# ELECTRONICS, ITS PLACE IN SCIENCE, ENGINEERING AND INDUSTRY.

By T. R. POLLARD, Canterbury College.

"ELECTRONICS" is a much over-worked word to-day, sounding modern and mysterious to the man in the street—in fact almost as modern as "Atomic." To the popular technical press it is a great asset; to the research physicist who first experimented with it many many years ago, it is less mysterious than the conduction of electricity along a wire; to the engineer it consists mainly of temperamental gadgets of glass that do rather wonderful things sometimes; to the man in industry, if he believes the popular press, it is the solution of all his troubles.

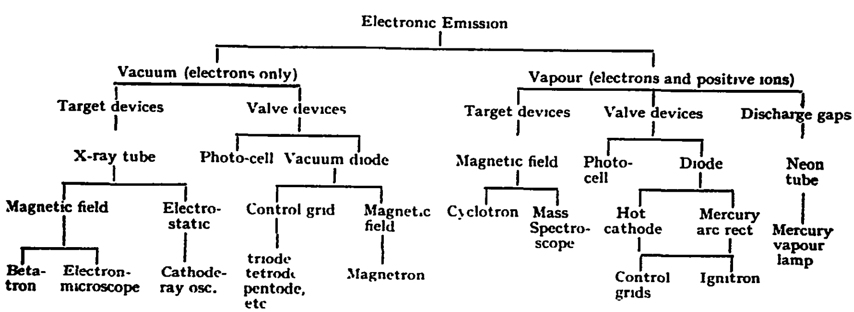
Definitions are many; I give but one, "that branch of science and technology which relates to the conduction of electricity through gases or *in vacuo*."

Given to us by the scientist as far back as 1870 (Crookes experimented with electrons), it probably had its first practical application in the X-ray tube. Fleming, in 1904, made use of thermal emission, and later, 1907, De Forest introduced the controlling grid. This gave us the "Electronic Tube," the main tool of electronics. For a long time radio had a monopoly of electronics, but, gradually, the field widened, and to-day radio is but a small part of the total field of electronics.

Some ten years prior to the war, it began to pass from the field of experimental physics to the field of electrical engineering. The grid-controlled mercury-pool rectifier, handling thousands of amps, could no longer be regarded as a fragile radio valve. The engineer began to realise that the physicist had given him a very useful control device that would assist in the solution of a number of his problems. The war brought before the scientist and the engineer a multitude of problems to which electronic control was the only solution. What device other than the electronic tube could have acted as a switch to give a radar pulse of hundreds of kilowatts one microsecond long, to control accurately the time base and mark of the cathode-ray tube so that time intervals of but a few microseconds were spread out over an inch or more?

By the end of the war an appreciation of the value of the "Electronic Tube" had been brought home to many thousands of scientific workers and engineers. To-day it has taken its rightful place in electrical engineering.

TABLE 1.




*Industrial Applications*

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|---|---|---|---|---|---|---|---|---|
| Electron microscope | Cathode ray osc. | Photo cell | Diode | Mass spectroscope | Photo-cell | Hot cathode | M A R & Ignitron | Neon tube |
| Metallurgy<br>X-ray tube<br>Research<br>Inspection | Research<br>Testing<br>Control | Safety<br>Control | Rectification<br>Triode, etc<br>Rectification<br>Amplification<br>Oscillation | Gas analysis<br>Isotope-separation | Safety<br>Control | Rectifier<br>Inverter<br>Control<br>Oscillator<br>Welding | Rectifier<br>Inverter<br>Control<br>Oscillator<br>Welding | Volt reference<br>Stroboscope<br>Mercury vapour lamp<br>Stroboscope<br>Multi-photo |

Fundamental research will still go on in this field, but it is mainly in the hands of the electrical engineers to develop and apply this electronic technology.

I do not propose to go into the details of electronic techniques, but I would like to show you a chart by Dr. W. G. Thompson which indicates the wide range covered by the words "electronic devices."

In the field of science these electronic devices play an important role; they give the research worker a very powerful tool. The chemist uses the mass spectrograph for sorting his elements; the photocell gives him precise control of colour solutions, the electron microscope allows him to see particles beyond the range of ordinary light. The physicist, who gave us electronics, is rightly its biggest user. The cathode-ray tube allows him to visualise fast transient phenomena, the X-ray tube allows him to see his molecular structures; ionisation counters in the head of V2 rockets have made possible quantitative cosmic investigation of the regions 120 miles above the earth's surface; the cyclotron and the betatron are the principal tools in nuclear physics. Without electronic controls the nuclear fission project would not have been possible. Medicine and biochemistry make use of "tabbed" elements from the cyclotron; they use the electron microscope. Even the field of mathematics finds assistance in the electronic analyser. I have but touched the fringe of applications to scientific work. Scientific research to-day is reaping the benefit of its electronic research of yesterday.

