Chapter Two

Evolution of Technical Reality; Element, Individual, Ensemble

I. – Hypertely and self-conditioning in technical evolution

There are phenomena of hypertely that manifest themselves in the evolution of 61
technical objects, giving each technical object an exaggerated degree of specialization and maladapting it to even a slight change in the conditions of its utilization or fabrication; the schema that constitutes the essence of the technical object can in fact adapt in two ways: it can first of all adapt to the *material and human conditions* of production; each object can utilize the electrical, mechanical, or chemical aspects of the materials that constitute it in the best possible way; it can then adapt to *the task* for which it is made: a tire that can be used well in a cold climate may not be appropriate for a hot climate and vice versa; a plane made for high altitudes may be disadvantaged by the need to function temporarily at low altitudes, in particular for landing and takeoff. The jet engine, which is superior in very high altitudes to a propeller engine precisely because of its principle of propulsion, becomes difficult
to use at a very low altitude; the great speed attained by a jet engine becomes a 62
rather paralyzing aspect when it needs to touch ground; the reduction of wing area, which comes with the use of a jet engine, requires landing at a high speed (almost the cruising speed of a propeller aircraft), thus requiring a very long landing strip.

The first planes, which were able to land in the middle of the countryside, were less functionally over-adapted than modern planes. Functional over-adaptation goes so far that it results in certain schemas similar to those which in biology, fluctuate between symbiosis and parasitism: some very fast small planes can take off with ease only if they are carried by a bigger plane that drops them in mid-flight; others use rockets in order to increase upward thrust. The transport glider is itself a hypertelic technical object: it has become little more than an air cargo ship or rather an air-barge without a tow plane, and as such, it is entirely different from a true glider that can, after a light launch, catch the air on its own, using air currents. The autonomous glider is very finely adapted to engineless flight, whereas the transport glider is only one of two asymmetrical halves of a technical totality, the other being the tow plane; the tow plane, on the other hand, is maladapted because it cannot, on its own, take off with a load corresponding to its power.

One could thus say that there are two types of hypertely: one corresponds to a fine-tuned adaptation to well-defined conditions without breaking the technical object up and without a loss of autonomy; the other corresponds to a breaking-up of the technical object, as in the case of the division of a unique primitive being into tower and towed. The first case preserves the autonomy of the object, whereas the second case sacrifices it. A mixed case of hypertely is one that corresponds to an adaptation to the milieu, such that the object necessitates a certain kind of milieu
63 in order to function properly, because it is energetically coupled to its milieu; this case is almost identical to that of the division into tower and towed; for instance, a clock synchronized by a grid loses all capacity for functioning if it is brought from America to France, because of the different frequency (60 Hertz and 50 Hertz); an electrical motor requires a grid or generator; a synchronous single-phase motor is more finely adapted to a determinate milieu than a universal motor; in this milieu, it functions even better, but outside of this milieu it becomes worthless. A synchronous three-phase motor is even more finely adapted to functioning in a certain type of grid than a single-phase motor, but outside of this grid it can no longer be used; as a result of this limitation its functioning becomes even more satisfactory than that of a single-phase motor (a more regular regime of functioning, high efficiency, very little wear and tear, and low losses in the connecting lines).

In some cases, this adaptation to the technical milieu is primordial; the utilization of an alternative three-phase current is thus fully satisfactory in the factory environment and for all kinds of motors regardless of their power requirements. And yet, no one has been able to this day to use alternative three-phase current for the traction of electric trains. A system of transfer is needed to connect and mutually adapt the locomotive motor using direct current to the three-phase high-voltage transportation grid: it is either the sub-station delivering direct voltage to the feeders of the catenary or the transformers and rectifiers on the locomotive that provide the motor with direct current, even though the catenary is subject to

alternative voltage. The locomotive motor would in fact have been constrained to lose too great a part of its range of utilization by adapting in terms of its energy and frequency to the energy distribution grid; a synchronous or asynchronous motor provides large quantities of mechanical energy only when it has reached its design 64
speed; while excellent for a stationary machine like a lathe or a drill that starts up with zero load and is only required to overcome an important degree of resistance once the design speed is reached, this type of utilization is not suitable for the motor of a locomotive; the locomotive starts up with a full load, with all the inertia of its train; it is when it is functioning at operating speed (if one can speak of a system's operating speed, strictly speaking, in the case of a locomotive) that it has the least amount of energy to provide; the motor of a locomotive must provide maximum energy in its transition phases, either during acceleration, or deceleration, or for braking using counter-current. Rich in frequent adaptation to the variations of the operating system, such usage is opposed to the reduction of the spectrum of the modes of utilization characteristic of the adaptation to a technical milieu, for which the factory with its polyphase grid and constant frequency is an example. The example of the traction motor allows us to grasp the existence of a twofold relation that the technical object entertains, with its geographical milieu on the one hand, and its technical milieu on the other.

The technical object is situated at the meeting point between two milieus, and it must be integrated to both milieus at once. In any case, as these two milieus are two worlds that do not belong to the same system and are not necessarily completely compatible, the technical object is to a certain extent determined by human choice, attempting to realize the best possible compromise between these two worlds. In a sense, a traction motor, like a factory motor, is what is fed by the energy of high voltage alternative three-phase lines; in another sense, it is what deploys its energy to pull a train, from stop to full speed and once again to a full halt, via degrees of decreasing speed; it is what must pull the train on its ramps, through turns, and on slopes, while maintaining its speed as constant as possible. 65
The traction motor not only transforms electrical energy into mechanical energy; it applies it to a varied geographical world, which translates technically into the shape of the tracks, the variable resistance of the wind, the resistance of snow that the front of the locomotive pushes out of the way. The traction motor's reaction rebounds on the line that feeds it, creating a reaction that is the translation of this geographical and meteorological structure of the world: the absorbed intensity increases and the voltage in the line decreases when the snow thickens, when the slope rises, when lateral wind pushes the wheels' guards against the tracks and

increases friction. *The two worlds act upon each other* via the traction motor. A three-phase factory motor, on the contrary, does not establish a reciprocal relation of causality between the technical world and the geographical world in the same way; its operation takes place almost entirely within the technical world. The uniqueness of this milieu explains why there is no need for an adaptation milieu in the case of the factory motor, whereas the traction motor requires an adaptation milieu such as is constituted by the rectifiers, which are placed in the sub-station or on top of the locomotive; the factory motor requires only the transformer as an adaptation milieu that lowers voltage, which could be done away for high powered engines, and is necessary in the case of average power engines, as a safety requirement aimed at human users, rather than as a true adaptor to the milieu.

Adaptation follows a different curve and has a different sense in this third case; it cannot lead as directly to phenomena of hypertely and maladaptation following hypertely. The necessity of adaptation, not to a milieu defined as exclusive, but to the function of relating two milieus that are both evolving, limits adaptation and gives it more precision in the direction of autonomy and concretization. This is
66 where true technical progress resides. Thus the use of silicon plates, having greater magnetic permeability and lower hysteresis than iron plates, facilitates a reduction of both the weight and volume of traction motors even while it increases their efficiency; such modifications tend toward a function of mediation between the technical and geographical worlds, since a locomotive can now have a lower center of gravity, with its motors often located at the level of the bogies; the inertia of the rotor is reduced, which is desirable for the sake of rapid braking. The use of silicon insulation makes greater heat tolerable without the risk of deteriorating the insulation, which in turn increases the possibilities of over-intensity, increasing the motor torque during start-up and the resistant torque during braking. Such modifications do not restrain, but rather extend the areas whereby traction motors can be used. A motor insulated with silicon can be used without supplementary precaution in a locomotive climbing steep slopes or in a very hot climate; the engine's relational use extends itself; (a small version of) this type of improved motor can be used as a truck speed-reducer; the motor is in fact adapted to the relational modality as such and not only to this precise type of relation that links the grid and the geographical world for the purpose of the train's traction.

