State approximately ................ $20,000.
County approximately .................... 100,000.
Township approximately ................ 30,000.

The annual cost of maintenance of the 70 miles designated in this project is approximately $50,000 or about $700 per mile. When paved, the annual cost of maintenance would be reduced at least $500 per mile, or a saving of $35,000. The paving of these main roads will naturally attract a large amount of the traffic which is now going over the unpaved roads which will result in a material reduction in the cost of upkeep on the latter.

Types or materials for the proposed paving have not as yet been selected, but this will be done following the taking of a traffic census of the various routes.

The system as planned, in addition to the state highways located in the county, will place 95% of the population of the county within two miles of a paved road with connecting paved roads to any town or community in the county and to every part of the state.

The county is in excellent financial condition, having no outstanding obligations of any kind. The valuation for taxation in the county is $66,000,000 of which approximately 30% is in the city of Newcastle.

SOME COUNTY DRAINAGE PROBLEMS

By H. C. Morrison,
Gibson County Surveyor.

I have decided to handle the subject assigned me by discussing some of the problems and difficulties arising in the design and construction of a particular drainage system on which I am now engaged. This drainage system is known as the Wm. Metz et al., or Big Creek, and is located in Vanderburg, Gibson and Posey counties. It consists of a system of one main ditch, 30 miles long, and 30 laterals varying from a few hundred feet in length to 9 miles, making in all, main and laterals, about 60 miles.

The drainage area comprises about 260 square miles or 166,400 acres, extending from state road 41 on the east to the Wabash River on the west and covering a territory averaging 6 to 7 miles north and south.

This work consisted in the reconstruction of the main ditch and one of the main laterals. These we cross-sectioned. Our
first work in the preparation of the report consisted in the preparation and drafting of a map. We were confronted with the enormous task of verifying the descriptions of the lands contained in the petition, which in the first place only contained perhaps a third of all those assessed. This petition for the reconstruction was begun before the recent law came into effect requiring two-thirds of the land owners affected to be named in the petition. The records were located at three county seats and this made the work more complicated as different counties have systems of their own in keeping records. This map showed the lands, civil and congressional township lines, county lines, present location of ditches, railroads, roads, etc, but no contour lines. We were fortunate in having Geological Maps in this section of the state showing all surface contours at 20-foot intervals.

After the map was prepared we began our field work. This did not include very much location work on the main ditch, as it had been dredged about 15 years previous and new location meant in a good many instances three ditches, the old natural water course, the old dredged ditch and any new location that might be made. Since, in many places, the valley is narrow, I did not think it advisable to make new location, except in one or two places. The old dredged ditch had a fairly good alignment.

You note I used the word advisable. Sometimes in order to keep peace among the land owners, we engineers have to forego good location practice for policy’s sake and make up for the poor location by better design.

The Survey

Our first surveying consisted of running a line of levels along the edge of the ditch. This proved to be a very long and tedious job. You are all familiar with dredge ditches and know just about what kind of growth to expect where no attempt at maintenance has been made for fifteen years. Right here is the place to call on some of Purdue's material. This is a good place to try out some of the boys who have had their training in the Purdue civil camp and give them a real taste of engineers' life, cutting briars, fighting mosquitoes, chaining, rodding etc. I employed two local boys who had completed two years at Purdue and started them off right. They made good and have since been promoted to better jobs. After or co-incident with our level work we cross-sectioned each station. We endeavored to adopt some easy way of cross sectioning by use of tapes, plumb bobs, gages, etc., but we were unable to find anything better than tape, rod and hand level—picking up our elevations previously run at station stakes.

On the laterals we ran our location lines with the transit and for the most part no serious problems were encountered.
By the time the cross sections were completed we had become pretty familiar with the various drainage basins, water-sheds and nature of soil as to texture, throughout the whole watershed and along the route of the ditches. This familiarity enabled us to better determine what we might reasonably expect in the way of run-off, and what slope of banks would be necessary.

**Hydraulic Determinations**

In determining the run-off, I made a thorough investigation at three weather bureau stations, regarding the duration of various storm periods and made a record of all rainfalls of more than one inch in twenty-four hours. At Evansville, which is not in the district, but is not far from the boundary of the watershed, I found very complete records. With this data at hand, and with other data concerning run-off, I decided to design the main ditch for a little more than one inch run off in 24 hours for the upper stretches of the ditch which was fed by streams from the steeper part of the watershed, and a one half inch run-off for the lower stretches of the ditch.

The amount of run-off to be provided in farm drainage varies considerably depending upon the degree of improvement and the damage that would result from overflow. Farm drainage is seldom complete enough to prevent all overflow as the cost would be prohibitive and short periods of overflow on farm lands are not serious during the time of year when the heaviest rainfall usually occurs. If a drainage system is well balanced, any overflow occurring after unusually heavy rains will be well distributed and of short duration.

