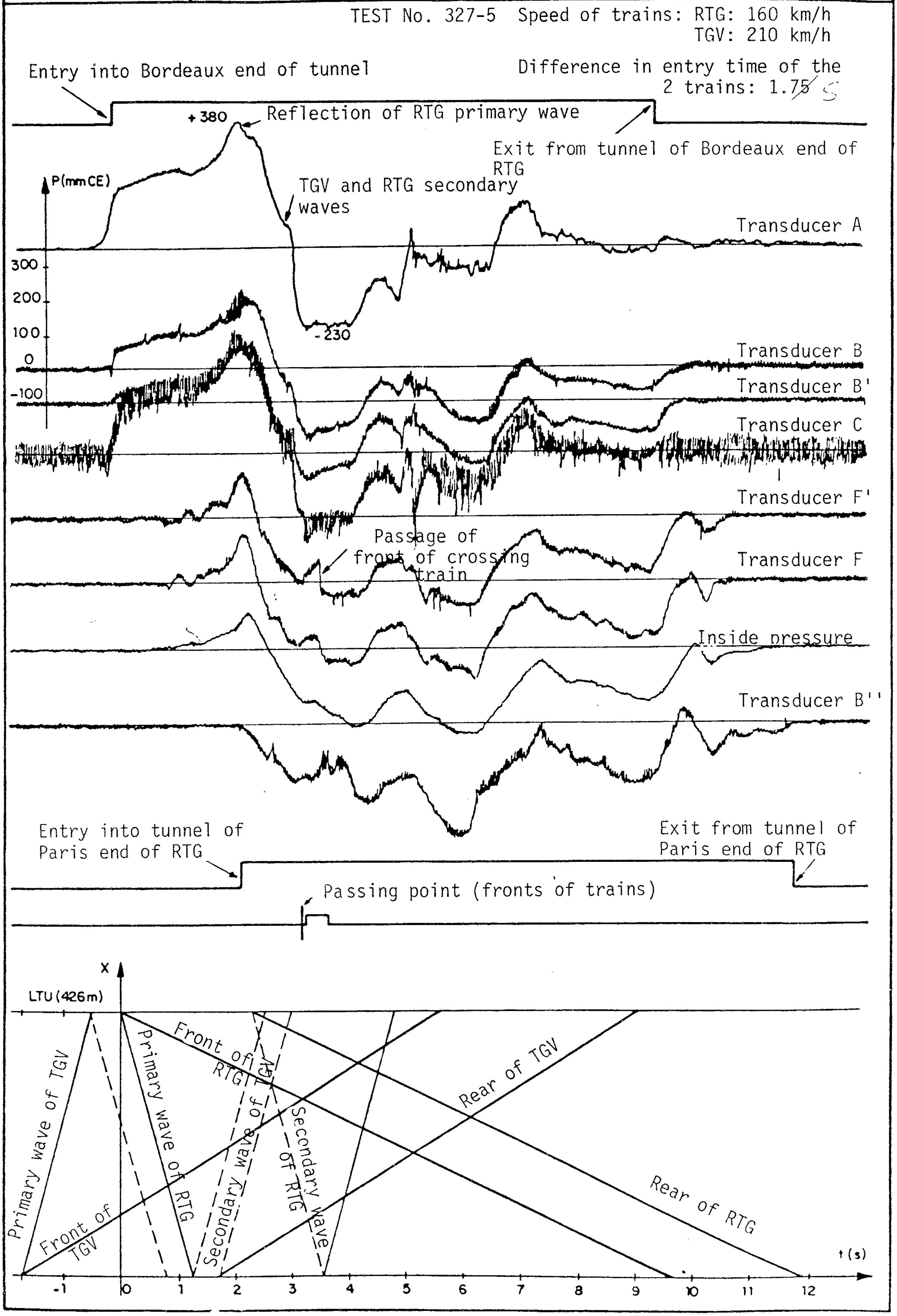
No. of Test	φ (s)	SPEED (km/h)					
		RTG train			TGV train		
		Entry	Exit	Mean	Entry	Exit	Mean
326-2	-7,1	192	188	189	189	188	189
326-4	-4,8	193	189	189	187	190	18[illegible]
325-2	-1,3	162	158	159	189	188	188
326-6	1,2	163	159	161	183	187	184
327-2	0,6	163	157	160	189	192	190
327-4	-0,5	165	158	162	193	191	192
327-6	14,7	133	128	129	187	190	187
