

Measuring the Flow of a Stream

How Water Powers Are Accurately Calculated

By Richard Hamilton Byrd

IT is one thing to own a waterfall or a power-site capable of producing sufficient hydro-electric power to run a big plant; it is another thing to develop this power and apply it to the wheels of industry or to find some one who wants it badly enough to pay the owner what he considers it worth. The conversion of falling water into cheap merchantable power is always a large and most expensive undertaking. It is true that certain large corporations have of late years been acquiring water-power properties of great extent, but that the major portion of the water-power that can be generated in the United States is controlled by a few individuals or combinations, as has been freely stated, is not to be credited. The power which is at present running to waste in the navigable rivers alone of the United States, which are of course controlled by the Government, is much greater than all the power that has thus far been developed or projected, to say nothing of the millions of untouched horse-power in the rivers flowing through the public lands of the West which have been reserved by the Federal Government. The chief hydrographer of the United States Geological Survey estimates the developed water-power in the United States to-day in round numbers at 6,000,000 horse-power; but he believes the undeveloped water power which might be realized from the normal flow is 66,000,000 horse-power. Further, he estimates the possible ultimate development through the building of flood storage reservoirs at the tremendous total of 200,000,000 horse-power. It is thus seen that even with the enormous developments which have been going on in recent years we are but at the threshold of our water-power development, having so far utilized less than one thirtieth of this resource.

To obtain a mind picture of what this power means it may be reduced to terms of operating locomotive engines. There are in the United States about 51,000 locomotive engines, and the average engine has approximately 1,000 horse-power. The annual consumption of all the railroads is about 90,000,000 tons of coal. The maximum power from all the streams of the United States would, therefore, operate four times the number of all the locomotives of the country if they were running day and night every day in the year, or would do the work about twelve times greater than that actually performed by all American locomotives or represent a consumption of over a billion tons of coal a year—double our coal consumption of last year. While these are enormous figures compared with the actual power development to date, there is nevertheless intense interest throughout

the entire United States at the present time in the value and the possibility of the country's waters and their utilization for power, for irrigation, for navigation, and for municipal purposes. What study is being made of the great resource in connection with any of these vital problems? What information, if any, is available to the owner of a water-power to enable him to determine the equity of the price offered? There is a branch of the Government service whose

work is devoted to all these matters—study of the volume of streams, in low water and in flood, current velocity, gradient, storage, power, irrigation and drainage possibilities—in fact, it makes river surveys; it is the Water Resources Branch of the United States Geological Survey. Since such work was systematically undertaken by the Survey in 1895 Congress has appropriated \$2,032,500 to carry it forward, and the result is that we have now a pretty fair working knowledge of most of our principal rivers and many tributaries. In some years over 1,000 stream gaging stations have been maintained in most sections of the United States. This season the Survey has approximately four hundred such stations in operation, and is doing co-operative stream measuring with States and individuals at as many more.

In the contemplated development of a stream for power, irrigation, or any other industrial purpose the first question that arises is "What is the flow, the volume, of this stream?" How much water will it deliver in a day, in a month, in a year, in a period of years? To what extent can it be depended upon as a never-failing servant of man? To answer these questions the Government hydrographic engineers are making their thousands of measurements annually and computing the results for the information of the public. At each Survey gaging station the height of the river is recorded daily. Then at frequent intervals with the river at different heights, the hydrographer visits the station and makes soundings across the stream bed every few feet so as to get a cross-section of the river bottom. With this cross-section of the body of water and the speed of the flow, usually obtained with an electric current meter lowered into the water, he can readily compute the number of cubic feet of water passing a given point per second. This flow, of course, varies greatly at different seasons. Variation is of the greatest importance in considering the river's flow for both irrigation and power. The low-water flow largely fixes the river's value in both cases. If for irrigation it must be known how much water can be depended on during the irrigation season, and if the water is to be stored in a reservoir the total annual flow must be determined. If for power the low-water flow largely fixes the value. If a factory is to be run by the power twelve months in the year then the two or three months of lowest water will measure the capacity of the plant. The fact that an ordinary flow may be a hundred times greater, as is the case in many rivers, will be of no importance, unless storage reservoirs are provided.

