THE INFLUENCE OF THE TECHNICAL SCIENCES UPON GENERAL CULTURE.

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No student of the world's present state of general culture can have failed to observe the potent influence which the technical sciences of our day are exerting, nor the extent to which they have fitted us for incomparably greater achievements than were possible a few centuries ago. Be it in the field of rapid transportation, at sea or on land; be it that we tunnel mountains, that we rise into the realms of air or delve into the bowels of earth; that quick as the lightning flash we speed our brain images to the antipodes, or carry the very sounds of our voices through the length and breadth of the land; or, viewed in another way, that on one hand we subject to mechanical service the mightiest forces, while on the other we let the innermost processes of nature, actions so subtile as to escape all ordinary observation, operate for and accomplish our own ends—everywhere in modern life, all around us, about us, with us, beside us, technical science is the busy handmaiden, the untiring companion, of whose presence we are only fully conscious when for a brief span her help is withdrawn.

But all this is well known, and even trite, and yet among the generality of educated people, and perhaps even within the narrower circle of professional men, it hardly seems to meet with the appreciation which it merits. The useful arts, scientifically developed, have not as yet been accorded a sufficiently extended and deserved recognition as a factor—aye, and more—as a powerful lever in elevating the standard of general culture. This lack of appreciation may be ascribed to the fusion of the technical sciences at certain levels with mere empirical knowledge of the arts, and conversely, to their frequently having sprung from such empiricism, and possibly also, to the fact that in their special sphere of activity these sciences abstain so largely from all ideality; that without the motive of gain, without the social ills which are still inseparable from industrial labor, they would not have found, would not attain to-day, their actual development. But interesting as this phase of the question is, it must not detain us now. Do not expect a panegyric on the technical sciences, nor a confutation of the argu-

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ments which would deny them their due acknowledgment. Both of these points are but of outward significance. Let us rather approach some of the weighty inner questions of the subject which appear to stand in need of special discussion.

In the first place: *What position do the technical sciences occupy in the active solution of the great problem of general culture?* This position has never been defined with half the precision that has marked our account of their social, political, and economic importance. A second question is: *What, in its leading features, is the general method pursued by the technical sciences in the accomplishment of their ends?* This method must underlie more or less distinctly all inventive effort, and the question is one which has excited, and will probably long continue to excite, lively interest among technists, jurists, and practical managers because of its connection with patent legislation. A third question that we may touch upon is: *What are the true ends and principles of technical education?* Investigation in this department has been very profitably forwarded by many professional bodies, but yet the subject has not ceased to furnish matter for controversy. If we consider the question here, it is because the answers to our foregoing queries may have an influential bearing upon its solution.

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To compare the civilizations of other races with our own, we must evidently disregard all those communities that stand upon the lowest steps of the social scale, those, for example, that have not yet aspired to a written language; for among such the cultivation of the sciences is not conceivable. But over and beyond these limits we soon come upon great nations that for centuries, and even millenaries, have been the possessors of an advanced degree of culture. Such are the races of Eastern and Southern Asia—the Chinese, the Japanese, the Indians, Persians, Arabians. If we regard their civilizations without prejudice, we must admit that they are in many respects of a high order, and were so, indeed, when Central Europe still lay mired in the slough of barbarism. Even then sciences and the arts blossomed among the nations of the East, nor have they ceased in their development to this day. In most exalted form did the Hindoo worship the Deity three thousand years ago; a full two thousand years ago, and Indian poets had produced their nation's Odyssey, the Mahabharata, and dramas too, in rich abundance, and among these one, the Sakuntala, whose delicate charm remains ever fresh as its sources which well from the depths of the soul. Philosophy flourished, and philology, too, even to such degree that the Indian grammarian of to-day looks on an unbroken line of antecessors reaching upward to the idolized Panini. Mathematics, too, was fostered—do we not even now write our figures with Indian characters? And the industrial arts; how they flourished then, and how, in part, they flourish still in India, in Eastern Asia! And Persia; how brilliantly her poetry shone through ages! Her illustrious Firdusi, followed by her "Horace" of Shiras, Hafis, with his never aging songs, have both become endeared to us in excellent translations.* And, then, the literature of Arabia; what wealth of investigation has it not handed down to us; how profitable the cultivation of its Grecian heritage, and how it advanced astronomy, so that to this day we name half the heavens by its designations! And with what care did Arabians in Charlemagne's time, under tolerant and enlightened rulers, foster numbers and many far profounder sciences; and did they not, indeed, anticipate our own chemists in divers essences and principles?

Where, then, is the difference in intellectual sphere which has allowed a separation between them and us? Are we not confessedly their inferiors in sundry arts? Valor is theirs, nobility and justice are priceless virtues with them, even as with us. Where do we mark the points of distinction in a purely human sense?

Or let us rather put the question otherwise, if comparison upon intellectual domain cannot solve the problem which is certainly presented. Let us ask, whence is the source of our material preponderance over them? How, for example, has it become possible that England, with a few thousands of her own troops, should rule supreme over a quarter of a milliard of the natives of India? How was it possible for her in 1857 to suppress their terrible, fanatical revolt? How has it come to pass that we Europeans, or, not to necessitate a special mention of America, settled as it has been by Europeans, that we Atlantic nations are the only ones who have girt the globe with lines of railroad and of telegraph, and furrowed the seas with powerful steamships, and that to these great achievements the other five-sixths of mankind have contributed not a jot—the same five-sixths that are for the most part socially organized and in some cases highly cultured.

In various ways an explanation, or rather a definition, of this stupendous fact has been sought.

* See "Characteristics of Persian Poetry," North American Review, April, 1885. —TRANSLATOR.

Klemm, the industrious Leipsic collector, an archæologist years before the discovery of the lake dwellings, proposed the distinction between *active* and *passive* races, and many at the present day still hold to his classification. In his conception we Atlanticists are the active races, and those others, downward to the entirely uncivilized, are the passive ones. We enact history, they endure it. This theoretic distinction, while seeming to have much in its favor, is none the less untenable. The chapters of history teach us that through long ages nations can be active, then passive, and then active again. Activity and passivity are not, therefore, inherent attributes of nations, but conditions into which and out of which they can come without essentially altering their intellectual status. But according to Klemm's view, with each of their transitions the nations altered their entire state as well. In fact, continual changes were going on, according as the adventitious fortunes of—let us say, secular—history superinduced them. This theory cannot stand the test of real experience. Europe might be subjugated, rendered passive, to-morrow by Asiatic hordes, without forfeiting those qualities which make the railroad, the steamship, and the electric telegraph her intellectual possession. The Arab might destroy the works of our technical science, as repute has it that Omar destroyed the books, without being able to reproduce, even in part, as he did, what his vandal hand had despoiled.* We must, therefore, discard Klemm's distinction, at least for all purposes of our research, as it fails to offer us any elucidation.

