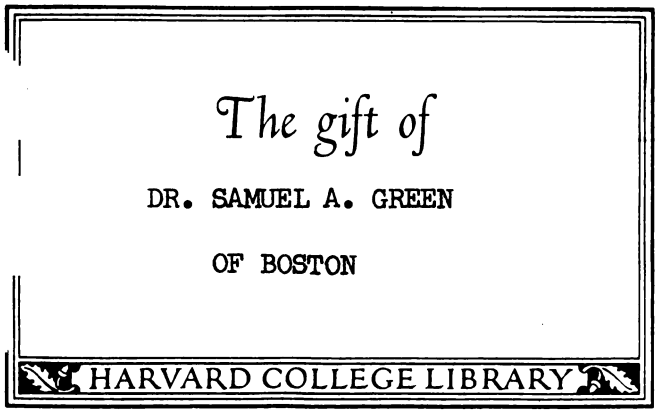
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TECHNOLOGY AND CIVILIZATION

BY

F. REULEAUX.

FROM THE SMITHSONIAN REPORT FOR 1890.

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From the present status of the world's culture, one can not fail to discern the significant influence of our scientific technology in qualifying us for greater achievements than the past centuries have yet witnessed, whether in connection with rapid transit by land or sea, tunneling mountains, piercing the air, making the lightning our message-bearer from pole to pole or sending our voices across the land; or whether, indeed, from another point of view we bring into our service the mighty mechanical powers, or adapt and make use of those intangible contrivances usually unnoticed by the world at large.

Everywhere in modern life, about us, in us, with us, beside us, is felt the influence of scientific art acting as an agent and as companion, whose ceaseless service we never realize until for a moment it fails us.

Commonplace though this be, still it seems to me that in the cultured world and perhaps in the narrower circles of scientific men, this truth is too slightly valued. The value of scientific technology in its true character as producer and promoter of civilization, is too little recognized.

This may result from a confusion of the so-called technical with the unscientific; or on the other hand, from concealment of its results under a preponderating mass of idealism, its development being cramped by ambition for gain and trammeled by social evils, which go hand in hand with industrial labor. But I will not here consider this side of the question. I would attempt a nearer approach to the inner sanctuary of technology to certain weighty questions, which appear especially deserving of present notice, as:

What place, particularly in associate working, the technology of our day takes in civilization? A place not so well defined, it appears to me, as is that we assign to less important social, political, and scientific events.

Again, a question occurs as to the chief features of the method followed by technology to attain its ends, and concerning the plan which

* Translated from *Prometheus* (Berlin), 1890, vol. I, pp. 625, 641, and 666.

must more or less underlie device and invention; a question which (especially for patent legislation) has long employed and must long continue to employ the scientist as well as the administrative practitioner.

If we will compare our civilization with that of other nations we must understandingly glance at the people and their pursuits, which we find upon the lowest stratum; for example, those who, lacking a knowledge of writing, that wondrous thought transmitter, have, of course, no care for science. In this comparison one will soon encounter peoples whom a high culture has for centuries, yes, thousands of centuries, been a part. These are the peoples of eastern and southern Asia, the Chinese, Japanese, people of India, the Persians, and Arabians. Noting without prejudice their culture, we must concede them to be in a state of high development, indeed to have been highly developed, when middle Europe still remained deep in barbarism. Even then science and art flourished among them, and is still advancing.

For 3,000 years the Indian Vedas have devoutly proclaimed the Deity; 2,000 years ago the Indian poets produced their odyssey the "Mahabharata"—the great Bharata, the forerunner of many dramas, among them the tender "Sakuntala," the charm of which is still potent since its sentiments found their origin in the heart of man. Philosophy flourished likewise, and the science of language in so great degree that the Indian grammarians of to-day can look back upon an unbroken line of predecessors, the vista terminating in Panini, whom they reverence like a god. Mathematics, too, were fostered, and to-day we write our numbers in Indian characters. In parts of India and in eastern Asia the commercial arts progressed then as now. Persia, too, was laurel-crowned among the world's poets. Following the great Firdousi came the "Horaz" of Schiras, and in his footsteps Hafis sung his immortal songs, all of which have become a part of our literary treasure through the sesame of translation. And the Arabian literature, to which we have not yet had access in its entirety, how has it laid under tribute the Grecian inheritance, and so perfected astronomy that at the present time we name half the heavens after them. How, under the patient and studious princes of the time of Charles, did they foster the growth of arithmetical and still deeper science! How too have they surpassed our knowledge of chemistry in various substances and essences!