An analogous example of concretization is the Guimbal turbine[6]; this turbine is
immersed in the penstock and directly coupled to a very small generator contained
in a crankcase filled with pressurized oil. The dam wall thus contains an entire
electrical factory within the penstock, since the only thing that appears at ground-
level is the gatehouse containing the oil reservoir and measuring instruments. The 67
water becomes pluri-functional: it conveys energy by activating the turbine and
generator and also transfers heat from the generator; the oil is also remarkably
pluri-functional: it lubricates the generator, insulates the windings, and transfers
the generated heat from the winding to the crankcase where it is evacuated by
the water; lastly, it prevents the seepage of water into the crankcase through the
shaft packings, since the pressure of the oil in the box is greater than the pressure
of the water outside the box. This over-pressure is itself pluri-functional; under
permanent pressure it greases the bearings while at the same time preventing the
water from seeping into the bearings if they fail to be watertight. However, it is
worth noting that it is as a result of this pluri-functionality that this concretization
and relational adaptation became possible. To put the generator into a penstock
containing the turbine was unthinkable prior to Guimbal's invention, because
even if the problem of water-tightness and insulation were supposedly solved, the
generator was too large to be lodged within the conduit; it is the mode of resolu-
tion of the problems of water-tightness and electric insulation that allows for the
insertion of the generator into the conduit, while also facilitating excellent cooling
through the double intermediary of both oil and water. One could go so far as
to say that the insertion of the generator into the conduit *renders itself possible* by
simultaneously authorizing the energetic cooling by water. Additionally, the great
efficiency of cooling allows for a considerable reduction of size while maintaining
the same power. The Guimbal generator would be rapidly destroyed by heat if it
were used at full load and out in open air, whereas it barely registers any increase
in temperature within its double pool of concentric oil and water, both of which
pulsate energetically, the oil according to the generator's movement of rotation,
and the water according to the turbulence of the turbine. Concretization is here 68
conditioned by an invention that *presupposes the problem to be resolved*; indeed it
is due to the new conditions created by concretization that this concretization is
possible; the only milieu in relation to which there is non-hypertelic adaptation, is
the milieu created by adaptation itself; here the act of adaptation is not merely an

6. These turbines are of the same type as the bulb units used in recent French tidal power schemes. They are reversible and can pump water during low tide with low energy expense.

act of adaptation in the sense in which this word defines the adaptation to a milieu that is already given prior to the process of adaptation.

Adaptation-concretization is a process that conditions the birth of a milieu rather than being conditioned by an already given milieu; it is conditioned by a milieu that only exists virtually before invention; there is invention because there is a leap that takes place and is justified by means of the relation that it brings about within the milieu that it creates: the condition of possibility of this turbo-generator couple is its realization; it can only be geometrically situated in the conduit if it is physically situated in such a way that it realizes the thermal exchanges that allow for a reduction of its size. One could say that a concretizing invention realizes a techno-geographic milieu (in this case the oil and water in turbulence), which in turn is a condition of possibility of the technical object's functioning. *The technical object is thus its own condition, as a condition of existence of this mixed milieu* which is simultaneously both technical and geographical. This phenomenon of self-conditioning defines the principle according to which the development of technical objects is made possible without a tendency toward hypertely and then mal-adaptation; hypertely occurs when adaptation is relative to a given that exists prior to the process of adaptation; such adaptation effectively seeks conditions that always outpace it, because its reaction does not impact them and in turn doesn't condition them.

69 The evolution of technical objects can only become progress insofar as these technical objects are free in their evolution and not pushed by necessity in the direction of a fatal hypertely. For this to be possible, the evolution of technical objects must be constructive, which is to say that it calls forth the creation of this third techno-geographic milieu wherein each modification is self-conditioned. Indeed, this is not about a form of progress conceived as a march in a direction fixed in advance, nor about a humanization of nature; this progress could just as well present itself as a naturalization of man; between man and nature a techno-geographical milieu arises that only becomes possible through man's intelligence: the self-conditioning of a schema as a result of its functioning necessarily requires the use of an inventive function of anticipation, which cannot be found in nature or in already constituted technical objects; thus a vital work [*une œuvre de vie*] is required to take the leap beyond a given reality and its current systematization, toward new forms that only maintain themselves because they exist all together as a constituted system; when a new organ appears in the evolving series, it maintains itself only if it realizes a systematic and pluri-functional convergence. The organ is its own condition. It is in a similar manner that the geographical world and the world of already existing

technical objects enter into a relation in which concretization is organic, and which defines itself through its relational function. Like an arch that is stable only once it is finished, this object that fulfills a function of relation maintains itself and is coherent once it exists and because it exists; it creates its own associated milieu from itself and is really individualized in it.

II. – Technical invention: ground[7] and form in the living and in inventive thought

We can therefore affirm that the individualization of technical beings is the condition of technical progress. This individualization is made possible by the recurrence of causality within a milieu that the technical object creates around itself and that conditions it, just as it is conditioned by it. This simultaneously technical and natural milieu can be called an associated milieu. It is that through which the technical object conditions itself in its functioning. This milieu is not fabricated [*fabriqué*], or at least not fabricated in its totality; it is a certain regime of natural elements surrounding the technical being, linked to a certain regime of elements that constitute the technical being. The associated milieu mediates the relation between technical, fabricated elements and natural elements, at the heart of which the technical being functions. Such is the case of the ensemble constituted by oil and water moving in and around the Guimbal turbine. This ensemble is concretized and individualized by recurrent thermal exchanges that take place within it: the faster the turbine spins, the more there is an increase in the heat generated by the generator through magnetic losses and the Joule effect; but the faster the turbine spins, the greater the increase in the turbulence of the oil around the rotor and that of the water around the crank-case, thereby activating the thermal exchanges between rotor and water. It is this associated milieu that is the condition of existence for the invented technical object. The only technical objects that can be said to have been invented, strictly speaking, are those that require an associated milieu in order to be viable; these cannot in fact be constituted part by part via the phases of successive evolution, because they can exist only as a whole or not at all. Technical objects that essentially put into play a recurrent causality in their relation with the natural

7. The phrase "fond et forme" nearly always means "content and form", and it is important to be aware that Simondon is here employing this typical expression, but changing the content of its meaning, as soon becomes clear in the text; "fond" here and throughout is rather used in the sense, taken from Gestalt theory, of a "ground" or "background" against which a form or figure can emerge – the constant with reference to which a variable can emerge –, without, however, completely losing from view its primary meaning of "content". [TN]

world must be invented rather than gradually developed, because these objects are
71 the cause of the condition of their functioning. These objects are viable only if the problem is solved, i.e., only if they exist together with their associated milieu.

