Trains of Thought
The Fifth Dimension of Time and its Fabrication[1]

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Prologue

"It's sunny, this morning on the Neuchâtel lake, and windy and cold. What's that bright little shape out there? Ah, a sailboard out there in the wind. It's moving fast. How fast? I could use the lampposts along the quay to tick the time it takes him to pass behind each of them. With a good Swiss chronometer, a knowledge of how far the sailboard is from the land, an evaluation of the angle of its course – not an easy task given the erratic moves of the board – I could end up with a speed, that is a ratio of distance over time. Of course I really couldn't because I'm pretty bad at calculating, even worse than at sailboarding. I can only play the observer on the edge. Oops, here he is in the water! There he is again, back on the board, on a different tack, even faster along the waves now crested with the white foam triggered by the fiercer swerving wind. Now that he is closer to me, I see a broad smile on his face. The surfboarder seems to enjoy himself immensely. He does not see time passing by. Strange to try to measure time while strolling along the lake, during the break of a meeting on Piaget. Even stranger to play the outside observer. Of course, I could calculate the surfboard trajectory, and obtain a ratio, a form, a speed, something that would neither be in time, nor in space. A timeless number. I too could reach, from the safe and solid ground of that most sturdy and stolid Swiss city, the sure grasp of a formalism. But then, would something be missing? What, what exactly would be missing? No hurry here. Take your time. The meeting is full of psychologists, of phenomenologists. They talk about "lived" time. Careful. They have an axe to grind. They want to criticize scientific time, the atemporal and atopical coordinates of what they call science. (Here he has fallen again, brought down by a sudden gust! Here he is again, darting away now.) Is the surfboarder moving like an arrow in "lived" time and space? Unlikely. "Lived," one of these empty words that have no opposite, and are given a semblance of profundity because they appear to attack the cold and timeless and spaceless apparatus of dead reason. If I had managed to calculate the speed of that darting sailboarder, in what way would I have abandoned the "lived" world of this sunny day in Neuchâtel? I would have needed a watch, and a benchmark, and posts, and rulers, and a staff of helpers, and theodolites, the whole equipment and crew that Ed Hutchins describes so well when he shows the number of operations necessary to steer a dreadnought into San Diego harbor (Hutchins 1995). In what sense are these operations not "lived"? And yet, in the end I would have obtained a speed, that is a timeless spaceless figure, a form, a ratio, on a piece of paper, held in my hand, inside my world, along the beach, under the sun, on the campus. So then, at no point would I have left the world. I would have added to the Neuchâtel lake another piece, another feature, an observer setting up apparatuses to calculate surfboard speeds. But then the surfboarder (now barely a spot on the horizon) is not adding "fun" to the calculated speed. He is not adding the "lived" feeling of a sunny morning, to the accurate definition of a timeless and spaceless instant and place. Why are all these psycholo-

[1] Since this lecture was written to be read out loud as a eulogy in honor of Jean Piaget's anniversary, I kept most of the oral tone and abstained from adding footnotes. Many thanks to Anne-Nelly Perret-Clermont whose meetings in Neuchâtel are always a source of deep enjoyment. This paper owes a lot to the fascinating exploration in the structure of physical time by Niels Viggo Hansen from Aarhus University. I thank him for his extremely helpful comments. I also acknowledge my debt to the decade-long meditation by Geff Bowker on the production of time and to the notion of trails developed by the philosopher Adrian Cussins (Cussins 1992).

gists comparing the "lived" time to the "real" time, the "subjective" time to the "objective" time? My calculation of speed, I mean my apparatus, my institution to extract speed from the surfboarder, is inside the world where he sails fast, and is not the depth feature on which his own psychological world would be built. How could I be so arrogant as to imagine that my calculation defines the primary quality of everything else? How could I be so forgetful of watches, and staff, and poles, and rulers, and crews, and compasses, and serious Swiss helpers? Especially here, just a few hours after having visited the Museum of Time in La Chaux-de-Fonds? No, the watch is not the depth feature of the horizon, but is added to the world, and so is this tenacious and ingenuous industry cuddled in its mounain valleys, bringing so much wealth to this doll-house university. But then, if I am right, in what sort of world is the surfboarder moving? (Now, his dark speck and triangular wing are growing fast again straight towards me.) No, no, he is not in a human, subjective, psychological, mental time-space. I want no part in this painting job, where the "lived" world adds false but warm colors to a real but bleak reality made of measurements. (He is still grinning, going fast towards the beach as if he wanted to skateboard onto the campus green straight from the lake, enjoying himself immensely. At the last second, he briskly veers away and he is gone again). Enjoyment. That is the space-time in which he resides and moves. He is no more moving in space than he is in time. He is not adding a subjective morning to real mornings. Subjective lakes to real lakes. He explores the multiplicity of ways of being, he goes from some to many, from boring to alert ones, from a little wind to a fierce gale, from a low intensity to a higher intensity. Yes, that's it, he is moving into enjoyment, intensity, ways of being, alterations, and if I want to calculate his speed, I can, but I won't define the depth of his world, the backdrop of all existence, I will simply add a color to the many colors there are already, maybe a grey, a dark color, but still a color. And thus, and thus, my dear psychologist colleagues, there is no need to turn towards the mind, or to subjectivity to escape from the cold and objective time to find the rich "lived" world of meaning. To find richness, one only has to turn towards the world itself, to the wind, the foam, the sun, the snow-capped mountains in the back, the earnest miniature city behind the harbor. "Objective" time and "subjective" time are like taxes exacted on what peoples the world, they are not all that these multitudes do and see and mean and want. We are not forced to choose forever between losing the feeling of time or the structural features of the world. Processes are no more in time than in space. Process is a third term, as if the surfboarding were moving into ways of being, exploring its alterity, its alterations. A third term! My poor fellow, are you growing tired of always trying out third terms, only to hear your audience object: "Yes, but time is not a mere social construction?" Who said so? Not me anyway, but nobody listens. Their love-hate affair with science has blinded them to any other possibility. If it is not objective, then it is subjective. If it is not subjective, then it is objective. Chances are that if they understood that I am not a social constructivist, they would recoil in horror: "But this is abject metaphysics!". Well, too bad, I'm afraid it is. (The surfboarder is back now, folding his equipment, packing it up, seems happy). Time to resume the session and hear more about the many differences between the "lived" notion of time and "real" time ..."

