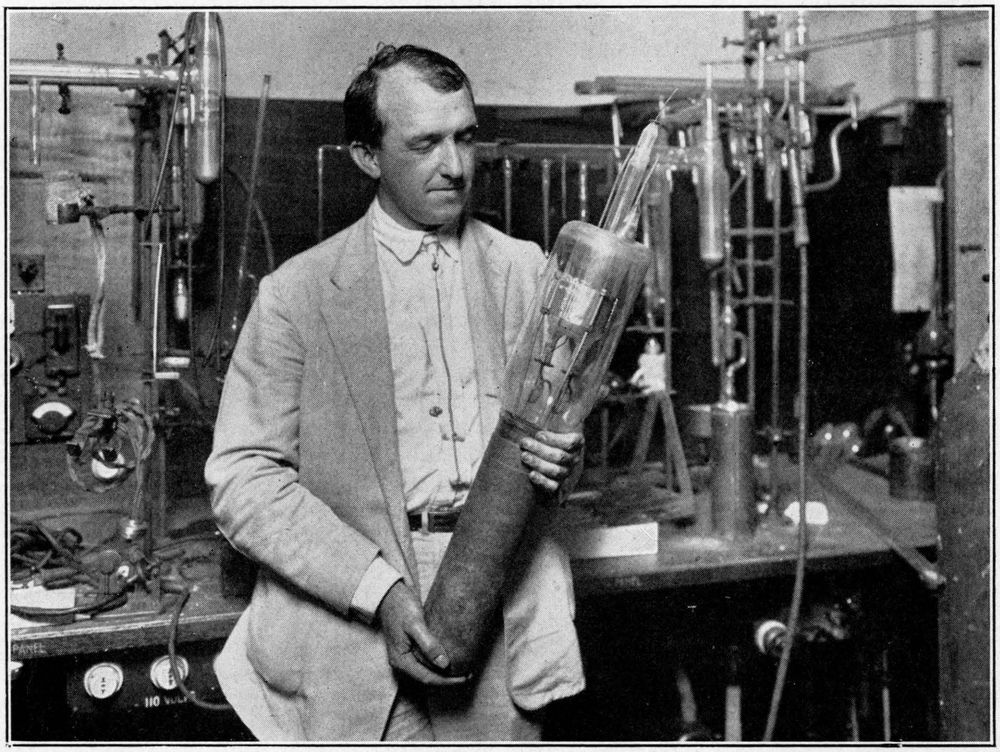
# A New Type of High-Power Vacuum Tube

There is an old saying to the effect that success in little things leads to success in big things. The author of this maxim probably wanted to express the fact that a little job well done prepares the way for the doing of a big job.

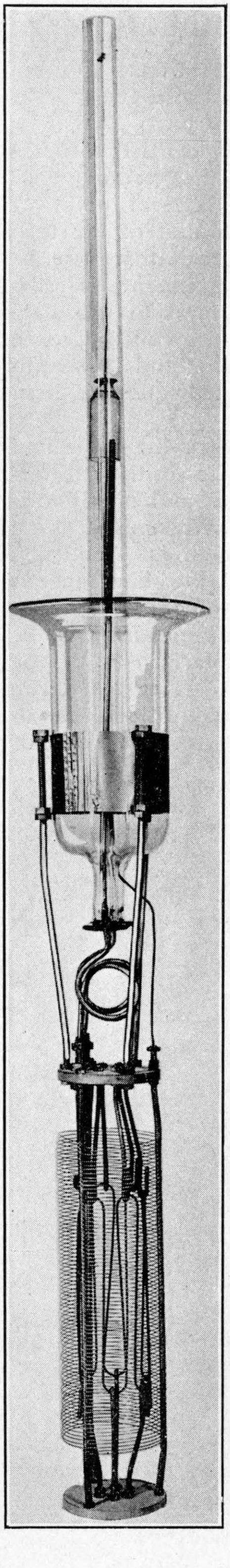
It is not exactly this kind of a situation that we shall consider here, but the old saying seems, in a sense, applicable. Here is a case in which the successful development of a very small piece of apparatus paved the way for the successful development of a very large piece. To the uninitiated there may seem to be little connection between the tiny switchboard lamps which flicker on the modern telephone switchboard and a vacuum tube (using this term in the sense in which it is applied to telephone repeater tubes) which requires a 250-horsepower engine and electrical generator of corresponding size to keep it supplied with electrical energy. As every telephone employee knows, the switchboard lamp is scarcely as big as a peanut while the large vacuum tube, which in a way is its descendent, many generations removed, is about three feet long and four to six inches in diameter.

