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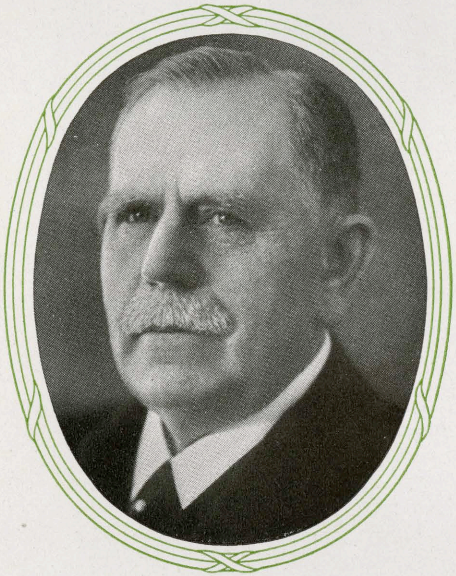
HE MEASURES IN MILLIONTHS

BY JAMES SWEINHART



Carl Edward Johansson

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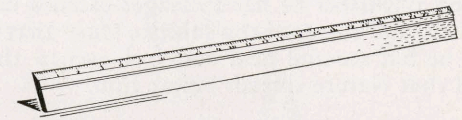


A common ruler is a simple thing. Graduated in inches or centimeters one can be bought for a nickel. Sometimes they are given away as souvenirs. And yet on MEASUREMENT, the science of which they are an expression, is founded the whole Progress of Man!

In centuries of searching of the Past to learn the lessons of Antiquity, History records no time when it does not find man struggling with the problems of measurement, striving to measure accurately, sometimes succeeding crudely, frequently failing.

And yet, for countless ages before that, of which History has no record, Man had the concept of measurement, the idea of Space and the comparative length of different objects within the space. Nature, as revealed to Man by his Senses, forced the concept of measurement upon him! Distance was one of the first words whispered to the primitive mind of Man.

> "*To him who, in the love of Nature, holds*
> *Communion with her visible forms, she speaks*
> *A various language* —"

So run the opening lines of "Thanatopsis"—but the thought which they convey is but half the picture.

Nature indeed speaks—voluminously, on every hand—but so limited in range and power are the perceptive faculties of man that even today, after countless ages of effort, he yet catches but a whisper of her message; catches but a faint syllable, here and there, of the sublime story that would be his could he but see and hear and feel even a thousandth part of all that Nature spreads before him.

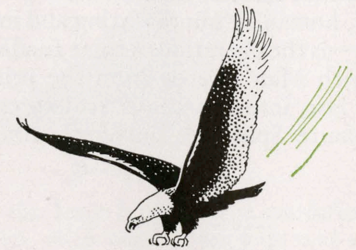
A COMMON house-fly alights on my table. I HEAR nothing. All humans about the room testify that there has been no noise. But in a great Eastern laboratory the tread of a house-fly has been amplified until it sounds like a hoofbeat. Were there no noise at all, there would be nothing to amplify. The noise is there but the human ear cannot HEAR it.

Night falls. Our faces are upturned in wonder at the sky. We know a few of those starry lanterns there and point them out. Between them, all seems dark, empty. But look through a telescope! There, between two favorite stars where all seemed dark, a thousand flares are burning. There they have shone for ages unknown to humankind. Man's eye could not perceive them.

Or, looking down,—upon my desk lie a bit of polished granite and a square of polished steel. The fingers like to feel their exquisite smoothness. Dead matter! But put them under a microscopic lens of great power! The surfaces now are seen as rough as a rubber-sponge. And something there is moving, writhing, twisting. Life is there, but the human eye cannot SEE it, nor human touch sense it.

Again! Here upon my finger is a bit of talcum. I cannot feel it. From it I get no sense of weight. But scales exist

which will show precisely that the tiny speck of talcum weighs four 200,000ths of a grain. In the particle are mass and form and weight. But the human touch cannot detect them.