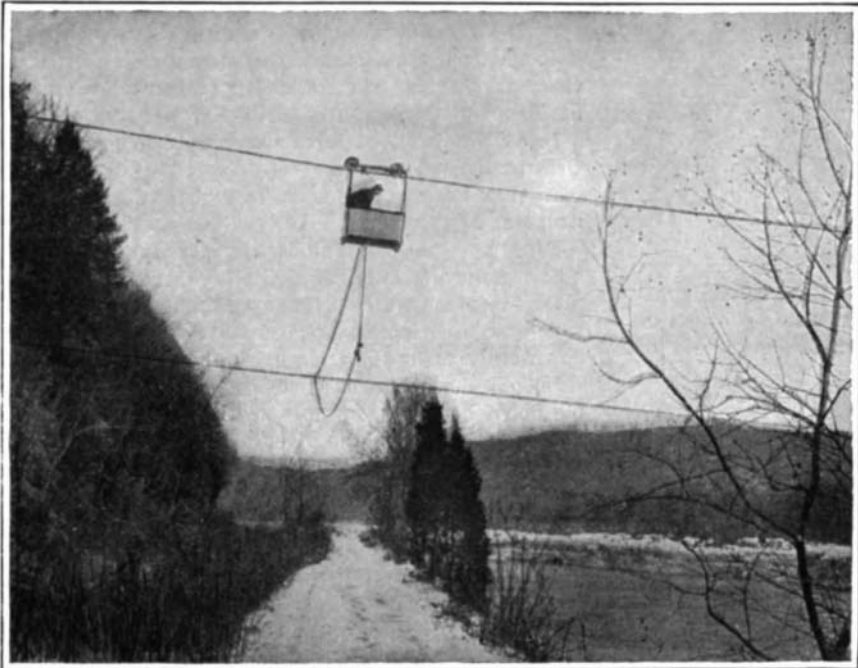
Because the Geological Survey has accumulated a



Gaging car and United States Geological Survey engineer on the Yakima River, Washington.

TABLE SHOWING IN SECOND-FOOT THE FLUCTUATIONS IN FLOW OF EIGHT REPRESENTATIVE WATER-POWER RIVERS IN 1903—A TYPICAL NORMAL YEAR.

	Maximum.	Minimum.	Mean.
Susquehanna	276,000	5,600	47,500
Potomac	99,600	2,000	12,480
Housatonic	25,700	550	3,000
Savannah	130,000	3,400	13,900
Chattahoochee	15,400	415	1,690
Grand (in Colorado)	17,900	400	2,700
Sacramento	131,000	4,800	13,900
Columbia	903,000	72,200	236,000