This is why we notice such discontinuity in the history of technical objects, with absolute origins. Only a thought that is capable of foresight and creative imagination can accomplish such a reverse conditioning in time: the elements that will materially constitute the technical object and which are separate from each other, without an associated milieu prior to the constitution of the technical object, must be organized in relation to each other according to the circular causality that will exist once the object will have been constituted; thus what is at stake here is a conditioning of the present by the future, by that which is not yet. Such a futural function is only rarely the work of chance; it requires putting into play a capacity to organize the elements according to certain requirements which act as an ensemble, as a directive value, and play the role of symbols representing the future ensemble that does not yet exist. The unity of the future associated milieu, within which the causal relations will be deployed that will enable the functioning of the new technical object, is *represented*, it is *played* or acted out as much as a role can be played in the absence of the true character, by way of the schemes of the creative imagination. The dynamism of thought is the same as that of technical objects; mental schemas react upon each other during invention in the same way the diverse dynamisms of the technical object will react upon each other in their material functioning. The unity of the technical object's associated milieu is analogous to the unity of the living being; during invention, the unity of the living being is the coherence of mental schemes, obtained by the fact that they exist and deploy themselves in the same being; those schemas that are contradictory confront and reduce one another. The reason the living being can invent is because it is an individual being that carries its associated milieu with it; this capacity for conditioning itself
72 lies at the root of the capacity to produce objects that condition themselves. What has escaped the attention of psychologists in their analysis of the inventive imagination aren't the schemas, forms, or operations that stand out as the spontaneously salient and striking elements, but rather the dynamic ground upon which these schemas confront each other and combine, and wherein they participate. Gestalt psychology, while recognizing the function of totalities, attributed force to form; a deeper analysis of the inventive process would no doubt show that what is determinant and plays an energetic role are not forms but that which carries the forms, which is to say their ground; the ground, while perpetually marginal with respect to attention, is what harbors the dynamisms; it is that through which the system of

forms exists; forms do not participate in forms, but in the ground, which is the system of all forms or rather the common reservoir of the formes' tendencies, well before they exist separately and constitute themselves as an explicit system. The relation of participation that links forms to ground is a relation that bestrides the present and diffuses an influence of the future onto the present, of the virtual onto the actual. For the ground is the system of virtualities, of potentials, forces that carve out their path, whereas forms are the system of actuality. Invention is the taking charge of the system of actuality through the system of virtualities, the creation of a unique system on the basis of these two systems. Forms are passive in so far as they represent actuality; they become active when they organize in relation to this ground, thereby bringing prior virtualities into actuality. It is no doubt very difficult to shed light on the modalities according to which a system of forms can participate in a ground of virtualities. We can only say that it happens according to the same mode of causality and conditioning as the one which exists in the relation of each of the technical object's structures which are constituted with the dynamisms of the associated milieu; these structures are inside the associated milieu, they are determined by it and, because of it, they are also determined by the other structures of the technical being; they also partially determine it, but each one for its own sake, while the technical milieu, which is determined separately by each structure, in turn determines them altogether by providing the energetic, thermal and chemical conditions of functioning. There is a recurrence of causality between the associated milieu and the structures, but this recurrence is not symmetrical. The milieu plays the role of information; it is the seat of self-regulations, the vehicle of information or of energy that is already governed by information (for instance, the water that is animated by more or less rapid movement, cooling the crank-box more or less rapidly); while the associated milieu is homeostatic, the structures are animated by a non-recurrent causality; each goes in its own direction. Freud analyzed the influence of ground on forms in psychic life by interpreting this influence as one of hidden forms on explicit forms; hence the notion of repression. Experiments have indeed proven that symbolization exists (experiments where a violently emotional scene is described to a subject in a hypnotic state and who, upon waking, recounts this scene by using symbolic transposition), but this does not prove that the unconscious is populated by forms comparable to explicit forms. A dynamics of tendencies is sufficient for explaining symbolization if one considers as effective the existence of a psychic ground, upon which the explicit forms that are generated by the conscious and wakeful state are deployed and in which they participate. It is the milieu associated with a systematics of forms that institutes

relations of recurrent causality between these forms and that which causes recastings of the system of forms taken as an ensemble. Alienation is the break between ground and forms in psychic life: the associated milieu no longer regulates the dynamism of forms. To date, the imagination has been poorly analyzed because
74 forms have been invested with the privilege of being active and are thought to have the initiative in psychic life and in physical life. In reality there exists a great kinship between life and thought: within a living organism all living matter cooperates in life; it is not only the most apparent, or the clearest structures that have the initiative of life in the body; blood, lymph nodes, and conjunctive tissues partake in life; an individual is not only made up of a collection of organs combined with one another into systems; an individual is also made up of that which is neither organ nor structure of living matter, insofar as it constitutes an associated milieu for the organs; living matter is the ground of the organs; it is what allows them to relate to each other and become an organism; it is what maintains the fundamental thermal and chemical equilibriums upon which the organs deliver brisk, but limited variations; the organs participate in the body. The living matter in question is far from being pure indeterminacy and pure passivity; nor is it blind aspiration: it is the vehicle of informed energy. In the same way, thought comprises clear, separate structures, such as representations, images, certain memories, and certain perceptions. All these elements, however, participate in a ground that gives them a direction, a homeostatic unity, and which acts as a vehicle for informed energy from one to the other and among all of them. One could say that the ground is the implicit axiomatic; in it new systems of forms are elaborated. Without the ground of thought, there would be no thinking being, but rather an unrelated series of discontinuous representations. This ground is the mental milieu associated with the forms. It is the middle term between life and conscious thought, just as the associated milieu of the technical object is the middle term between natural world and the fabricated structures of the technical object. We can create technical beings because we have within us a play of relations and a matter-form relation that is highly analogous to the one we constitute in the technical object. The relation
75 between thought and life is analogous to the relation between the structured technical object and the natural milieu. The individualized technical object is an object that has been invented, i.e., produced through the play of recurrent causality between life and thought in man. An object that has only been thought or only associated with life is not a technical object, but a utensil or apparatus. It has no internal consistency, because it has no associated milieu instituting a recurrent causality.

III. – Technical individualization

The technical object's principle of individualization through recurrent causality within an associated milieu enables us to think with greater clarity about certain technical ensembles and to know whether to treat them as a technical individual or as a collection of organized individuals. We shall speak of a technical individual whenever the associated milieu exists as a condition of functioning *sine qua non*, whereas it is an ensemble in the contrary case. Take a laboratory, such as a laboratory studying the physiology of sensation. Is an audiometer a technical individual? No, not if one considers it independently of the power supply and headphones or speakers used as electro-acoustic transducers. The audiometer is defined, then, by certain requisite conditions of temperature, voltage, and noise levels, so that its frequencies and intensities may be sufficiently stable for the measurements of thresholds. The room's coefficient of absorption, its resonance at this or that frequency must be taken into account; the room is part of the complete apparatus: for the audiometer to operate properly it requires either a flat and barren landscape, or that its measurements be made in an anechoic chamber, with a suspended anti-microphonic floor and a thick layer of glass-wool on the walls. What then is the audiometer in itself, such as it is sold by a manufacturer or such as one makes oneself? It is an ensemble of technical forms, wherein each has a relative indi- 76
viduality; in general it has two high-frequency oscillators, where one is fixed and the other variable; the lower of the two frequency beats serves to produce audible sound; a fader facilitates the dosage of the intensity of the stimuli. Neither of these oscillators constitutes a technical object in itself, because in order for it to be stable the technical object requires the stabilized voltage of both heater and anode. This stabilization is generally obtained through an electronic system with a recurrent causality that functionally constitutes the associated milieu of the oscillators' technical forms; this associated milieu, however, is not entirely an associated milieu; it is, rather, a system of transfer, a means of adaptation enabling the oscillators not to be conditioned by the natural and technical external milieu; this milieu would become a truly associated milieu only if a random drift in frequency in one of the oscillators were, as a consequence, to entail variation in the supply voltage opposing this frequency drift; there would be an exchange through reciprocal causality between regulated supply and the oscillators; it is the ensemble of technical structures that would thereby be self-stabilized; here, on the contrary, only the supply is self-stabilized and it does not react upon random variations in the frequency of one of the oscillators.