Now a word as to what this enormous vacuum tube does. Its principle of operation, from an electrical point of view, is identical with that of the telephone repeater tube. It can, therefore, be used to generate high frequency oscillations, to detect them, and to modulate them as repeater tubes are called upon to do in carrier telephone and telegraph sets. The large tube may also be used as an amplifier.

The difference between the large and small tubes, therefore, lies in their different electrical capacities and not in difference of principle. When used as an oscillator to generate high frequency electrical oscillations, the big tube is capable of an output of fully 100 kilowatts. Just what this means can be gathered from a comparison with the oscillating tube in a carrier set. The latter, under normal conditions, might be capable of developing one watt of



*W. G. HOUSKEEPER OF THE BELL SYSTEM RESEARCH LABORATORY*



high frequency energy. In figures, then, the large tube is 100,000 times as powerful as the small.

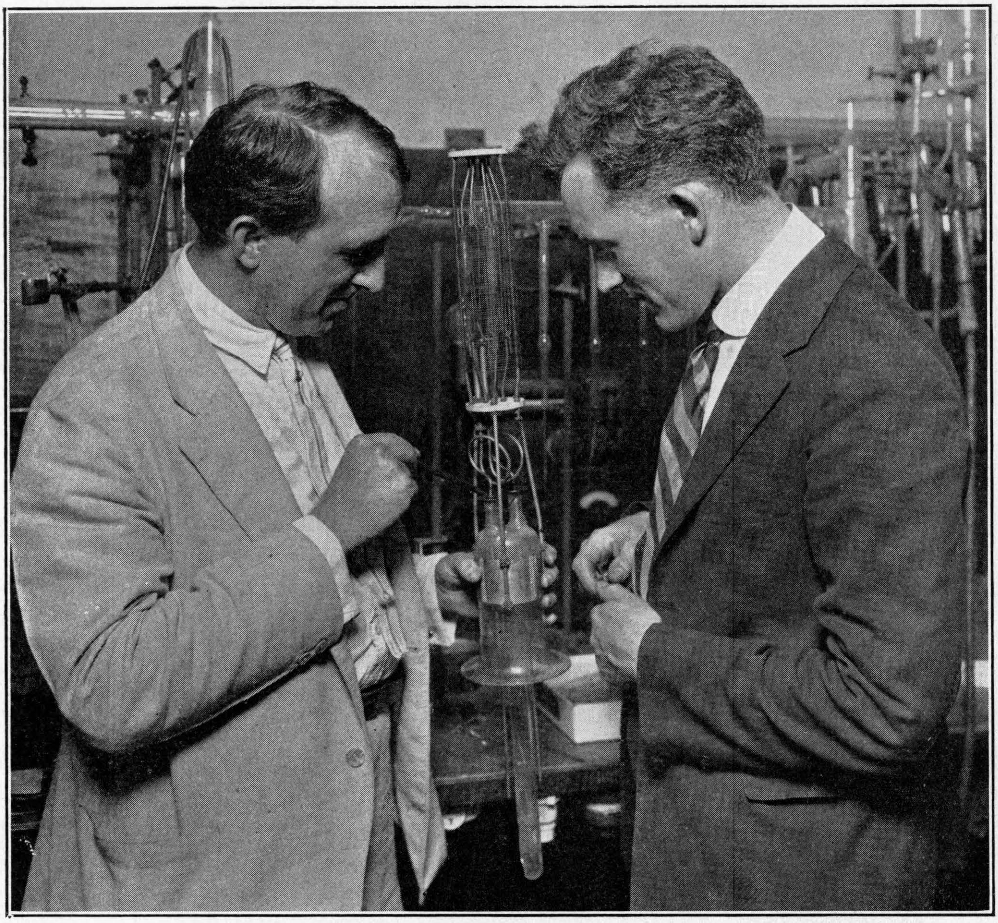
Needless to say, these new tubes will not be used in carrier sets and as telephone repeaters. However, there are various important uses in sight for them, particularly in connection with radio telegraphy and telephony, and to these we shall return later.

