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SHORT COMMUNICATION

COMPUTER AIDED DESIGN OF WASTE WATER TREATMENT PLANTS

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THE PURPOSE of this brief note is to show some new applications of digital computers in the planning and design of waste water treatment plants. To emphasize that computers are now being used in just about every aspect of engineering design such as hydraulic computations and structural analysis, or in management and administration, is hardly worthwhile. These aspects have been explored and will continue to be improved and expanded.

In the past few years, however, two new developments in the computer field have taken place which have increased the capability and utility of computer systems greatly. The first development was the creation of very large and extremely fast computers which many people can use at the same time via remote terminals—the so-called time-share systems. The second development was the design of automatic plotting systems which operate under the control of digital computers. In the following, some preliminary experiments and ideas are shown which were aimed to explore the use of these technologies in the design of treatment plants.

The design of treatment plants is to a large degree regulated by standards and rules of design. Thus, for example, the so-called "Ten State Standards" (*Recommended Standards for Sewage Works*, 1960) specify:

surface settling rates for final settling tanks, based on their design flow should not exceed 800 gal/day/ft^2;
minimum slope of the side walls of sludge hoppers shall be 1.7 vertical to one horizontal;
the liquid depth of mechanically cleaned settling tanks shall be as shallow as practical but not less than 7 ft.

These types of standards—whether they are dictated by empirical observations, needs of equipment manufacturers, or just plain regulations aimed at creating a certain uniformity in the design of treatment plants, are constraining the choice of the designer. Since they are numerical in nature, they may be expressed in equations and inequalities, which in turn lend themselves to be programmed for digital computers.

Not much latitude is left to the designer. The basic idea then is to store all these rules in a digital computer and have the designer interact with such a system via remote terminals. If these instructions are stored in a large time-share computer they can be shared by many users at different geographical locations. Thus, for example, a state agency could specify its particular design standards and have them entered in a state owned or leased computer system. Any consulting engineer designing a treatment plant to be built in this state could use the system from his offices via telephone lines. Since he would design a plant based on these state regulations, the design would automatically be approved; the agency itself could keep track of the design and the user of the system.

To explore these possibilities several computer programs were written in FORTRAN IV which allow the engineer the design of different units of a treatment plant from a terminal.* FIGURE 1 shows such a terminal, in this case an ASR 35 teletype terminal, located in the School of Public Health at The University of Michigan. FIGURE 2 shows an example of an actual conversation on the terminal using these computer programs. All statements underlined were typed by the persons sitting at the terminal. The first line of the exhibit requests that the program called TREATMENT be run and that all input and output is to be done via the teletype unit—this unit is the source of all statements and all responses should be printed out here. These particular commands are part of the MTS system (acronym for Michigan Terminal System). The first question posed to the user is whether or not he would like an explanation of the system—in the example shown, an explanation of the system was requested by typing "yes" on the teletype; the system responds with typing out the appropriate instructions.

* They are based on some earler work by DEININGER (1966).

The program then proceeds to querry the user which part of a treatment plant he wishes to design and he proceeds then to design two primary, circular settling tanks based on a settling rate of 600 GPD/ft^2. At any time the user has the option to stop the process—modify some results—and/or accept the suggestions of the system. The end results of such a conversation are the general dimensions of the units. What is not shown in the example are the many choices and safeguards that can be built into such a system. Every individual response of the user may be examined and appropriate, reasonable bounds may be established which inform the user that his choice of design parameters is outside the usual range. Thus, there are natural limits on the settling rates which when exceeded will cause specific remarks to be printed informing the user of his "poor" choice—only after insisting and confirming his choice he may override the limitations built into the design program.

While at the present time the system is limited to the rough outline of a treatment plant, it can be extended to include the hydraulic layout of the plant, the calculations necessary for the structural design of the various parts, and may yield tabulations of the amount of earth work, concrete, reinforcement, etc.

