INTRODUCTION TO THE THESIS

For teaching and research in an engineering College two indispensable topics are "Instrumentation" and "Measurement of properties of materials". The author has a privilege to work as a research scientist on measurement of properties of engineering materials in an engineering research institute and to make critical study in an engineering College on some typical electronic circuits used in modern instruments.

The progress of instrumentation technology depends mainly on the newly developed electronic circuits. Many speakers and writers have implied that the recent technological progress of U.S.S.R., U.S.A. and other developed countries is due to the fact that they have given more stress on the study of modern physics and electronics in all other branches of engineering subjects. In most of the engineering Colleges in India the students are interested in the technical application of physics and electronics. The author of the text books and the teachers are tempted to catch their interest by loading the course with newly developed technology. Some of the text books abound in pictures and diagrams of sophisticated instruments along with newly invested electronic circuits. No one can object to the use of practical study of modern electronic circuits to explain the working of recently developed instruments and machines, but one must protest when the text is so overloaded with these illustrations that the basic principles and previously invented mother electronic circuits have to be treated in a summary fashion, if not omitted entirely. In fact 'Electronics' is at heart of modern technology. Critical study of elementary electronic circuits are most essential for science and engineering students of a progressing country like India.

Many of the effects of advances in electronic circuits on modern instrumentation can be seen at any industrial exhibition. It is easy to see, for example, that instruments are smaller and more elegant than they were a few years ago and at the same time have better specifications. The greatly improved ergonomic designs of to-day's instruments make them easy to "drive" and greatly reduce the chance of operator error. There is also the trend to make even highly sophisticated instruments fully portable. Most powerful single influence on modern instrumentation comes from the rapid development in solid state circuitry. For it is the harnessing of these advances and their applications to instrumentation that enable manufacturers to meet the market requirements in terms of price, ergonomic layout and reliability. For example, the use of remote d-c logic switching, such as in the PM 3260 oscilloscope[35], results in greatly improved ergonomic design, higher control reliability and simplified servicing. Previously, front-panel layouts were determined by the electronics behind the control knob or pushbutton. Remote d-c switching, however, allows the designer to position the 'front-panel' controls for optimal functional requirements and operator's convenience. They are connected by their own plug in cable harness to the appropriate circuitry, which, in turn, can be laid out so that all components are accessible when the case of the instrument is removed, thereby simplifying servicing. Cable harness per control function facilitates easy fault finding and individual checking. This technique also means that the controls can be designed for maximum mechanical strength and electrical reliability. Since their contacts do not form part of the measuring circuit.

Further many modern instruments or machines are too complex to be described adequately or to be examined critically for future design and development without the proper knowledge of semiconductor electronic circuits. In recent years it is seen that modification in certain electronic circuits are in the same footing as the rapid developments of related components. It frequently happens that in the quick progress of such a field, the research studies on new circuits appear in the literature, where they can be easily found, while the more basic studies on the mother invented circuits are found scattered throughout the literature. An occasional critical study of certain original circuits is sometimes helpful for further improvement of design and construction of recent electronic circuits used in to-day's instruments or machines. Such type of study is narrated in the first part of the thesis.

High a-c supplies from low d-c voltage from batteries are often required and these were done with the help of mechanical vibrators in previous days. But the contacts of mechanical vibrators due to constant use often become corroded and they often give troubles and had to be replaced very often. In the d-c to a-c converters using transistors these troubles are not confronted with and for this reason their uses are being so wide and popular. The high a-c output can also be rectified to give high d-c voltage and thus we can have d-c transformers so to say. Such d-c transformers may be found also very useful in producing sparking in ignition circuits from low d-c battery voltages. So critical investigations of such a converter semiconductor electronic circuit, which have been narrated in the first chapter of this thesis, are so important and justified.

Another simple semiconductor electronic circuit, is the diode switching modulator, which is widely used in modern instrumentation, particularly for the small output signals from thermocouples. The imperfection in switching action of this type of semiconductor diodes, used in the form of a bridge, is noted in the second chapter. The third chapter narrates the different types of gate circuits with complementary transistors which exhibit d-c characteristics similar to those exhibited by resonant, low pass, high pass, band pass and band elimination filter circuits. These types of gate circuits find their uses in multiplex signal transmission and in instrumentation such as in computers. Gate circuits that have been investigated here, are voltage operated devices and may be used to accept or to discard some voltages or to select some voltages, and thus they may be used for selective purposes in instrumentation.