After platting our elevations, profiles were made. In determining the grade of the main ditch, I found that an economical grade could be made with just one break in the upper part of the ditch. From station 0 to 943 (about 18 miles) a grade of 3.06 feet per mile was fixed and the remainder was given a fall of 1.37 feet per mile.

The next step in the design consisted in determining the areas to be taken care of up to the various points of confluence of the several laterals. For instance, the area above station 0+00 of the main ditch is 37.6 square miles. With a run-off as previously decided upon of 1 inch in 24 hours, which is equivalent to 26.88 cubic feet per second per square mile, I found that the ditch should take care of 37.6 times 26.88 cubic feet or 1010 cubic feet per second. I decided on making a twelve foot base. The reasons for using a twelve foot base were: that above station 0 an old ditch had been constructed some years ago which emptied at our station 0 with a twelve foot base and also that we could get the full benefit of the old excavations by using that width.

With a section of 12 foot base, depth 15 feet and slope of
banks 1:1, I next determined what velocity to expect in the new ditch. This was calculated from the old reliable Chezy Formula

$$V = C \sqrt{rs}$$

where $V$ is the mean velocity in feet per second, $r$ is the hydraulic radius (the area of the cross section divided by the wetted perimeter), and $s$ is the slope.

We also used Kutter's Formula for calculating the value of $C$, which formula is,

$$C = \frac{1.811}{n} + 41.65 + \frac{.00281}{s}$$

Where $n$ for such a ditch may be used as .025

$$r = \frac{a}{p}$$

$a = 405$, $p = 54$

$$r = 7.5$$

$s = .00058$ (this is a slope of 3.06 feet per mile)

Solving the above equation we get the value of $C = 83.7$.

Then solving the equation for $V = C \sqrt{rs}$ we get $V = 5.52$ feet per second.

With a cross sectional area of 405 square feet and a velocity of 5.52 feet per second a run-off of more than 2,000 cubic feet would be taken care of when the ditch is running full. If we assume that a ditch running 4/5 full is a proper one to design we still have an excess capacity, but in view of the fact that just a short distance below station 0 some 20 square miles more drainage area is added by laterals, and in order to have a base width conforming to the ditch above station 0, and also to take care of some silting that may occur in the upper part of the ditch caused from deposits being washed from above our improvement, I deemed it advisable to construct the ditch with this factor of safety.

This same process was followed in designing the entire system.

At present the work is about one third completed and it is gratifying to note on those completed sections how nearly the calculated velocities approach the actual velocities which obtain. I have already had occasion to test out a few of them.

One of the first difficulties which we encountered was the presence of rock on the main ditch at about station 264. This we had not expected. In our preliminary work we made a number of borings to determine the location of rock, but at this place we had not tested. This stone proved to extend for a distance of about 150 feet and from one to three and one half feet above grade. After the rock was discovered, the contractor attempted to blast the stone by making some depth charges. This failed to loosen it, so we allowed the contractor...
to go on with the floating dredge and will remove the stone after the ditch runs dry or nearly so during the dry season. This will be done by drilling, blasting and removing stone with a drag line which the contractor has near that location.

Highway Crossing Difficulties

Another difficulty was encountered in crossing a state road. A 2 1/4 yard drag line machine was assembled on the west side of state road number 65 which leads from New Harmony to Mt. Vernon in Posey County. This boat dug down stream about 2,000 feet on the north or right side of the stream and then crossed to the left side and proceeded up stream to the state road. Here we were confronted by a federal injunction issued to prevent the crossing of the road. After some delay an attorney for the contractor got permission to jump the road and begin excavating some 100 feet above. The work has continued up stream about four miles where the drag line again crossed to the right side of the ditch and is now digging back toward the state road. We are unable at this time to say just what the outcome of the affair will be, as there seems to be no law permitting a dredged ditch to cross a state road.

Fortunately we have the old channel of the stream which forms a diversion, leaving the dredged channel some 3,000 feet above the state road and rejoining about 2,000 feet below the road, crossing the state road some 3,000 feet north of the dredged channel. We had planned to close this at the upper end by the construction of a substantial levee across the old channel thus causing all of the water to flow through the new channel. With the removal of this levee we will be able to obtain the necessary capacity for the drainage areas above and thus be relieved of the embarrassing situation of crossing and excavating across the state highway the full specified width.

The total amount of the excavation in the drainage system is 2,084,000 cubic yards and the contract price is $196,000. The work is being done by the Walb Construction Company of Lagrange, Indiana, with Mulgrew & Sons Company, of Dubuque, Iowa, sub-contracting about 672,000 cubic yards of the main ditch. The base width of the main ditch varies from 12 feet at the beginning to 54 feet at the outlet, with top widths varying from 35 feet to 110 feet.