The advantages of this highly interactive form of conversation is that the engineer need not be familiar with the particular computer language, but need only be capable of operating a teletype terminal.

Once the basic dimensions of the units of a treatment plant are established, it may be desirable to prepare the drawings of the individual units on an automatic plotting system. These systems represent an efficient means of generating ink-drawn graphs with a high accuracy and speed. The general principles of operation of such systems are based on bi-directional step motors for both x and y axes. The actual graph is produced by moving an ink-filled pen relative to the surface of the drawing paper in either or both the x and y directions. Electrical signals are used causing movements as small as 0.0025 in. and either raising or lowering the pen. Thus practically any line, curve or symbol may be generated as a sequence of such small incremental steps. The ability of a plotting system, similar to the digital computer, depends to a large degree on the availability of extensive software and programming support.

The University of Michigan Computing Center features a CALCOMP 763 plotting system with a large subroutine package. Using this system graphs of various units of a treatment plant have been produced. As an example, FIG. 3 shows the drawing of a circular settling tank. Although some detail is still lacking, it could serve as a basis from which a draftsman could start and add more details or serve as a preliminary drawing. The graph can be generated in any size within the limitations of the plotting system which is about 30×120 in. The plotting times are in the order of 10 min.

In the not too distant future it may be possible to generate and display these graphs on cathode ray tube terminals. These terminals again are highly interactive and through the use of light pens the user may alter, add or delete certain features of his graphs before issuing commands to the plotting system to provide a hard copy.

The studies to date have been mostly of an exploratory nature; nevertheless they have established the feasibility and economy of a computer-based design system. While it will never replace good engineering, it will provide for more efficient engineering by alleviating routine calculations and drawings and thus provide the engineer with more time to attend to non-programmable details.

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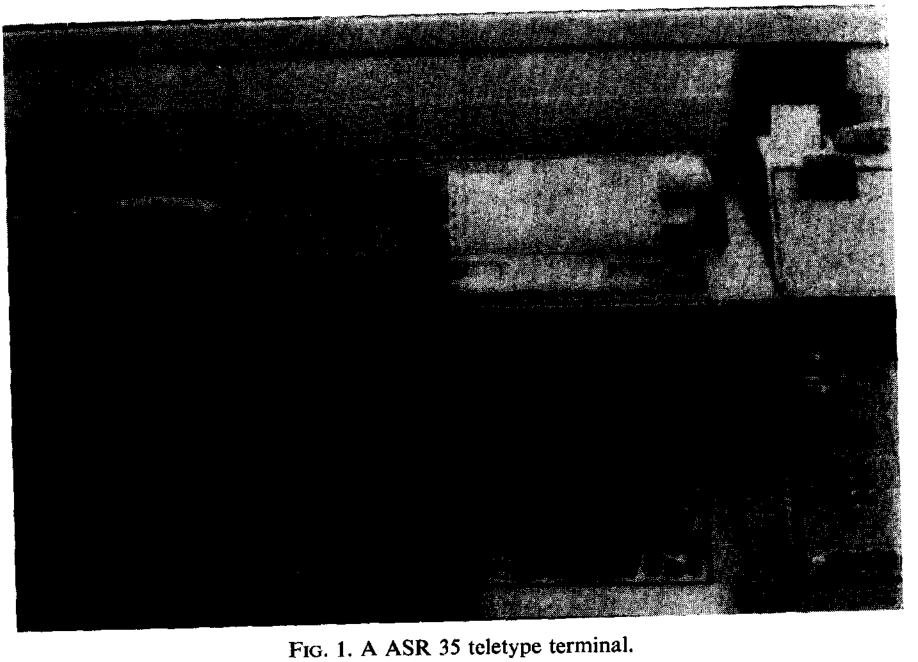

FIG. 1. A ASR 35 teletype terminal.