In the field of engineering the progress of electronics was at first slow; it was regarded as something to do with radio and used fragile glass tubes. This outlook was understandable and often was justified. Prior to 1930 the engineer was given little or no training in electronics in his engineering course. Electronic apparatus was often poorly engineered and placed on the market in its experimental stage. Thus, lack of appreciation on one side and lack of sound engineering design on the other, slowed the application of electronics to engineering problems.

Over the last decade this position has changed; electronics forms part of the electrical-engineering course of most universities. Electronic apparatus is being designed by engineers, and, although it uses the electronic tube, still often made of glass, it is usually more trouble free than the mechanical apparatus it replaces. Compare the mercury-pool rectifier with the rotary converter, the thyratron or ignitron control unit with a mechanical contactor for welder control. Consider the excitation problem in a large power station. It is not uncommon to have a small sub-exciter to excite a larger sub-exciter, which, in turn, excites the main exciter which supplies the excitation D.C. for the alternator, the small sub-exciter being controlled by voltage-operated relays and thus allowing the final A.C. voltage to be controlled. The grid-controlled mercury-pool rectifier is a much simpler and more economic solution. In the engineering field electronics is going through the same phase as electrical engineering went through many years ago. Electronics is part of engineering, it will play an ever-increasing part in engineering, but it cannot do it overnight; it will progress and take its part as a rightful place in engineering just as electrical engineering did some 60 years ago.

In the industrial field, the rate of growth of electronic application is phenomenal. This is understandable when we consider:—

1. Under the pressure of war, industry was forced into many new methods of production, and it found electronics a great solver of control problems. Initial expense was no object if man hours and material could be saved, and very often industry found that the initial outlay was more than offset by the quality and quantity of the product.

2. Having gained an appreciation of electronic methods under war-time conditions, industry wished to apply them in their new production setups for post-war work. The field of application is unending-high-frequency induction heating for production-line methods of joining metals, high-frequency dielectric preheating reducing the time of curing of large plastic mouldings to a fifth, high-frequency heating for synthetic-resin bonding of plywood, the electronic sewing or welding of thin synthetic fabrics, the high-frequency warming of frozen products, the control of resistance welders, wide-range accurate speed control of motors, etc. Pick up any trade journal, and, irrespective of what

trade it is, there is almost bound to be a mention of some electronic apparatus for that trade. Electronics can help industry, it cannot make it. Careful investigations and understanding are necessary before its introduction.

There is another aspect I must mention before concluding—electronics in defence. Although we have progressed greatly in science, developing and controlling many hitherto hidden forces, we have developed but little in the control of ourselves as human beings. Until we do so, we must consider the problem of, shall we say, defence. If another war is fought, it is certain that the machines of war, the rocket, atomic bomb, the interception rocket, or other weapons, will be electronically controlled. The man-piloted bomb carrier will be soon a thing of the past. The training in electronics and the development of electronics are essential parts of any defence programme.

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# MEASUREMENT OF STRAIN BY ELECTRICAL RESISTANCE GAUGES.

By W. B. Dunn.

## *Types of Gauge.*

Within a reasonable degree of accuracy, the engineer has long been aware of the properties of various materials used in construction—e.g., aluminium, wood, etc. However, he has in the past failed to achieve a comparable knowledge of the effect of loads, pressures, earthquakes, etc., on the structures he has designed. Hitherto to solve the problem of complex strains has been a job of complicated mathematical treatment, protected by large factors of safety or ignorance. Modern equipment for stress analysis, such as electronic strain gauges, photo-elasticity, etc., provide useful means of solving such problems. The most popular method of measuring surface stresses in structures is by means of the resistance strain gauge, developed by Dr. Simmons at the California Institute of Technology.

Essentially the gauge consists of a length of fine wire, firmly attached to an insulating layer, usually of paper. In use, the complete gauge is glued to the surface of the object to be tested. Such a gauge is capable of registering minute changes in strain, both tension and compression, by corresponding changes in electrical resistance measured on an accurate Wheatstone Bridge. In a few cases a single length of wire can be used, but usually the total length of wire necessary to meet the needs of accuracy and sensitivity is greater than the gauge length, and the wire is formed into multiple layers. This may be done in one of three ways:—

1. The wire is cemented to the surface of a piece of paper in a series of parallel lengths, joined by semi-circular arcs.
2. Wire is wound around a piece of paper so that alternate lengths are parallel and at a slight angle to intermediate lengths.
3. Wire is wound as the weft of a composite fabric.

Each form has its advantages and disadvantages as summarised below:—
No. 1: This gauge has a short drying time and is the easiest to build, but is in itself mechanically weak. No. 2: This gauge has a long drying time, due to the fact that more paper is used and a stronger bond is required. The gauge has increased mechanical strength over type No. 1, and can be made in very short gauge lengths. Gauge 1-16in. long have been made. No. 3: This gauge is hard to make and is not in use in New Zealand. The makers claim for this gauge a very short drying time.

## *Strain Sensitivity.*

The strain sensitivity of the gauge is the figure representing the ratio of change of resistance for change of strain.

$$S = \frac{\frac{dR}{R}}{\frac{dL}{L}} = \frac{dR}{Re}$$