The paradox of the twin travelers

To meet together in order to celebrate Jean Piaget's centenary, we need some *measure* of time – for instance, his birth certificate as recorded by the well-organized Neuchâtel bureaucracy, the computing of days and months calculated by the Annals of astronomers and various Bureaus of Longitudes, and we also have to rely on a venerable Western tradition that stresses anniversaries and prefers nice round numbers like 100 or 1,000 to more exotic ones like 88 or 133 or 666, and that puts special emphasis on someone's birthplace instead of, for instance, the city where his books were first published or from which his first grant was awarded... Simply to gather at the right time, 1996, and at the right place, Neuchâtel, it is already clear that we need maps, institutions, recording devices, and traditions of ritual.

If I remind the audience of these trifling details, it is not to be impolite and criticize the title of this symposium – Mind and Time – just when it begins, but to stress in this paper that "time" is not something that is in the "mind" or that is

"thought" by a mind, but something rooted in a long material and technical practice of record keeping, itself merged into institutions and local histories. In philosophical discussions about time, the work of inscription and the fabrication of tim*es* – in the plural – is all too often forgotten. To recover time we need to delve into the machinery of measuring it, for which Neuchâtel and its region are known the world over. The amusing paradox of our international conference is to have chosen, in honor of the local hero, a theme – the measurement, recording, and fabrication of times – which is well known to the Swiss economy but which Piaget did his utmost to ignore, even to repress, during all his scholarly life. "How the fabrication of time *never* entered Piaget's *mind*" could be the title of my somewhat embarassed eulogy... I will not talk as a specialist on Piaget which, of course, I am not, but as a philosopher of science interested in understanding why close attention to the practice of fabricating time and space in science and technology has not done more to renew the philosophy of time. Piaget, in this respect, stands as having launched the most forceful intellectual enterprise of the century to ignore the fabrication of time and its consequences on philosophy.

In the first part of my paper, I simply want to set up what I will call the paradox of the twin travelers and draw a few lessons from these little thought experiments to open a third avenue between subjective and objective time. In the second part, I want to use some results from science and technology studies to see the impact they could have on the machinery of space and time formation. Finally, at the end, I want to interrogate the link between formalism and timelessness and imagine some of the reasons that could have led Piaget to insist so much on forms.

Imagine two twins. The first voyager sets off in a deep jungle and cuts her way with a hatchet along a trail which is barely visible. Each minute, she opens a few centimeters of a pathway, but she ages more than one minute. She sweats. Her body bears the traces of her efforts; each meter can be read in the bloody scars made by thorns and ferns. The path gets cut as she goes along, but she is lacerated as well. A suffering body strives among other suffering bodies, vines, grass, and woods. She will no doubt remember all her life every minute of this excruciating trip across the jungle. The reason she will remember it is that each centimeter has been won over through a complicated "negotiation" with other entities – branches, snakes, sticks – that were going in other directions and had other ends and goals.

See by comparison how comfortable is the other traveler, her twin brother, who came to this conference, for instance, like me, by TGV! He sat quietly in his first-class air-conditioned carriage and read his newspaper, paying no attention to the number of places crossed by the speedy train which all looked to him like landscapes projected on a movie screen. He did not age more than the three hours of the trip. His body does not bear any trace of the voyage, except for a few wrinkles on his trousers and maybe a few cramps because he did not stretch his long legs often enough. He will not remember anything except having boarded the train instead of coming by plane. Only the articles he read in the newspaper might be briefly recalled. The trip for him was like nothing. All the atoms of steel, all the electrons, all the gates, all the switches, all of the efforts of the train companies, SNCF and CFF, were *aligned* in the *same* direction, going fast through space in time obeying to the millisecond the world-famous Swiss exactitude and the almost as famous French TGV quality of service. No negotiation along the way, no event, hence no memory of anything to mention. "An uneventful trip," as he says to his friend when alighting from the train.

Why am I comparing these two twins and the way they age? Because I want to direct our attention to a phenomenon that is logically *prior* to the fabrication of times, and that consists in a relation between *transportation* and *transformation*.

For each move of the woman traveler she is modified and ages more than a bit, maybe to the point of losing her life. The male traveler is not modified a bit by the trip and only an anonymous bomb or, as we shall see, a strike might interrupt his smooth and speedy run. Thus, the first traveler will equate transportation (or displacement) with modification, aging, history, transformation, metamorphosis. The second will differentiate two apparently different phenomena: moving through space in time, on the one hand, and aging, living, suffering, participating in events on the other. Since the relation between transportation and transformation differs in both cases, the production of times and spaces, I want to argue, will be *entirely* different. The first voy-

ager will not differentiate space, time, and aging; we will call her indifferentiation processual. Her twin brother will see no difficulty in distinguishing what is displaced from the immutable framework *in which* it is displaced.

The separation between time and space on the one hand and entities, beings, or events on the other, is *not* a fundamental distinction, but one made by *some* travelers in some very specific and historically situated means of transportation (it is for instance hard to get this distinction in Chinese thought according to Jullien (1992). Hence, in discussing time we may not have to pay an exclusive attention to the two main positions which have occupied modern philosophers. Time and space are not the Newtonian *sensoria* in which events occur and planets fall along ellipses. But they are not, either, the forms of our perception, the universal *a prioris* that our mind has to use in order to frame or accommodate the multiplicity of beings and entities. Far from being primitive terms, they are, on the contrary, *consequences* of the ways in which bodies relate to one another. We will thus link our meditation to the third tradition, the Leibnizian one, that considers space and time as expressing some relation between the entities themselves. But instead of one Space-Time we will generate as many spac*es* and tim*es* as there are types of relations. Thus, progressing along trails will not produce the same space-times as going smoothly along networks. It makes an enormous difference if those bodies are suffering bodies among other suffering bodies, or a relaxed air-conditioned executive in a bullet train.