There is a big theoretical and practical difference between these two cases; if the supply is indeed simply stabilized without a recurrent causal link with the oscillators, then simultaneous utilizations of this supply can be limited or extended without inconvenience; it is then possible to plug a third oscillator into the same supply without disturbing its functioning, provided the normal limits of output are not exceeded; however, in order to obtain an efficient feedback regulation the exact opposite is required: no more than a single structure can be attached to a
77 single associated milieu; otherwise opposed random variations in two structures that are linked non-synergistically with the same milieu might compensate for one another rather than resulting in a regulatory reaction; the structures attached to the same associated milieu have to function synergistically. For this very reason the audiometer comprises at least two distinct parts that cannot be stabilized by the same associated milieu: the frequency generator on the one hand and the amplifier-fader on the other. An action by one of these ensembles on the other must be avoided, which notably leads to the careful separation of both their power supplies and to electrically and magnetically shielding the partition that separates them, in order to avoid any interaction. The material limit of the audiometer, however, is not a functional limit; the amplifier-fader is normally extended by way of the acoustic transducer and by the room or external ear of the subject, depending on whether or not one employs speakers or headphones for coupling with the subject. Henceforth, one can posit the existence of relative levels of individualization of technical objects. This criterion has an *axiological value*: the coherence of a technical ensemble is at its maximum when this ensemble is constituted by sub-ensembles with the same level of relative individualization. In a laboratory of physiology of sensations there is thus no advantage in grouping the audiometer's two oscillators together with the amplifier-fader; however, it is worth grouping the two oscillators together so that both are affected simultaneously and in equal proportion by any variation in voltage or temperature, so that the variation of the lower frequency of the beat, which will result from the two correlated variations of the frequency of each of the oscillators, should be as low as possible, given that the two basic frequencies will rise or fall at the same time. It would be perfectly contrary to the functional unity of the beat-frequency generator, however, if two separate power
78 supplies were used and if one oscillator were plugged into one phase of the mains and the other into another phase. One would thereby cancel the self-stabilizing effect of compensation between two variations, which gives the *ensemble* of the two oscillators its great stability in low beat frequencies. On the other hand, it becomes useful to plug the oscillators into a mains phase different from the one

the amplifier-fader is plugged into, so as to avoid any reaction of variations in the amplifier's anodic consumption of the oscillators' power supply.

The principle of individualization of technical objects in an ensemble is thus one of the sub-ensembles with recurrent causality in an associated milieu; all technical objects having recurrent causality within their associated milieu must be separated from one another and connected in such a way as to maintain the independence of these associated milieus from one another. The sub-ensemble of oscillators and that of the amplifier-fader-transducer must therefore be more than simply independent in terms of power supply, they must also be independent in terms of coupling to each other: amplifier input should be of very high impedance in relation to the oscillators' output, so as to ensure that any reaction of the amplifier on the oscillators is very weak. If one were, for instance, to plug the fader directly into the outlet of the oscillators, then the setting of this fader might react on the frequency of the oscillators. An ensemble of a higher degree comprising all these sub-ensembles is defined by the capacity to freely realize any form of relation, without thereby destroying the autonomy of individualized sub-ensembles. This for instance is the role of a general power switchboard and wiring-board in a laboratory; electrostatic and electromagnetic shields, the use of non-reactive coupling such as what we call the *cathode-follower*, aim at maintaining the independence of these sub-ensembles, while also allowing for the diverse combinations among the functioning of sub-ensembles that are necessary; such is the second degree of the functional role of the 79
ensemble that one can call a laboratory, namely the utilization of the results of functioning without any interaction with the conditions of functioning.

We might ask then, on what level is the individuality found: at the level of the sub-ensemble or at that of the ensemble? The answer lies, as always, in the criterion of recurrent causality. At the level of the higher ensemble (such as that of the laboratory) there is indeed no truly associated milieu; if it exists, then it does so only in certain respects, and it is not a general milieu; the presence of oscillators in the room where the experiment in audiometry takes place is often problematic; if the oscillators use transformers with an iron magnetic circuit, then the magnetostriction* of the iron plates creates a vibration, which in turn emits an undesirable sound; an oscillator with resistances and capacities also emits a slight sound due to alternative electrical attractions. For fine-tuned experiments it is necessary to place the devices in another room and to operate them by remote control, or to isolate the subject in an anechoic chamber. The same applies to the magnetic radiation of power transformers, which can be very problematic in electro-encephalographic and electrocardiographic experiments. A superior ensemble such as a laboratory is thus above all constituted by un-coupling devices, in order to avoid creating associated milieus by accident. The ensemble distinguishes itself from technical individuals in the sense that the creation of a unique associated milieu is undesirable; the ensemble is comprised of a certain number of devices in order to counteract this possible creation of a unique associated milieu. It avoids internal concretization of the technical objects it contains, and uses only the results of their functioning, without allowing any interaction with their conditioning.

80 Are there other groupings with a certain individuality below the level of technical individuals? — Yes, but this individuality does not have the same structure as that of technical objects with an associated milieu; it is that of a plurifunctional composition without a positive associated milieu, which is to say without self-regulation. Let us take the case of a hot-cathode lamp. When this lamp is inserted into an assembly, with an automatically polarized cathode resistance, then it is indeed the site of phenomena of self-regulation; for instance, if the heating voltage increases, cathodic emission increases, as a result of which negative polarization increases; the lamp's amplification hardly increases nor does its output or its anodic dissipation augment much; a similar phenomenon enables class A amplifiers* to automatically equalize output levels despite variations in the input level of the amplifier. Such regulatory counter-reactions, however, do not uniquely reside within the lamp alone; they depend on the whole of the assembly, and, in some cases, within particular assemblies, they do not exist at all. A diode whose anode heats up thus becomes a conductor in both directions, and this also increases the intensity of the current going through it; the cathode receiving the electrons from the anode heats up even more and emits more electrons: this destructive process thus manifests a positive circular causality partaking in the whole assembly and not only in the diode.

Infra-individual technical objects can be called technical elements; they distinguish themselves from true individuals in the sense that they do not have an associated milieu; they can integrate into an individual; a hot-cathode lamp is a technical element rather than a complete technical individual; it is comparable to an organ in a living body. It would in this sense be possible to define a general
81 organology, studying technical objects at the level of the element, and which would belong to technology, together with mechanology, which would study complete technical individuals.