Let us look for a moment at the sequence of events which has caused the switchboard lamp to give rise to such enormous progeny. Several years ago W. G. Houskeeper of the Bell System research laboratory at the Western Electric Company in New York City became interested in cheapening the manufacture of switchboard lamps. One of the things he aimed to accomplish was the elimination of platinum wire, which was being used for the leads to bring the filament heating current through the glass wall of the lamp. His study showed him that copper wire possessed one of the requirements necessary to a vacuum tube seal when fused through glass This requirement is that the molten glass "wet" or adhere closely to the wire. Another requirement, of course, is that the wire should not cause the glass to crack upon cooling. Now platinum and glass contract about equally upon cooling, and the glass is not strained sufficiently to crack. Copper and glass, however, have quite different coefficients of expansion with regard to temperature, and Mr. Houskeeper found, after many trials, that only by giving the copper wire a peculiar cross-sectional shape could he prevent cracking.

His success with the very fine copper wires which he was using as leads for his experimental switchboard lamps led him to study other and bigger types of seals between glass and copper. Prolonged study led him to bring some of these to enormous sizes compared to seals which had previously been made.

It was about this time that it became apparent to the Bell System engineers who were interested in the development of radio apparatus that vacuum tubes of very much greater capacity than those which had ever been used would find applications in future. One of the major problems connected with the building of a successful high-power vacuum tube has to do with the removal of the heat generated in the tube during operation. In the small tube the removal of this heat can be taken care of by radiation. But experiments showed that, with present known methods of construction and using a glass bulb as container, a radiation cooled tube could not handle more than one kilowatt or possibly two. This fact indicated that the desired solution of the high-power tube would involve some auxiliary means of cooling, as by a circulating stream of water. To employ water cooling successfully requires that those metal parts that are most subjected to heating (the plate or anode) should come directly in contact with the cooling water.

In the early experiments in the research laboratory various types of water-cooled tubes were tested. The most promising of these involved the use of a small platinum tube as anode. This tube was closed at one end and opened at the other to admit the stream of cooling water, the grid and filament being

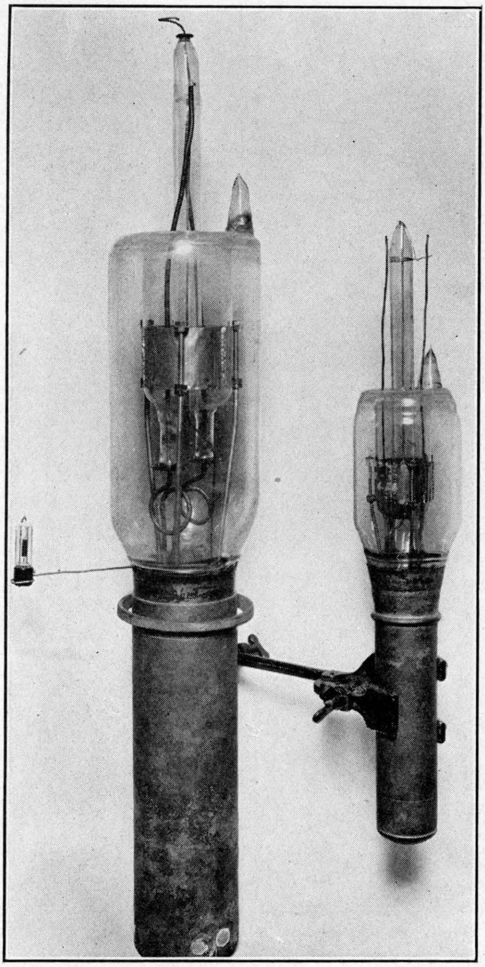


*THE INTERNAL ASSEMBLY OF THE 100 K. W. WATER COOLED TUBE*
*W. G. Houskeeper pointing out one of his remarkable metal-to-glass seals, here used to conduct the 91 ampére filament heating current through the glass wall of the tube*

placed outside of the tube and concentric with it.