What is this difference? Can we make it more precise? Yes, because I was wrong in the brief sketch I gave of the man's trip. In spite of his smooth voyage, something marked and shocked him, making the trip memorable for him. The train passed at 150 kilometers an hour without stopping in the very place, Culoz, where all the trains for the Alps and Switzerland used to stop a few years ago. He remembered the buffet, the decks, and the easy access it gave his family to go bathing in the Bourget Lake when he was a kid. What used to be an important *place* had become a non-existing, undifferentiated *instant* along the train path. The event here for our voyager was the very fact that nothing in this station could make this place eventful, memorable, remarkable in any one of the passengers' lives any more. They just zipped through with a strident noise. More than that, the natives of this little town who, before, had the dignity of being able to stop the train, to board it or alight from it, now had their town cut into two halves and could not cross or stop the train anymore. Their ties accross the station had earlier resembled the lianas of the first voyager, blocking the pathway, forcing the voyager to make detours, to accept delays, to wait for later trains; they now ressembled more the open path left through the jungle by the woman cutting trees and lianas. This little station counted, it no longer counts. It interrupted the trip, it no longer interrupts it. It was a station, it is no longer a station. The rails, well aligned, now run in only one direction, from Paris to Geneva.

So the difference between our two voyagers comes from the *number of others* one has to take into account, and from the *nature* of those others. Are they well-aligned *intermediaries*, making no fuss and no history and lending themselves to a smooth passage, or full *mediators* defining paths and fates on their own terms? Are they more of the same – that is, intermediaries – or are they really others – that is, mediators? Timing depends on that sort of ontological difference, not on the mind's apperception. If other entities are necessary for our existence (and surprising at that), then times and spaces will proliferate. In the opposite case, times and spaces will rarefy to the point of becoming *one* time-space, or even, as we shall see at the end, no time and no space, only *forms*.

So we can now situate our twins along one dimension that takes into account the ratio of transformation over transportation or else the number of mediators compared to the number of intermediaries. But if we want to escape the usual opposition between subjective and objective time, we can go further and imagine a second dimension, so that we can obtain a richer grid to develop our discussion of time-space fabrication. To define this second dimension, we may connect our two twins' biographies in the same scenario and insist now on the *labor* necessary to reach one position from the other. Imagine, for instance, that the woman is an explorer sent by a company to explore the future path of the bullet train which is, a few years later, planned, designed, decided, built, successfully completed, and eventually used by her forgetful brother in his executive suit. Each locus, each site which, before, in the pionneering old days,

forbade or slowed down the moves of his sister, forcing her to age and suffer in order to make her way, have later been turned into well-aligned intermediaries which lend their forces, goals, wills, or ends to the path of the train coming fast from far away and darting as quickly as light. Each tree, house, hut, vine, is now cut in two by the path of the bullet train, and the train, *because* of that, goes fast. Why? Because nothing interrupts it, or slows it down. Speed crucially depends on the number of intermediaries relative to the number of mediators. The speed of the train and the uneventful trip of the passenger are entirely dependent on the complete *obedience* of the places that are traversed – and also, of course, on the smooth functioning of the train companies' organization, running, as the saying goes, "like clockwork."

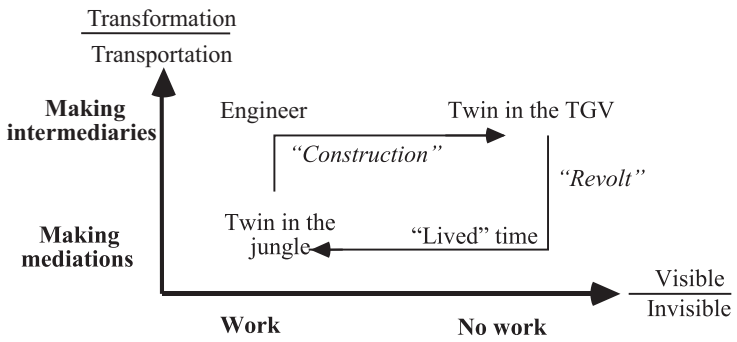
Well, this is not exactly true, because our story can also go in the other direction. The inhabitants of the city that is cut in two by the line may decide to protest and to demonstrate by sitting on the tracks or even putting logs on the rails and setting them on fire (not in Switzerland, of course, that would be unthinkable, but let's say on the French section!). Then what would happen? The passengers on the train would suddenly start to age. They would be stuck and blocked in this hitherto meaningless hamlet which has, because of this very revolt, become a place, a site, what we could call an event-producing *topos*. Hostages of fortune, the passengers will start to remember the trip. They will begin to feel the passage of time and to feel time going slowly or fast. They will begin to have the impression of a "lived" time and space that they didn't feel before when the train was going fast, uneventfully. Buses will have to take them away from the station and they will lose hours because of the angry demonstrators who, on the other hand, will have been "making history," taking pride in their strenght, and realizing anew that they were not living in a nowhere place which one can cross at high speed as if it were simply a path leading further, but a memorable spot to be reckoned with, negotiated with. To use another cliché, angry demonstrators will be proud of having put their little village "on the map." Let us pursue our story to its end. Imagine a revolt along all the points of the trip, at each station along the railway and then also on each of the roads taking the buses to get past the striker blockades. What would happen? Well, we would be *back* in the jungle we started with! Each centimeter would have to be negotiated and it would be impossible for anyone to go straight through without being deeply and lastingly modified. Each transportation would have to be paid for with a huge transformation, a lasting and memorable metamorphosis. (Although my story is a thought experiment, in the Amazon I have seen a former highway taken over by a jungle even more impenetrable than the original trail where Indians feared to tread).

My little story is now enriched by four situations:

(a) the woman traveler in the jungle;
(b) the man in his bullet train;
(c) the progressive *passage* from a trail to a high speed railway network; and, finally,
(d) the *reverse* passage from a network to a jungle where each move has to be discussed and won the hard way.

So we now have two dimensions to take into account in discussing space and time construction. The first one that defines the ratio of transformation over transportation, and the second one that defines the relative *visibility* of the work to be done in order to obtain a displacement. This gives us the diagram shown in Figure 1.

Figure 1



The first twin produces mediations, she sees and feels the work of transformation and is unable to differentiate space and time on the one hand, and moving bodies on the other; she does not differentiate her own suffering body from all the others through which she is slowly drugding either. The engineer is aware of the mass of work necessary to produce calculation, frames of reference, smooth transportation, but his energy is invested in making sure that the routine institutions on which these transportations depend are running "like clockwork." The second twin sees no difficulty in distinguishing a moving body from an intact frame of reference, since the work of the others has become invisible and since no transformation forces him to pay for his transportation – except, of course, the price of the ticket. For him, as for all the angelic philosophers of physics who play the role of the Queen of the Night (Stengers 1996), "time is like nothing." The passenger whose train has suddenly stopped because of the riot does not see more of the work of mediation than the Newtonian philosopher. But he feels the passage of time and the importance of space. Aware that something has gone wrong in the timelessness and spacelessness of before, he concentrates his attention on his "lived" time and space, as if this phenomenon were something psychological, human, subjective. Most of the debates in the philosophy of time will oppose the two train passengers on the vertical right of this diagram: The one for whom there is no time, and the other who harbors a subjective feeling for time. But if we alight from the train and concentrate our attention also on the institutions responsible for making sure that trains arrive on time, on the revolts where space and time are decided on the spot, and on the processes through which those institutions are built or those movements are squashed (Lolive, 1997), we should be able to add another dimension to the debates. What are the lessons that we can draw by thinking in two dimensions instead of one?

