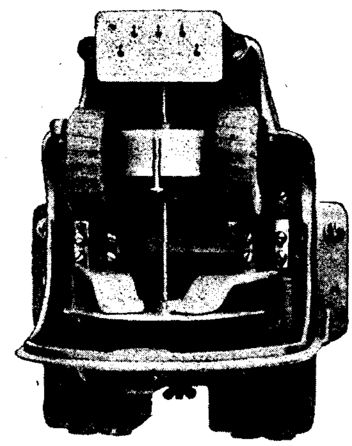
problem to curtail the total discharge of water so that the total power developed may be handled without mechanical inconvenience by the working parts of the motor.

In order to develop considerable power, with a comparatively small head using an impulse wheel, one of two things must be done: either the area of the nozzle and consequently that of the vanes must be made very large, which is only practicable to a limited extent, or else the number of nozzles and wheels must be multiplied. Thus the use of impulse wheels under small heads involves a large amount of machinery for the power obtained. On the other hand, the impulse wheel has many points in its favor, chief among which is its simplicity of construction, which leads directly to the absence of mishaps and to ease of maintenance. The bearings are simple, being merely those on the horizontal shaft, in such a position as to be easily got at when necessary to make any repairs or adjustments. There are no bearings running under water; and the bearings are not subject to any other reaction than that due to the useful effect of the water on the wheel; no difficulty is met with corresponding to that of balancing the static pressure of the water on a turbine, which becomes such an important problem when large heads are being used. The impulse wheel has no watertight joints, as there is no water pressure to be maintained among the working parts. The mechanism also does not contain any parts which are likely to work loose or otherwise become deranged and so lead to trouble.

An important point in determining the practical usefulness of water motors is their adaptability to be run with a fair degree of efficiency under a fraction of the full load. This state of things is generally liable to occur either intermittently, as where a number of loads are being continually put on and off the mechanism driven by the motor; or periodically, as where for portions of a day or week or year the work required from the motor is heavier than at other times. Three methods will be mentioned which are employed to vary the output of work from the wheel. It was mentioned that three nozzle tips of different sizes were supplied with the wheel with which the tests were made. By changing these the quantity of water discharged under a given pressure can be varied as the area of the orifice. The power of the jet will consequently vary in the same ratio; and so any change of load which can be anticipated and will last for a considerable period can be provided for. The changing of the nozzle tips need not be a very difficult operation. It is, however, a very inconvenient plan to have to resort to to regulate the output of power from the wheel. These wheels are sometimes built with several nozzles placed at intervals round the periphery of the wheel. When this is the case the power can be reduced by shutting off the stream from one or more of the nozzles. The third method is to employ a valve or gate in the supply pipe which can be shut off to any desired extent by hand or by some automatic regulating machinery. This method is almost always necessarily employed in addition to those aforementioned. It will be noticed that the effect of the valve to reduce the power is reached by throttling the water as it passes the gate, thus reducing the pressure of the water as it reaches the orifice and consequently reducing also the discharge. It need hardly be pointed out that there is a great loss of efficiency when the motor is running under a light load, as the pressure energy which is not required to drive the machine is all absorbed without useful effect in the resistance of the partially closed valve. An idea of the actual efficiency reached can be gained from a consideration of the foregoing results, obtained for the small nozzle, for the range of heads from 120 to 300 feet. In calculating the efficiencies previously given, the available work was calculated on the assumption that the pressure under which the test was made was the total pressure available. But if that pressure is not the total available pressure as when the pressure is reduced by throttling from 125 to 100 or 75 lbs. per sq. in., then the total available work must be considered to be the product of the weight of water used and the head equivalent to the total available pressure before any throttling took place. In the preceding remarks an attempt has been made to describe and discuss the action of impulse water wheels, and more particularly of the wheel on which the experiments described were carried out; the question of efficiency has been illustrated and examined, and the advantages and disadvantages connected with the use of such a system have been pointed out. It is hoped that these notes may throw some light on this interesting and important subject.

DUNCAN INTEGRATING WATT METER.

This instrument embodies all the essential points that go to make it perfect in every respect. Its operation, like the lamp and ampere hour meters made by the Fort Wayne Electric Corporation and which are giving such good satisfaction, depends upon the induction principle, so that it is very simply constructed and entirely free from any commutator, brushes or other rubbing contacts. It is also the lightest and most compact induction watt meter on the market, so that it is very easily handled and installed. It also has an accuracy on all loads that is excelled by none. When once standardized it will remain accurate for years, this being due to the permanent



magnets forming part of the retarding device being artificially aged by a new process. Another feature that readily recommends it, is a variable friction compensator with which it is equipped. This is something entirely new and provides for cases where the meter should run slow on one lamp after being installed some time, due to the jewel becoming rough. This is a complaint so familiar to the users of electric meters that it does not require to be dwelt upon here. Suffice it to say, however, it does the work and does it well, and without interfering or modifying the speed on any of the other loads. This meter is also applicable to systems having a varying rate of alternations due to uneven speed of the motive power, registering with extreme accuracy.

The principal elements employed in its construction are: Series coils that are mounted upon a laminated iron core which forms the greater portion of the magnetic circuit; an aluminum closed conductor or armature in the form of an inverted cup; and a shunt or volt coil mounted inside the said aluminum armature. The series coils are traversed by the main currents supplying the lamps or other translating devices, and magnetize the iron core in proportion to the amount of current through them. The volt coil is traversed by a current proportional to the electromotive force of the circuit, and is caused to lag

behind the pressure by the addition of an impedence coil connected in series with it. This lagging or difference of phase between the magnetisms of the series and shunt coils causes them to combine into a common resultant which rotates the aluminum armature with a torque proportional to the watts. To make the speed correct and reliable, an aluminum disc is mounted upon the spindle with the armature and rotated be-