Some find in Christianity an efficient cause for the great difference that we have observed; but this, too, upon investigation, fails to meet the case. It is true that a considerable proportion of the discoveries and inventions which have shed their transmuting light upon our world of ideas was made in Christian countries, but by no means all. See in that brilliant galaxy the effulgence of the art of printing! Yet we know that the Chinese had invented it a thousand years before ourselves. The same is true of gunpowder, which was so potent an agent in the metamorphosis of our own civilization: Arabians used it long before the day of the Freiburg

* It is about time that we should cease from repeating the myth of Omar's destruction of the Alexandrian Library. In the first place, the capture of the city was not effected by Omar, but by his general, Amru. Further, the larger part of the library had long previously been destroyed—once, in the year 415, by a conflagration, which was fanned into flame by fanatical Cyrillians of the Academy at the time of unhappy Hypatia's murder; and earlier still, in the year 30 A.D., when the city fell into Roman hands, and when likewise a great number of the books were lost by fire.

monk. And in mechanics, the powerful waterwheel traces an Asiatic descent from far primeval times. These are merely illustrations. But turn to a true offspring of Europe's brain, the steam-engine, and note in its gradual development into practical shape the activity of the renaissance in Italy, Germany, France, and England, yet nowhere else in Christendom—not, therefore, Christianity identified with that progress, but on the contrary, her priests too frequently throwing the whole weight of their authority against its onward course. But let us look still further. Are there not Christians in the East to-day, in Armenia, for example, and throughout the broad extent of Abyssinia, who are living entirely without the pale of our victorious modern science? Naught have they contributed towards it, nor aught will. It is not the things, therefore, not the inventions in themselves, but the ideas, the thoughts which accompany them, that must have called into being the great cultural transformation.

We cannot, indeed, do otherwise than attribute the change to a remarkable progress in the intellectual process; a difficult, hazardous ascent to higher and freer interpretations of nature. The idea was conceived, soon to burst all fetters that would bind it, that nature's forces in each of their manifold effects obey not the mandates of an ever intervening—a divine—Will, but act by the governance of immutable laws, and never otherwise.

> " *Nach ewigen, ehernen,*
> *Grossen Gesetzen*
> *Müssen wir alle,*
> *Unseres Daseins,*
> *Kreise vollenden,*"*

so thrills the inspiring genius of Gœthe in presence of nature's inexorable powers. But also, *nach ewigen, ehernen, grossen Gesetzen* great worlds revolve, and stars in their distant orbits course—falls the roof-tile, too, from the weathered eave, and the rain-drop from the cloud.

> " *Sonnen wallen auf und nieder,*
> *Welten geh'n und kommen wieder,*
> *Und keim Wunsch kann's wenden!*" †

* " According to great
Adamantine laws,
Eternal, unchanging,
Must we all
Our earthly being's
Cycles complete."

† " Suns are fading, suns are glowing,
Worlds are coming, worlds are going,
And no will can stay the change!"

Thus in admirable poetic garb has the soul-fraught prelate, Hebel, informed the consciousness that not a material, but a spiritual, world compasses the apprehension of God, and that in the very immutability of its laws lies the grandeur of the material creation. To lay hold upon this idea thought broke down the old barriers, nor did it then tarry long before making its deductions for the practical exigencies of life. The conclusion that was reached, when stated in the abstract, and freed from all secondary matter, was this: *If inanimate bodies be brought into such situations or conditions that their action under natural laws will subserve our purposes, then we can let them perform work for, and in the place of, living beings.*

Conscious practice on this basis has created modern technics. Technical science I have called it, and must abide by the name. For those very laws of nature which intelligent endeavor was striving to apply were scarce known when the intellect of Europe entered upon its new path. They had, for the most part, still to be unfolded, and to obtain knowledge became the burden of an arduous strife. For the world of letters believed at the time that it possessed the hidden secret of these laws, and so it was that the innovators had not merely to make the discoveries, but to dethrone old, opposing convictions—verily a herculean task, but at once a militant movement toward the heights of intellectual freedom. This advance encountered vehement opposition in the prejudices of the Church. Many a milestone of its progress is marked by bloody sacrifice. Galileo's bent form here rises before us: what if he did not pronounce the memorable *e pur si muove*, as the micro-historic investigation of recent years pretends; the thinking mind of Europe spake it for him. The victory was gained and the domain for our modern technical science conquered. To-day the old-time reaction has spent its passion; small skirmishes may still occur in the rear guard, the results of obstinacy rather than conviction, but at all events the great onward movement is not retarded in the least.

What would have happened had reaction vanquished—for reaction indeed it was, since Germany had begun the advance over a hundred years before, and Copernicus had lain in his grave for more than ninety years when Galileo was forced to testify against him—what would have happened, it is hard to conceive, or rather no, we can see it, we can note the very thing in the fate of the great Arabian family of nations. There reaction had really carried the day. The Galileos of the East, the Averrhoës and unnumbered others, men of free conviction all, were completely overthrown, and with their fall Arabian culture, just stretching forth her hand to grasp the trophy of freedom, was stricken down by the victorious fanatic, and there she has lain, stunned, paralyzed in every limb, for half a thousand years. *Allah aalam!* "God only knows!" And hence—"nothing is that thou must want to know." Such has been the pure Mohammedan's creed ever since; all investigation is denied him, is declared a sin. A refined and noble moslem* expressed the hope not long since that even yet his people might be called to the front to take up the lost banner of leadership. But who can possibly believe him? † It seems but too certain that the defeat of intellectual enfranchisement in all lands of the Arabian tongue has sealed the doom of the other Asiatic civilizations. Like a broad dam the heavy mass of deadened mind lies between them and us, and so it has come to pass that we alone have trod that path of progress which was pioneered by the great intellectual evolution which I have described.

The forces of nature which that advance taught us to look to for service are mechanical, physical and chemical; but the prerequisite to their utilization was a full equipment of mathematic and natural sciences. This entire apparatus we now apply, so to say, as a privilege.

For the convenient designation of the two systems which we have recognized it will serve us to select a special name for each. A penetration into nature's secrets was revealed at quite an early day among the Medes and Persians, and especially among the tribe of the Magi, who earned thereby so great repute that their name devolved upon a priesthood caste. Even the Greeks were so much imbued with an appreciation of their knowledge, not to mention the fear it created among the ignorant, that they called any skilful device, or any arrangement by which extraordinary results were achieved, a magic work, or, accommodating the word to their tongue, a *manganon*. All kinds of contrivances cleverly

* The Afghan sheik, Dschemnal Edin, according to whose own testimony in the *Journal des Débats* of 1883, "the caliph, Al Hadi, put to death 5000 philosophers in Bagdad in order to exterminate science, root and branch, in all Mohammedan countries.