(*Facing p.* 788)

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$RUN TREATMENT 5=*SOURCE* 6=*SINK*
#EXECUTION BEGINS
  DO YOU WISH TO SEE THE INSTRUCTIONS FOR EXECUTION OF THIS PROGRAM?
    (TYPE "YES" OR "NO" - WITHOUT THE QUOTES.)
YES

  WELCOME TO COMPUTER ASSISTED DESIGN OF WASTE WATER TREATMENT PLANTS.
    WHEN EXECUTING THIS PROGRAM AND A NON-NUMERICAL RESPONSE
   IS REQUESTED, CERTAIN EXACT RESPONSES MUST BE MADE TO BE
   RECOGNIZED BY THE PROGRAM. ALL RECOGNIZABLE CHOICES WILL
   BE PRESENTED INSIDE OF PARENTHESES FOLLOWING EACH QUESTION.
   EACH INDIVIDUAL RESPONSE WILL BE PLACED INSIDE OF QUOTATION
   MARKS WITHIN THESE PARENTHESES BUT THESE QUOTATION MARKS
   MUST NOT BE INCLUDED IN THE RESPONSE. BLANKS MUST NOT
   PRECEED THE INTENDED RESPONSE UNLESS THEY ARE EXPLICITLY
   INCLUDED WITHIN THE QUOTATION MARKS OF THE ANSWER CHOICE
   LIST. IF A RESPONSE IS LONGER THAN FOUR CHARACTERS, THE
   FIRST FOUR CHARACTERS WILL BE A SUFFICIENT RESPONSE. NUMERICAL
    RESPONSES WILL BE CHECKED FOR REASONABLE SIZE. TO TERMINATE
   THE PROGRAM TYPE "STOP" FOR ANY RESPONSE.

  WHICH TREATMENT PLANT SEGMENT DO YOU WISH TO DESIGN?
   ("BARSCREEN", "PRIMARY SEDIMENTATION TANK",
   "TRICKLING FILTER" "ACTIVATED SLUDGE TANK",
   "SECONDARY SEDIMENTATION TANK", OR "STOP".)
PRIMARY SEDIMENTATION TANK

  DO YOU WANT A RECTANGULAR OR CIRCULAR TYPE BASIN?
   ("RECTANGULAR" OR "CIRCULAR")
CIRC

  INPUT THE AVERAGE FLOW IN MILLION GALLONS PER DAY.
1.00

  DESIGN BASED ON PERCENT BOD REMOVED OR SETTLING RATE?
   ("BOD" OR "SETTLING RATE")
SETTLING

  SHALL I ASSUME A SETTLING RATE OF 600 GPD/SQ FT?
   ("YES" OR "NO")
YES

  HOW MANY TANKS SHALL I DESIGN FOR IN THIS TRIAL?
2

  SHALL I ASSUME THE MINIMUM TANK DEPTH OF 7 FEET? ("YES"  OR "NO")
  NO
  WHAT TANK DEPTH SHALL I USE (IN FEET)?
8

  SUGGESTED DESIGN OF CIRCULAR PRIMARY SETTLING TANKS:

  AVERAGE FLOW                 1.00  MGD
  TANKS                        2.
  TANK DIAMETER               35.    FEET
  TANK DEPTH                   8.00  FEET
  DETENTION TIME               2.76  HOURS


  WOULD YOU LIKE TO START WITH NUMBER OF TANKS, DESIGN ANOTHER
   UNIT OR STOP? ("TANKS", "ANOTHER", OR "STOP")
STOP

  END OF PROGRAM
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FIG. 2. A sample conversation.