After a thorough investigation of the platinum anode tube, the engineers turned to the large copper seals as a possible key to the making of high-power tubes, and Mr. Houskeeper's experience with these seals qualified him to take part in this phase of development. As a result of many experiments, a tube designed successfully involving copper seals has been worked out and is quite clearly illustrated by the accompanying photographs. The plate, instead of being supported within a glass bulb, in the new tube takes the form of a large copper thimble with thin walls. This is attached by a vacuum tight seal to a glass structure which supports the filament and grid and through which the lead wires are carried. As shown in the photographs the filament lies within the cylindrical grid and this whole structure is placed within the copper anode and concentric with it. The cooling water is circulated around the outside of the anode and does not enter the evacuated space within. It is, of course, necessary that the anode be very free of minute holes which would tend to admit air or water vapor, a requirement which had led to the drawing of anodes from a single disk of copper.

At present the new water-cooled tubes are being constructed in two sizes, the large one already mentioned, which is capable of delivering 100 kilowatts, and a small one whose capacity is ten kilowatts. One of the accompanying illustrations shows these two tubes side by side and for the sake of comparison a



*EXTREMES IN VACUUM TUBES*
*In the center the 100 k. w. water cooled tube, on the right the 10 k. w. water cooled tube, and on the left the little "peanut" tube (Type H.) whose filament can be lighted with a single dry cell. The filament heating current of the 100 k. w. tube is 91 amperes.*

third tube has been included which is the smallest one being manufactured and which is popularly known as the "peanut tube."

A few figures in regard to the 100 kilowatt tube may be of interest. The anode is 14 inches long and 3.5 inches in diameter. The filament is of tungsten wire and is .060 of an inch in diameter and is 63.5 inches long. The current required to heat the filament is 91 amperes and the power consumed in it is 6 kilowatts. The filament leads are of copper wire 1/8 of an inch in diameter and are sealed through the glass wall by means of a special disk seal. To those who are at all familiar with glass blowing, it will be apparent that the handling of the parts of this tube during manufacture presents a task of no mean magnitude, and numerous fixtures have been devised to assist in the work.

The significance of this tube development to the radio art can scarcely be overestimated. It makes available tubes in units so large that only a very few would be necessary to operate even the largest radio stations now extant with all the attendant flexibility of action which accompanies the use of the vacuum tube.

From the standpoint of radio telephony, the development of these high-power tubes makes possible the use of very much greater amounts of power than have ever been readily available before. The 100 kilowatt tube by no means represents the largest made possible by the present development. There is no doubt that if the demand should occur for tubes capable of handling much larger amounts of power they could be constructed along these same lines.—*R. W. King.*

### Telephone Demand Increases

In a statement accompanying the one hundred and thirty-second dividend, President H. B. Thayer of the American Telephone and Telegraph Company said:

The demand for telephones grows faster than our population. It is an intensive growth; an increasing percentage of the population is seeking telephone service. It is a function of the American Telephone and Telegraph Company to study the future requirements for telephone facilities and to coöperate with the associated companies of the bell system in provision for adequately handling the new business as promptly and economically as possible.

To take care of new telephone business, approximately $175,000,000 worth of new telephone plant—Consisting of land, buildings, switchboards, cables, toll lines, and telephone instruments—is built by the Bell System annually. These new telephone facilities mean additional revenues and increase the value of the service to all telephone subscribers by increasing the number of people with whom each subscriber can talk.

In view of the needs of the business, the company offered to its stockholders of record on September 8, 1922, additional stock in the proportion of one share of new stock to five shares of stock then outstanding. As stated in advising such stockholders of the details of this offer, this substantial issue makes any further issue of stock to stockholders improbable for a considerable period to come.