What is then the spiritual difference which sunders their path from ours? Are we in certain arts still behind them? They are brave soldiers, gentle and industrious citizens, wise statesmen and scholars; honor and justice hold high rank among them. Where then, considered as men, lie the points of difference?

Or, on the other hand, do we question whether the spiritual boundaries lead to the good, and would we fain know whence springs our superiority over them?

How is it possible, for example, that England with a few thousand of

her own troops, rules the two hundred millions of India; how was it possible for her to remain victor in opposition to their terrific and fanatical revolt in 1857? How does it happen that we, Europeans or (not particularly to mention the European-settled America,) that the Atlantic nations alone compass the earth with railroads, surround it with telegraph lines, traverse its water girdle with mighty ships, and that to all this the other five-sixths of the earth's inhabitants have not added a span—the same five-sixths which still, for the greater part, are grandly organized and highly cultivated?

There are different ways of explaining this astonishing fact, or rather, of at least attempting to determine it comprehensively. Klemm, the industrious Leipsic collector, who was a pre-historian long before the discovery of pile habitations, has propounded the distinction between "active" and "passive" peoples; and many to-day follow him therein. To him the Atlantic nations are the active; all others, down to the utterly uncultivated, the passive. According to this theory we make history, they suffer it. Although this discrimination appears to have so much in its favor it does not hold. Nations can (as history teaches) be a long time active, then passive, and later again active. Activity and passivity are not to nations indwelling characteristics, but circumstances into which and out of which they can fall without changing their spiritual, essential position. One proof of reality the Klemm theory does not stand. Europe could, to-morrow, unyoked from Asia, be made passive without losing the character which makes railroads, steamships and telegraphs belong to her as her spiritual possession. The Arabian, on the contrary, could destroy the products of scientific technology as the pretended Omar the books, but would not be able to re-produce them, as has many times been done in case of the books.

Others have supposed, and still believe, that it is Christianity that establishes the distinction.

This however does not stand the test. Of course a considerable part of the thinking which resulted in metamorphosed inventions and discoveries was done in the Christian empire, but by no means all. What an innovation was made by the art of printing, and yet we know that 1,000 years earlier the Chinese had found a way to this art. Gunpowder, too, that marks so decisive a step in the progress of our civilization, was used by the Arabians long before the time of the Freiburg monks. Then in mechanics we find those important power machines, the water wheels, are very old and of Asiatic origin.

But passing from these examples to a genuine offspring of Europe, the steam-engine, watching its gradual development up to its actual use—the time of the Renaissance—in Italy, Germany, France, and England, but never outside of Christendom, even this, we find, does not encounter progress, but on the contrary, its adherents often oppose it up to the last.

We look further and do we not find to-day Christians living in the

East, for example, in Armenia and in Abyssinia, entirely outside the contemplation of our victorious modern technology? In the past they have added naught thereto and to-day they are not its contributors.

It can not be the things themselves, the inventions, but the engendering thought which must have produced the change, the innovation. In fact we can but ascribe this to a peculiar progress in thought precedence, a difficult, dangerous ascent to a higher, freer comprehension of nature.

The spell which bound us was broken by our understanding when we found the forces of nature following in their operations no capricious will—a Godly will—but working according to steadfast, unchangeable laws—the laws of nature; never otherwise.

> According to laws mighty, fixed, eternal,
> Must we complete our being's circle

breathe Goethe's words from out the terrors of nature's inexorable power. But according to "laws mighty, fixed, eternal" roll the worlds, the stars pursue their course, a tile falls from the roof or a drop from its cloud height.

> Suns wander up and down,
> Worlds go and come again,
> And this no wish can alter.

In this grand poetical form is seized the same uplifting knowledge that not the bodily but the spiritual force incloses within itself the presentiment of God, that even the world's creation consists in the immutability of its laws. That it might win the knowledge, thought broke through the old barriers, but immediately drew from real life conclusions such as these, if we may utter them quite free from secondary considerations.