Further, 'Measurement' is as essential as instrumentation. We are all, to varying degrees, involved in measurement in our day to day activities. It is as old as civilisation itself. The old Testament provides us with an early reference :

Zecbariab 2 : 1 and 2.

"I lifted up mine eyes again and looked and behold a man with a measuring line in his hand. Then said I, whither goest you ? And he said unto me, to measure Jerusalem, to see what is the breadth thereof and what is the length thereof."

In the words of Werner Von Siemens, "To measure is to know". Advancement of technological progress of a country must be preceded by advancement in the art and science of measurement, for the whole foundation of modern technological base, lies in the measurement of

physical properties of matter. Moreover to-day's measurement technology is classified in two groups viz.

(a) Direct Measurement and (b) Indirect Measurement.

Measurement of depths and types of subsoil strata by making drill holes at any place is an example of Direct Measurement. But direct measurement of properties of matter is not always possible, however, and then indirect measurement must be restored to. In Indirect Measurement an empirical relation is generally established between the measurement actually made and the results that are desired. Indirect measurement of the properties of matter may be made by Non-destructive techniques which have been developed in the past two decades. Bodies which were formerly regarded as opaque are now known to be penetrated readily by passing electric current, X-rays, γ-rays and even by sound wave of short wave lengths, commonly known as ultrasonics.

Applications of electric current and ultrasonics for indirect measurements of types and physical properties of soil are discussed in this thesis (Chapters IV and VII).

The fundamental and underlying purpose of measurement is for development of scientific research, design and construction of engineering projects. Measurement of engineering properties of materials are badly needed for electrical, mechanical, civil and other branches of modern technological fields.

In the present work measurements (both direct and indirect methods) have been made by the author on properties of subsoil physics and other related materials for development of tube-well irrigation in Bihar (India). This portion of the work is narrated in "Second Part" of the thesis which is contained in four chapters.

In recent years deep tube-wells have come to be recognised as an integral part of irrigation work in India, specially in the Gangetic Plains of Uttarprodesh, Bihar and West Bengal. They are being constructed and used in ever increasing numbers. Crores of rupees have already been spent on tube-well schemes, which irrigate extensive tracts of land, which were once uncultivated or poorly cultivated for want of sufficient and suitable means of irrigation. In near future the ground water irrigation is bound to increase and large sums of money are to be invested in them.

But the main problem, which this type of ground water irrigation is facing, is the decrease of water discharge of most of the tube-wells within few years of their sinking. This is causing a heavy loss to public money. The failure of these tube-wells of certain area is mainly due to improper design of tube-well sinking suitable for that area. Uptill now very little investigation has been made in India on "Measurement" of Physical properties of subsoil water-bearing strata and other engineering materials, which are most essential for proper design of tube-wells. Further the results of scientific investigation of one area would have little use for design of tube-wells for another area. This is due to the fact that the subsoil strata physics of Gangetic Plain at the foot of the Himalaya has a considerable flexture and dislocations for its seismic instability of the area. Thus for proper design of tube-well sinking of any part of this area, a thorough measurement of the properties of subsoil strata formation is required.

Considering the above facts investigations on subsoil physics and other engineering properties of materials have been carried out

in certain areas which might help for proper design of future tube-wells of Bihar. First two chapters (Ch. IV and Ch. V) of the second part of the thesis relate ~~with~~ to the "Measurement" of the subsoil positions and depths of water bearing strata formations by Electrical Resistivity method, and investigation of causes of low discharges of some of the tube-wells of Bihar (India) by estimating geological profiles and several other engineering properties of water bearing strata samples. Further, design of "Gravel treatment" by model tube-well experiments along with the 'Measurement' of engineering properties of Bentonite as lining material of tube-well channels are narrated in chapter VI.

The above investigations on subsoil physics may be considered as a pioneer work, as no such type of study was previously done in these areas of Bihar.

Moreover, while dealing with the problems in connection with 'Soil Physics', it has been felt by the author that, there should be more quick method for "Measurement" of "Optimum Moisture Content" of soil than the existing "Standard Proctor" method, which is tedious and time consuming. Thus in the chapter VII, an effort has been made to find a correlation between "Ultrasonic Wave Energy Attenuation" with soils compacted with different moisture contents.

The "Measurement" of the ultrasonic wave energy absorption by soil and its theoretical interpretation may be utilised, in future, for development of a method for quick and nondestructive testing of "Optimum Moisture Content" of any soil.