328-2	0,2	132	130	131	192	192	191
328-4	2,2	133	127	130	192	193	191
328-6	1,9	102	102	101	188	191	139
329-2	0	99	93	96	191	192	190
326-5	8	184	182	183	213	213	212
326-1	4,9	180	182	180	213	215	211
327-1	1,3	160	162	160	212	211	211
327-3	2,3	164	161	163	211	210	211
327-5	-1,7	162	161	160	211	211	211
328-1	4,3	128	127	127	213	211	212
329-1	-7,2	98	105	99	212	-	190
329-3	5,3	103	99	101	211	211	211
325-1	0,6	156	158	156	192	191	191
328-5	4,4	99	102	100	162	161	161
328-3	-8,4	133	130	130	121	112	114

φ → difference in entry time of the two trains

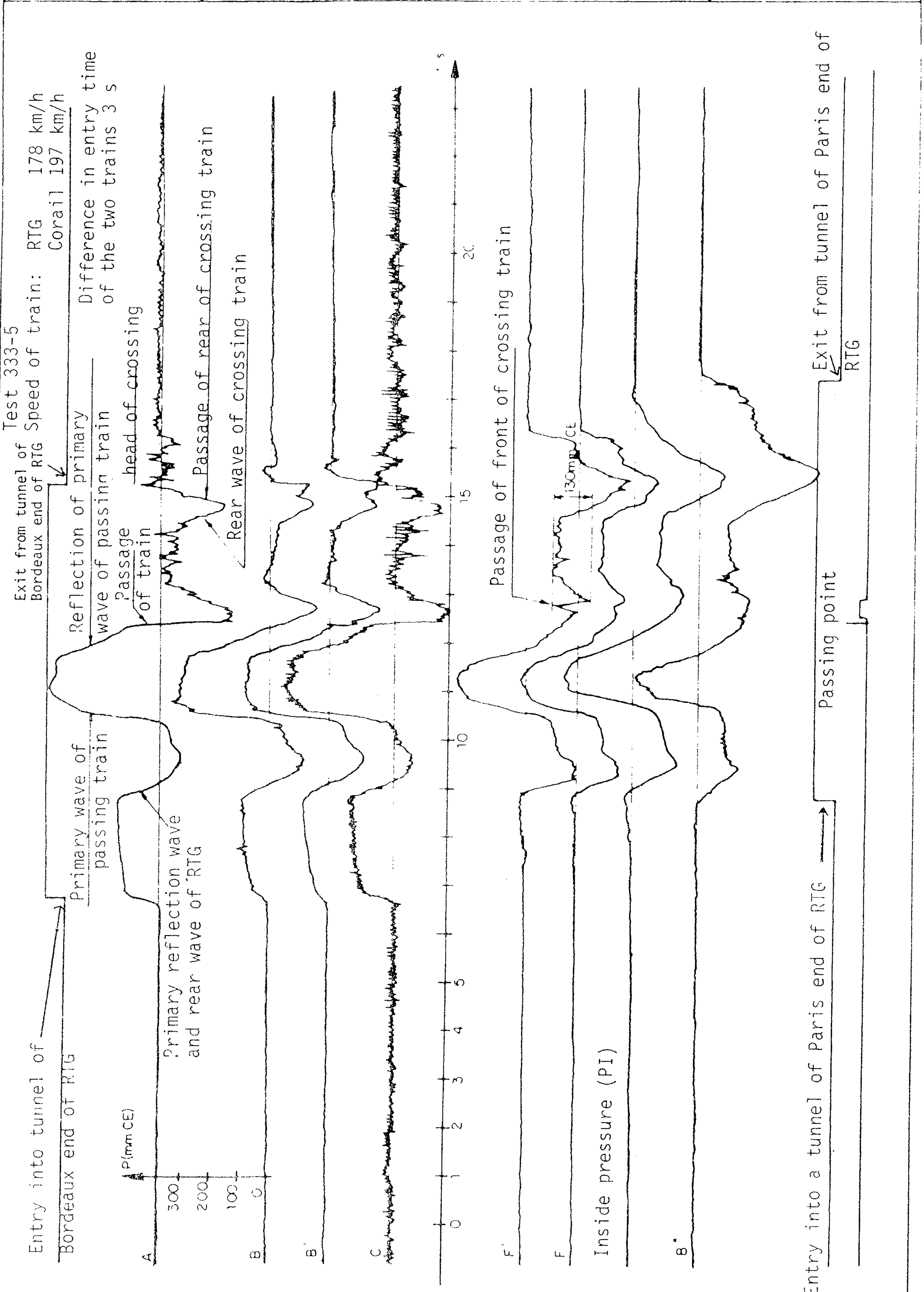
No. of Test	φ (s)	SPEED (km/h)					
		RTG train			Corail train		
		Entry	Exit	Mean	Entry	Exit	Mean
333-4	-1,4	190	183	186	179	176	179
333-6	-4	193	188	190	174	176	174
334-2	-1	175	159	161	184	183	183