First, the distinction between subjective and objective time is only part of the story. It concerns only train passengers! In the notion of objective or scientific time, two entirely different phenomena are lumped together: the routine work of engineers inside huge institutions, and the feeling of a user who is *allowed* to completely *forget* the work of making time *because* the engineers are watching day and night over his safe passage. Similarly, in the notion of subjective or "lived" time, two entirely different questions are confused: the surprise felt by a user when the smooth running of time machineries is interrupted, and the labor of those engaged in processes so little made routine that the difference between subjectivity and objectivity cannot even be recognized. Those who explore the intensity of multiple beings cannot be accounted for by a subjective definition of an internal state.

Second, time is not in itself a primary phenomenon. Time passes or *not* depending on the *alignment* of other entities. In a world made of intermediaries, of displacement without transformation, there is a time separated from space, an immutable frame to measure displacements and, by definition, no process. In a world made of mediations, of transportation by deformation, there are a lot of tim*es* and plac*es*. Deeper than time is the question of the obedience and disobedience of humans or non-humans.

Third, the notion of *event* cannot be differentiated into its spatial and its temporal component. If a place counts as a no-place it also counts as a non-event. Place is not a feature easier to understand than time. When a place counts as a *topos* it also counts as a *kairos*. Deeper than time and space there is another question about who or what counts. Which actants can interrupt, modify, interfer, interest which others, thus producing as many *topoi-kairoi*?

Fourth, to talk like the semioticians, there are always *three* shiftings simultaneously at work in each account: a shift in space, a shift in time, and a shift in actor or actant, the latter always forgotten in philosophical or psychological discussions. When I told you my little story of the woman traveler in the jungle, for instance, I sent you, the listener, along the three different axes at once: at another time, in another place, but also in someone else's character (Greimas & Courtès, 1979). Deeper than the question of time and space is the very act of *shifting*, delegating, sending away, translating. We should not speak of time, space, and actant but rather of temporalization, spatialization, actantialization (the words are horrible) or more elegantly, of tim*ing*, spac*ing*, act*ing*.

Fifth, and finally, the question of spacing, timing and acting should always be combined with that of their *intensity*. Is it an event or a non-event? Process is not in itself associated

with time more than space. It is not the fourth dimension, but a *fifth* dimension. We know that very well, as far as time is concerned, since we have used (at least since Husserl) the notion of "historicity" in order to differentiate it from the "simple" passage of time – measured by the watch (more of that later). But it should also be the same for space, although there is no term as widely accepted as for time. To differentiate the intensity of being in a space, a *topos-kairos*, instead of being simply located on a map, we would need a term as clearcut as historicity. When, as in the anecdote above, a no-place becomes a master place, a *chef-lieu*, a *topos*, we should be able to say that it gains "sp*a*cificity" with an "a" – "*médiance*" as Augustin Berque has proposed (Berque, 1993), or "situatedness." The same thing goes for the shift in actantiality. We should be able to have a word that differentiates the move from one actant to another – extensive repetition – from the modification of all the actants – intensive repetition. Unfortunately, there is no such term. Since we do not have such a triad of concepts, I would use the simple contrast of my little story between trail-making and network-following, between transportation *with* transformation and transportation *without* deformation, and will use the word intensity to trace this fifth dimension.

Writers like Bergson with his distinction between spatialization and duration, Péguy with his contrast between the history of historians and the history of events (Péguy, 1961), Whitehead with his insistence on process (Whitehead, 1929, 1978), Deleuze with his earlier work on difference and repetition (Deleuze, 1968), were obsessed by this question of the *intensity* of time in contradistinction to its *expansion*. The difficulty of using their insights to trace the fifth dimension of process is that they are engaged in a battle with what they see as a scientific definition of time and space and also because, to avoid what they see as the inherent spatialization produced by science, they always unfairly favor time over space, as if process was in any way more easily connected with the former than with the latter. What I want to do in the second part of this paper is thus to shift attention to the labor that goes into the fabrication of spaces and times – going from the right to the left of the diagram above – so that we don't take scientific practice for the same thing as objective time and space; I also want to redress the imbalance between space and time by using work recently done in technology studies .

Processing time and space

If I have taken the case of a train and invented another paradox involving twin travelers, it is not only because I am a fan of the TGV, or a great admirer of the "Rätische Bahn" leading to the Nieztschean valley of the Upper Engadine, but also in honor of that most famous Swiss engineer from Zurich, Albert Einstein, obsessed by bullets, trains, and clocks. What I am going to say should be obvious to the La-Chaux-de-Fonds clock makers, to the Geneva train company managers, to the Zurich bankers: the fabrication of a certain type of space-time-actor crucially depends on our ability to *measure* intervals by relying on bodies which have the strange peculiarity of remaining *immutable* through *motion*: planets, falling stones, pendulums, bullets, scales, geometrical shapes, and, of course, trains, cars, satellites, accounts. As it has been studied by many scholars as diverse as David Landes (Landes, 1983), Otto Mayr (Mayr, 1986), Daniel Headrick (Headrick, 1988), Simon Schaffer (Schaffer, 1994), Wolfgang Schivelbusch (Schivelbusch, 1977), Eviatar Zerubavel (Zerubavel, 1985), and Geffrey Bowker (Bowker, 1995), there is in our civilization a fixation on how best to transport something without deforming it, an infatuation for what I have called "immutable mobiles" (Latour, 1987). To the search for constants, for what can be carried around and resists deformation in spite of transportation, everything will be sacrificed, even, as in the case of Einstein's relativity, the very definition of Euclidian space and clock-work time. Piaget, of course, shares this obsession to the point of having turned the ability to conserve constants through transportation into the very definition of intelligence and the best way to distinguish its successive stages. As we will see at the end, everything will be sacrificed by him, really *everything*, to this conservation of constants.