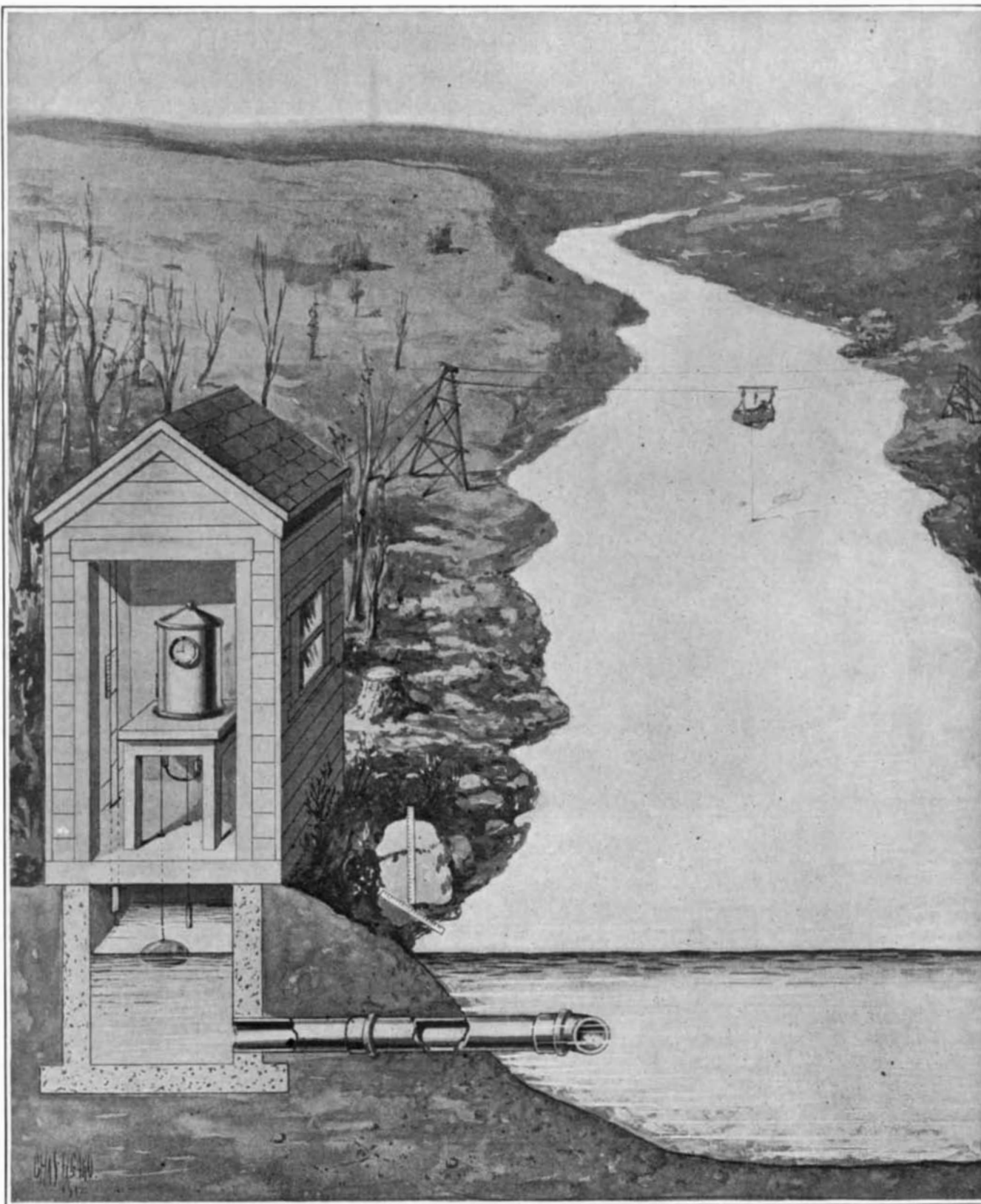
Long trolley line and car for measuring the volume of the Susquehanna River.



In rivers that are not too deep the gaging is done by wading in high rubber boots.

great amount of river data, the Government was able during the first year of the adoption of the present water-power regulations for the public lands to make withdrawals along ninety-seven western rivers, including thousands of water-power sites and involving millions of horse-power. To have acquired the information for these withdrawals specially for the purpose would have necessitated an enormous amount of field work, in fact, it could not have been accomplished in a single year with even an unlimited force and expenditure.

This stream measurement work of the Survey carried on throughout the West for many years prior to the passage of the irrigation law enabled the Reclamation Service to begin its construction work at once and to push it with a rapidity that was the astonishment and envy of visiting British irrigation engineers who had worked in India and Egypt. It is admitted that the integrity of these great irrigation works in the West, upon which over \$70,000,000 is being expended by the Government, rests upon the hydrographic work of the Geological Survey. The formula for arriving at the horse-power in any river is a simple one. Multiply the volume of the stream flow in second-feet, i. e., the number of cubic feet of water passing a given point every second, by the fall of the river in feet and divide by 11. This will give the actual horse-power, which is 80 per cent of the theoretical horse-power. One second-foot equals approximately 7.5 gallons; thus



Instruments in house give continuous automatic record of the rise and fall of a river which, in connection with the measurements made from the gaging car, furnishes data for computing the daily flow of the stream for every day in the year, or for any hour of the day or night.

if a small stream has a flow of 100 second-feet, or 750 gallons per second, and a fall of 50 feet, it will develop 454 horse-power.