IV. – Evolutionary succession and preservation of technicity. Law of relaxation

The evolution of technical elements can have repercussions for the evolution of technical individuals; composed of elements and an associated milieu, technical individuals depend to a certain extent on the characteristics of the elements they implement. Electric magnetic motors can thus be much smaller today than in Gramme's days, because magnets have been greatly reduced in size. In certain cases, elements are like the crystallization of a preceding technical operation that produced them. In this sense, magnets with oriented grains, which we refer to as magnetically tempered, are obtained through a procedure that consists in maintaining a vigorous magnetic field around the molten mass that, once cooled, will become the magnet; starting with the magnetization of the molten mass at a temperature above the Curie point, its intense polarization is then maintained while the mass cools; when the mass is cold, it constitutes a far more powerful magnet than if it had been magnetized after cooling. Everything happens as if the vigorous magnetic field produced an orientation of the molecules in the molten mass, an orientation that maintains itself after cooling, if the magnetic field is sustained during its cooling and transition into the solid state. Now, the furnace, the melting pot, and the coils creating the magnetic field all together constitute a system that is a technical ensemble; the heat of the furnace shouldn't have an impact on the coils, the induction field creating the heat in the molten mass shouldn't neutralize the continuous field aimed at bringing about the magnetization. This technical ensemble is itself constituted of a certain number of technical individuals that are 82
organized in relation to each other, both in view of the result of their functioning and so as to prevent the conditioning of each particular functioning from being disturbed. In the evolution of technical objects we thus witness a passage of causality proceeding from prior ensembles to subsequent elements; such elements, once introduced into an individual whose characteristics they modify, in turn enable technical causality to rise from the level of the element to that of the individual, then from the level of the individual to the level of the ensemble; here, in a new cycle, technical causality once more descends to the level of the element via the process of fabrication, where it reincarnates itself in new individuals and then in new ensembles. There is thus a lineage of causality that is not rectilinear but serrated, where one and the same reality exists first in the form of an element, then as the characteristic of an individual and finally as the characteristic of an ensemble.

The historical solidarity that exists among technical realities is mediated by the fabrication of elements. For a technical reality to have posterity, it is not enough for it simply to improve in itself: it must also reincarnate itself and participate in this cyclical coming-into-being via a process of relaxation within the different levels of reality. The solidarity that exists among technical beings masks this other much more essential solidarity that requires the temporal dimension of evolution, not identical with biological evolution, however, which in turn is not characterized by these successive changes of levels and which occurs along more continuous lines. If transposed into biological terms, technical evolution would consist in the fact that a species could produce an organ that would be given to an individual, which would thereby become the first term of a specific lineage, which, in turn, would produce a new organ. In the domain of life, an organ is not detachable from the
83 species; in the technical domain, an element is detachable from the whole that produced it, precisely because it is fabricated; and here, we see the difference between the *engendered* and the *produced*. In addition to its spatial dimension, the technical world has a historical dimension. Its current solidarity mustn't mask the solidarity of succession; this latter solidarity is in fact what determines the great epochs of technical life through a law of serrated evolution.

Nowhere else does such a rhythm of relaxation find its equivalent; neither the human nor the geographical world can produce such oscillations of relaxation, with successive fits and spurts of new structures. This relaxation time is the technical time properly speaking; it can become dominant with respect to all other aspects of historical time, to the extent that it can even synchronize other rhythms of development and appear to determine the entire historical evolution, when in fact it only synchronizes and brings about its phases. An example of this evolution following a rhythm of relaxation can be found in energy sources since the eighteenth century. A large part of energy employed during the eighteenth century came from waterfalls, displacements of atmospheric air and from animals. These types of prime movers corresponded to artisanal exploitation or rather limited factories distributed along waterways. From these artisanal factories emerged the high efficiency thermodynamic machines at the beginning of the nineteenth century, and the modern locomotive, which is the result of the adaptation of Stephenson's valve gear to the multi-tubular boiler designed by Marc Seguin, lighter and smaller than a French boiler. This valve gear allows for the variation of the relation between admission time and expansion time, as well as for the ability to reverse gears (the reversal of steam), through the intermediary of a neutral position. This artisanal type of mechanical invention, which grants to the traction engine the capacity to

apply itself with ample variations of the engine torque to highly varied profiles, 84
at the cost of a loss of efficiency only in high power regimes (where the time of admission is almost equal to the totality of the expansion stroke), makes thermal energy easily adaptable to traction on rails. Stephenson's valve gear and tubular boiler, which are elements that emerge from the artisanal ensemble of the eighteenth century, enter into the new individuals of the nineteenth century, especially through the form of the locomotive. High tonnage transportation, which had now become possible throughout all regions, and which was no longer constrained to the contour lines and meandering of navigable tracks, led to the industrial concentration of the nineteenth century, which not only incorporates individuals whose functioning principle is based on thermodynamics, but is essentially thermodynamic in its structures; it is therefore around coal sources of thermal energy and close to the sites of the greatest deployment of thermal energy (coal mines and iron works) that the great nineteenth-century industrial ensembles, at the peak of their reign, are concentrated. We have gone from the thermodynamic element to the thermodynamic individual and from the thermodynamic individual to the thermodynamic ensemble.

The principal aspects of electrotechnics will in turn emerge as elements produced by these thermodynamic ensembles. Before acquiring their autonomy, the applications of electrical energy emerge as highly flexible means for the transmission of energy from one place to another by way of energy transport cables. Metals with high magnetic permeability are elements that are produced by way of the application of thermodynamics to metallurgy. Copper cables and high resistance porcelains for insulators emerge from steam-powered wire mills and coal furnaces. The metallic frameworks of pylons as well as the cement for dams are both born out of great thermodynamic concentrations and enter as elements into the new
technical individuals that the turbines and alternators are. A new wave and a new 85
constitution of beings become emphasized and concretized. In the production of electrical energy Gramme's machine gives way to the polyphase alternator; the direct current of early energy transport gives way to alternative currents with constant frequency, adapted to being produced by thermal turbine and consequently also being produced by hydraulic turbine. These electrotechnic individuals have integrated themselves into the ensembles of the production, distribution and utilization of electric energy, whose structure differs vastly from that of thermodynamic concentrations. The role played by the railway in this thermodynamic concentration is now replaced by the role played by high voltage transmission lines in the ensemble of industrial electricity.

At the moment in which electrical technics reaches its full development, it produces new schemes in the form of elements that initiate a new phase: first, there is particle acceleration, initially realized through electric fields and then through continuous electric fields and alternative magnetic fields, which leads to the construction of technical individuals, having enabled the discovery of the possibility of exploiting nuclear energy; subsequently, and quite remarkably, there is the possibility, afforded by electrical metallurgy, of extracting metals like silicon, which allows the transformation of the radiant energy of light into electrical current, with an efficiency that already reaches a level relevant for limited applications (6%), and which is not much lower than that of the first steam engines. A pure silicon photo-cell, produced by large industrial electrotechnical ensembles, is the element that hasn't yet been incorporated into a technical individual; it is still only an object of curiosity situated at the extreme end of the technical possibilities of the
86 electro-metallurgic industry, but it is possible that it may become the point of departure for a new phase of development, analogous to the one we have experienced with the development of the production and utilization of industrial energy, which itself is not yet complete.

Every phase of relaxation is capable of synchronizing minor aspects or those of almost equal importance; the development of thermodynamics thus went hand in hand with railway transportation, not simply with the transportation of coal but of passengers; on the contrary, the development of electrotechnics went hand in hand with the development of automotive transport; the automobile, albeit thermodynamic in principle, uses electric energy as an essential auxiliary, in particular for ignition. Industrial decentralization, facilitated by long distance electrical energy transfer, needs the automobile as a corresponding means for the transportation of people to locations that are distant from each other and at different altitudes; corresponding to the road rather than railway. The automobile and the high voltage line are parallel technical structures that are synchronized, but not identical: electrical energy cannot currently be applied to automobile traction.

Furthermore, there is no intrinsic relation between nuclear energy and energy derived from the photoelectric effect; these two forms are nevertheless parallel, and their developments are susceptible to mutual synchronization[8]; nuclear energy will thus probably remain, for a long time to come, inapplicable to direct forms of restricted utilization, such as those consuming a few dozen watts; photoelectric energy, on the contrary, is a highly decentralizable energy; it is essentially decen-
87 tralized in its production, whereas nuclear energy is essentially centralized. The

8. And to conjugate each other: a solar cell can be irradiated by a radioactive source.

relation that existed between electrical energy and energy derived from the combustion of gasoline exists once more between nuclear energy and photoelectric energy, perhaps with a more accentuated difference.