334-4	3,7	163	160	160	178	176	177
334-6	-2,	134	129	133	179	178	178
335-4	1,4	133	126	129	180	182	180
335-2	7,5	102	95	98	176	176	177
335-6	4,8	100	98	99	178	178	178
333-5	3,	180	176	178	198	194	197
336-3	4,7	177	175	176	199	198	198
333-3	-0,5	161	158	160	197	194	196
334-3	1,2	163	158	163	198	197	198
334-5	-	-	-	160	-	-	200
335-1	7,2	122	128	127	196	192	195
335-3	11,3	118	116	121	197	196	196
335-5	4,3	106	103	105	200	200	196
336-1	4,1	103	97	101	199	199	199

φ . difference in entry time of the two trains

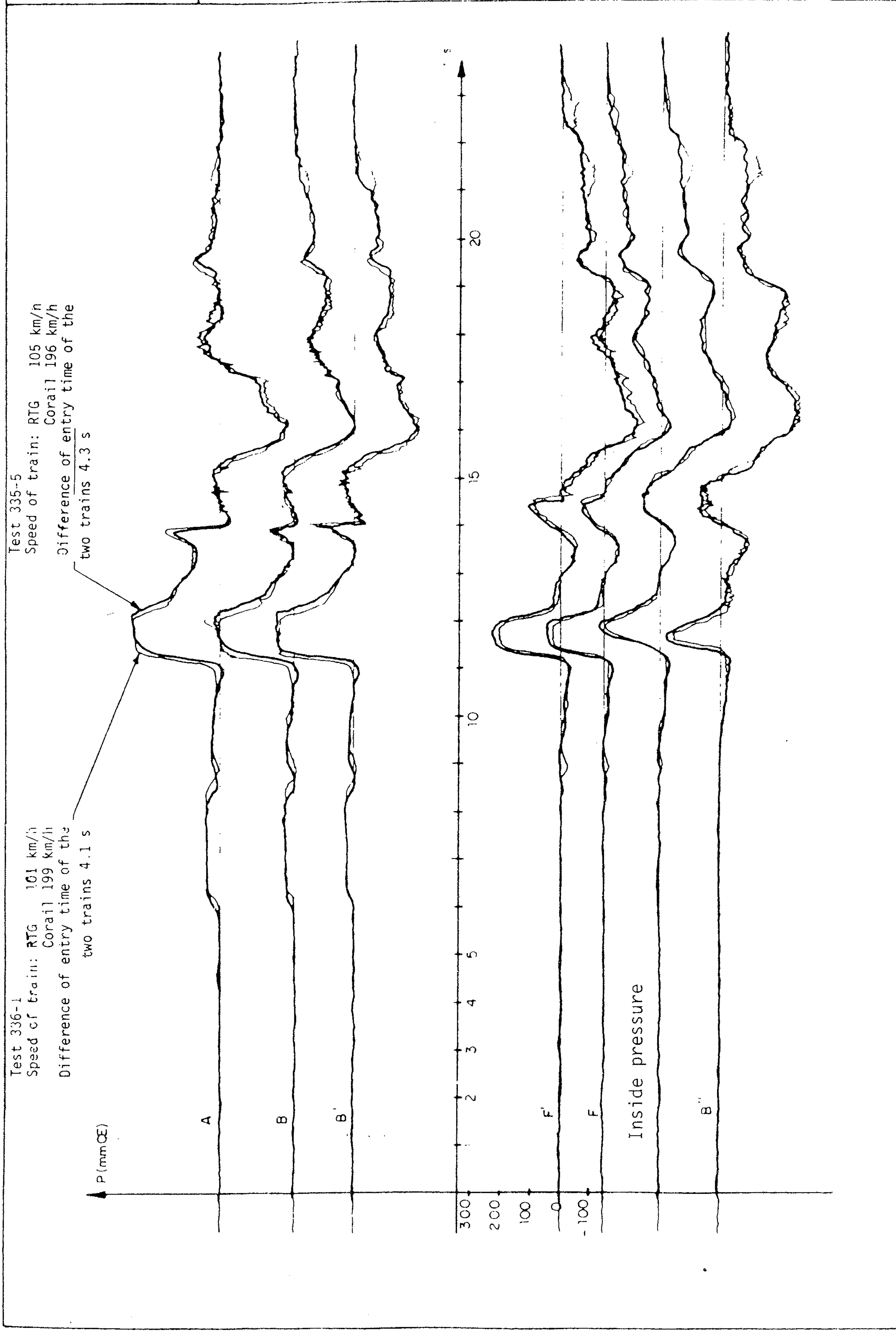
ORE C149/RP 12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig. 23



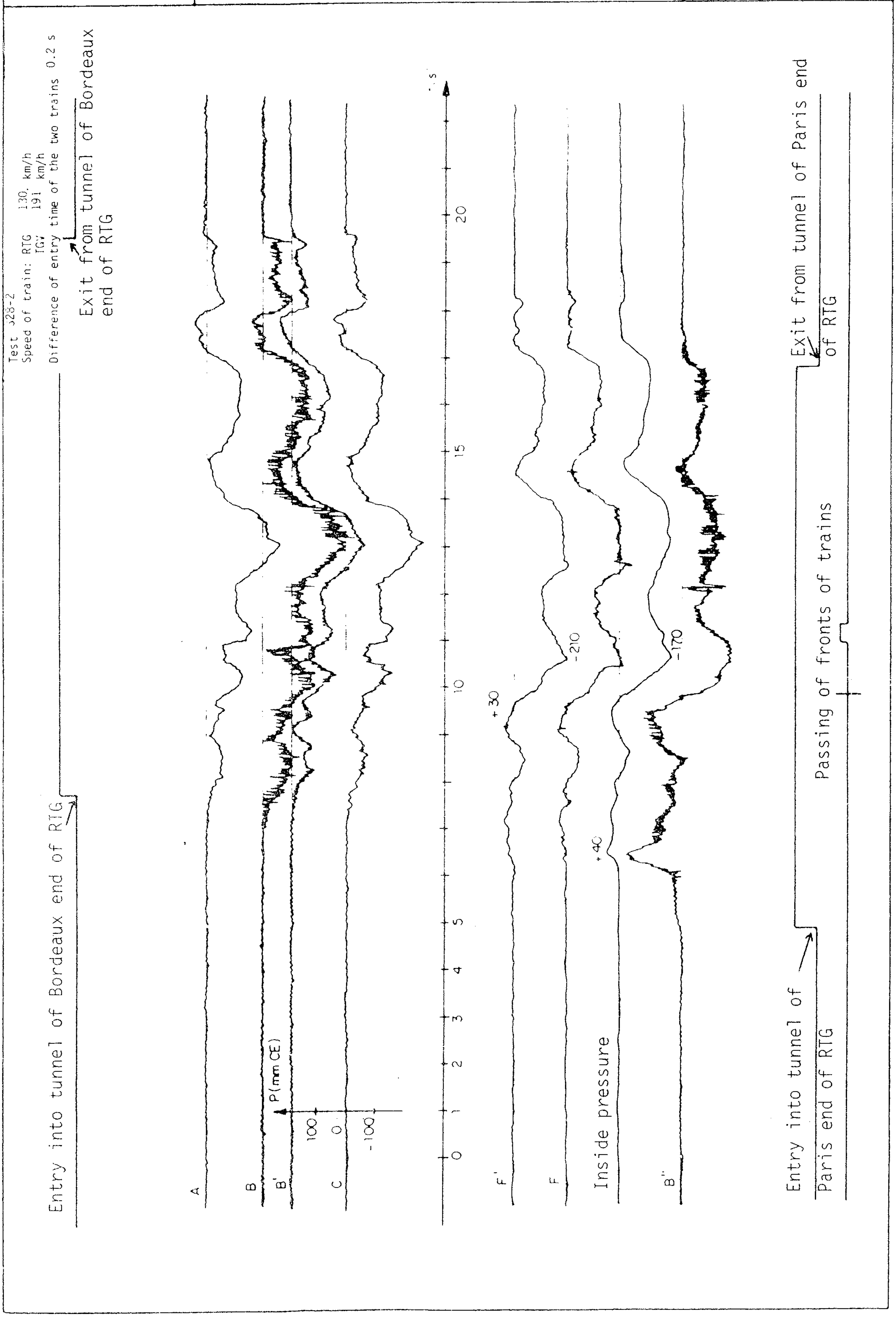
ORE C149/RP12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig. 24



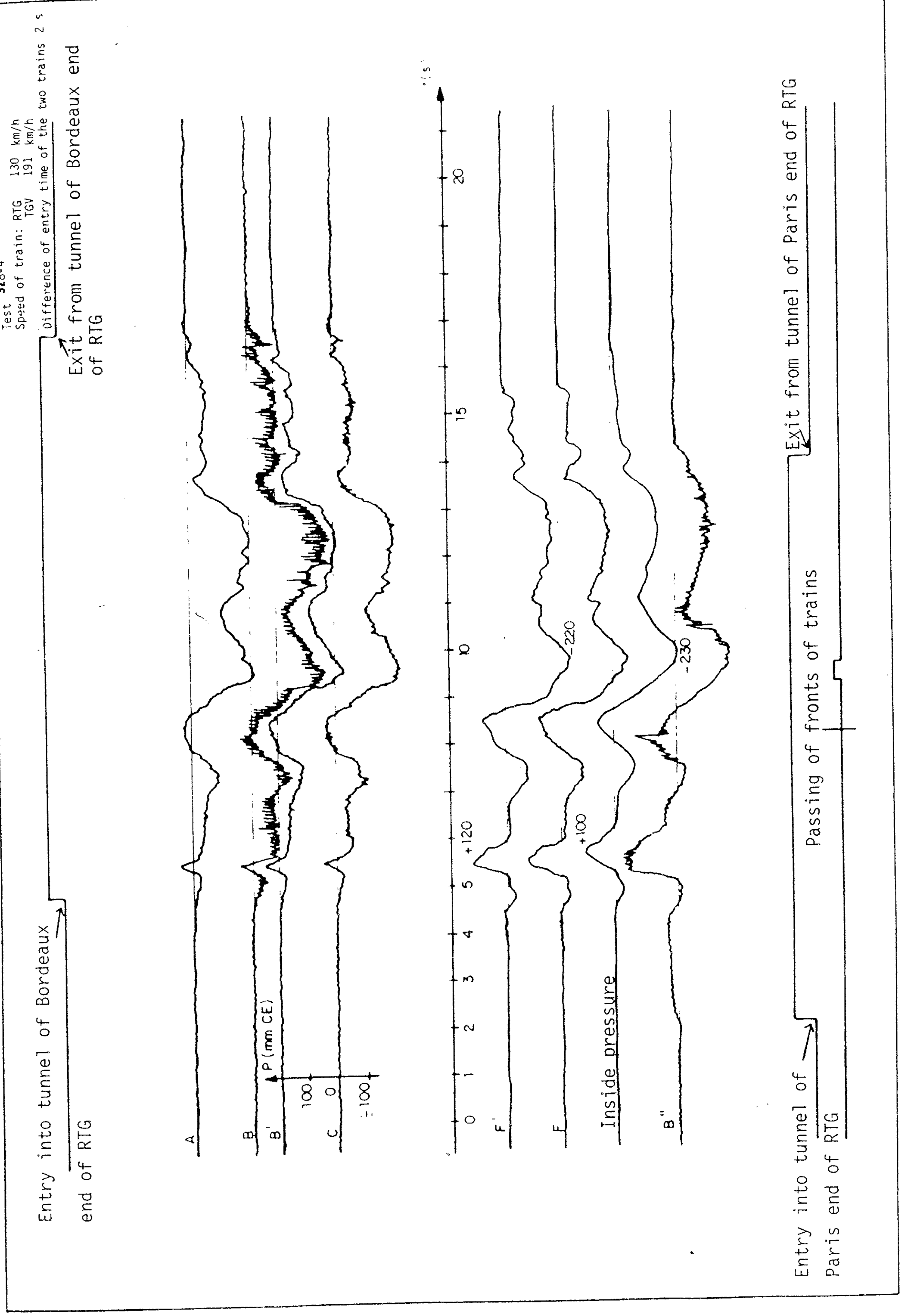