If we bring lifeless bodies into such circumstances that their working of natural laws answers our purposes, we may permit them instead of this labor to work for living beings.

This began to be carried out with intelligence, and thereby was created our present technology. Scientific technology I must name it. When the spirit entertained the idea which sought to make natural laws a conscious power, scarcely anything was known of these laws and they must first be wooed. Through hard battle indeed must they be won, for the learned world believed itself to have them in its possession. The reformer had therefore not simply to make the discovery, but to accomplish the gigantic task of overcoming antagonistic convictions and at the same time to support a spiritual campaign up to the heights of freer knowledge, for this march found weighty opposition in the decrees of the church, which had demanded its sacrifice. The victory was won, and therewith our present technology gained the command. The opposing current of the time had spent itself, comprehending, perhaps, its injustice, for do not its first representatives travel as gaily upon the railroad, telephone, and telegraph as do others? Only small

skirmishers exist as a reserve, and this more from stubbornness than conviction. At all events they do not in the least retard the chief movement.

What had happened had the reaction of that time prevailed—for it was a reaction begun in Germany more than 100 years before, Copernicus having lain more than 90 years in the grave when Galileo was unwillingly compelled to witness against him—what had happened in such an event is difficult to conceive; and yet not so, for we may see it exemplified in the great Arabian nation. Among this people the reaction had, in truth, conquered. Their Galileos, their Averrhoës, and numberless others, were defeated, together with their free convictions; with them their entire sect, and therewith the Arabian culture, which already had lifted the hand to grasp the palm of victory of free knowledge, was paralyzed by the fanatical victors, and paralyzed they still lie low, already half a thousand years. Allah aalam! "God alone knows," therefore shalt thou not desire to know! So sounds it since then for the pure Mohammedan; all investigation is cut off from him, forbidden and declared sinful. A noble and refined disciple of the Prophet has given expression to the hope that the Moslem may yet be called to take up the lost leadership. Who may believe him? However, it appears certain that the overthrow of free thought in the Arabian language has become decisive for the remaining Asiatic culture. Like a dam lies the spiritual-slain mass between them and us, and so has it come that we alone have entered into the development to which the pictured progress of thought led the way. The powers of nature which she has taught us to make useful are the mechanical, physical, and chemical; to permit them to work for us requires a great outfit of mathematical and natural science. From this entire equipment we exercise a portion as a privilege.

It seems necessary, in order to briefly distinguish the two directions of development, to call them by particular names. The Greeks named an artistic mechanism, an arrangement through which the unusual could be conducted, a *manganon*, which word goes back, according to some, to the name of the eminent race of magicians. All kinds of definite tangible things which were considered skillfully and wisely thought out were so titled; among others, a catapult for projectiles for purposes of war. With this the word comes into the Middle Ages. Then, early in the seventeenth century, a great machine was invented for rolling and smoothing the washing, and since this contrivance bore a remarkable outward resemblance to the catapult, it was also given its name, whereupon the word wandered further into the remaining European tongues, as every house-wife knows, or perhaps does not know, if she send her washing to a "mangle."

Again, for our purpose, I would generalize that old word and name, on the one hand, that something by means of which the forces of nature are known in her laws, *manganism*, and on the other, that which

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We may now turn, without anxiety lest we sacrifice clearness, to the side of the most modern of all technical novelties, the electro-mechanical. Here we recognize in the Galvanic battery, or chain, a *chemical running work*, which expression can well be conceded, as it depends upon motion excitement, although it be atomical; the induced physical-electrical stream, the valves of which are the obstruction ratchet, the contact, polishing springs, etc., is used in various arts; in telegraphy it works in leap work of the second order, provides by relay for release and making fast again, and a mechanical running arrangement of writing work; it results, according to circumstances, from the third to the fourth order.

The usual sound-contrivances of the railroad work in the fifth order, chemically in current producers, physically leaping in the anchor pulling through which a mechanical tension work, that is one bent by the hand, is released; the same drives a check work which again the little hammer tension work (Hammerspannwerke) springs, makes taut, and then releases.