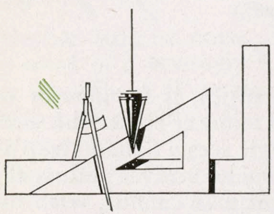


THUS man, in his perceptive faculties, is far inferior to many insects and animals. The reindeer scents the wolf miles distant—man cannot. The eagle sees a Salmon leap at 2000 yards—but man cannot. The spider weaves and works with strands so small and light that man cannot, with his fingers, weigh them—so delicate that man's slightest touch tears them asunder. Henry Fabre, one of the greatest students of insect life the world has known, once said that the rain will wash away the mountains before man attains the wisdom of the ant.

A stupendous contrast there—the amazing lavishness of Nature's fascinating unfoldment confronting man's limited means and power to perceive! But there is another factor at work in the situation—that is the insatiate longing in the heart and mind of man to see, to hear, to read and know the very heart of Nature; to understand, and with understanding, to combine, to co-ordinate, to CREATE!

Nothing else that lives possesses THAT faculty to anything like the degree that it is instinct in Man!

Is there not THERE something for earnest contemplation? Could we but read the very heart of Nature might we not find that that triple combination—first, Nature's infinite field of exploration; second, the limited capacity of Man to perceive; third, humanity's unremitting and insatiable thirst for knowledge—is the operation of some fundamental law of Nature by which Man ascends from the primeval wastes, developing, at last, into a more perfect expression and symbol of the Infinite Spirit? A universal, limitless Law of Aspiration?



CONSCIOUS of the inadequacy of his physical senses, but whipped on by his desire to learn to the uttermost, Man has again and again devised means outside his physical self to help him in his approach to Nature—the sound, to measure the deep; the plumb, to attain a straight line; the prism and lens, to guide light; the square, the angle and the triangle to measure the circumference and area of many-sided objects; the telescope, to measure the heavens; the miscroscope, to watch the minute operations of Nature in her smaller forms of life, and a host of other devices and instruments. But always, eventually, their limit of use was reached. Always came a question of extension or refinement. Always, confronting, arose the inescapable problem of smaller and more accurate measurement. In many different branches of his explorations and investigations there came into being an unwritten but un-

deviating law that Man's knowledge advances to the degree that he can measure precisely.

THROUGH the long lapse of the centuries of which we have record, with what passionate zeal and courage has Man applied himself to KNOW Nature! We can only conjecture how it started—but perhaps in the long nights when he watched with wonderment the seeming movement of the stars came the first stirring of the mind asking "How?" and "Why?" Gradually came the power to discriminate, compare, reason. Forty centuries before Christ the Chinese, the Chaldeans and the Mayans were seeking the cause of the apparent flight of Sun and Moon. Thirty centuries before Christ the Egyptians were building the Great Pyramid of Gizeh, with a structural and astronomical knowledge that makes the modern world marvel. Twenty-five hundred years later, with the Christian Era still five hundred years off, Pythagoras, a Greek, had caught the idea that the Earth is round and rotates. For his pains his fellows burned his house and drove him into exile.

He is the first scientist, in the modern sense, of which History has record. He first dealt with geometric forms and studied the use of the angle. Even in those far-gone days he emphasized to those who would listen the supreme importance of accurate measurements. He, so early, had already known the bitterness of being able to sense the next step in his investigation, but unable to make it, and prove it, because his powers of measurement were too crude.

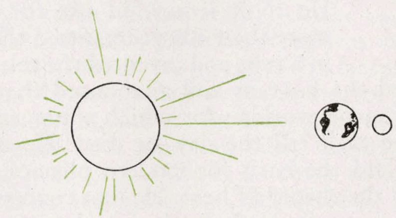
FROM Pythagoras on the growth of science follows one of Nature's designs. It is like a tree. From the seed, a trunk; from the trunk, limbs; from the limbs, branches; from the branches, twigs—each, in its turn, making the next extension possible. So with science. Man's DESIRE TO KNOW is the seed. From it grows the trunk on which all scientific knowledge is based—MAN'S UNREMITTING LABOR THROUGH THE AGES! From this labor knowledge has spread in many different directions—the LIMBS. Each new discovery along the different lines makes possible another discovery or attainment—the BRANCHES.

Thus man, in his search for knowledge climbs a ladder, the rungs of which are his discoveries—a ladder whose base is planted in the inscrutable mists of antiquity; its top—who can tell?