But how is it possible, without a current meter or the services of an engineer, to make a rough estimate of the flow of a stream? First, make soundings across the stream, say, every 10 feet, and from this compute the number of square feet in the cross-section. Then

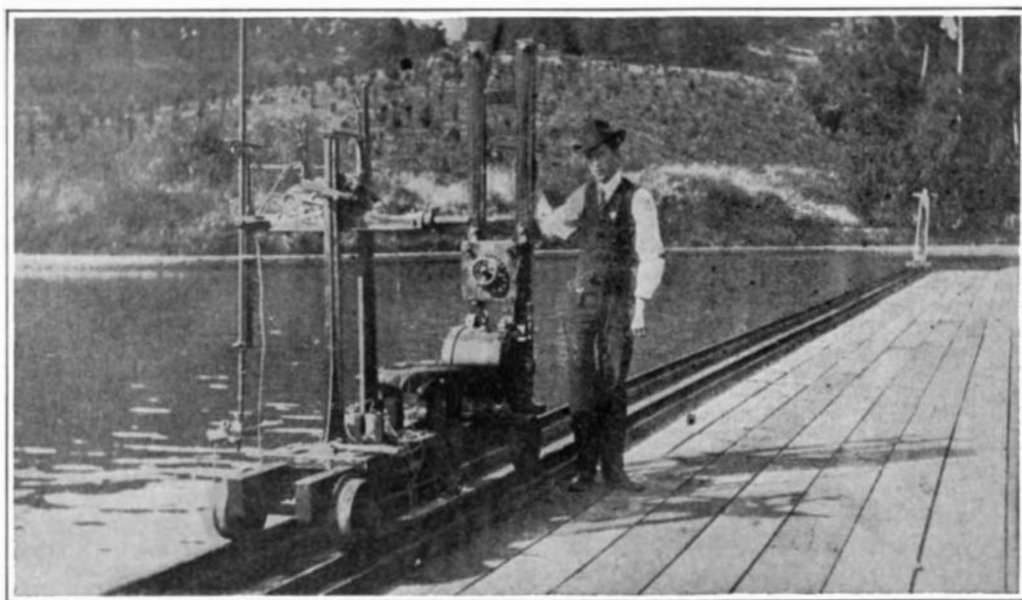
to find the speed of the current, stake off a straight reach of 100 feet, and drop a piece of cork in the stream near the right bank. Note the time it takes to float the 100 feet between stakes. Repeat the operation from the opposite bank, and again for the middle of the stream. From these three find the average flow of the river per second. Multiply this by the square feet in the cross-section and the result will be an approximation of the volume of the stream in second-feet.

Thus, for example, a creek 50 feet wide has an average depth of 6 feet, the soundings showing 6, 8, 9 and 7 feet of water at the four 10-foot intervals, and, of course, 0 at either shoreline. Adding these, 30, and dividing by 5 we get 6 feet of average depth, which, multiplied by the 50 feet of stream width, gives 300 square feet for the cross-section. Now the two corks dropped in near the banks each consume 100 seconds in floating the 100 feet, while the center chip floats the distance in 50 seconds. The flow of the shore water is thus 1 foot per second—an average for the stream of $1.33\frac{1}{3}$ feet per second.

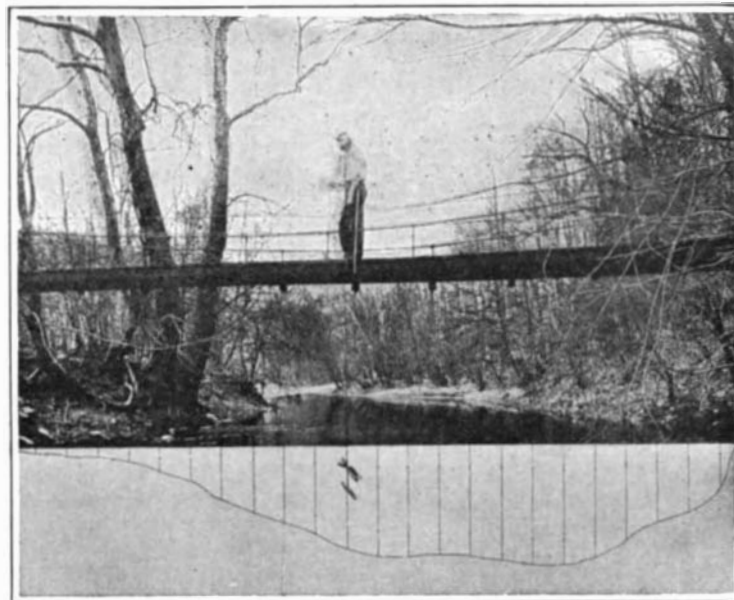
This multiplied by the 300 feet cross-section gives a stream flow of 400 second-feet. If this creek should be found to have a fall of 40 feet in a certain distance, say, a mile, it would be capable of developing 1,455 theoretical horse-power at 80 per cent efficiency.