† One can hardly do otherwise than regard the case as utterly hopeless, for the Arabians have lost the national unity which alone could infuse them with a sufficiently strong initiative, and because their whole family of languages has become so dismembered that all thought of reunion is now indeed futile.

conceived and deftly wrought were so styled, and among others, a catapult, a powerful engine of war, with which the word travelled down into the Middle Ages.* Then, early in the seventeenth century, when large machines were invented for rolling and smoothing linen, and the apparatus happened to possess marked outward resemblance to the ancient catapult, that accidental circumstance gave it its name, and this soon passed into all the languages of Europe, as every housewife knows—or possibly does not know—when she sends the domestic linen to the "mangle." † Let us rehabilitate the old word for our purposes, and designate by the term *manganism* the utilization and control of the forces of nature through their own recognized laws, while the opposite aim, which remains set against the study of nature, or at most, in ways mysterious and beguilded, catches a few whispers of her secrets, we may call *naturism.*

Adopting these names, we see, then, that all nations, or in fact, all orders of civilization, can be classed either as manganistic or naturistic, and we have already remarked how the former, by developing their material resources upon a broad basis of knowledge have far outstripped the latter in the march of progress. Indeed, we need not hesitate in asserting that to the manganistic nations belongs the empire of the earth. Now, as in all times past, war is waged for this dominion, but every observer can predict with certainty that the manganist will issue victorious from the conflict, or that those nations which cannot resolve upon adopting manganistic tenets must face the alternative of subjection and decay.

That with set determination it is not impossible to pass from naturism to manganism, we can see to-day in the action of Japan. With keen insight the Japanese appreciated the truth of their position, and they are now attempting the feat, without parallel in history, of passing almost at a stride from naturism to manganism. The clearest-headed thinkers of the nation have understood the

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* The *mangano* of the Italians, and *mangan* of the French.

† Zonca, *Novo Teatro di Machine*, Padoua, 1621, p. 34: "Mangano in questo luogo si dimanda quelle Machine con laquale si lisciano et lustrano le tele, ciambolette, rasse et altre cose, che nell' arte militare, il Mangano s'intende uno stromento per lanciar armi, pietre et altre materie, come si puo vedere presso d'alcuni Auttori." It appears, then, that in 1621 the catapult was already antiquated, though still holding a place in the books. The illustration shows a mangling press more than thirty feet long, and driven by two men in a tread-wheel; another machine is described as being driven by horse power.

necessities of the case and have been able to win over the political powers for their cause, and so we behold a clever and sensible people altering their entire system of education, and summoning their full strength for an earnest engagement in the new undertaking. Difficult as the task may be, yet its beginnings presage success, for these have consisted in a constant learning, learning, learning!

Manganism cannot be bought; it must be a product of education, a growth. The demonstration of this is fulfilling itself in China, where all the purchases of most improved European munitions of war seem to avail nothing in face of the systematic attacks of the manganists. The naturists of the Celestial Empire probably overlook the fact that mere drilling in will not suffice; a single minute detail in a process, omitted or forgotten, may endanger the success of the whole. Many may perhaps remember the little mishap which befel the Japanese ten or twelve years ago when, jealous of their independence, they dismissed their English instructors from the first of their large men-of-war, and forthwith undertook great evolutions with her; how beautifully, too, they manœuvred, but how, finally, to the amazement of all spectators, they continued steaming for hours in wide circles around the bay. The engineer had forgotten his last potent "sesame;" he could not recall how to get rid of the superfluous steam in his boilers, and so the vessel was kept under way until the entire steam supply had been exhausted. To-day the Japanese know better, and laugh as heartily as any over that first trial.

In India the English have, in a quiet and unobtrusive way, initiated a movement toward manganistic methods of education. All endeavors, however, are as yet in the bud, though some day they may ripen into fruitful bearing.*

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* In a clever essay entitled "*Islam and Science*," Ernest Renan shows by an interesting illustration how deep and strong a root naturism has taken among the nations of Islam, the heirs of a once glorious Arabian culture. The English Nineveh explorer, Layard, had addressed himself to the Kadi of Mossul for certaine data concerning the population, commerce and history of the city. The Kadi replied by letter in this wise:

"Oh, my illustrious friend, oh, joy of the livinge! What thou askest of me is at once useless and hurtful. Though I have lived all my days in this land, yet has it never entered my mind to count its houses nor to trouble about the number of the dwellers therein. And to your question how many goods this one may load upon his ass, or that one into his boat, such matter indeed is no concern of mine. As for the history of this city, God alone knows it; He alone could say with how many errors its in-

But we need not go to distant lands in quest of naturism, for here in Europe we may find it still; indeed, we can detect a trace of it in every living man. It is only through education that manganistic modes of thought ally themselves to man's own self; that the higher rational faculties and dispassionate logic are linked to the naïve and to whatsoever in man is fair nature's unconditional devotee; but then this intellectual balance gives growth to calm deliberation, and enduring steadfastness against assaults of nature that threaten ruin—in a word, it develops a type of character absolutely antagonistic to fatalism.

In Spain the development of manganism has been insignificant. The Iberian peninsula did not contribute to the great, revolutionizing inventions, and we must assume that any expression of reform sentiment there could be the more easily suppressed because all popular interest was directed toward the newly discovered western world. What Spain has lost by her standstill is beyond all power of calculation.

Greece, once at the bright summit of attainment in sciences as in arts, found herself, when the day of modern technics dawned,

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habitants were filled prior to the day of Islam's conquest. For us the wish to name them would be dangerous.

"Oh, my friend, my lamb! Seek not to know what concerns thee not. Thou camest, and we bade thee welcome; depart in peace! In very truth all the words thou hast spoken have not pained me in the least; for the speaker is one, but the listener is another. After the manner of the men of thy people, thou hast wandered through many lands, yet nowhere hast thou found happiness. But we, God be praised, we were born here, nor have we any wish to depart.

"Listen, my son, there is no wisdom like unto a belief in God. He created the world. Is it for us to strive to equal Him by searching into the secrets of his handiwork? See yonder star which circles in the heavens about yonder other star; mark again, still another star, drawing in its wake a tail, requiring so many years to come and then so many years to go. Leave it, my son; He whose hand fashioned it will surely guide it.

"But perhaps thou wilt say: 'Oh, man, withdraw, for I am more learned than thou; many things have I seen of which thou knowest nothing.' If thou believest that these things have made thee better than I, then I bid thee doubly welcome; but I thank God that I search not where I need not know. Thou art versed in things that are indifferent to me, and what thou hast seen, I despise. Will thy farther reaching knowledge procure thee a second stomach, and thine eyes which have cast their glances everywhere and have searched through all, will they espy thee a paradise?