V. – Technicity and evolution of technics: technicity as instrument of technical evolution

The different aspects of the technical being's individualization constitute the center of an evolution, which proceeds via successive stages, but which is not dialectical in the proper sense of the term, because, in regard to it, negativity does not play the role of an engine of progress. In the technical world negativity is a lack of individuation, an incomplete junction of the natural world and the technical world; this negativity is not the engine of progress; it is rather the engine of transformation, it incites man to seek new, more satisfactory solutions than those he possesses. This desire for change, however, does not happen directly within the technical being; it happens within man as inventor and user; this change moreover must not be confused with progress; a change that is too abrupt is contrary to technical progress, because it prevents the transmission, in the form of technical elements, of what an age has acquired to the one that follows.

For progress to exist, each age must be able to pass on to the next age the fruit borne of its technical effort; what is capable of being passed on from one age to another are neither technical ensembles, nor even individuals, but the elements that these individuals, grouped as ensembles, were able to produce; thanks to their capacity of internal inter-commutation, technical ensembles in fact have the possibility of going beyond themselves by producing elements that differ from their own. Technical beings are different from living beings in many respects, but they differ essentially in the following respects: a living being engenders beings that are similar to itself, or that can become so after a certain number of successive reorganizations occurring spontaneously if the required conditions obtain; a technical being, on the contrary, does not have this capacity; it cannot spontaneously produce other technical beings similar to itself, despite the efforts of cyberneticists who have tended to force technical beings to copy the living by constructing beings that are similar to them: this possibility is currently a mere supposition and is without foundation; but the technical being has greater freedom than the living, afforded to it by its infinitely lesser degree of perfection; in these conditions the technical being can produce elements that harbor the degree of perfection at which the technical ensemble had arrived at, and which, in turn, can be reunited to enable the construction of new technical beings in the form of individuals; there is thus no engendering here, no procession or direct production, but only indirect production through the constitution of elements that contain a certain degree of technical perfection.

This affirmation requires that we specify what the process of technical perfection is. Empirically and externally one can say that technical perfection is a practical quality, or at the very least the material and structural basis of certain practical qualities; in this way a good tool is not simply one that is well put together and well crafted. In practical terms an adze can be in poor condition, blunt, and yet not be a bad tool; an adze is a good tool if, on the one hand, it has a curve suited for a straight, well aimed strike at the wood, and, on the other hand, if it can be sharpened and keep its sharpness even when employed to work on hard wood. This latter quality in turn results from the technical ensemble employed to produce the tool.
89 It is because it is a fabricated element that the adze can be made of a metal whose composition varies at different points; this tool is not only a hunk of metal shaped into a certain form; it has been forged, which is to say that the molecular chains of the metal have a certain orientation that varies in certain places, like a piece of wood whose fibers are oriented in the direction that offers the greatest solidity and elasticity, especially in the intermediary parts between the cutting edge and the flat thick part which goes from the socket to the cutting edge; this region close to the cutting edge deforms itself elastically during work, because it acts as both wedge and lever on the piece of wood being chipped off. And finally, the cutting edge has a higher steel content than the other parts; its steel needs to be hard, but in a proper delimited way, for too much of hard steel in the cutting edge would make the tool brittle and the edge would shatter into splinters. It is as if, in its totality, the tool was made of a plurality of functionally different zones, welded together. The tool is made not only of form and matter; it is made of elaborate technical elements according to a certain schema of functioning and assembled into a stable structure through the operation of fabrication. The tool unites within itself the results of the functioning of a technical ensemble. In order to make a good adze a technical ensemble of a foundry, forge, and quench hardening is required.

The technicity of the object is thus more than a quality of its use; it is that which, within it, adds itself to a first determination given by the relation between form and matter; it acts as an intermediary between form and matter, here for instance as the progressive heterogeneity of the quench hardening in different points. Technicity is the degree of the object's concretization. During the period of wood foundries, it

was this concretization that gave Toledo's blades their value and prestige, and more recently, led to the quality of Saint-Étienne's steel. These types of steel express the 90
result of the functioning of a technical ensemble comprising in equal measure the qualities of coal used, as well as the temperature and chemical composition of the soft water of the Furan river, or the species of green wood used to stir and refine the molten metal prior to casting. In certain cases, technicity becomes predominant with respect to the abstract aspects of the relation between matter and form. A coil spring is thus a very simple thing in form and matter, yet the fabrication of springs requires a high degree of perfection in the technical ensemble that produces them. The quality of individuals, such as an engine or an amplifier, often depends much more on the technicity of simple elements (valve springs, for instance, or a modulation transformer) than on the ingenuity of their assembly. Technical assemblies, however, that are capable of producing certain simple elements, such as a spring or a transformer, are sometimes extremely vast and complex, and almost coextensive with all the ramifications of several global industries. It would not be an exaggeration to say that the quality of a simple needle expresses the degree of perfection of a nation's industry. This explains why there are judgments that are legitimate enough in both practical and technical terms, such as when a needle is specifically called an "English needle." Such judgments have a practical sense, because technical ensembles express themselves in the simplest elements they produce. This mode of thought of course exists for other reasons besides those that legitimate it, and particularly because it is easier to qualify a technical object by its origin than to judge its intrinsic value; what we have here is a phenomenon of opinion; but even if this phenomenon gives rise to numerous exaggerations or intentional exploitation, it is not without foundation.

Technicity can be considered a positive aspect of the element, analogous to the self-regulation exerted by the associated milieu in the technical individual. Concretization is technicity at the level of the element; it is the reason why the ele- 91
ment is really an element produced by an ensemble, rather than being an ensemble itself or an individual; this characteristic makes it detachable from the ensemble and frees it so that new individuals may be constituted. There is of course no peremptory reason why one would attribute technicity only to the element; the associated milieu is the depositary of technicity at the level of the individual, just as extension is the depositary of inter-commutativity at the level of the ensemble; it is nevertheless good to reserve the term technicity for this quality of the element, which expresses and preserves what has been acquired via a technical ensemble so as to be transported into a new period. What the element transports is a concretized

technical reality, whereas the individual and the ensemble contain this technical reality without being able to transport and transmit it; elements have a transductive property that makes them the true bearers of technicity, just as seeds transport the properties of a species and go on to make new individuals. It is thus within elements that technicity exists in the purest way, in a free state as it were, whereas in the individual or the ensemble, technicity only exists in a state of combination.

However, this technicity, borne by the elements, contains no negativity, and no negative conditioning intervenes in the moment of production of elements by the ensembles or of individuals by invention, which reunites the elements in order to form individuals. Invention, which is a creation of the individual, presupposes in the inventor the intuitive knowledge of the element's technicity; invention occurs at this intermediate level between the concrete and the abstract, which is the level of schemas, and presupposes the pre-existence and coherence of representations that cover the object's technicity with symbols belonging to an imaginative sys-
92 tematic and an imaginative dynamic. The imagination is not simply the faculty of inventing or eliciting representations outside sensation; it is also the capacity of the prediction of qualities that are not practical in certain objects, that are neither directly sensorial nor entirely geometric, that relate neither to pure matter nor to pure form, but are at this intermediate level of schemas.