Beautiful waterfalls by no means afford all the power possibilities of rivers. As much power can be extracted

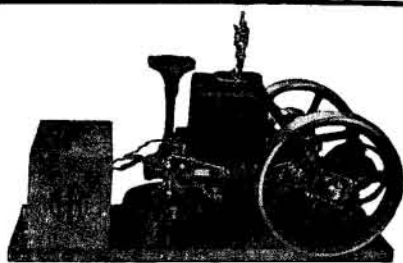
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Where possible, railroad bridges are utilized for measuring streams at five- or ten-foot intervals.



Rock Creek, Washington, showing stream bed survey and method of gaging velocity every five feet, by electric current meter.



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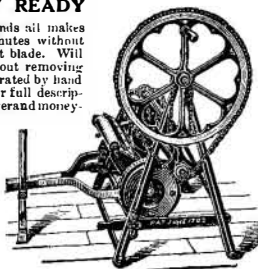
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"cracking" of the kerosene caused by the high ignition temperature. It is proposed to overcome this difficulty by injecting a small quantity of water along with the charge. The water is converted into steam, thereby lowering the initial temperature and preventing the "cracking" and the consequent carbon deposit. But it is obvious that the necessity of the water injection again complicates the problem of the carbureter.

The compounding of a new fuel resembling gasoline in its physical properties must meet the following demands: Its exhaust gases or products must not attack the cylinder; the explosion must not be too violent; it must leave no solid residue; and last but not least it must be cheaper than gasoline and the supply of its base or main ingredient must be so abundant that even an enormous demand therefor will not raise its price to any extent. The last requirement rules out with one sweep all vegetable and animal oils and fats. This would confine us to hydrocarbons and their derivatives obtained from mineral oils, distillation products of carbonaceous material, coal tar, alcohol, etc.

In Germany industrial alcohol, being lower in price than gasoline, the latter selling at 40 cents, is used as a base for the new fuel. In this country industrial alcohol has not as yet realized in any measure the high hopes entertained at its introduction. As it is considerably higher in price than gasoline it offers no prospect of being of any aid in the solution of the gasoline question. Several patents have been granted in Germany covering interesting and suggestive processes. One proposes to increase the power and explosibility of alcohol by the addition of mono nitro-benzol. Another process is to dissolve a small quantity of acetylene gas, as little as 0.2 to 0.5 per cent of acetylene by weight of the new fuel mixture being sufficient to increase its power and explosibility considerably. At 0 deg. Cent and 760 millimeters atmospheric pressure, gasoline absorbs 4 to 5 per cent of acetylene, kerosene 1.5 to 2 per cent, alcohol 5 to 6 per cent, and acetone 30 per cent. Therefore, using acetone saturated with acetylene for dosing the fuel base, such as alcohol or kerosene, the desired result is obtained, acetone being miscible with the mentioned fuel bases.

