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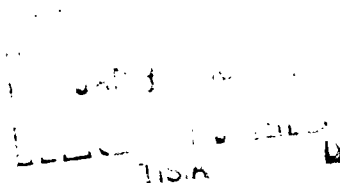
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CUTTING TOOLS, FIRE, WATER, POWDER

By

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Cutting Tools, Fire, Water, Powder

by

B. Zubkov

Rapid development is being acquired by such machine constructions, which assure high technical properties, will lead to a reduction in the consumption of raw materials and energy, to a rise in labor output

From the Program of the Communist Party USSR.

Is it possible to make an original metal processing machine from an ordinary file? Yes it is possible. And it is not too difficult. It is a common tool, the velvety filings from which were kneaded between the fingers already back in the school workshop, it can be simply bent into a ring. A skillfulless operation! and yet it is equipotential to the most technical revolution.

The fact is, a file, bent into a ring, can easily be fitted over the shaft of an electric motor, and in our plant you can obtain something in form of a grinding stone, but a metal one, with cuts. After this the tool can be clamped in vices and with the aid of a screw-worm gear bring the vices with detail close to the round file, or remove same. The tool with one jump will become transformed into a machine with mechanical transmission and electric motor. It is easy and useful to build such a small machine in your own workshop.

The main factor here is that we have freed the worker's hands from holding the tool.

But it is far from just so simple to create new things in technology.

Its laws are just as objective, as the laws of nature. They were not just created by the fancy of the engineer, they were discovered by men in the process of laboring. In time the old technical principles, based on these laws, promise no greater perspectives for use on the new industrial level. Engineers and scientists are trying

to get behind these laws ,capture them by trick. This is particularly clear by the example of "classic" metal processing methods.

Cutting Tool-Rocket

Engineering cunning begins where a simple mechanical increase in machine dimensions begins, where a rise in speed and power of the machine begins. The real cunning- when the restless engineer-discoverer says: "This is not all so! it all has to be done in a different way "; the words "entirely different" sometimes become useful for this purpose.

We all know that a cutting tool has to be cooled. And to cool, we pour liquids emulsions, compiled by skillfull prescriptions, a cooling oily fog is passed, special pumps are set up. Not very long ago, the first metal treating processes in history treatment on a machine has come to being... the furnace. Electric induction furnace. True the furnace heated not the tool, but the detail, namely in the place ,where the cutting bit of the tool bites into it. The high frequency furnace was moved together with the cutting tool, and over the round detail following the furnace ran a cherry red annulet of red hot metal. This is a new and reassuring experience- the entire red hor metal is softer, wear of cutters lesser, meaning that they will serve for a longer time period, even without such a primary and unchanged cooling.

On an ordinary lathe the cutting tool removes the shavings at a rate of 50-60 meters per minute. High speed laborers brought up this rate to a dizzy number of 1000 and more meters per minute. But now we have the rocket and atomic technology. It required refractory, light and ultrahard hardly machineable alloys-titanium, vanadium, tungsten. And again revolutions of machines have been slowed down. Not with the speed of a fast train, but in lazy curls crumbs of metal the chips came to a slow crawl. And here the gaze of the engineer-cutter came upon the very same rocket, on account of which he blunted and crumbled his cutting tools. The engineer was suddenly attracted by the present day cosmic velocities. A non-subjugated ,too hard detail, on which the teeth of threaders and drills have already been broken

were harnessed...in a gun. At the mouth of the weapon was fastened the cutting tool. Shot is fired...The detail striking the cutting tool, let out a piercing scream . Then the detail was secured in stationary position on a massive concrete plate and the cutting tool was adjusted to the tail...of the rocket. More accurately, to rocket sleds ,on which models of supersonic aircraft are tested . The rockets screamed with a rocking motion they entered the rails, over which the sleds became accelerated, and with a full, truly cosmic, speed the cutting tool bit into the detail.

drawing

drawing

As long as these are only experiments and it is difficult to imagine future machines-rockets and details-sleds, but the test results are paradoxical. It was found that at cosmic velocities, measured in thousands of meters per second, the cutting tools wear surprisingly little and remain practically unheated. Why then ? An unsolved secret of metal processing !

And still another secret. The cutting tool was irradiated (bomarded) with ultrasound. After this its durability rose by eight times ! Once more, why ? Scientists investigated the metal of the cutter, examined the crystals of the metal under an electron microscope and found no changes. But the present fact is that the tool becomes much more serviceable (greater service life), and technicians are hurrying in making use of same, without waiting for theoretical explanations.

As long, as you see, there is still powder in the powder horn, it would appear, everybody knows that machining of metals by cutting will for a longer time surprise us with its secrets and findings.

Powder Cuts and Presses

All this - are just roundabout maneuvers in the struggle with the nonsubdued metal. It is necessary to make a thorough search, to work out a plan of a principally new strategy, for decisive action.