ORE C149/RP12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig. 25



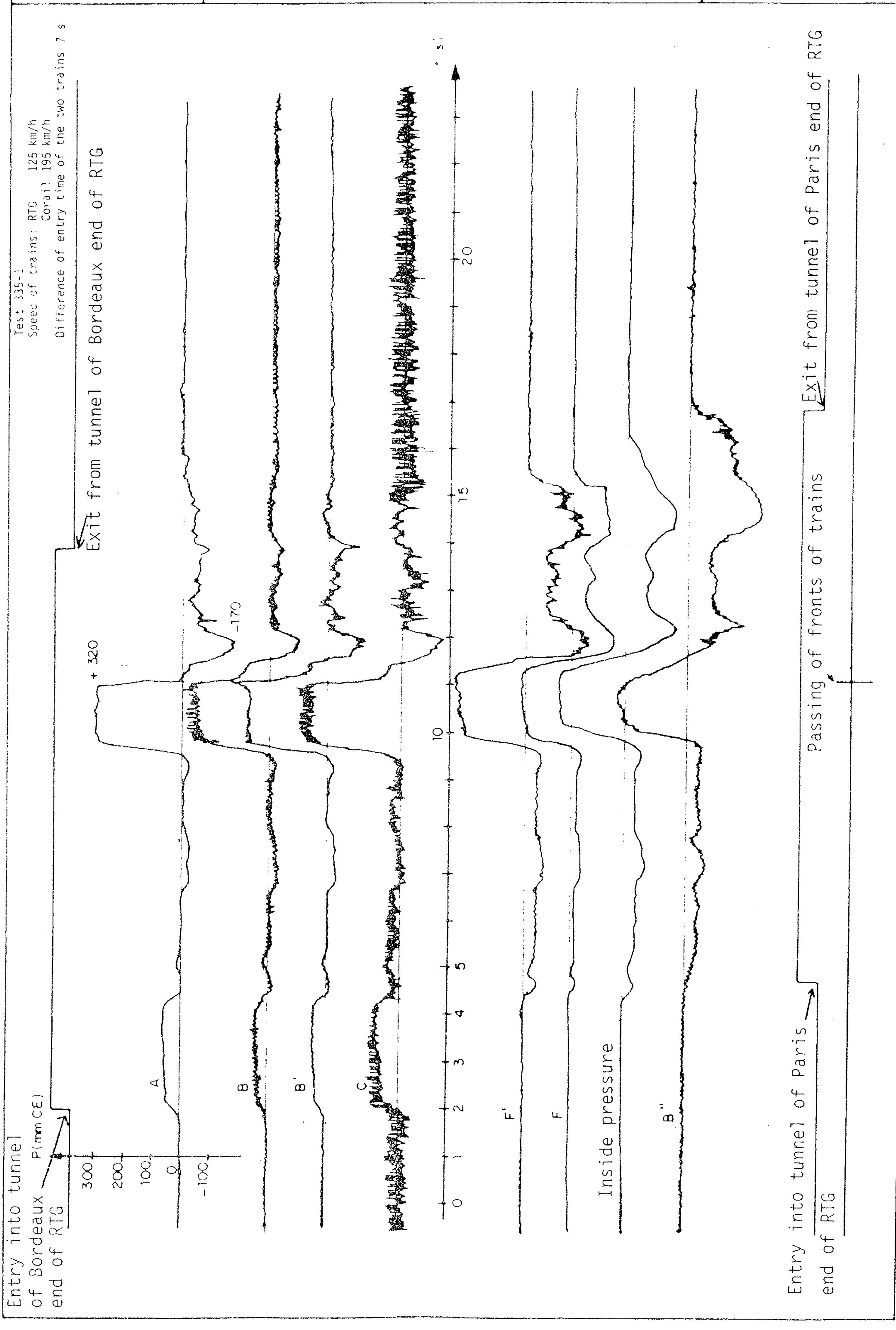
ORE C149/RP12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig.26



ORE C149/RP12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig. 27



ORE C149/RP12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig. 28



ORE C149/RP12	VARIATION OF PRESSURE INSIDE AND OUTSIDE THE TRAIN	Fig. 29