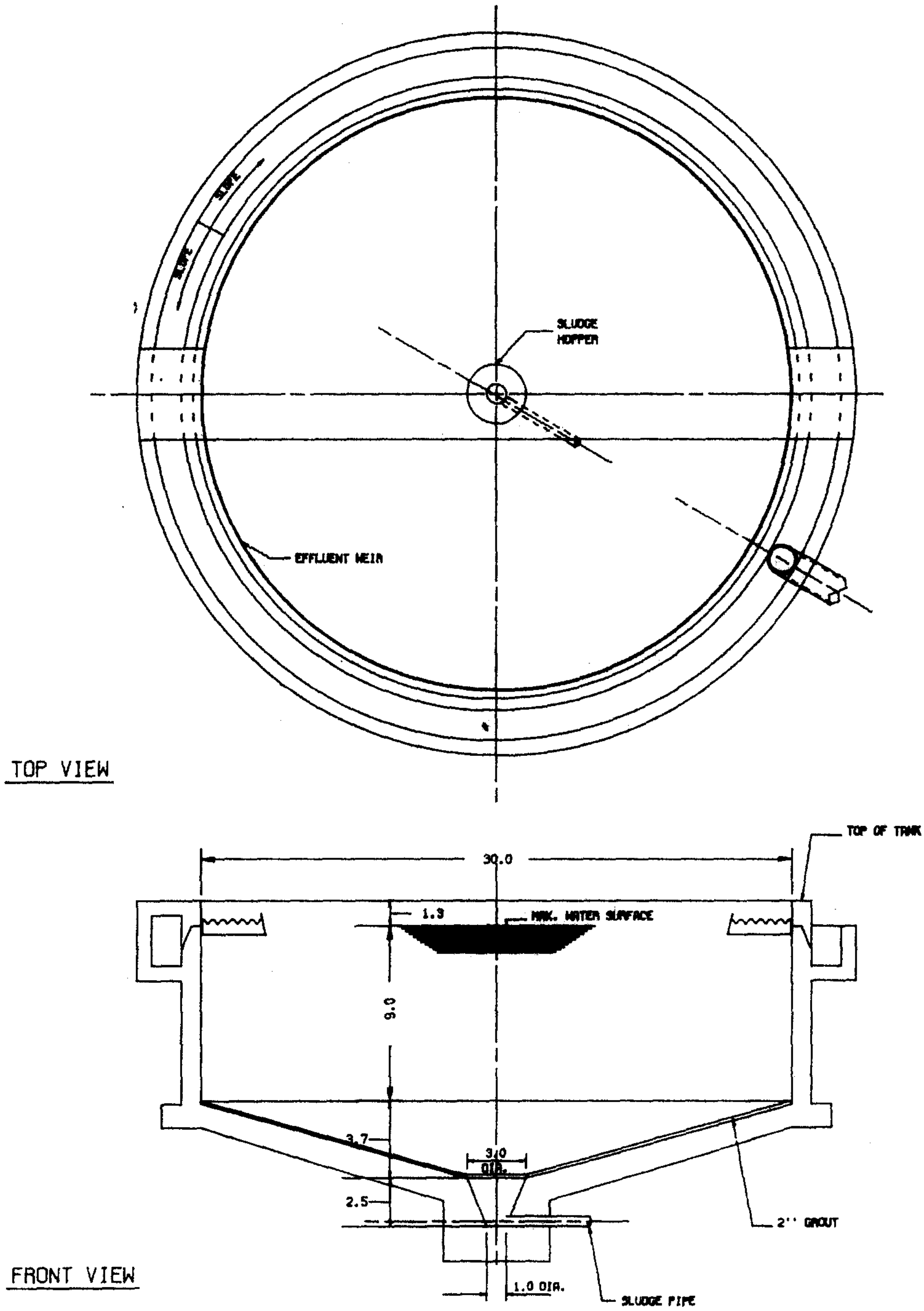

FIG. 3. Drawing of a circular settling tank.
Scale 1 in. = 6.6 ft.

REFERENCES

DEININGER ROLF A. (1966) Computer aided design of waste collections and treatment systems. *Proc. 2nd Annual American Water Resources Conference*, November 20–22, Chicago, Illinois pp. 247–258.

Recommended Standards for Sewage Works (1960) Great Lakes Upper Mississippi River Board of State Sanitary Engineers.