"Oh, my friend, if thou wouldst secure happiness, cry aloud 'God alone is God.' Shun evil—then wilt thou fear neither man nor death, for thine end will surely come."

still so crippled by the fall from her high estate, that the new born spirit could not infuse her. But to-day her people are striving to elevate themselves out of their naturism, and with interest we may follow the efforts made upon the classic soil of that fair land to recover the old heritage of intellectual vigor. Yet without a method, based on manganism, all endeavor will be in vain.

Italy offers us a remarkable spectacle. Her masses, deeply devoted through ages to the spirit of naturism, even after her active participation in the great scientific discoveries of the renaissance, have eschewed well nigh completely the younger genius of manganism, but the flower of Italian art has ever been kept in bloom, and therein her gifted people sought and found their country's fame. But now, in the day of her political regeneration, Italy feels the necessity of repairing the neglect of centuries, and so we see the whole country applying itself with astonishing energy to spreading wide the introduction of manganistic industries and a knowledge of manganistic capabilities. It cannot be disguised, however—and the recent national exposition at Turin seemed to emphasize the fact—that the rapid and really significant industrial progress of the country has tended to weaken its productiveness in art.* In making such observations it seems indeed—and like a cloud the thought shadows our reflections—as though a trenchant antagonism separated the two aims, demanding the sacrifice of one. But happily such is not the case. Fine arts and scientific technics do not preclude each other. But justice to both calls for all the stronger effort—greater firmness, deeper intellectual absorption in the refined laws of æsthetics, to repel the shocks of the machine's disturbing onslaughts. That both may flourish side by side bear witness the active movements of each in Austria and Germany to-day.

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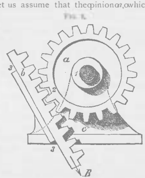
In turning now to a consideration of the method of manganism, a whole series of familiar introductory steps may be passed by, and, for the sake of brevity, we may confine ourselves to dwelling upon certain fundamental principles common to widely different and

* In conversation with an eminent Italian, a man of acute perception, the latter said on this very point: "Speak your thought openly, and say we have fallen back in the fine arts. We are well aware of that ourselves, nor do we grieve about it either. First we must retrieve in the other direction what we have lost through long neglect, and for this work we require our best brains. Later on we will manage to regain our old standing in the line of art."

quite distinct operations. The crowding of new phenomena upon the technical field is so tremendous, and the difficulties thereby cast in the way of including them in any of the accustomed categories so formidable, that only a comprehensive theoretic generalization can command a complete survey. The formulation of such an expression presents no difficulty, but in order to obtain full bearings on the subject, it will be well for us to consider the following simple cases from which important definitions issue

In Fig. 1, let us assume that the pinion a, which engages at 2

FIG. 1.



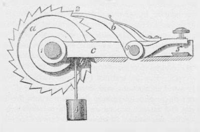
in the rack b, can rotate upon its axis 1 in the stationary support c; assume further that the rack, which we will suppose to be of considerable length, slides in the same support at 3, and that a weight B is suspended from it. If the wheel a be so revolved that B is raised, or lowered, the combination will be an example of a train of mechanism, that is, of a piece of machinery capable of a continuous transmission of motion, either forward or backward. Let us term this, because of its continuous transmissive action a *Laufwerk* *—or transmitting element. There are any number of

* This is the first of a series of terms which the author has employed, and in part coined, with consummate skill, for which no equally comprehensive and at once concise expressions exist in English. The *werk* of the German compounds is rendered in literal translation by "work," in the sense of its occurrence in such terms as wheel-work and link-work; it conveys the idea of a combination, usually mechanical, but extended in this essay to embrace certain physical and chemical combinations as well C[illegible]dered in the author's [illegible]ing as a compound unit, the word "element" has been selected as possibly the most suitable, though not a literal, nor an exact, rendering for it.—TRANSLATOR

familiar transmitting elements in which shafts, friction and belt pulleys, gear wheels, cranks, etc., are employed in various assemblages.

Distinct from these is another class of mechanisms characterized by quite a different kind of motion. Fig. 2 will furnish us with examples:

Fig. 2.



The wheel *a*, Fig 2, is again assumed to rotate in a stationary bearing about the axis *1*; it is armed with teeth in which the ratchet *b* engages at the point *2*. These teeth prevent the wheel from yielding to the impulse of the weight *A* which is suspended from it. But if the wheel be so revolved as to wind up the suspending cord, the ratchet will not interfere with this action, though it remains ready at all times to prevent the wheel from reversing its motion upon a cessation of the impelling force. The arrangement may be designated as a *Sperrwerk*—or engaging element. Its motion is intermittent, and moreover, the positive and negative movements are of different character, so that the mechanism is quite distinct from the transmitting element.

But the engaging element is by no means the only one that can be derived from our combination; no less than five others are possible

Suppose, to begin with, that the ratchet *b* be released by pressing upon the button at *5*; the weight *A* then drops, and in its fall rotates, or drives, the wheel *a*. The motion thus impressed upon the wheel can be variously utilized—either all at once, for percussion, as in a ram, or gradually, as in clocks, or intermittently, according to need. In every case the mechanical work that has been stored by raising weight, an elastic body, a spring, for example, can be brought into the weight can be usefully employed. But instead of raising a tension. We may therefore call the arrangement a *Spannwerk*—that is, a tension, or storing, element.* The old cross-bow was such an element, and millions of them are used to-day in gun-locks.

We obtain a third mechanism by a slight modification of the procedure, namely, by allowing the ratchet to reëngage in the wheel after its first release. It then stops the wheel and so arrests the weight in its fall. The mechanism can therefore serve for checking falling bodies, and hence its name, a *Fangwerk*—or checking element. The safety catches employed for arresting the fall of cages and elevators in cases of rupture of the hoisting cables are such elements. But the teeth of the wheel *a* may be reduced to extremely small dimensions, and even to the point of vanishing altogether; the serrated periphery then passes into the form of a smooth rim, the ratchet becomes a body in mere sliding contact, and the whole mechanism is transformed into a frictional catch. Thus it appears that brakes of all kinds, the common train-brake included, are species of checking elements, and that applications of this kind of mechanism occur frequently and are extremely useful.

A fourth mechanism is developed from our combination by the addition of a second ratchet, similar in general form to the first one, but attached to the end of a swinging arm. By the vibrations of this member, the wheel can be intermittently revolved so as to effect a gradual raising of the weight; with each forward stroke it is turned through a certain arc, while during each return stroke the fixed ratchet prevents it from reversing its motion. The mechanism formed and driven in this way is known as a *Schaltwerk*—an intermitting element. Its applications in practice are not uncommon; the automatic feed motion of many machine tools is a familiar example of its use.