This eagerness for knowledge has expressed itself in many different forms—efforts to wrest from Nature her secrets in the physical, chemical, magnetic and electrical fields; strivings for perfection; search for the absolute, for accuracy, for truth, for an ideal. Called by many different names, it goes

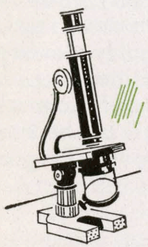
on throughout the ages. On and on and on, with limitless patience, in spite of handicaps and obstacles; in spite of lack of tools and materials; in spite of poverty, hunger and cold; on and on in spite of mountainous prejudice and injustice; in spite of the attacks of ignorance and superstition, of statecraft and church; on and on, in spite of persecution, imprisonment, exile, death in the dungeon, at the stake, on the rack! On and on and on! Can it be otherwise than that this indomitable urge for knowledge in the heart of man partakes of the Divine?

After Pythagoras came others who, in thought or deed, stamped themselves upon their times. Euclid took Pythagoras' knowledge of the angle and, with it, first investigated space, laid the foundation for geometry and mathematics, investigated the heavens. Two hundred and fifty years before Christ he studied force at work without motion (static) and gave the world the laws of the lever and pulley, developing any desired power. From studying the inclined plane he evolved the "Archemedes Screw," a vital part of the mechanism of the "Industrialized American Barn" in the Ford Motor Company's exhibit at the Century of Progress Exposition.



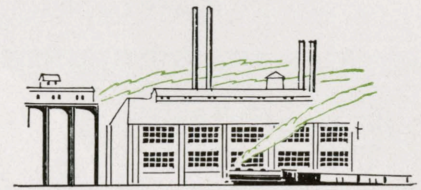
SOON after Archemedes, Hipparchus took Pythagoras' angle and Euclid's mathematics and computed the distance of the Sun and Moon, laying the foundation for celestial measurements to come centuries later. In Hipparachus' time cultural civilization was already decadent. Rome soon went crashing down, bringing an era of world confusion. Science was forgotten. Then, after 1500 years, men began to be interested in the arts, in literature. Soon science had a new birth—and there emerged one of the great intellectual mile-posts on man's long journey—Copernicus.

Reaching back to the already ancient calculations of Hipparchus, Copernicus went on and proved that the Earth rotates once daily on its own axis and moves, yearly, around the Sun. He gave mankind its first glimpse of the infinity of the universe. For which colossal contribution to human knowledge the powers of his time burned him at the stake.