Among chemical drive work, we notice that the tension works take a prominent place. Those placed here will be of the number so artistically prepared by chemists that they give up their tension, or expansive force, slowly or rapidly. Gunpowder is the most powerful tension work, which the naturistical groping Middle Age set in the place of the mechanical tension work stretched by the hand of man out of netting, bows, and sinews in large and small throwing machines. The purpose remaining exactly the same, the kind of tension work was changed. The fuse releasing the new tension work was in itself a slow running, chemical tension work, entirely separated from the larger. Later we got so far as to take the two together in a single contrivance, at first in flint-locks, then in percussion locks. There one entered the third order. The percussion cap, a chemical tension work rather easily liberated, is set free by a mechanical tension work attached to the guncock. The ball is thrown by a tension work of the third order, as occurs in the set-trigger in the fourth order.

Allow me to say a word concerning a petty example, the match. Not two generations have we possessed it, and previous to this brief period we manganists, in point of fire kindling, were very nearly on a par with the lowest naturists.

In a natural state, as we know, people, through laboriously acquired skill, kindle a fire by rubbing together two pieces of wood; in other words, they set free that tension work, heat. The old Greeks used for the purpose the *pyreion*, the under piece of which, called the eschara, contained a bore, in which the rubbing piece, the trypanon or borer, was inserted and then turned by twisting the hands.

Ought not in some hidden corner of the Grecian mountains the pyreion still to be found? It would be very serviceable to bring it to light.

The little fire-chests containing flint, steel, tinder, and threads dipped

in sulphur, which in my earliest childhood I saw used in my home, are examples which have kept their places in spite of the all-conquering match; it would be well to have specimens of these preserved in ethnographical museums.

Later came steel and flint, a physical tension work used for itself. With their help one kindled—and many still do it to-day—the tinder, an easily freed tension work, especially prepared for the purpose and consisting at that time of burnt linen.

On the tinder as soon as it glimmered, was set free a chemical tension work rather difficult to release, the thread dipped in sulphur, and finally with this, a thin piece of wood, but not for a time a coal. For the kindling of the wood alone one used, in succession, four distinct tension works, one physical, stone and steel, and three chemical, tinder, sulphur, and wood.

We now see the match fully in the domain of the former developed principle. The little important fire tool was made by combining three, but soon after four tension works, and is a chemical tension work of the fourth order, formed from the tension works phosphorous, chloracid kali, sulphur, and wood. For the sulphur, as is known, was later substituted in many ways wax or paraffine. But the principle is very plainly recognized; each one of the tension works following one upon another, is more difficult to set free than its predecessor, but was freed definitely, and then through a very easy mechanical action upon the little tension work most highly sensitive, the hair-trigger, brought about the deliverance, as it were, of each of the four obstructions which had caused such trouble, demanding the entire force of one and frequently of two men. That the combination of the four tension works was so recently attained proves that the fundamental principle of the train of thought must have been quite difficult.

We have now, at last, the manganistical principle fully before us, in a common form as well as in the greatest, the examples embracing the most powerful forces, down to the finest and smallest, and we can declare that the method consists: *In the cultivation depending upon a scientific knowledge of the laws of nature, and the resulting higher orders, and those standing side by side, of mechanical, physical, and chemical drive work.*

If the foregoing is developed essentially with a consideration of mechanical technical aims, it permits itself to turn without any compulsion upon the precedency of chemical technology and may, therefore, be found to embrace in itself the entire problem. One has only, for example, to think of a chemical manufactory, etc., and how sulphuric acid enters as a physical and mechanical medium in the colors. As in the above both of the others are side by side with the mechanical.

From the standpoint now gained, if we again consider scientific technology, we shall see how its results are closely bound with our life habits, indeed, with our entire culture. We may overlook the fact that

we are directly surrounded in our dwellings by thousands of obstruction works which have made our rooms safe, comfortable, and convenient for light, air, and warmth. We may overlook this because naturistical labor is able to produce similar, although less perfect, results. But let us notice other things whereby our dwellings have received their character. There is the gas-light in the house, on the street, in the public building. We may thank for it a chemical tension work of the fourth order—fire, retort, gasometer, conduction by stop-cocks, passing by all intermediate works—all of them important, all ramifying through the city pipes. The water for house and street necessity, when taken from a river-water conduit, furnishes a drive work of at least the sixth order. Upon the railroad we move by drive work of a higher order, regulate the powerful service with another, by means of drive works permit freight to be carried on the rails from place to place, from land to land, from one part of the earth to another, a thousand-fold more than a person could carry. Throughout the earth by means of physical drive work we have the messenger service, both written and spoken.