A fifth modification of the arrangement arises in the employment of merely a small sector of the wheel to block the passage between the points *1* and *2*. By closing the gate, or lock, at *2*, all passage is prevented, and only a subsequent release can reëstablish it. In this particular application the mechanism is a *Schliesswerk*—or blocking element. It is used in millions of locks for

* Or, more nearly, a potential element.

windows, doors. chests, etc., and frequently in connection with the intermitting element.

The sixth, and from a mechanician's standpoint perhaps the most remarkable mode of applying the combination. is in form of an escapement, or *Hemmwerk*—a releasing element, as we will call it. It is produced by tapping lightly on the button at *5*, releasing the engagement for a moment and then, almost instantly, closing it. When this movement is carried out with perfect regularity, the progression of the wheel *a* can serve for measuring intervals of time. Releasing movements fulfil this important function in untold millions of clocks, the uniform release always being effected by means of an organ of isochronous vibration, such as the pendulum or the balance-wheel. But besides this application of the element, many others occur in practice.

Thus we see in these six movements, these six *Gesperrwerken*—or interfering elements, as we may collectively term them—the solution of a vast number of practical problems. Yet our survey of their applications is far from complete. We find upon continuing our examination, that these elements are frequently combined with one another, the action of the first being transmitted to the second, and so on. A pretty illustration is afforded by the hair trigger of a target rifle. This device is no more than a small storing element which is very easily disengaged, and the potential energy so liberated acts upon and releases the firmer storing element of the hammer.* This is a case in which one storing element disengages another. We may call such a combination a storing element of a higher order, or, in general, when any interfering element is combined with another in such a way as to impress its action upon it, we may speak of an interfering element of a higher order. Such, by way of illustration, we find in the works of a clock, in which either a gravity, or spring, storing element actuates the releasing element of the clock, operating therefore in second order. Manifestly we are here confronted with a principle—for the action can be impressed equally well by an element of interference upon one of transmission, and by that one upon any other. In fact, in the example of the clock we have just had before us, the releasing element actuates a spurwheel gear—in other words, a transmitting element—which in turn moves the pointers. If we agree upon

* It may be remarked in passing that a hair trigger of highly developed form was used in cross-bows toward the end of the Middle Ages.

the term *Treibwerk*—or driving element—as generic for any simple or complex movement gear * whatever, then the works of a clock constitute a driving element of the third order, compounded in ascending order of three simple driving elements of storage, release and transmission.

After this expansion of our horizon, there is yet a further development for us to seek, an extension in another direction. If we consider the many machines in practical use, we observe that fluids serve for the translation of motion in quite a number of them—in the hydrostatic press, for example, as also in the pump, and hydraulic engine, and in waterwheels, turbines, etc. Not liquids only, but gases are similarly employed, in gas motors and air engines, and, especially, in the steam engine. Closer investigation reveals that in all these cases the fluids are so constrained to move by means of inclosing ducts and vessels that they act in suitable machines the part of solid bodies, but always with the advantage of conforming perfectly to the varying shape of the confining sides.

Let us apply this idea to the transmitting gear illustrated in Fig. 1. By substituting a stream of water for the rack the element becomes a waterwheel, if the water acts as driver, or a lift, or flashwheel, when the wheel is the driving body and water the driven one.

Machine practice applies the same process of substitution to our several interfering elements. If a fluid fulfils the functions of the wheel *a*, or of any of its equivalent sectors, racks, or other modifications, then the ratchets are called valves. Valves in fact, however they may be regarded, are nothing but the ratchets of fluids. What a new, what a grand, extension the application of the driving element now acquires! Illustrations abound; they fairly crowd upon us. Our ordinary pump with its valve-piston and suction valve is a hydraulic intermitting element, developed on precisely the same lines that we followed in forming such an element from Fig. 2. And as for hydraulic storing elements, they are coming more and more into use every day, particularly in the form of so-called accumulators.

In releasing elements, too, fluids have been put in the place of the balance-wheel, or of its equivalents, as we see in all hydraulic engines and in the steam engine. Considered purely as driving elements, these machines correspond with the clocks which served

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* *Bewegungswerk.*

anon as our example of a releasing element, the only substantial difference between them being that the releasing element of the clock overcomes none but hurtful resistances, whereas engines overcome mainly useful resistances. If our limits permitted, it would be an easy matter to mark the points of correspondence throughout. Take the valves, for example, which frequently occur singly, but also combined in twos and greater numbers in a single piece —the slide-valve of the steam engine is the anchor escapement of the clock; the pendulum of the latter is the reciprocating piston of the former, and so on throughout. See how the mighty steam engine ranges itself into line and modestly occupies its proper station. Thus should it always be in a scientific conception, for therein neither sensation nor aught else save true logical connection avails.

But still we have not quite finished with this machine nor with this principle. One final ascent has yet to be made ere we can command a perfect, theoretic horizon. If we consider the source of power of our steam engine from a general standpoint, we find that the living force imparted to its molecules, which we call heat, is intensely active, and that by virtue of this activity there resides in the aggregate mass of stored up steam a certain tension. The steam boiler, therefore, with all its valves and fittings—what is it other than a tension, or storing, element, and one that differs only from those of our former consideration in that here the tension is produced by physical means. In the steam generator, then, we recognize a physical storing element. This idea soon leads us further; it draws us onward to seek, in the line of causal connection, whence the heat in the boiler water. This we find in the furnace fire, in the glowing, flaming fuel which disengages by combustion, through chemical action, the thermal energy that it has stored. The fire, then, is the dissolution, or running down, of a chemical storing element which, when released by the act of ignition, disengages with sudden vehemence the thermal energy that, in the case of coal, was stored within it æons ago by the slow alchemy of nature.

Now we know our steam engine in its completeness, for we can clearly recognize:

In the furnace fire, ...	a released chemical storing element;
In the steam boiler, ...	a physical storing element brought into tension by it;
In the engine proper, consisting of cylinder, piston, and valve gear,	a mechanical releasing element driven by the preceding one;

taken as a whole, therefore, and neglecting all merely adjunctive parts, it is a driving element of the third order. If in the place of a simple engine with reciprocating motion only, we have an ordinary fly-wheel engine, then the releasing element is supplemented by one of transmission in the form of a crank gear which we utilize in thousands of familiar ways. In this, its commonest type, the steam engine therefore proves to be a general driving element of the fourth order.