In this respect the metallurgist turned to the chemist.

I have been expecting you - said the chemist - it is about time! you have been carrying around your cutting tools, you have totally neglected my test tubes. I can present you with the recipe of the substance, which has always become disintegrated, but which should and can construct. Take a look at this black powder. It will replace the flames of heating furnaces and the power of milli-ton presses. It is a powder. Yes what will you do if you don't pay attention to it.

The metallurgist took a handful of the powder and went back to the factory. The suggestion of the chemist tempted with its simplicity. But, not being able to immediately

get away from the primary cutting tool, the metallurgist adopted a compromising decision and created a construction which combined the force of the explosive with primary cutting tool. In this way came to being the invention by a group of soviet engineers - the explosive knife. The peculiar metallurgical ax - knife for cutting metal ingots were provided with connecting rods and piston. The piston fitted closely in a massive cylinder. Between the bottom of the cylinder and the piston was placed the explosive charge. Now the mode of operation of the new shears for cutting metal looked as follows: button-electric contact-ignition-explosive-explosion! the piston moved down- the knife cuts the metal in two parts.

Without thinking too much the ax with piston were adjusted for cutting thick sheets only. And with sheets of ordinary thickness the process became even more simple. The explosive was placed exactly along the line of cut. And that is all! Explosion replaced the guillotine shears.

To cut - still does mean to machine. The cut sheet or strip in best case only a billet. But from under the dies of heavy duty presses come out actually ready made details. And the explosive moved even farther ahead, it even eliminated the press from operation. Sheet forging- one of the most progressive and high yield types of metal machining processes. This is what the chemical energy of explosion did! it began immediately with large size details: covers for chemical towers, bottoms of petroleum reservoirs, gas holders, boilers. For this ordinary hunting gun powder is suitable.

For example, as a mold for a spherical boiler bottom was a ferro-concrete plate with an indentation in accordance with the form of the bottom. On the plate was placed a metal sheet and then covered with a ferro-concrete cover. Under the lid (cover) were placed not too many grams of the powder - 50 - 100 grams. The expanding explosive gases bent the sheet, upsetting the metal in exact form of the indentation.

Do not think, that in the workshop because of this "explosive puncher", the noise of the explosion become unbearable . There is no such thing, you hear only a dull impact and the safety conditions are here quite simple, step aside, the powder will do the whole job, without your help.

And so, a one hundred gram cluster of powder has replaced the cumbersome, in size of a good house, press, developing a power of hundreds and thousands of tons !

The explosion can also reinforce details. Right now for such a reinforcement the detail is filled (shot) with cast iron shots or rolled with rollers. The surface layer of the metal is compressed under the impacts of the shots or under the pressure of the rollers, it becomes harder, stronger. But what is the shot expenditure in this case, what kind of complex and accurate units have to be constructed for this purpose? the new type of explosion has solved the problem of hardening, it reduced the operational time to a thousandth fraction of a second. An explosive layer is placed all around any large size detail, e.g. a crankshaft of an engine, and a percussion cap is used in detonating the explosive layer. By the force of explosion the detail is immediately compressed (upset) from all sides, the microstructure of the surface does change, it becomes hard, submitting to no abrasion in bearings. This method has already passed laboratory tests, waiting for a turn now to be widely introduced into industry.

Powder has begun cutting, forging, reinforcing. It can be used for drawing of wire, manufacture of pipes. Powder can also cast details. Powder casting...it is no casting at all. But details are being obtained ,actually, like casted ones. You have no doubt heard about powder metallurgy. This is a perfectly original process, used

as a technological tool for a short time only. Fine metal powder is pressed together into details - bushings, bars, tumblers, almost into anything desired. The detail is then placed in an induction furnace, the furnace is filled with inert gas, so that the detail will not become oxidized, and it is baked.

drawing (page 12...bottom)

The powder becomes sintered, the detail acquires the strength of a monolith.

Now it appears, that the ferro-concrete dish is filled with a uniform layer of iron powder. Over the iron powder - explosive. All this is covered with a ferro-concrete plate...Explosion! The gases press the powder, forced against the walls of the dish the liberated heat sinters the particles of the metal. A metal shell exactly in form of the dish, ready detail is obtained. Gun powder from the metal powder! The energy of explosion has not only replaced the heat of the furnace and mechanical forces of presses and stamping machines, it took up the task of working, pressing by 10000 times faster, than these machines. What more qualitative changes, what more revolutionary transformations is modern technology capable of!