How fare we in war? In millions of chemical tension works, large and small, generally of higher order, we carry the driving force to the distant battlefield and there set it free by means of a high order of drive works.

Upon the ocean we are carried hundreds of miles from land, for weeks and months, by means of tension-work activity.

Rich productions, such as coal, we have gained from nature. The naturistical man early found upon the high mountain range the water course, that running work subordinated to tension work, and very likely the future will bring to light other products, such as petroleum, which we may say was discovered three decades ago. This product is a highly elastic chemical tension work fitted to play its part under a clear flame. In reality it is a combination of two or more chemical tension works, each under such slight restraint as to free itself invisibly.

We had, therefore, to submit this product of nature to a process of separation, according to the manganistical principle, into groups of small parts easily liberated and on which the tension work was first transmissible and generally applicable. Police directions required that if the product were made an article of trade the obstruction (sperrung) should be a safe one; but how favorable has been the result. This fluid tension work discovered, as it were, "ready made" in nature for purposes of illumination, has displaced those products which, by the aid of noticeable manganistical implements had previously been obtained from the seeds of plants. Let us turn to another phase of tension work. The conflagration is but an invisible liberating of a chemical tension work, as is well proved. The obstruction ratchet is raised in opposition to our will with ever-increasing rapidity and the powerful, liberated tension work often overleaps our control, but we bring to bear upon it for the purpose of its capture, another drive work, formerly operated by main strength only, but now usually by chemical tension-

work under the application of drive works of a still higher order. We also turn a chemical tension work, the gas or chemical engine, as the Americans call it, which acts instantaneously upon the water being used. In the last case the drive work connected with the water is of a very low order; this furnishes an example of the manner in which drive works contest for the same intended motion and seek each to gain for itself the palm in lessening the number of drive works, that is, the height of the order number. Everywhere it is the manganistical thought, the manganistical principle whereby we in part preserve, in part make easier, in part defend our life, and whereby we also advance annihilatingly against others.

Our industries, finally, which produce as well the necessities as the manganistical mechanisms, what have they not brought about for culture advancement by means of this same manganistical principle? Here let us venture a little nearer by attempting to apply a measure.

Coal serves us as an essential assistant in manganistical labor. This is now obtained in an abundance of over 400,000,000 tons, the greater part annually converted to industrial purposes. The surplus above 400,000,000 tons suffices to cover heating necessities. So we have for each of the 300 working days of the year one and one-third million tons of coal, which are used for chemical, mechanical, and physical-technical purposes. If we sum up the entire labor arrived at therewith for the sake of the survey of dynamical execution, the results under this acceptation of uses of coal show $1\frac{1}{4}$ kilograms for horse-power in a working day of 12 hours, *i. e.*, $4\frac{1}{2}$ tons per hour during the year, together with the horse. A horse-power, in round numbers, of 90,000,000, statistical numbers and taxes, in fact, would in dynamics yield 20,000,000. For every horse-power must be reckoned the working force of six strong men, which results in 540,000,000 active man-power during a day of 12 hours. It is this powerful executive force which the 250,000,000 of Atlantic nations entirely alone (since the other 1,250,000,000 of naturists have added nothing to it) have accomplished by man through the manganistical principle! When we consider that every tenth one of the 1,250,000,000 men exerts daily such labor as before contemplated, probably a much too high estimate, there results an execution of 125,000,000 man-power. We Atlantic peoples, a sixth of the earth's inhabitants, perform by our manganistic labor more than four times as much as those can execute. The superiority of the manganist over the naturist is attained and reimbursed through useful labor, and thereby also reaches, taken only humanly, its right. This so much the more as our labor execution is transmitted to each of them. I speak of the great, entire development, and not perhaps of its still existing deficiencies, to the extension and under the extension of culture and civilization.

So, then, has scientific technology become the bearer of culture, the powerful, tireless laborer in the service of civilization and cultivation of the races of men, and promises for a long future to add a line of greater results than is at present attained.