One other illustration from steam engineering is particularly instructive: let us glance for a moment at the railway train. In the locomotive engine we have, according to our last development, a driving element of the fourth order. To this we must add the driving wheels as a frictional transmitting element, and to this, in turn, as a second transmitting element, the moving train upon the track;* the train of cars and engine together thus constitute a driving element of the sixth order. But suppose our train to be a modern one, equipped with the Westinghouse brake. Why is it, indeed, that this appliance has become so popular and so important? Our theory explains it at once. The brake itself is a checking element which had formerly to be set in action by hand, but note how different our procedure is to-day. We have at our command in the Westinghouse apparatus a powerful and ever ready storing element with which, in form of an air receiver, each car of our train is provided. By the movement of a single valve, in which we recognize the transformed ratchet of our earlier descriptions, this multiple storing element is easily disengaged and allowed to act upon an air piston, that is upon a releasing element, which in turn acts upon the brakes. Examining now the complete assemblage, we recognize—

In the small steam engine, a . .	*Hemmwerk*—or releasing element,
" " air compressor, a . . .	*Schaltwerk*—or intermitting "
" " air reservoir, a . . .	*Spannwerk*—or storing "
" " air piston, a	*Hemmwerk*—or releasing "
" " friction brake itself, a . .	*Fangwerk* —or checking "

and in the whole appliance a mechanical *Treibwerk*—or driving element—of the fifth order. If we extend this combination, as we properly should, so as to embrace the steam boiler and

* In a cog-wheel railroad, the guide rails are not identical, as in this case, with the rails used for the transmission of power, but a separate power rail and power wheels are provided between the regular guiding tracks.

furnace, the apparatus develops into a general driving element of the seventh order. Assemblages of still higher orders are by no means of uncommon occurrence.

We are now in a position to explore without fear of confusion the newest of technical domains, the field of electro-mechanics. Here we find in the galvanic battery a chemical transmitting element—for we may permit ourselves the use of the term, seeing that a transmission of motion, albeit molecular motion, is involved. The physical current of electricity, whose valves or ratchets now take the form of contacts and brushes, is used in manifold ways. In telegraphy it acts as an intermitting element of the second order in the relay battery, starting and stopping a mechanical transmitting element and operating the recording pencil, so giving rise to combinations of the third and fourth orders. The ordinary railway bell signal operates in the fifth order—chemically, in the generation of a current; physically, as an intermitting element, by the attraction of an armature, which effects the liberation of a storing element that has previously been brought into tension by hand; then mechanically, in the operation by this latter of a releasing element which in its turn sets and releases the small spring hammers that form the final storing elements.

Among the chemical *Treibwerke*, or driving elements, it appears that those whose function it is to store energy occupy a very prominent position. Those among them that are artificial are so prepared by the chemist as to liberate their energy slowly or quickly, according to his purpose. Gunpowder is the powerful chemical storing element with which the groping naturism of mediæval Europe replaced the lesser mechanical element of cord and bow, that depended for its energy upon the unaided action of human muscle. The purpose remained the same; only the species of the storing element was changed. The tinder which liberated the new element was itself a slowly disengaging chemical storage element, entirely distinct from the greater one. At a later period inventive genius incorporated both in a single contrivance, first in the flint-lock, and then in the percussion-lock, entering in this way upon combinations of third order. The percussion cap, as an easily liberated chemical storing element, could be readily released by the mechanical element provided in the gun hammer. The ball was projected, therefore, by a storing element of the third order, or, in the case of a hair trigger lock, with one, even of the fourth order.

To conclude our survey let us devote a few words to that small but very interesting object, the common match. How short, indeed, is the period, scarce as yet two generations, during which we have possessed it! And prior to that time we manganists stood, in point of lighting a fire, on very nearly the same level with the humblest naturist. The latter, as we know, starts his fire by a dexterous and laboriously acquired manipulation of two pieces of wood. In other words he releases the very stable, or difficultly liberated storing element, fuel, by the immediate act of friction. The method of the ancient Greeks was the same.* Flint and steel were the invention of a later day—a physical storing element which was applied to igniting a specially prepared and easily liberated chemical storing element, tinder, and this, as soon as it glowed, was used to release a more stable element, the sulphur string, with which, finally, thin slivers of wood could be lighted. Four superimposed storing elements were involved in the process: one of them physical (the flint and steel) and three chemical (the tinder, sulphur, and wood).

The philosophy of the match lies clearly within the limits of this evolved principle. That important little instrument was the result of combining at first three, and subsequently four, storing elements. It is a chemical storing element of the fourth order, comprising the elements phosphorus, potassium chlorate, sulphur, and wood. More recently paraffin and wax have been substituted for the sulphur, but the same principle is maintained and may be clearly recognized. Each of those storing elements that follow upon one another is more stable than the one it precedes, but its release in due turn is accomplished with certainty; and hence, as ultimate effect, a light and even delicate, mechanical action upon the first, most sensitive element, the hair trigger, so to say, of the whole,

* Their instrument was the pyreion. It consisted of two parts: a lower piece, or eschára, which was bored with a hole, and a trypanon, or borer, which set into it and was rapidly twirled around. Could not the pyreion, perchance, have been preserved in some hidden nook of the Grecian hills? Worthy, indeed, would be the service that should bring it to the light of day. The small tinderbox, which many of us can recall from earliest childhood, with its contents of flint and steel and sulphur thread, must surely have escaped utter extermination by the little match, and it were well to preserve it from absolute extinction by donating the few remaining specimens to ethnographic museums.

effectuates the release of that last, very stable engagement which once caused so much trouble, and made such arduous demands on the strength of one, or even two, active men. That the combination of the four storing elements was not realized until so late a day argues that the underlying mental process must have been a difficult one.

At last we have obtained a complete view of the manganistic principle, not in general outline only, but in the detail of great examples illustrating the activity of the most powerful forces, as also in cases involving the minutest reactions, and now we are able to state that *the method of manganism consists in the development of mechanical, physical, and chemical driving elements upon the basis of a scientific knowledge of natural laws, and in their subsequent combination in super- and juxtaposition.*

Although this principle has been unfolded with reference mainly to mechanic arts, it permits of an equally ready application to the processes of technical chemistry, and so we may regard it as embracing the problem in its entirety.* A single thought directed to the manufacture of sulphuric acid, or the coal tar colors, or any other chemical products, suffices to remind us of the mechanical and physical elements which operate there as intermediates, just as in mechanical combinations the other two classes were frequently found to enter.

