

DEPARTMENT OF DENTAL AND ORAL RADIOGRAPHY

JAMES DAVID MCCOY, D.D.S., EDITOR,
LOS ANGELES, CALIF.

A CONSIDERATION OF SOME PHASES OF X-RAY MACHINE CONSTRUCTION FROM AN ENGINEERING STANDPOINT

By J. B. WANTZ, E.E., M.E., CHICAGO, ILL.

SOME time ago, an article entitled "The Price of Progress" was published in the *Interstate Medical Journal*. This article showed how the rapid developments in the field of roentgenology cost the medical profession and the manufacturers great sums of money. In the case of the doctor, this cost was due to the fact, that, before a first class machine had become at all impaired through use, it was so far out of date, that the doctor was forced to purchase a new one. As can be readily understood, the loss of money the doctor suffered was due to no defect of the machine itself, nor was it due to some fault of the manufacturer, but was caused only by the rapid progress of the art, and the author, therefore, rather aptly called this "The Price of Progress."

The money paid out in this way brought a tangible advance in the method of using and generating the x-rays. In other words, the advantages of a certain amount of knowledge were obtained by the spending of this money. This knowledge, once gained and paid for, is not the property of the individual, but of the world at large, and it should be so considered.

Engineering in its broadest sense is the application of known facts and principles to new problems. Dental radiography is, comparatively speaking, a new science. Its importance is such that a prominent professor of dentistry recently said, "I would buy an x-ray outfit if I had to mortgage my office to do it." Fortunately, dental radiography is very closely allied to general radiography, as employed by the medical profession. The latter is already well beyond its infancy, and is, in fact, a recognized and respected branch of medical practice. Looking then at dental radiography from the viewpoint of an engineer, what would be more natural than to apply the principles and methods learned in general radiography to dental radiography. The "Price of Progress" in general radiography has already been paid—knowledge has been gained. What is more natural than to apply this knowledge to a science so closely related to the one in whose development the knowledge was acquired.

From an economical and an engineering standpoint, then, it is but natural to expect that the manufacturers, in designing machinery for this new purpose, would bear in mind the knowledge and experience so dearly bought in their old field of endeavor. One has but to look through the catalogues of some of the manufacturers of x-ray equipment for dentists to know that the answer in

many cases must be "No." Whether through a desire to exploit this virgin field, whether through a wish to unload old apparatus, or whether through inexcusable ignorance will in the end make little difference. A retrogression in the class of machines advertised is apparent, both from the economical and the engineering standpoint. It is safe to say, then, that if these machines are sold, the dental profession will be forced universally to pay the "Price of Progress" for knowledge which the world already possesses.

There are machines advertised which consist of an induction coil with a fixed primary winding, a single point "self-adjusting" electrolytic interrupter, a fixed resistance supposed to "regulate the tube current gradually," a milliamperemeter, and a valve tube. The milliamperemeter is the only piece of apparatus in this entire machine which is applicable to a modern x-ray generator.

The induction coil with a fixed primary winding has been discarded by all manufacturers of x-ray apparatus for the medical profession, for all machines except some of the very smallest. A catalogue, issued by a once prominent x-ray coil manufacturer in 1907, fails to show a single coil with a fixed primary winding, although twenty-six outfits are listed.

The type of interrupter, advertised as a "self-adjusting" electrolytic interrupter, has not been used by any large manufacturer since about 1905, on account of the necessity of controlling the amount of current admitted to the apparatus by the variation of the amount of the electrode point exposed to the action of an electrolyte. An interrupter of this general design is described in a catalogue issued in 1907. There is, however, a method of controlling the amount of the point exposed in that interrupter, which is not the case in the interrupter in question. The description in the catalogue states that this improvement (the method of controlling the amount of the point exposed) was one of the things which made the interrupter practical. The use of the interrupter direct on alternating current is also "taboo" with most responsible manufacturers, as, in nearly all cases, rectifiers are listed with alternating current outfits.

The amount of energy transmitted to the apparatus can, as before mentioned, be controlled by the area of the surface of the interrupter point exposed to the action of the electrolyte. On all machines, since practically 1900, another means of control was provided; namely, a rheostat by which a more refined and gradual control was possible. In all cases, however, some resistance was always left in circuit. This resistance acted to limit the current when a very soft tube was used. Without it, the tube would "pull" enough energy to destroy itself. The fixed resistance then acts only as a current limiting device, and therefore could not be used to "reduce the current so that the x-ray tube..... may be regulated gradually" as the advertisers so blithely state of their "resistance unit."