We can consider the technical imagination as being defined by a particular sensitivity to the technicity of elements; it is this sensitivity to technicity, that enables the discovery of possible assemblages; the inventor does not proceed *ex nihilo*, starting from matter that he gives form to, but from elements that are already technical, with respect to which an individual being is discovered as that which is susceptible to incorporating them. The compatibility of elements in a technical individual presupposes the associated milieu: the technical individual must therefore be imagined, which is to say presupposed as already being constructed in the form of an ensemble of ordered technical schemas; the individual is a stable system of the technicities of elements organized as an ensemble. What is organized are these technicities, as well as the elements as basis of these technicities, not the elements themselves taken in their materiality. An engine is an assemblage of springs, axes, and volumetric systems, each defined by their characteristics and their technicity, not by their materiality; thus, a relative indeterminacy can subsist in the localization of this or that element in relation to all the others. The location of certain elements is chosen more by virtue of extrinsic considerations than by intrinsic considerations of the technical object in relation to the diverse processes of its functioning. The intrinsic determinations, based on the technicity of each

element, are those which constitute the associated milieu. This associated milieu, in turn, is the concretization of the technicities contributed by all the elements, in their mutual reactions. Technicities can be thought of as stable behaviors, express- 93
ing the characteristics of elements, rather than as simple qualities: they are powers, in the fullest sense of the term, which is to say capacities for producing or undergoing an effect in a determinate manner.

The higher the technicity of an element, the more the margin of indeterminacy of this power diminishes. This is what we want to express when we say that the elementary technical object concretizes itself as its technicity increases. One could thus name this power *a capacity*, if one intends to characterize it in relation to a determinate deployment. Generally, the higher the technicity of an element, the wider the conditions of deployment of this element are, as a result of the high level of stability of this element. The technicity of a spring increases when it is capable of bearing higher temperatures without losing its elasticity, when it preserves its coefficient of elasticity without significant modification within larger thermal and mechanical limits: it technically remains a spring but within a much larger framework, and is suited to a less restricted incorporation into this or that technical individual. An electrolytic condenser* has a lower degree of technicity than a dry dielectric condenser, such as paper or mica. An electrolytic condenser in fact has a capacitance that varies as a function of the voltage to which it is submitted; the thermal limits of its utilization are more restricted. At the same time it varies when submitted to constant voltage, because the electrolytes as well as the electrodes become chemically altered during the course of their functioning. Dry dielectric condensers, on the contrary, are more stable. Nevertheless, the technical quality once again increases with the independence of its characteristics from the conditions of utilization; a mica condenser is better than a paper condenser, and the vacuum condenser is the best of all, since it is not even subject to the condition that the voltage be limited lest the insulation risk perforation; an intermediary 94
degree, the ceramic silver-plated condenser for instance, which hardly varies with temperature, and the air condenser, both provide a high degree of technicity. It must be noted that in this sense there is not necessarily a correlation between the commercial price of a technical object and its elementary technical quality. Very often, considerations of price do not intervene in absolute terms, but via another requirement, like that of space; an electrolytic condenser is thus preferred to a dry dielectric condenser where its high capacity would require too much space to house the condenser; similarly, an air condenser is often cumbersome with respect to a vacuum condenser of the same capacitance; although it is much cheaper, and

is equally safe to deploy in a dry atmosphere. Therefore, in many cases, economic considerations do not intervene directly, but through the repercussions that the degree of concretization of the technical object has on its deployment in an individual ensemble. It is the general formula of the individual that is subjected to economic repercussions, not that of the element as element. The liaison between the technical and the economic domains occurs at the level of the individual or the ensemble, but very rarely at the level of the element; in this sense, one could say that technical value is largely independent of economic value and that it can be appreciated according to independent criteria.

This transmission of technicity by its elements is what grounds the possibility of technical progress, above and beyond the apparent discontinuity of forms, domains, the types of deployed energy, and sometimes even beyond the schemas of functioning. Each stage of development is the inheritor of previous ages, and its progress is all the more certain as each stage tends increasingly and more perfectly
95 toward a state of sole beneficiary.

The technical object is not directly a historical object: it is subject to the course of time only as a vehicle of technicity, according to a transductive role that it plays with respect to a prior age. Neither the technical ensembles nor technical individuals remain; only elements have the power to transmit technicity from one age to another, in the form of an effectuated, accomplished, materialized result. For this reason it is legitimate to analyze the technical object as consisting of technical individuals; but it is necessary to stress that at certain moments in its evolution the technical element makes sense in itself, and is thus a depositary of technicity. In light of this, one can establish the foundation of the analysis of the technics of a human group through the analysis of elements produced by its individuals and its ensembles: often these elements alone have the power to survive the downfall of a civilization, and remain valid witnesses of a state of technical development. In this sense, the method of ethnologists is perfectly valid; but one could prolong its application by equally analyzing the elements produced by industrial techniques.

Indeed, there is no fundamental difference between a people who have no industry and those who have a well-developed industry. Even in a people without any industrial development, technical individuals and technical ensembles exist; nevertheless, rather than being stabilized by institutions that fix and perpetuate them by installing them, these individuals and ensembles are temporary or even occasional; what is preserved from one technical operation to another are merely the elements, which is to say tools or certain fabricated objects. To build a boat is an operation that requires a truly technical ensemble: a fairly flat ground, yet close to the water,

sheltered yet luminous, with supports and wedges to keep the ship standing while it is being built. The shipyard, like the technical ensemble, can be temporary: it is 96
no less a shipyard constituting an ensemble. Even today similar temporary technical ensembles still exist, sometimes even highly developed and complex ones, such as the construction sites of buildings; others are provisional while being durable, like mining facilities or the drilling rigs for oil exploration.

Not all technical ensembles necessarily take on the stable form of the factory or the workshop. On the other hand it seems that non-industrial civilizations differentiate themselves from ours mostly by the absence of technical individuals. This is true only if what is meant is that technical individuals do not exist materially in a stable and permanent way; the function of technical individualization, however, is assumed by human individuals; the process of learning, through which man forms habits, gestures, and schemas of action that enable him to use the highly varied tools that the totality of an operation requires, pushes this man to individualize himself technically; it is he who becomes the associated milieu of these diverse tools; when he masters all of his tools, when he recognizes the moment he must change tools in order to continue working or to use two or three tools at a time, he ensures an internal distribution and self-regulation of the task[9] through his body. In some cases, the integration in the ensemble of technical individuals happens via the intermediary of an association of human individuals working in twos, in threes, 97
or in larger groups; when these groupings do not introduce functional differentiation, then their only direct purpose is to increase the available energy or speed of the work, but when differentiation is called for, they clearly demonstrate the genesis of an ensemble on the basis of men employed as technical individuals rather than as human individuals: this was the case with bow drilling, as described by the authors of classical antiquity; it is still the case with the felling of certain trees; it was also commonly the case, not so long ago, with the use of a two-man cross-cut saw to make planks or rafters; two men working together in an alternating rhythm. This explains why, in some cases, human individuality can be used functionally as the basis of technical individuality; the existence of separate technical individualities is a rather recent development and even appears, in some respects, like an imitation of man by the machine, where the machine remains the more general form of a technical individual. Yet, in reality machines are very dissimilar to man,

9. This is where a certain nobility of artisanal work comes from: man is the bearer of technicity, and work is the only mode of expression of this technicity. The imperative to work translates this requirement of expression; to refuse to work when one possesses a technical knowledge that can only be expressed through work, because it cannot be formulated in intellectual terms, would be to hide one's light under a bushel. The requirement of expression, on the contrary, is no longer linked to work when technicity has become immanent to a knowledge that can be formulated abstractly and outside of all concrete actualization.