High Speed Chemistry

Chemistry is rich not only in one energy of explosion. On a copper paddle, drawn by a quartet of copper horses, which is displaced in front of the Bolshoy Theatre in Moscow, rode in into the world of industry-galvano-technique. It happened after this, when in 1840 a member of the Petersburg academy, Russian physicist Boris Yakobi published his first in world manuscript: "Galvanoplastics or a method which in a certain way produces copper objects from cupric solutions with the aid of electroplating". The statues and bas-reliefs of the Isaakiev Cathedral, wheels and horses of the Bolshoy Theater have become a memory to the creator, inventor of electrochemical processing Boris Yakobi.

drawing

One hundred and twenty years in baths with cupric salt, silver, iron, nickel and chromium solutions, metal layers deposit on sheets, strips, wire, on various art

objects and items. The coatings are thin, ranging into hundredths and thousandths fractions of a millimeter. The process is not a hurried one. Metal ions float in the solution. The greater the number of ions the faster to they float around, the greater is the current in the electrolyte, the faster are deposited on the cathode nickel, chromium, silver coatings. They ordinarily work with small currents - two-three amp per each square decimeter of cathode-object. Much more is used when the operation goes up to twenty [—]thirty amperes. It is everywhere customary and legal.

Electrochemistry can grow metal atoms on any electroconductive surface. Or, vice versa, remove, [—]scrape off these atoms. Current carries off electrons from the surface of the billet, transforms the atoms into positive charged ions, which dissolve in liquid electrolyte. The electric current as if scrapes the metal. But at what a rate? How will you scrape under current at a pair of amperes per square decimeter. Is it necessary immediately to start with a thousand...no twenty thousand amperes. Is it necessary to employ a trick so that the electrolyte will not boil up in a violent gusher, will not run out from the bath, like boiling milk, is it necessary to carefully change the batches of the solution, pump in and remove same by a reliable pump. Electrochemists have become high speed operators!

To obtain detail, assuming of the most fantastic form, billet-anode - are placed between electrodes-cathodes of corresponding configuration. The electrolyte under pressure is run between the billet and [—]electrodes. As the electric current dissolves (melts) the metal, giving it the necessary form, the electrodes are brought closer and closer.

Results! Stationary bath with quiet liquid has transformed into a fast acting unit! The stream of the electrolyte in the plastic bath scrapes and polishes turbine blades within five minutes. Ordinary polishing lasted two hours.

The rapidly flowing solution of metal salts became here the heir of the file, and an energetic heir too.

A Television Set Cuts Metal

Vladimir Il'ich Lenin said: " it is not enough just to understand, what electricity is : it is necessary to know how to technically apply same in industry, agriculture etc...."

A whistling and hissing steam engine has one upon a time plugged up workshops with a web of transmissions. The power of steam was poorly broken down into components. It is impossible to built to each machine even the smallest steam locomobile. That is why many belt transmission have been suspended from the air. What has the fractionation of electric energy provided machine constructors with? Not only for each machine but to each individual unit of same they have succeeded in attaching an independent electric motor. The electric motor has slowly replaced, forced out other driving modes and became the core of mechanisms. They have succeeded, for example, to equip each conveyer-roller with an individual electric motor.

But this was only mechanical, philosophers would say- quantitative fractionation of energy and first timid approach to the point of direct action on the machined detail. But in 1943 the Soviet inventor and scientist B.R.Lazarenko was the first one in the history of technology who succeeded in directly prodding the metal with an electric spark . A qualitative jump was made, a new principle of metal cutting has been found. The truth is, electric energy from the power source of the motor was transformed into the very power, which penetrated directly into the cutting zone.

With the aid of electric spark soft iron wire cut, as a twine cuts butter, a plate of tool steel. A brass button made a copy of itself from superhard alloy. Very small sparks beat tungsten molecules, and this is the most hardest metal yet it gave way to the pressure of a brass disk.

In spite of the fact that the spark became the tool directly chiseling on the metal, the old methods still remained means of processing. It was necessary to have a cathode, made in shape of the future item, i.e. nothing in form of the traditional

die matrix. The electrospark jig saw - sparking wire-wore out intensively. Further more thorough search was instigated in the world of electrical technology.

And from the pedestal of pure science came into the workshop a  beam of elementary particles. Engineers came upon an idea to create an electron microscope for cutting of metal...From it they took all the basic components. First an electron gun, cathode of red hot tungsten spiral, emitting a stream of electrons. Secondly, magnetic lenses- coils of wire, wound on massive iron bobbins and producing the magnetic field, which concentrated, and focuses a beam of negative particles. The beam, like bees sting the skin, penetrates the metal, like a solar crest from the "igniting glass", melts same.

The ^{density} of the energy in this place, which is being bombarded by electrons, reaches fantastic magnitudes - 100000 kw per square centimeter. But this is far from the limit. The temperature in the machining zone is solid - 5000 degrees. But the electronic scalpel is so well sharpened, the beam of electrons so well focused, that already at a distance of only one micron, the temperature is already fully tellerable, only 2000 degrees.