Instead of taking displacement without deformation as an obvious feature of what the world is like as so many philosophers of time and train passengers tend to do, I simply want now to use this rich literature on the fabrication of time and space to free the fifth dimension of time from

both its subjective and objective interpretation. How is the discussion changed when the work necessary to construct scientific facts and technical artefacts becomes visible again? The first thing to do is to elevate spacing to the same philosophical dignitiy as timing.

Far from being obvious common sense terms, spacing and timing are in fact quite difficult to tell apart. Through what sort of labor do we produce the difference between space and time? The question is not as trivial as it seems. For instance, the legendary wandering Jew could not distinguish the two, every spot along his way being also a date. Since he never retraces his step, never stays in the same place, never settles, never comes back, there is no meaning for him in the notion of "place" differentiable from "date" – except, of course, the City of Jerusalem that he will reach "next year." His itinerary would be made of "date-places," of a string of events. It is only because we come *back* to the same place over and over again that we generate the notion of a place, of a *topos*, that lasts and stays the same, while we have moved. The size of the castle of Chatelperron diminishes irreversibly in the distance as the wandering traveler moves away from it. It is thus as much part of time as the hour he spent walking by. It is only if the walker stops and reverses his step that the castle size reverses itself and grows again, and, then, that the voyager can conclude that this is a place and not only a date. It is in comparing the irreversibility of his aging body with the reversibility of the castle's size that there is a sense in the expression space *and* time, as in the usual definition of space as the "series of coexistences" and time as the "series of successions." "I have changed and the castle has not, thus there is a space, a somewhat longer lasting landscape inside of which I move and age," space offering the measure for time, and time the measure for space.

According to our principle above, we cannot say that the castle is *in* space since we claim that times and spaces – right side of the diagram – are generated by a certain type of work and the displacement of certain kinds of bodies that usually remain invisible. We should say that the voyager's displacement, by returning, has put the castle into space instead of time, that this type of move has, so to speak, "spaced" it. But why does the castle co-exist to the point of being there intact, two hours after the traveler has passed to the bottom of its mount? Certainly, this too has to be accounted for. "Castles in Spain," "castles of clouds" would not have this ability. If everything changed at the same *tempo* as the wanderer, he would never be able to measure the reversibility of shape, even if he retraced his steps. He would have aged, but the castle too would be so different that he would never be sure that it is not another castle, another date-place. Even Heraclitus' proverbial river does not flow at the same speed as its embankment. This is where we encounter the importance of techniques which I will define here as a very peculiar way of *folding* times and actants of different qualities and tempos (Latour, 1994, 1996).

The castle of Chatelperron, across the foot of which the walker passed an hour ago, was renovated four years ago, was built eight centuries ago on an earth mound elevated thousand years ago, with stones generated hundreds of millions of years ago – we will leave aside for two minutes the question of the measurement of these different time scales. In other words, what makes the traveler encounter a place, a *topos*, is the connexion of actions taking place in different sites and times by various actants. The hard labor of the feudal villains hewing the huge stones and putting them into place is still present today as much as that of the ancient seas and telluric activities of the geological past, and as much as the more recent work by the courageous owner who fixed the roof and consolidated the walls – not to mention the Neanderthal cavemen who placed Chatelperron on the paleontologists' mental maps. Far from being a point in an isotropic space, the "*spa*cific," "situated" site met by the traveler who comes back becomes a *connexion* of interactions dispersed in time, space, and action and reassembled, kept up, instituted in an event-producing *topos*. Because of the ancient, enormous, and continuous mass of work connecting various interactions over ages, the castle still holds, makes space, makes history, breaks the continuity of vision, bends attention, interrupts the travels of voyagers, and creates hierarchies, and thus the wanderer at its foot rightly feels that it differs from his own fast-aging flesh. He passes, and the castle does not. The castle co-exists, holds its ground, occupies space, creates a landscape, becomes a *chef-lieu*, whatever the expression, not because it is a spot "in" space, but because it is itself the event connecting interactions on a large spread of

space-time-actants. Here history was locally made and traditions continuously kept it in place. Thus, there is a place.

It might seem strange to define techniques as what connects interactions from different times, places, and actants, but this is a consequence of our attention to delegation and shifting. Let us take the very simple example of the mouse trap I set up against the many mice that live in my house at the foot of the Chatelperron castle. It took ten minutes for Korean housewives to make them last year in their sweatshops, a minute for the import/export trade company to order them by fax, three months to carry them in a container across the Far East trade routes. It took me a few minutes and a few francs to buy them at the local hardware shop last week; I am presently hooking a portion of Swiss cheese on the nail and, cautiously, setting the spring, making sure it is not my finger that gets snapped by the miniature guillotine... Tonight, the kinetic energy of the spring set in place by my cautious action will be swiftly unleashed in my absence as soon as a gourmet mouse starts sniffing the succulent Swiss cheese. How many actors present at once? Korean workers, French traders, wood from the mountain, cheese from the Alps, my action from yesterday delegated to the spring in this oldest of techniques, the trap. More primitive, more basic than a point in an isotopic space, is this subtle weaving together of interactions from many places, times, and types of material: the week-old mouse body, the month-old cheese, the age-old trap, the five-year-old wood, the night-old action of the exasperated kitchen owner, all of them contributing to this very humble *topos-kairos*, to an event-producing spot – and it is certainly an event for the mouse who will meet its death, hopefully, tonight ...

We never encounter time and space, but a multiplicity of interactions with actants having their own timing, spacing, goals, means, and ends. Nothing in the mind, nothing, but a lot in the know-how of those who, by clever technical action, can weave together types of actants that were incommensurable a minute before. What could be farther away than Korean sweatshops and Swiss cheese? Yet they are now connected by the shortcut of the mouse trap. Long before we talk of space and time, it is these sorts of connections, short-circuits, translations, associations, and mediations that we encounter daily.