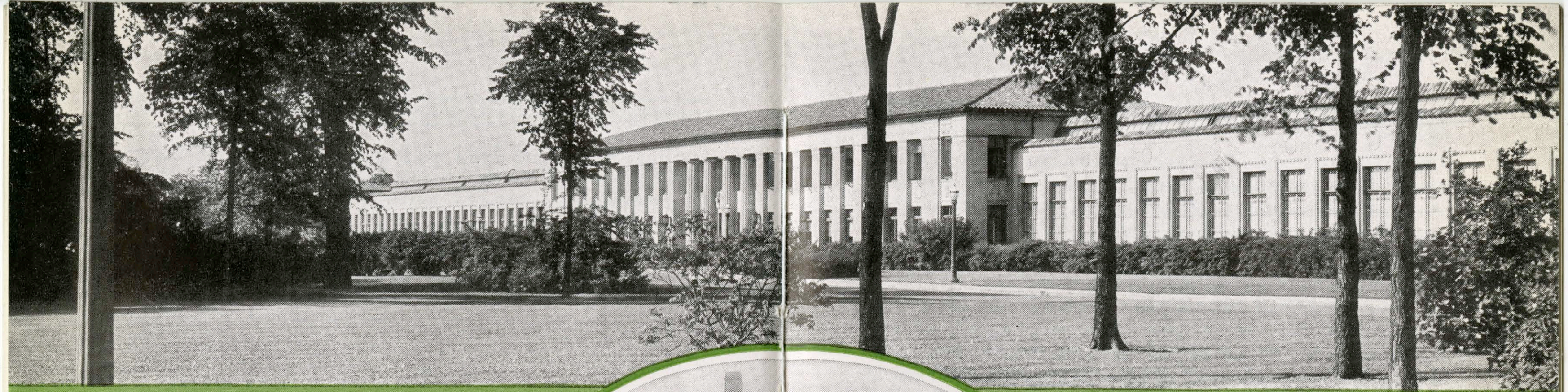


But Gallileo, 50 years later, began where Copernicus left off and went vastly further. From this mind spring many different branches of modern science. He took lenses, in use for reading for more than 300 years, fitted them together in a tube and invented the telescope. With it he watched the heavens and announced that this Earth is but one of many worlds—for which statement he was in danger of the rack till the day he died. He invented the microscope, laid the basis for modern physics, mechanics, acoustics and the theory of heat. He first conceived air pressure and was first to investigate the tensile strength of many materials. Soon thereafter came Kepler, proving Copernicus' theory, laying the foundation for Newton's discovery of gravity; Pascal, who proved the pressure of air which

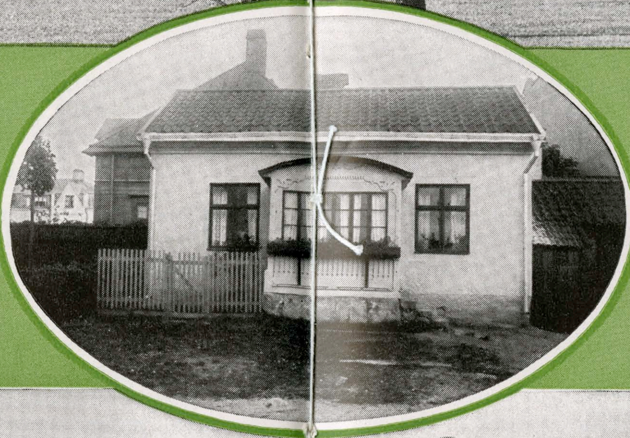
Gallileo sensed and Snell who, going farther with Hipparchus' angle and Euclid's mathematics laid the foundation for all modern surveying and first measured the refraction of light. So it went on through the centuries, each searcher mounting higher on the work of another, each creating a new epoch in human knowledge—and, oftimes, succeeding only to that degree that he was able to refine his measurements.



Finally history gives us the name of James Watt. He literally changed the face of the earth—for he, applying principles which he got from others before him, invented the steam-engine, gave the world steam-power, laid the basis for large scale mechanical manufacture. Before him some of the world's work was done by water-power or power applied by the horse, the ox or the camel—but the vast bulk of the world's manufacturing was done by hand, in the home. But, with Watt, came the factory. Great industrial centers began to evolve. A tide started moving from the farm to the cities, and the land, stripped of manufacture, was left to agriculture. Man had taken his first step toward modern mass production. Then, as never before, arose the need of accurate measurements. Mechanical manufacture, steam-driven, in a thousand different forms was evolving. In a new and stupendous way mankind was confronted by need of accurate measurements in many varied forms.

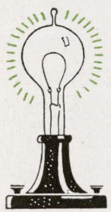


Above are the Engineering Laboratories of the Ford Motor Company at Dearborn, Michigan. Here, under ideal conditions, Johansson Gage Blocks are produced for North and South America.



At the left is the home and workshop in Eskilstuna, Sweden, where Mr. C. E. Johansson developed his first set. *Below* is the Johansson factory in Eskilstuna. Milestones in the growth of industrial accuracy.

Every advancement of science creates a new need. In filling the new need, man finds a wider field for his employment. With the great populous centers and quickened tempo of life brought by steam power there came a new need for quicker, better transportation, faster communication. Lo, Nature had already prepared the way. For, along with their studies of force, static and in motion, astronomy and chemistry, Scientists had been passionately trying to grasp the nature, meaning and use, first of magnetism and then of electricity. Galvani, Volta, Ampere, LaPlace—a long list of earnest searchers had accumulated a vast store of knowledge. The world now saw the evolution of the steamship, the railroad, the telegraph, the cable, the telephone.

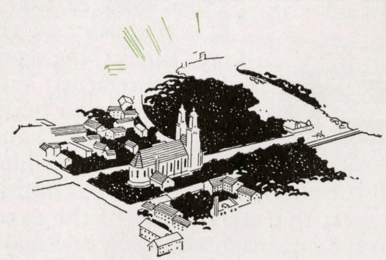


AND in the sky of science looms that marvelous star—Edison! He gave all humanity a constant, dependable, efficient light. He showed the world how to distribute electricity for a thousand uses in home, factory and office. He devised a machine that registered and then resounded the human voice. He invented motion pictures. He put electricity to work in the chemical world in literally thousands of different uses. And from each of these inventions, great new industries sprang into being. He, too, changed the face of the Earth.