A new process, recently patented in Germany, is still more promising. A mixture of alcohol, kerosene, coal tar oil and coal tar is distilled at a high temperature. Thirty-six parts of the resulting distillate, 100 parts of 94 to 95 per cent alcohol, 2 parts of distilled wood spirits—all parts being by weight—are distilled between 66 to 70 deg. Cent. until no more vapors pass over. About 12 per cent of the mixtures is thus distilled over. The remaining 88 per cent is cooled to 10 deg. Cent. About 8 per cent of paraffine and naphthalene are thus precipitated out and removed by filtration. The remaining liquid constitutes an alcohol highly carbureted, which contains neither substances excessively explosive nor those which precipitate out in the cold. For automobile use 64 per cent of this resulting liquid is mixed with 36 per cent of the light distillate obtained in the distillation at 66 to 70 deg. Cent. This new fuel, it is claimed, is an excellent substitute for gasoline.

Measuring the Flow of a Stream

(Concluded from page 269.)

theoretically from a reach of river ten miles long having an even gradient of 5 feet to the mile, as from a clear drop of the river of fifty feet at one point, although in rare instances, owing to the topography of the river banks it may be cheaper to extract power from rapids than from a straight fall.

The question of flood water storage is also a vital one in considering the maximum power of any stream. This is a great and fascinating department in itself. The storage of water in natural mountain reservoirs, of which many streams have a good supply, smacks of the providence of the thrifty husbandman who in time of plenty lays up a store of provisions against the season of hardship which he foresees.

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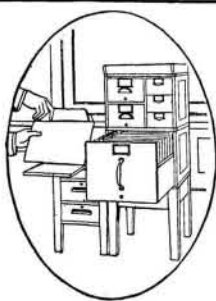


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Water is the country's greatest resource. Coal, oil and other power producers are exhaustible, but the use of water, never. So long as rain and snow fall moisture is evaporated and clouds formed and their particles precipitated again, so long the endless chain will revolve and streams can be employed for power, irrigation and navigation in their travels from mountain heights to ocean level, over and over, again and again. But we should know our rivers more thoroughly, and eventually we should control and utilize them with almost the certainty that is attained in the handling of a city water supply. Where the Government has now one gaging station, it should have a dozen.

The Chemistry of a Soldering Flux

THE action of a flux during the operation of soldering consists, briefly, in cleansing the surfaces to be soldered, keeping them clean, and letting the solder make contact with them.

The impurities generally occurring on metallic surfaces are grease or other organic matter and oxides. An effective flux must have the power of dissolving all those and flooding them out of the way.

Zinc chloride is the flux most commonly used. It fuses upon the surface at a low temperature, and dissolves organic matter with great readiness. It removes oxides by converting them to chlorides of low melting points, which flow out of the way, either alone or in solution with the fused zinc chloride. The chloride of iron even volatilizes to a considerable extent. Zinc chloride is usually applied in water solution. But its flowing power and its cleansing action are increased when it is used in solution in some alcohol, fatty acid, or oil, such as oleic acid or castor oil. With all these solvents it combines in large proportion to form thick, syrupy liquids with high boiling points. The cleansing action is improved by the solvent, which dissolves metallic oxides and chlorides.

Ammonium chloride in solution in glycerine is frequently used as a flux, and is especially suitable where a very clean job of soldering is necessary, since these materials are driven off by heat and leave very little residue. The action upon organic impurities is not so strong as that of zinc chloride, but the glycerine flows very readily, and readily dissolves the chlorides formed by decomposition of the ammonium chloride, so that this mixture is a very effective flux.

Of the organic fluxes, rosin is perhaps the one most commonly used. It is most effective for soldering tin and lead surfaces. It owes its efficacy in cleansing to its ability to form soluble resinates with tin and lead oxides. Similarly, various oils and fatty acids, such as palm and castor oils, oleic and stearic acids, have value as cleansing agents and make good fluxes.

The physical properties of a material also determine its usefulness as a flux. Its viscosity should be light enough at the melting temperature of the solder to permit of a free flow on the surface. Its surface tension in contact with the heated surfaces and melted solder should be quite high. This is a vital characteristic. That is, these surfaces should not be easily "wetted" by the flux. The importance of this may be seen by comparing the fluxing power of a petroleum oil with that of rosin. It will be seen that the mineral oil wets a globule of melted solder completely, while the rosin shows a negative tendency. The oil forms a film which separates the solder from even a clean metal surface, while the rosin film breaks, lets the solder touch the metal, and even draws the two together.

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