But how do we register these many differences in timings and relative resistance? Through the various *instruments* invented by many scientific disciplines – in the largest sense of the word – to record and document them, and this is where we have to shift from technology studies to science studies. In what may be the most unfair account of science given by any philosopher, Bergson criticized scientists for being unable to pay attention to duration, to "*la durée*," because, according to him, scientists always turn it into meaningless and timeless spatial delineations. Bergson would have addressed the theme of this conference – Mind and Time – in a much less polite way than I, since for him there is one thing the mind can never think of, and that is time. Extravagant claim, since scientists are the ones who made it possible to speak of the "*longue durée*," of the eons of biology and geology out of which the very same Bergson made his "creative evolution." Without Linnaeus, without Cuvier, without Lamarck, without Darwin, there would be no long history of life for Bergson to pit against the obsession with geometry and space. The very idea of an evolution unfolding over billions of years emerges out of no other site than the natural history museums and the collections of geologists. What Bergson puts aside when he makes the vain opposition between the warm and rich duration of time and the poor and cold spatialization of mind is the work of registering differences, the work of the clever scientists, another labor which philosophers have ignored as much as that of the able engineers.

Let me take a contemporary of Einstein and Bergson who has the advantage of being one of these clever scientists inventing traps, not for mice but for time, and who has the distinct advantage (for me) of being a compatriot from Beaune. When Etienne-Jules Marey invented his photographic gun to visualize at last the precise motions of doves in flight, it was certainly not to "geometrize" the passage of time (Dagognet, 1992). It was to produce time *as much* as space. More exactly, it was to produce something entirely different from both which we can call *synopticity*. In the same way as an attention to technical know-how completely subverts the definition of a time and of a space, since it wreaks havoc on interactions by creating events and topoi, an attention to synopticity, to what can be seen at once by the gaze of a scientist, completely redistributes the ability of the mind

of the scientists to know, to see, to imagine, to think anything at all (Lynch & Woolgar, 1990).

What is important about Marey looking at the successive images of the dove in flight impressed on the circular silver-coated plate is not, in spite of Bergson's condemnation, that he has lost the passage of duration, since it is precisely to lose it that he went to great pains to invent his photographic gun! If anything, he was utterly fed up with "*durée*," with uncontrolable, invisible fuzzy patterns of doves flying in the air without being seizable, fixable, catchable. (This is why, by the way, he never invented the movie camera, to the great shame of my Burgundian compatriots; what Marey wanted was to invent the *anti*-movie camera! Something that would turn movement into a succession of images synoptically and not successively visible).

The flying dove did not live "in time" before being killed by the gun "in space." The photographic gun does *not* kill, that's the trick. What is important for Marey is that the events of the flying dove occur now many times, there, in the beautiful summer sky, but also, hundreds of times at will, down there in the *Station physiologique* of the Collège de France. Marey is not losing the lived and rich *durée* of the dove for the poor and cold geometry of the dove. On the contrary, he is *adding* to the flight of the dove, something never observed by anyone on earth before, the enrapting contemplation of the successive motions transformed, on the plate, into coexisting shapes. He has not "degraded" time into space as Heidegger would say; the leap is much more innovative and daring than that: the few flash seconds of the dove's flight have been transformed into an ever-lasting silver photograph that can be contemplated for hours and quickly scanned by Marey's gaze again and again, in search of structural features that will explain the muscles' position and the energy balance. For someone who observes scientists at work there is no more one time and space than there is for someone who observe engineers at work. The phenomena are much more stunning; they rely on the subversion, disjunction, displacement, rescaling, crossing-over of relations between spatial, actorial, and temporal features (Schaffer, 1988 ; Latour, 1995 ; Lynch, 1991). Science does not withdraw time from the world, it adds many spaces and times to it by constantly modifying scales, lengths, units in those strange sites, the laboratory, the institute, the collection, which are utterly different from "a mind."

If this is the case, then, where does this obsession with a time-space frame "in which" entities would reside or which the mind would "impose on" things in order to apprehend them come from? No suffering bodies opening up trails through labor, as in the anecdote I recounted earlier, will ever produce that sort of space and time. But *no* engineer and *no* scientist at work either. And it is useless at this point to oppose, as is so often the case, the "lived world" of human subjectivity apprehending space and time with all the rich colors of intentions and affectivity on the one hand and, on the other hand, the scientific and technical objective world ceaselessly beating the isotopic and isochronic meaningless space-time. The scientific and engineering practice of subverting spaces and times through maps, charts, digs, traps, tricks, and knacks exceeds by far any subjective time and space described by phenomenologists. The subjectivity of space and time is not what is left when the objective space-time has been thoroughly described. It is only in some very peculiar circumstances that the two can be differentiated. Only the man in the TGV may distinguish transport and transformation, not the woman opening the trail with her hatchet, not the engineers of the train companies making sure trains do not run out of synch, not the scientists watching over the coordination of atomic clocks, and not Marey trembling at the idea that his photographic gun might give fuzzy, blurred or overlapping images.

But certainly, the space-time used to imagine the frame of all events has to come from somewhere? Its origin seems to reside in the peculiar nature of the *objects* used in the scientific disciplines to build their measuring instruments (Stengers, 1996). Whitehead once quipped that it is all very well to praise Galileo for his study of the inclined plane, but what if he had tried with bags of wheat instead of spherical billard balls! Try to detect a seven-year-old conserving from non-conserving kids using callabasses instead of beakers controlled by metrology and standardization – inspectors and instruments and institutional bodies are necessary there, as well as in the case of trains and clocks to hold them "up to standard" and coordinate action and certification (see Houdé, this volume). I bet that in Africa, away from their laboratories, most

Piagetian testers would qualify as non-conserving (Lave, 1988)! As I said above, there is an inordinate number of rigid bodies in the paraphernalia of laboratories. But this does not mean that scientists are *themselves* rigid bodies or have rigid geometrical minds! It means that, in the laboratory, to detect differences they use benchmarks. The circulation of those rigid bodies will locally generate a specific type of space-time like the circulation of any other body with different properties will generate other spaces-times-actants. This does not mean that we are *in* an isotropic space and an isochronic time, but that locally, *inside* metrological chains, there are *effects* of isochrony and isotopy, produced by the carefully monitored and heavily institutionalized circulation of objects that remain relatively untransformed through transportation: high-speed trains, rulers, standards, canons, weight, constant relations, bullets, ballistic missiles, falling stones, accounts, and various other rods, hands of clocks, gears, and structural isomorphies. All of that instrumentation, being very practical, very clever, very material, very local, but at no point saying anything about the mind's inner workings or explaining the ways by which no-place becomes event or events become non-event. The building of metrological networks for space and time is a crucial feature of Western history. It has to be documented, to be sure, it should be studied, respected, but it must *not* be confused either with an account of how our mind evolved, or with the understanding that other civilizations may have of time, or with the ontology of world-making.