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From the height of our newly gained vantage-ground, let us look once more upon the technical sciences, and in their every feature and detail we can perceive how closely their results are interwoven with all our habits and forms of life, indeed with our entire civilization. We need not here take cognizance of the fact that in our dwellings we are fairly surrounded by thousands of interfering elements† which have made our space enclosures what they are—secure and comfortable habitations, furnished with warmth, and light, and abundant air. All these features we may disregard, because naturistic practice might achieve similar, though less perfect,

* Modern chemistry has applied itself with remarkable success to the production of chemical storing elements of very high energy and instantaneous and complete release, that is, to the preparation of explosives. But the contrasting problem is also conceivable; the formation of storing elements of high energy but gradual release. As heat diffusers, with a mild and vivifying, instead of a destroying influence, they might be of vast importance.

† *Gesperrwerken.*

results. But look to other features which impart a character to our abodes. There is the gaslight in each house, and on the street, and in the public buildings. We owe it to a chemical storing element* of the fourth order (fire, retort, gasometer, conduit and cocks, neglecting all the secondary parts), and all of this wonderfully and systematically ramified through the town. The water supply for household and public use, when derived from a river, furnishes us with a driving element † of at least the sixth order. On our railways we are conveyed by driving elements of high order, whose service we regulate by means of others equally high; our freight is moved from place to place, from land to land, from continent to continent, in quantities greater a thousandfold than man and animals could carry. With a physical driving element we conduct a written and spoken message service the wide world over. And how do we proceed in war? In millions of chemical storing elements, great and small, and almost all of them of an advanced order, we carry potential energy out upon the distant battle-field, and there release it by means of driving elements of high combination. Out upon the broad ocean, hundreds of miles from land, the energy of a storing element, which we derive from a gift of nature, operates through driving elements of high order to carry us for weeks and months through wind and wave.

Highly potentialized storing elements, like coal, have been eagerly sought out in nature—at an early day naturistic man found the water-course, the subordinate element of transmission for the greater storing one in the mountain heights—and in future we may still find others, as petroleum was found, rediscovered we may say, three decades ago. In this nature provided us with a highly energized chemical storing element, particularly adapted to disengagement when its constituent particles were at a bright red heat. It really consisted of a number of storing elements, in some of which the engagement was so slight that their release was apt to occur unintentionally. We were obliged, therefore, to subject the natural product to a process of separation, which, by the manganistic means of fractional distillation, removed the groups of particles that were too unstable, and then only did we obtain a storing element that could be safely transported and come into general use. The restrictive police ordinances required, as we see, that the engagement should be a firm one, and how favorable

* *Spannwerk.* † *Treibwerk.*

in their action these regulations have proved, the results to-day abundantly testify. This liquid storing element which was obtained, so to say, almost ready made from nature, replaced for illuminating purposes a number of others which we had derived from the organic world with the aid of considerable manganistic machinery.

Let us, before concluding, direct our attention to another point. In a conflagration we see an unintentional release of chemical storing elements—the class to which so many bodies prove to belong. The ratchet has been raised against our will; with increasing velocity, frequently at raging speed, the tremendous storing element runs down. But we hasten to check its course with another driving element, once worked by man-power alone, but now just as commonly operated by a chemical storing element (fire and boiler) through the intervention of a mechanical driving element of high order. Sometimes, too, we apply the action of a chemical storing element directly upon the quenching water, as when we use a gas fire-engine, or chemical engine, as the Americans are wont to call it. In this latter case, the driving element for the water is of a much lower order than before. It furnishes an illustration of how driving elements, whose ultimate effects are the same, compete with one another by rival endeavors to reduce the magnitude of their ordinal coefficients, or, in other words, to diminish the number of simple elements in their combinations. Everywhere, therefore, the manganistic thought, the manganistic principle, with which we sustain so largely, and ease, and defend our lives, but with which, too, we accomplish so often the destruction of our fellows.

And, finally, our industries, the producers of all our articles of daily use, and in turn again, of the manganistic machinery we require—what powerful influences have they not exerted through manganism in promoting our general culture? Just here let us pause, to enter the subject a little more in detail, and fix, if possible, upon a unit or standard of measure.

An essential factor for manganistic work is coal. It is now mined to the extent of about 400 million tons per annum, and is used mainly for industrial purposes. The amount produced in excess of this quantity suffices to cover the consumption for general heating. We have, therefore, for each of the 300 working days in the year, 1 1/3 million tons of coal which are applied to chemical, mechanical, and physico-technical purposes. If, for the sake of convenience, we compute the entire resultant work in terms of its dynamic effect, the round figure obtained is 90 million horse-power.* Allowing as equivalent of each horse-power the work of six strong men, the quantity is represented by 540 million man-power, continually active during 12 hours of each working day. This vast amount of work we 250 million Atlanticists alone have furnished to mankind—for the other 1250 million naturists have contributed nothing toward it—and all of this through the agency of the manganistic principle. Were we to assume that every tenth man of the 1250 million performed each day such hard and continuous work as that on which we have based our figuring, an assumption which is probably far too liberal, it would yield a product of not over 125 million man-power. We Atlanticists, the one-sixth portion of our earth's inhabitants, consequently accomplish with our manganistic work far more than four times as much as the others possibly can. The preponderance of manganists over naturists is not casual, therefore, but has been earned and paid for in useful work, and attains thereby, in a purely material sense, its justification. And all the more is this true, because much of our work is conveyed in its products to the naturist, serving so—when we consider the broad traits of the procedure, and not the incidents of still existing imperfections—for the dissemination and growth of civilization and culture. Thus it is that technical science becomes the propagator of general culture, a vigorous and indefatigable worker for the melioration and advancement of the human race.

This inherent worth, this importance of the technical sciences in cultural development, is of itself sufficient natural cause for the wide field which they have opened to education. In proceeding to investigate the subject of technical instruction we recognize at the very outset that in its highest grade, that of the polytechnic school,† it is not conceivable without a thorough study of the sciences. For manganistic technics must, in all of its operations, apply the forces of nature in exact conformity with their laws. The instruction in the polytechnic school has of necessity, therefore, to adopt as fundamental principles the three natural sciences—mechanics,

* On a basis of coal consumption of 1¼ kg. per horse-power per hour, and 12 hours of work per day, *i.e.*, 4½ tons of coal per horse-power per annum. According to statistical count and estimates, the energy of 20 million tons is actually reproduced in dynamic form.

† *Technische Hochschule.*

physics, and chemistry, and the all-measuring master art of mathematics. To these the separate technical courses are allied, the special studies in each depending for their title to a place in the curriculum upon the provision that every legitimate problem which may present itself in practice shall be approached from the highest standpoint of intelligence. The polytechnic schools, arising as they did out of the requirements of a gradually developing system of manganistic technics, date their existence from a much later period than the universitiese it is only the present century that has substantially matured them. and even this not yet completely, for the signs of unrest which they have exhibited for some time past are indicative of a development that is still in progress.