The population of the civilized world had been increasing steadily. On the heels of invention came a tide of human needs such as the world had never known before. In all branches of industry in which the product is used by the individual the demand began to be numbered in millions.

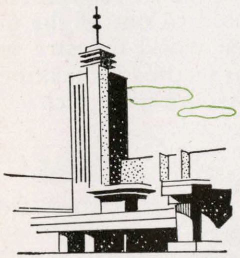
Millions of persons wanted electric lights, phonographs, telephones, tools, typewriters, toys, sewing machines, skates, guns, bicycles, watches, cameras, musical instruments, electric heaters, curlers, toasters and other equipment. A new urge had touched the blood of humanity—speed, volume, mass-movement. The world began to hear about "division of labor," about "mass production."

But there was a bar that blocked the way. In a great many of the manufactured articles, even in the crude form of their first presentation to the public, again smaller and more accurate measurements were required. Man already had equipment to do this slowly—but to do it rapidly was, as yet, out of the question. Then, as competition led to greater and greater refinement of all manufactured products, the problem of fine measurements steadily increased to one of the first magnitude. There came a time when world industry was being throttled by lack of some quick method for making a measurement so fine as one one-thousandth of an inch.



ONE day a youth in a little Swedish town, harrassed by the delays in the work of his lathe, determined to solve that problem. He had caught an idea of how it might be done. With the patience and earnestness worthy of some old master he persevered against all delays, disappointments and handicaps; all obstacles, all discouragements. And after years, he succeeded. Today in thousands of industrial plants scattered over the Earth workmen can make, in almost the twinkling of an eye, a measurement as fine as two one-millionths of an inch! In the long progress of man's advancement, the Swedish youth, also, did his part, in his time, to change the face of the Earth.

For he evolved one of the basic factors that make modern refined mass production possible. Before he fashioned his gages the world had fine watches, automobiles, machines and instruments. But it had them only in thousands; it required too long to manufacture them. Today the world has them in scores of millions.

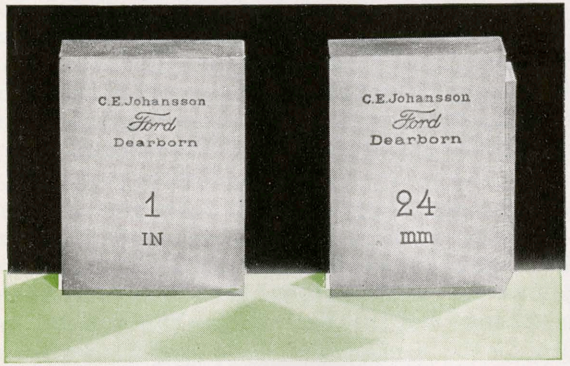


THE story of that achievement is the story of the Johansson Gage Blocks, the world's standard of measurement. Visitors to the Ford Exposition building and the Hall of Science at the Century of Progress Exposition, see a display of the blocks. It is in General Exhibit Building No. 5. There is nothing about the exhibit to suggest that a vast part of the exposition could not have been the fine machines, tools and instruments they are had there been no Johansson gages. The Ford automobile, for example, has 31 points of contact in which tolerances of less than three 10,000ths of an inch are required. Today's Ford car could not have been built in volume 25 years ago.

That the average person, unused to the ways of the laboratory and the tool-room, may see clearly the function of the Johansson gages and their stupendous significance to humanity, let us consider, for a moment two of the basic requirements to be met, apart from the exceedingly delicate and difficult task of the actual making of the blocks.

The Ford Motor Company is an excellent example of an industry manufacturing a product for world distribution. Cars and parts made at Dearborn and other points in the United States and England are used in all parts of the world. There are wide variations in temperature between the place of manufacture and the place of use. This makes a serious problem for the manufacturer. Most people know that heat expands metals. In the laying of railroad tracks, for example, a small space is left between rails because, were no such space left for expansion, the rails, lengthening slightly under the summer's sun, would "buckle" and tear loose from the ties. The automobile manufacturer must take account of this phenomena—otherwise parts made in northern temperatures would not fit in the tropics and vice versa. So, for years, the automobile manufacturer could not build motors of extremely fine adjustments—a certain amount of "play" or "tolerance" had to be left in pistons, connecting rods and other points of friction to allow for this expansion due to heat.