The electron-ray gun mills and drills micron size holes in hardest materials- quartz, tungsten, zirconium. It welds together the most unweldable materials, suitable in the processing of microminiature objects of cosmic electron equipment, for which ordinary metal cutting machines are too awkward.

In an electron ray machine electricity is the master, it furnishes the installation with power, it carries out the role of tool-stinger, it commands, controls, and stores (memory) the drawing. Here is also easy to control the beam, as in a modern TV set. The beam is, naturally, the same, but its power is different. No wonder that once for testing on a steel plate a TV image has been engraved.

And so, any kind of ultrapowerful televisior does cut metal. What is the perspective here! The machine itself reads the blueprint and without any aids from technologists, adjusters, tracers it draws accurate lines from the bluepring in the sonorous

elastic metal. The higher degree of automation, the actually deserving application of electric energies of better qualities to the needs of machining materials.

Magnetic Field Die Forging

Some new principles are based on the physical phenomena, which have been observed a very, very long time ago by our predecessors. Let us recall just a simple experience preceding the acquaintance with initial school physics. On a veneer panel were dusted iron filings and they were placed on the poles of a cheerful red-blue magnetic horse shoe. The filings, like alive, arranged themselves on the veneer panel, forming an ingenious, shaggy moustache pattern. The magnetic field directed, formed in space particles of the iron... Does it not appear to you, that in here is hidden the possibility for a newer method of metal machining?

The truth is, not very long ago came to being magnetic die forging. Metallic sheets or rods are surrounded by a spiral, connected with a source of electric current. The powerful magnetic field, excited by the spiral-solenoid, bends rods, presses out (extrudes) from sheets hemispheres and ripples. True, the solenoid windings are compressed by the forces of counteraction, which can destroy the coil. Nothing you can do about, any action causes a uniform, but counter action. A way out has already been found. The spirals should be made of single action, cheaper, of the price of a copeck. They broke up into small parts after one operation - nothing awful.

The horizons for searching for newer and newer principles of die forging, cutting, welding, grinding, are inexhaustible. They are waiting for the discoverers. Here is but one example of similar inventions.

The hydroerosion method of machining opening, by observing the falling of rain droplets. It was noted that the skin of an aircraft is exposed to erosion-cracking from the impetuous collision with streams of rain. Already at a velocity of 1 km/sec the stream of water makes a noticeable indentation in the solid steel. To strengthen the hydroerosion effect it is possible to add to the water stream grains of abrasive material.

Specialists assume, that by 1970 hydroerosion machines-water slingers will attain broadest application. The journal Znanie-SILA wrote about it in No 5 for 1961 a report entitled "Mining River in Workshop".

File and Architecture

Electricity and chemistry with a confident hand are marking the outlines of future machine construction without machines so accustomed to our eye and ear. What will it be - machineless machine construction ?

illustration...page 14

Ions and electrons work directly with molecules and metal atoms, they need no rough go-betweens, in form of cutting tools and dies. The electron beam and magnetic field do not wear, they do not rust and require no constant care about ^{the} completeness and sharpness of their "cutting bits".

The electronic machine-universal, it changes with exceptional ease from milling to grinding, from rough cutting to artistic engraving. Consequently the details are practically not transported- all operations on the details are executed on the spot. There are no great accumulations of chips and filings, which have been so diligently produced by cutting tool and filr. The very concept of "WASTE" disappears: the metal dissolved in the electrolyte can be easily recovered, put to useful work right there on the spot.

The future metal machining plant - is the kingdom of electron guns, magnetic solenoids, closed reservoirs with electrolyte, a kingdom of noiseless workshops, resembling library halls. Noiseless and humanless, these electric processes are most accessible for total automation and remote control. The plant will bid farewell to enormous presses, large scale machines, massive foundations.

Forgotten will be the chunks of metal which were necessary for the unsatiated rigidities of machines, for ultrastrong tools, for the transmission of greater forces. The new technology will alter the architecture of industrial buildings. The bodies near the ground will get off from their knees, they will expand into ten story

edifices. The lightweight of industrial constructions will make them look like fair pavilions.

New methods of metal machining will not only allow to create a tasteful architecture, they will also penetrate into the cosmos. Man will conquer cosmic distances not just as an individual person, but as a creative participant of a highly organized group producers of all material goods. Not only the omnivorous thirst for search and discoveries attracts us to the Moon and Mars. Engineers and economists consider the adaption of the cosmos as a real usefulness. The ore miners of the Moon and the Metallurgists of the Mars will come face to face with the problem of transferring to other planets electric locomobiles, hoisting cranes and rolling machines. And they will, most likely come to a conclusion, that the smartest thing is to produce same on the spot, from lunar ores and marsian minerals. Then will electron and chemical phenomena take on the job of workers in workshops of celestial plants, possibly, controlled by radio from the Earth.

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