When an x-ray tube, energized by a coil, begins to show "inverse," it is a sign that the tube is too soft for the voltage impressed across it; that is, the resistance of the tube is so low, that the electromotive force, generated by the make of the primary circuit, is great enough to force current through the tube in the wrong direction. The proper and standard remedy for this is to cut in more inductance,—decrease the ratio of transformation, by putting more pri-

mary turns in circuit. This procedure will lower the potential delivered by the coil, so that the electromotive force, induced in the secondary at the make, is no longer great enough to force current through the tube.

Now, if the coil is one in which there is no possibility of changing the ratio of transformation,—in other words, if the coil has no inductance switch,—there is no possibility of eliminating inverse by this method. There is, then, only one method left—the valve tube.

Theoretically, the valve tube is a good thing. Practically, it is not. A gas-filled x-ray tube, as all radiographers know, has a vacuum which must be frequently adjusted. The valve tube, too, has this self-same vacuum, and, in order to operate efficiently, must be adjusted very exactly. The radiographer, by using a valve tube, greatly increases his own troubles and complicates the operation of his apparatus.

As far back as 1907, valve tubes were not in great demand among the members of the medical profession. In fact, a catalogue of a prominent manufacturer, dated June, 1907, and dealing altogether with x-ray apparatus, fails to say a word about valve tubes, although twelve of its thirty pages deal exclusively with induction coils and coil accessories.

Another catalogue, of one of the largest coil manufacturing companies in the world, lists nineteen coil outfits, only four of which are equipped with valve tubes, and these four outfits are equipped with *triple* valves, in addition to the inductance switch, merely as an extra guard against inverse. The coil in question, however, has only a single valve to ward off inverse.

Now, if we trace the development of the induction coil, we see in it a perpetual fight against inverse. First, the series spark gap, then the valve tube, and last of all, the inductance switch, mark epochs in the struggle. The final product of this long period of development is, *on direct current*, a machine to be reckoned with. It is a coil with a potential high enough to break down a twelve inch air gap and with enough iron in the magnetic circuit and enough copper in the electrical circuit to make a large milliampere output possible. An inductance switch of at least four or five steps is always provided. The interrupter is either one of the gas-filled, mercury-turbine variety, or it is a multiple-point, electrolytic break with devices for making very close adjustments of the points possible.

The rheostat, too, shows the result of evolution in that instead of being merely any old regulating resistance, it is a rheostat of special design, with a great many points, and capable of running long periods with a high energy output without overheating. On alternating current, however, even this coil cannot do the work because of the necessity of rectifying elements and their attendant troubles.

As mentioned before, this type of coil is a very capable piece of apparatus on a direct current, but then *only* when it is in the hands of an experienced operator. You have three points of control to set or to operate when running the machine; namely, the inductance switch, the interrupter, and the rheostat.

On the modern x-ray machine,—the Interrupterless—there is merely a rheostat to be set. The result is that with a modern equipment, the operator has to spend a great deal less of his time and thought in the mere mechanical

act of operating his machine, and will, therefore, have more of his time to devote to the serious part of his business,—the patient.

This ease of operation is entirely due to the fact that this modern machine develops no inverse and needs no interrupter, because the current energizing it is alternating in character. This last fact is one drawback to this type of machine; when the service current is direct, it is necessary to provide each machine with a rotary converter of large capacity to change this current to alternating, but the simplicity of operation is still there.

The Interrupterless is, then, speaking in general, the real x-ray generator. With this in mind, it can be readily seen that if the manufacturers have enough foresight to apply the knowledge, which the "Price of Progress" has purchased for them, then the Interrupterless is the machine to be used in dental radiography.

As the field of dental radiography is new, new conditions will be found and, no doubt, a new machine, for this particular purpose, will be developed. If this is the case, by all means let the Interrupterless be the groundwork, for in it we have a sure foundation, proved by experience. To go back to the induction coil, is retrogression,—is an attempt to halt the march of progress; worse still, it is a disregard of all engineering principles, and those unfortunate enough to be misled by the selling patter of the wily agent will again be called upon to pay the "Price of Progress."