and even when they function in a way that produces comparable results, it is very rare that they use procedures identical to the work of an individual man. The analogy is in fact most often very external. Yet if man often feels frustration before the machine, it is because the machine functionally replaces him as an individual: the machine replaces man as tool bearer. In the technical ensembles of industrial civilizations, jobs where several men must work in narrow synchronization are becoming rarer than in a past characterized by the artisanal level. Conversely, at the artisanal level, it is very frequent that certain works require the grouping of human individuals with complementary functions: to shoe a horse, one man is
98 needed to hold the hoof and another to hold the shoe up and nail it on. In order to build, the mason has his assistant, the hod-carrier. In order to thresh with the flail, one needs a proper perception of the rhythmical structures that synchronize the alternate movements of the team's members. Yet one cannot affirm that what has been replaced by machines are only the helpers; it is the very basis of technical individualization that has changed: this basis was a human individual; it is now the machine; tools are borne by the machine, and one could even define the machine as that which bears and directs tools. Man directs and adjusts or regulates the machine, the tool bearer; he realizes groupings of machines, but does not himself bear tools; indeed, the machine accomplishes the core work, the work of the blacksmith and not that of the helper; man, disengaged from this function of the technical individual, which is the very essence of the artisanal function, can now become either organizer of the ensemble of technical individuals, or helper of technical individuals: he greases, cleans, removes detritus and burrs, in other words, in some respects he plays an auxiliary role; he provides the machine with elements, changing the belt, sharpening the drill or the lathe cutting tool. There is thus, in this sense, a role above that of the technical individuality, and one below it: servant and regulator, he supervises the machine, the technical individual, by looking after the relation of the machine with the elements and the ensemble; he is the organizer of relations between technical levels, rather than being himself, like the craftsman, one of the technical levels. A technician therefore adheres less to his professional specialization than does a craftsman.

This nevertheless does not mean that man cannot be a technical individual in any shape or form and work in conjunction with the machine; this machine-man relation is realized when man applies his action to the natural world through the machine; the machine is then a vehicle for action and information, in a relation with three terms: man, machine, and world, the machine being that which is between
99 man and world. In this case, man preserves some traits of technicity defined in

particular by the necessity of apprenticeship. The machine thus essentially serves the purpose of a relay, an amplifier of movements, but it is still man who preserves within himself the center of this complex technical individual that is the reality constituted by man and machine. One could say, in this case, that man is the bearer of the machine, while the machine remains the tool bearer; this relation is thus partially comparable to that of the machine-tool, if what is understood as machine-tool is that which has no self-regulation. It is man who is at the center of the associated milieu in this relation; the machine-tool is that which has no internal autonomous regulation, and which requires man in order to make it work. Man intervenes here as a living being; he uses his own sense of self-regulation in order to operate that of the machine, even without the need for it to be consciously formulated: in order to restart an overheating car engine a man will allow it to "rest," and in order to start it back up, instead of beginning by revving it up too much, he will progressively get it started from a cooler state. Such behaviors, which are technically justified, have their correlation in vital regulations, and are lived by the driver more than simply being thought by him. They apply all the better to the technical object as the latter approaches the status of a concrete being, encompassing homeostatic regulations within its functioning. For the technical object that has become concrete, there is indeed a regime in which the processes of self-destruction are reduced to a minimum, because of the greatest possible degree of perfection in homeostatic regulation. This is the case for the diesel engine, which requires a definite operating temperature and a regime of rotation confined within a narrow margin between minimum and maximum, while the gasoline engine is more flexible, because it is less concrete. Similarly, an electronic tube cannot function with a cathode at any temperature whatsoever or with an indeterminate anodic voltage; for power 100
tubes in particular, too low a cathode temperature causes the electric field to snatch electron emitting oxide particles; hence the need for a gradual start up, beginning with a warm up of the cathodes without anodic voltage, followed by the powering of the anodes. If the circuits of polarization are automatic (fed by the cathodic current), then they must be progressively powered through the gradual feeding of the anodes; omitting this precaution leads to a short instant in which cathodic current already occurs before polarization reaches its normal level (polarization produced by this current and proportional to it tends to limit it): the cathodic output, which is not yet limited by this negative reaction, would exceed the admissible maximum.

Speaking in very general terms, the precautions man takes for the preservation of the technical object have as their goal the maintenance of its functioning or its adjustment to conditions that prevent it from being self-destructive, which is to say to conditions where it exercises a negative stabilizing reaction upon itself; beyond certain limits, reactions become positive, and consequently destructive; this is the case with an engine which, when over-heated, initiates galling and which, in heating up even more because of the heat from the galling, subsequently deteriorates irreversibly; an electronic tube whose anode becomes red hot, similarly loses its asymmetrical conductivity, in particular within its rectifier function: it then enters a phase of positive reaction. Allowing it the proper time to cool enables it to return to its normal functioning.

Thus, man can intervene as a substitute for the technical individual, and connect elements with ensembles, in an age when the construction of technical individuals is not possible.

101 What one must take into account when thinking about the consequences of technical development in relation to the evolution of human societies, is first and foremost the process of the individualization of technical objects; human individuality is increasingly disengaged from the technical function through the construction of technical individuals; for man, the functions that remain are both below and above the role of tool bearer, oriented both toward the relation with elements and toward the relation with ensembles. However, as it was precisely the individuality of man that was once employed in technical work, and which had to technicize itself because the machine couldn't, it became customary to give each human individual just one function in regard to work; this functional monism was perfectly useful and necessary when man became a technical individual. But it now creates unease, because man, who still seeks to be a technical individual, no longer has a stable place alongside the machine: he becomes the servant of the machine or the organizer of the technical ensemble; yet, in order for the human function to make sense, it is necessary for every man employed with a technical task to surround the machine both from above and from below, to have an understanding of it in some way, and to look after its elements as well as its integration into the functional ensemble. For it is a mistake to establish a hierarchical distinction between the care given to elements and the care given to ensembles. Technicity is not a reality that can be hierarchized; it exists as a whole inside its elements and propagates transductively throughout the technical individual and ensembles: through the individuals, ensembles are made of elements, and from them elements issue forth. The apparent pre-eminence of ensembles comes from the fact that ensembles are currently given the same prerogatives as those of people playing the role of the boss. Yet ensembles are not in fact individuals; the devaluation of elements equally results from the fact that the use of elements has hitherto been

proper to helpers and that these elements were not very elaborate. The unease of 102
this situation relating to man and machine thus comes from the fact that one of the technical roles, that of the individual, has thus far and until this day been played by men; no longer a technical being, man is, henceforth obliged to learn a new function and to find a place within the technical ensemble that no longer corresponds to the technical individual; the first movement consists in occupying two functions that are not individual, that of elements and that of the direction of the ensemble; yet in these two functions man finds himself to be in conflict with the memory of himself: man has for so long played the role of the technical individual that the machine, once it has become a technical individual, still appears like a man occupying the place of another man, when it is, on the contrary, man who in fact provisionally replaced the machine before truly technical individuals could emerge. In all judgments made about the machine, there is an implicit humanization of the machine whose deepest source lies in this change of role; man had learned to be a technical being to the point of believing that the technical being, once it becomes a concrete being, begins illegitimately to usurp the role of man. Ideas of servitude and liberation are far too strongly related to the old status of man as a technical object for them to correspond to the true problem of the relation between man and machine. It is necessary, that the technical object be known in itself, in order for the relation between man and machine to become stable and valid: hence the necessity for a culture of technics.