I am well aware that we are here at the turning point (or maybe the breaking point!) of my chapter. Since this interest in the shift in times and spaces practised by technical action and scientific laboratories, and the attention on the instruments and their making instead of their results, cannot in any way be justified by demonstration, we have to choose here between philosophies. The first one would consider space and time in their isotopic and isochronic nature as being what the universe is made of, or, alternatively, what the mind needs to impose on the universe in order to make sense of it. In addition, as an afterthought, it might save for human subjectivity some other sort of relations that would explain how we relate emotionally to events and orient concretely in space, but all of this subjectivity will be understood in contrast to the objective space-time. Affectivity and effectivity will be clearly contrasted. Only the left side of the diagram will be considered and the right part will be taken as a purely instrumental aspect of no philosophical consequence for the elaboration either of the world or of the mind.

The second solution is to start from a phenomenon that is not in itself connected with subjectivity *or* objectivity, which ignores the quarrel between space-time as *sensorium* or as a frame of mind, and which begins with the *other entities* that are necessary for maintaining one in existence. It is the quality of this otherness and the "number" of others which become, in this philosophy, the crucial features. The key question is thus that of knowing if a transport, a displacement, a translation, a trajectory is either "paid for" in such a world by a small or a large deformation, transformation, metamorphosis. The major difference between the two outlooks is that, in this second view, the normal case of the first becomes the extraordinary rare *exception* of the second. That a mobile may travel without mutating is so rare, so miraculous, so expensive, that it has to be accounted for and explained in detail. And indeed, to account for the man in the TGV who does not age more than three hours going from Paris to Neuchâtel, one would have to take into account several huge bureaucracies, enormous networks, many clocks, flags, signs, and standards, a lot of electric plants, labor relations, and so on. Similarly, to account for Einstein's travels without deformation at the speed of light in spite of the acceleration of the frames of reference, one would have to count the whole establishment of physics, huge laboratories, most of astronomy, and quite a lot of the trains and embankments of Swiss railway authorities! In this second world, the measurement of times and spaces *makes* spaces and times whereas in the first, the instrument plays no other role than that of a practical means to reach space and time which exist independently either objectively or subjectively. In the second, instruments are mediators and shifters; in the first, simple means and intermediaries; they could, in theory, be discarded. In both worlds, the role of the mind as well as of ethics, politics, and religion will be entirely different, and this is what I now want to focus on briefly in the remainder of this paper. Why is the fifth dimension of time-space so difficult to register?

Formalism: A professional hazard

What happens if, instead of focusing on the circulating rigid bodies, on the instruments, on the laboratory sites, on the changes of scale, on the institutions in charge of time and standards, on the know-how that goes into the experimental trials, one focuses only on the *results* of that smooth displacement? To continue with my favorite example, what happens when the man in the first-class compartment of the TGV ignores not only the famous "man on the embankment," but also the inhabitants of the string of aligned stations and cities, the whole machinery and administration of train companies? He will really think that there is something like a displacement in time-space that does *not* require any aging, any transformation, something that is "paid for" nowhere by any costly network building. He may even start to think that isochronic time (measured by his watch in relation with the train's clock) and isotopic space (signaled by the number-bearing milestones that flee regularly along the track) are normal features of the world. Please note again, that this will not happen if he boards an Italian train, let alone an Indian train, and it won't happen either, remember, if there is a strike or any incident or even if the air-conditioning starts to malfunction slighlty. But if everything goes smoothly, this traveler will take the *result* of the railway companies' labor –smooth travel across space in time – as the normal *cause* of that huge organization. After having discarded as irrelevant the tracks, the trains, the switches, the bureaus of standards, the clockwork, the regulations, the timetables, and the whole menagerie, he will then be immensely tempted to believe that this whole system of isochronic and isotopic coordinates could be located, where? *In his mind!* That is the real great danger of train trips, they are too comfortable, at least in Switzerland. Epistemology is a professional hazard of first class air-conditioned train travelers. "Brain trips," it should be called, a disease of modernity and lack of exercise, much like a bad back!

More seriously, science is either praised or attacked for what it *cannot* possibly provide: timeless formalism. As we saw earlier, there exist, of course, scientists working on forms, on rulers, on maps, on coordinates, on structures, but their work is not itself formal, ruled, mapped, coordinated, structured. Formalisms circulate inside scientific networks with the regularity, efficiency, elegance, economy, of trains circulating on the "Rätische Bahn." But in the same way as no one could even imagine trains keeping regular schedules without railway companies, no one should imagine that formalisms could go on circulating smoothly without the costly institutions known as Research and Development. It is as strange to turn isochrony and isotopy into mental or natural categories as it is to turn the work of establishing constants into what the mind would be particularly good at. The unequipped mind of a desocialized scientist will be immediately unable to prolong the life of any constant. This is why researchers, well aware of these practical constraints, ceaselessly devise instruments, time and space subvertors, data-traps, scale-inverting inscriptions, and thus produce a fabulously interesting history in their own sciences. They resemble much more the worried train company managers than the careless, well-fed, ignorant traveler. Even Einstein, in his own Machian account of general relativity, has deployed very explicitly the engineering work that goes into shifting from one accelerated frame to the next without losing information on the way (Einstein, 1920). His proverbial "mollusk of reference" produces an absolute space-time, but cannot possibly be seen as being itself *in* this absolute space-time.

The idea that a mind could make formal reasoning would be as bizarre as imagining a solitary scientist making a discovery or a naked male traveler's body going by itself at 300 km/h from Paris to Neuchâtel. Only Superman or The Flash could do that. And yet, the very idea of a "genetic epistemology" goes even further than this thought experiment. It imagines not only that the mind undertakes formal reasoning through formal means, but that the whole history of biological life, from the earliest pre-Cambrian ferns to the superior cortex of primates, obsessively seeks nothing but the conservation of those formal relations (Piaget, 1967 [1992])! Thus formalism is not only taken as the pinnacle of human reasoning, but life itself is said to aim at nothing else. Here Piaget, the immanentist, takes apparently the opposite position of Bergson, the spiritualist, for whom life will remain forever foreign to *Homo faber*'s urge for geometry. In effect, however, his position starts from the same principle: Time and space can be said, unproblematically, to pertain to life itself.