It is worthy of remark here, that notwithstanding their intended pursuit of a strictly scientific aim, the technical schools have not yet concluded their peace with the universities. Even with the best of good will none of our efforts toward a real amalgamation of the two has ever been successful. In this connection I can vividly recall a bright, festal oration of the late Professor Kœchly, in which he dwelt on the social communion of the Zurich Polytechnic School and the University beneath a common roof. It was the same Kœchly who with Rüstow pursued technical philology, translating Philo of Byzanz, and Hero, and Aneas on the defence of cities, and Cæsar, and other works in which technical questions were always prominent. He said of the relations of the two schools: "And if not side by side, at least we can fight back to back." And to-day, after a lapse of twenty-four years, the fight is still carried on there, as in so many other places, back to back. It cannot be advanced as adequate explanation that the disparity in age is too great, or that the universities have let the right season slip by when the necessary polytechnic faculties might have been grafted to the older four. Deeper causes than these must militate against the coalescence. I look upon them as residing in the inherent difference in the purposes of instruction.

University education strives in all of its departments to enlarge the scope of human knowledgee the university pursues, to express it in brief, *the sciences of research.** In theology, in jurisprudence, in medicine, in all departments of the philosophic faculty, the advancement of pure knowledge is the one object of its endeavor.

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* *Die Wissenschaften des Erkennens.*

How different is the purpose at which technical instruction aims: it would teach and fit us to form and to fashion, to create what is new, to promote the objects of society by the application of science to the control of natural processes. The polytechnic school, in a word, promotes *the sciences of accomplishment*.* This contrast is decisive. It determines the whole tenor of instruction. In the university it carries its disciple ever farther toward specialization of study, toward segregation from the common matrix, and complete devotion to one object of research.† In the polytechnic school, on the other hand, the higher the student rises upon the foundation of firm and well ordered scientific elements, the greater becomes the necessity for coördination, for the organic, functional working of each separate study, and particularly of the disciplinary ones, and for an apt accommodation of the student to various related lines of activity. Later in life it is not otherwise, for every technical career may impose participation in organized operations, where on one man alone devolves the onerous responsibility for harmony of action in a complex whole; while university education fosters singleness of aim, and ever after, in a professional career, tends towards its further development.

It scarce may be necessary to mention that the limits between the two intellectual movements are not sharply defined, and particularly is this the case in the sphere of instruction itself. Not unfrequently, for example, the chemistry of the university, yielding to allurements, has swerved from its own course toward the field of active accomplishment; nor have the teachers of the polytechnic school always kept within the confines of a strictly technical treatment of their subjects. Hence the exchanges, both back and forth, in the forces of instructors, until a fair equilibrium is established. But besides, the true principles that should govern the polytechnic schools have not as yet crystallized everywhere, nor has the necessity for building up by thoroughly scientific methods received as unqualified an acknowledgment as it certainly should. Enlightened views in this direction, however, are steadily gaining ground, and we may regard the end as now being distinctly recognized.

Separately, therefore, as marching columns, the two forces are

* *Die Wissenschaften des Schaffens.*

† "Gentlemen," I have heard Dove say in one of his lectures on physics, "fix betimes upon a specialty."

advancing; their ranks, their aims are different; but in the same scientific plane they move, and always shall move, neighborlyt enough to extend to each other a friendly hand, and each striving to satisfy the full measure of all just demands. Let them, then, march on in peace; notwithstanding their separation both will surely do justice to their undertakings.

A blending of the two movements, be it said, has actually been triedt; that is, it exists to-day in the United States. The "university" in America is both classic and technic. The experiences hitherto gathered, however, have not shown, so far as my observation allows me to judge, that the union can be permanently maintained, or that it has furthered the interests of education in the way that legislation had anticipated.

There is one among the polytechnic departments, that of architecture, concerning which doubts as to the aptness of our observations may arise. Many would sever the architectural course from the technical schools and incorporate it with the academies of fine arts. The advantages of such a change appear to me extremely doubtful, but that there is a certain inherent justification for the desire must be allowed. For architecture is, and always has been, an own, peculiar growth of naturism, which had flowered in surpassing beauty long ere the seeds of manganism germinated in the soil. We can understand, therefore, and must respect the tendency that has recently manifested itself in efforts to reintroduce studio instruction in the architectural department of the technical school. In my opinion, however, it is a matter of serious doubt whether the expected advantages will be realized. For it is simply the old naturistic method which is thereby revived; the personal excellence of the individual artist again becomes the object to be taught and transmitted. But meanwhile the close attachment of architecture to the polytechnic school has certainly inculcated in it one idea which unites it in essence with the school, and that is the setting of scientific laws at the very foundation—not laws of natural science, as in the other technical branches, but laws of æsthetics and of style, which become thet highest intellectual guides in artistic creation, even as the laws of nature are the fundamental elements in the other departments. Of perhaps secondary, though not to be underestimated, importance for the connection of architecture with the technical schools is the circumstance that at the present day, and for our conditions of life, no building of any magnitude is conceivable in which manganistic technics do not figure in as prominent a rôle as artistic composition; in problems of heating, lighting, ventilation, water supply, drainage and many others, it is a vital requisite, and accordingly demands the fitting studies.

Let us terminate our discussion by just glancing at the intermediate and lower technical schools, the industrial art schools included, as almost all of them are related to the architectural branch of the technical high school, or range within a dependent province of the academies of fine arts. The further down the scale we look the more definitely must we recognize in the humbler institutions the training schools for the actual performers, while the polytechnic high school undertakes to educate the designing and directing staff. It is a facile deduction from our doctrine to see that the lower in the system we go, the more must the acquirement of law cede to the learning of rule. In the lowest grade, instruction should in my opinion embrace only the rule, which of course must be an emanation of law, in complete harmony with it, if it is to maintain any claim to value. The teacher, therefore, must, or rather should, know the law, but he should abstain from teaching it. For the free and unconstrained view of the immediate performer is sure to be disturbed if he is beating his brains about the deeper lawt; it troubles him and disquiets him, for, as a learner in this grade, he still stands as a general thing upon the naturistic level. He is the soldier of technics. But just because of this the thorough assimilation of the rule becomes a source of strength and capacity. The higher upward in the scale, the more of law may be introduced, and the more may we gradually pass over to manganism. "Rule, example, law,"* thus perhaps the rising gradation might be expressed in concisest form.

It should be the important duty of boards of education everywhere to determine for the course of studies in each of the several grades of schools just how much of the law shall be added to, shall be shown as rational basis for, the rule. Quite natural as this may appear, yet from my own experience it will not be superfluous to direct attention to this point, because teachers, and especially the younger ones, too often err in failing to impose upon themselves a wise restriction, obstructing thus the pathway to their own success, and frequently thwarting the intentions of educators.

* *Regel, Vorbild, Gesetz.*