This formed Johansson's first problem. A metal inch made in Sweden was slightly greater in length in warmer parts of the world. He met this situation by deciding to manufacture all his gages in a temperature of 68 degrees and then working out calculative adjustments making them applicable to manufacture in any temperature.



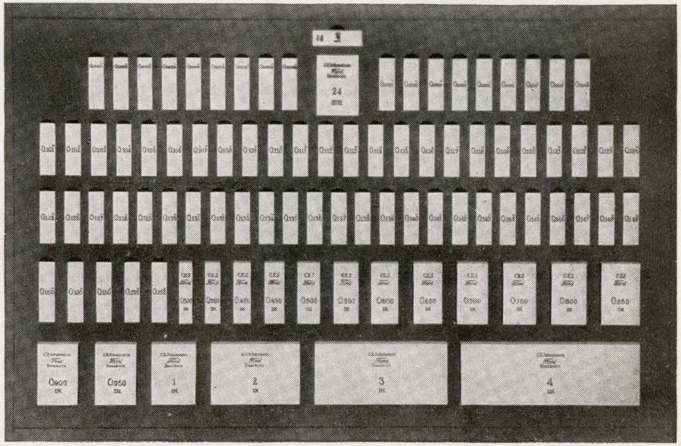
His second problem was that all the world does not measure with the units of the English system—the inch, foot and yard. A good part of the world uses the metric system, with the meter divided into 100 centimeters and 1,000 millimeters. After Johansson, by tireless efforts, finally got the industrial world to agree on an international adjusting temperature, he next achieved international acceptance of 25.4 millimeters and 1 inch as equal lengths, for all practical purposes, and thus made his gage blocks convertible from one system to another. This made them serviceable the world over.

The gage blocks are rectangular pieces of tool steel, hardened, ground, stabilized and finished to an accuracy one, two, four or eight millionths part of an inch according to requirements. In developing them and making their use available to general manufacture, Johansson produced something of which there is no counterpart in science or industry and did that which, up to his time, was believed

beyond the reach of Man. He made available to the use of humanity a precision that knows no parallel, and, practically, no limit, on a thoroughly practical and economical basis for widely varied craftsmanship.

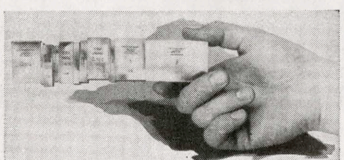
So exceedingly fine were the requirements, if his gages were to be of standard use, that Johansson knew he must perfect a special steel for his purposes. He did so—teaching the metallurgical world something unknown before. By special processes developed by himself he achieved a metal in which, when finished, all internal stress and strain is relieved. In a way the molecules may be said to be at rest or in equilibrium and warping or "growing" is very definitely checked.

His next problem was to approximate the absolute in attaining flat surfaces in steel. Two absolutely flat surfaces,



if placed together, will exclude all light. A prism, placed on either, would deflect no light upward and show no color. For generations the attainment of such surfaces in steel had been believed impossible. Johansson produced flat surfaces, with an extremely high finish, having the appearance of burnished silver, which more nearly approach the perfect plane than any other surfaces produced by the hand of Man.

These flat surfaces when thoroughly cleaned and slid, one on the other, with a slight inward pressure, take hold, as if magnetized. "Atmospheric pressure," "molecular attraction" and "capillary action of a minute film of oil on the surfaces" have been offered as explanations of this phenomena. Possibly it is a combination of all three, but certainly the result is surprising. In a demonstration before the Stockholm Technical Institute in 1917 Johansson "wrung" two blocks together, the sizes of the two surfaces in contact being approximately one-half a square inch—and the contact sustained a weight of 220 pounds! This weight was more than 30 times the atmospheric pressure present during the demonstration.