But if we have been right in locating the production of times and spaces in certain types of circulation, registration and instruments, one certainly cannot attribute to life itself the timing that is due in large part to the biologists' and evolutionary theorists' practice (Kohler, 1994). To stick to mollusks (of reference), there is a huge difference between a snail in Neuchâtel's lake, and the same snail inside Piaget's collection. The first is more like the female traveler of my story: It is a suffering body among suffering bodies, without any instrument to register its suffering, its metamorphoses, its mutations, and all the risks it dares to take to stay alive. It is only the second, inside a range of other snails of slightly different colors and shapes, that will begin to offer, through the invention of a new form of synopticity, a registration of mutations in relation to the changing environment, itself represented by colors, labels, lentghts on millimetered paper. As Stephen Jay Gould has so beautifully demonstrated in *Wonderful life. The Burgess Shale and the nature of history* (the full title should not be overlooked) one cannot account for the history of life without the history of the life sciences (Gould, 1989). To jump away from the instruments, the collections, the natural history museums, straight to what life in itself aims at, is a sure path to failure, to the fallacy of granting to all living organisms a "way of life," an obsession with constancy, a mad search for structures, a fixation on conservation, that might well be – dare I say it? – representative of Swiss watchmakers, Swiss train managers, Swiss record-keepers, Swiss bank collectors, but that cannot, at least without more research, be lightly granted to snails, birds, stomachs, brains, kids, mathematicians, elephants, or whales... One can be allowed to forget for a moment that smooth displacement in time and space is paid for somewhere else by other people, but not forever. Even if "time is like nothing" during the train trip and inside the compartment, to think that this is also true outside of the train would be like trying to suddenly jump out of a TGV at full speed...

Fernando Vidal has shown the paradox of accounting for Piaget's thought by pointing out its environment (Vidal, 1994). If we were to believe naive contextualists, a Swiss biologist born in Neuchâtel, working for many years on natural history collections, in a rich country of bankers and clockmakers, crisscrossed by trains, cars, trucks, and planes, and later fascinated by the exploring behavior of children, by the extent of their material manipulations, their reliance on social interactions, should have considered societies, children's peer groups, and scientific disciplines as so many *time-producing collectives*, and should have deconstructed, one by one, most Western beliefs into the asocial, atemporal nature of formalism. He should have wrenched *out* of the mind every single one of the concepts that rely so obviously on material, social, and practical mediations, and since he had the extraordinary chance of being a reasonably good biologist, he, and he alone, not taken in by the awe of Science with a capital S, should have seen how close children's controversies were to scientific controversies. Thus, struck by the extravagant ethnocentrism of most psychology, he would have founded "cognitive anthropology" and shown the gap that exists not only between practical cognitive cultures, as Ed Hutchins has recently shown in his fundamental book (Hutchins, 1995) but, going much further, he would also have started to study what times and what spaces suffering biological bodies would trace on their own terms...

And yet, and yet, as we all know, this is not what happened! Too bad for the social history of thought! The heroic effort we celebrate in this symposium under the paradoxical umbrella of Mind and Time aimed at eliminating from the mind, from the production of science, from ontogenic development, from the history of science and, finally, especially in *Biology and Knowledge*, from the history of life itself, any trace of history, of time-producing practice. Isabelle Stengers, a philosopher of time if any, has proposed, after Deleuze, to distinguish virtualities from potentialities. Potentiality is the realization "in time" of what was already there *in potentia*. Time unfolds determinations, but nothing really happens, exactly as it is possible to calculate all the positions of the pendulum from its initial position without the actual fall of the pendulum adding any new information. The same is true of development, if development is understood as the unfolding of potentialities – a problem, as is well known, that Piaget tackled twice in the growth of mollusks and of child intelligence. Virtuality is something altogether different. It depends on the *otherness*, on the fifth dimension of process, on this quality of connection with other actants that I took, earlier in this paper, as the deeper definition of time and space, that is,

the intensity of time and space. The question is thus to decide whether time is the realization of potentialities, or whether it emerges from the eliciting, the eduction of virtualities, of surprising differences.

The constancy of Piaget, during such a long career, in seizing any occasion, in all the many domains in which he worked, to turn virtualities into potentialities, this constant erasure of time and practice in all the topics he took on, is so stunning that it requires an explanation that I am not equipped to find but that, I am sure, we will uncover by the end of this symposium.

My own guess is that *theology* must have played an enormous role in this adequation of Switzerland, Western science, thought, mind, ontogenesis, formalism, and life. The timelessness thus produced had all the character of the timelessness of a *secular* protestant theology. Contrary to what is often thought, theologians are often more rationalists than epistemologists, especially because they imagine that God has something to do with the *same* time and space as the one produced by immutable mobiles, except that He is beyond. But, since theologians do not focus on the work of producing those mobiles but only on its result, much like train travelers and epistemologists do, they take isotopy and isochrony as features of the world. They commit, to use Heidegger's language, the sin of metaphysics. Thus, there is no other way for them but to consider God as an entity which is somewhat "beyond" space-time, in a transcendant "other world." If one wishes, like the young Piaget, to maintain the anhistoricity provided by this God of beyond and above, but wishes, at the same time, to distance oneself from the embarrassing baggage that goes with Christian theology, one of the solutions is to make sure that *this* world itself has all the characters of constancy, formalism, anhistoricity of the "other" world.

The enterprise resembles somewhat the experiment to reach absolute zero by progressively slowing down the motions of atoms. The fusing together of psychology, history, life, logic, mathematics, and pedagogy, creates a confined space in which this extraordinary trial can take place: The slowing down of history, the slow replacement of virtualities by potentialities, the transformation of process into the actualization of constants, one of the most daring scientistic enterprises of this century, already rich in such endeavours, to make sure that – how can I put this as politely as possible? – to make sure that nothing unanticipated or untowards happens; to make sure that every stage will be regulated according to schedule; that ontogeny will recapitulate phylogeny; that this world will be as well regulated as the lost other world; that balances and accounts will always be kept in spite of all the imbalances; that constancy will always be maintained in spite of the turmoil of history and world wars; that capitalization will go on for ever without losses or spending... Ah hah, maybe the contextualists are right after all, a Swiss dream if any, the paradoxical timelessness of clockmakers! The ideal for an army of passive defense. A world run smoothly like clockwork, where trains, colleges, and classrooms run on time, a world where nothing would happen. A mind and no time...? Yes, a magnificent experiment to show in relief what has been missed so far in discussions about timing, spacing, and acting.

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