MODERN science cannot explain, as yet, the reason or mechanics of that terrific adhesion. Perhaps, Johansson, having nearly attained the absolute in flat surfaces, has

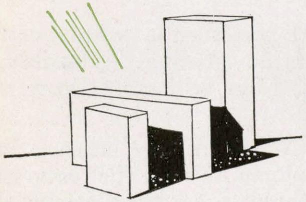
released to mankind the initial secret of a whole new "limb" on the "tree of scientific growth." Possibly, from this, 100 years from now, Man will erect "towers unto heaven" without mortar.

With the aid of these gages Man can now measure in terms 15,000 times finer than a human hair! In the realm of measures, at least, he can now begin to get the message of Nature. Only the future can reveal the amazing things that will develop as science, in all its branches, takes up Johansson's contribution and makes full use of it.

Carl Edward Johansson has, this year, reached his full "three score and ten." He was born at Frotuna, in the parish of Gotlunda, Province of Westmanland, Sweden, on March 15, 1864, the son of Johan and Carolina Rask Johansson.

Having finished the grades in the public schools of his parish he came to America, in 1882, and spent two years in study at Gustavus Adolphus College at St. Peter, Minnesota. Returning to Sweden in the summer of 1884 he worked for a time at the Beronius Mechanical Works at Eskilstuna, which is also the seat of Sweden's government armory, Carl Gustavs Stads Arsenal.

For several years he studied at a technical school and eventually was employed at the arsenal. The government authorities, recognizing his ability, placed him in charge of making special machinery. Although the shop was equipped with the best measuring devices of the time the results obtained were so divergent that Johansson recognized here was a field of effort that would bring the most far-reaching effects. There was no machine, tool, instrument or apparatus that would indicate correct, accurate measurements that could not be disputed.



JOHANSSON, as a beginning, used a small block of steel whose accurate dimensions had been tested by every known means. As a check for their tools the block proved very handy to Johansson and the men working beside him. It gave him an idea—why not a series of blocks of varying, known, exact dimension? Johansson began making them in different shapes.

Sent to Germany to study arms manufacture, Johansson, at the Mauser arms plant at Oberndorf, saw solid, block gages similar to those he had made. But they were gaged to a size equivalent only to the required measurement to be taken in making the different parts necessary in the manufacture of rifles. Johansson went back to Sweden with the firm conviction, for the first time, that if he could work out a practical series of blocks that would give any differential of measurement desired, he would do an immeasurable service for all manufacture, industry and science.

The story of his efforts for the next several years, the obstacles to be overcome, the failures and disappointments and his final triumph would make a great book. In 1896 he brought out his first series with which, in combination, he could measure, within the limits used in manufacture, any imaginable size in terms of millionths of an inch.

In 1911 he left the arsenal and gave his whole time to manufacturing his series of blocks on a commercial basis and, slowly, they came into general use throughout Europe. In 1923 he came to the United States, to begin manufacture here, but here he found another man deeply

interested in fine measurements and the solution of the problem of introducing their use in mass production—Henry Ford.

Ford had given the world its greatest demonstration of the "division of labor" and "mass production." The results had been startling. He was making automobiles at the rate of one every nine seconds! He had already made more than 1,000,000 in a single year and was by far the world's greatest producer. But he had this in common with Johansson—an insatiate desire for refinement of his product and improvement of its distribution. A mechanical genius, he loved things made with precision. He was constantly striving to improve his car and had already found that co-ordination of fine measurements and mass production was a knotty problem.

And then Johansson came along. He explained his precision gages and their adaptability to industry. Ford saw at once the vast significance of Johansson's accomplishment. The two men talked—with the result that, shortly, the Ford Motor Company had a new division—the Johansson Division, making Johansson's Standard Gage Blocks for the North and South American fields of trade, and with Mr. Johansson in charge.

Johansson, with his gages, went far toward filling the demand of the ages for measuring with exactness in a thousand different fields of human activity.

With his gages Ford puts out an automobile within the reach of every family's pocketbook but which runs so smoothly and sturdily because, at 31 points, the measurements used in its manufacture are as fine as those used in the making of a watch! In the whole automobile world the Ford car has no equal for painstaking, sturdy construction.

And because of the union of effort of the two men the lives of millions of human beings are richer!

FORD MOTOR COMPANY

DEARBORN, MICHIGAN