

results of various experiments, this equivalent may be taken at 778 foot-pounds. It may be stated, for example, that 778 pounds falling through one foot will develop energy sufficient to raise one pound of water one degree Fahrenheit. This heat unit is termed a British thermal unit, or B. t. u.

Now, by definition, a horsepower is 33,000 foot-pounds per minute, or 33,000 x 60 foot-pounds per hour. If, therefore, we divide 33,000 x 60 by 778, we obtain 2,545 as the heat units derivable from one horse-power-hour of energy. Correspondingly, the heat units derivable from one kilowatt-hour are 3,412.

It makes no difference, of course, what prime agency has resulted in the development of the power. Consequently, it may be stated that a horse-power-hour of electrical energy can only yield approximately 2,545 heat units. One pound of anthracite coal contains about 14,000 heat units.

During the past year increased attention has been given to this subject, and the press, both technical and public, has referred to the matter in a manner which clearly shows that at last it is dawning upon the public mind that electrical energy as a wholesale substitute for coal is a forlorn-hope.*

If it is to be used wholesale, then electrical energy is more efficiently employed for power than for heating purposes. For many manufacturing processes requiring heat, and as an auxiliary heating agent for buildings, etc., electricity has a wide field of usefulness. Great economies in coal will be effected by a proper co-ordination of electricity and coal according to their respective spheres of greatest efficiency.

Growth of Co-ordination of Power Production

Greatly increased attention is being given to the subject of the inter-connection of various electric plants—whether steam-electric or hydro-electric, or combinations of both—with the object of securing greater efficiency in the supply of power and light to districts respectively served. The editor of the "Electrical World," referring to this subject, recently stated that "Economic co-operation is going to be one of the keynotes of the reconstruction period, and whether an engineer believes that inter-connection will pay or not in a given case, he will do well to analyze its prospects."†

In the United States, the fuel administration commenced investigations in different sections of the country to ascertain the operating status of various power-producing companies in order to determine how best to co-ordinate their activities to the end that coal might be conserved. Commenting in general terms upon these efforts, the chief of the states conservation bureau of the federal administration, L. R. Clapp, writes:—

"The inter-connection of power systems, both steam and hydro-electric, offers an opportunity for real fuel economy and has received the active attention of this bureau. In many parts of the country duplicate transmission systems exist, serving practically the same territory. One or more of such lines may derive all or nearly all of its power from water, while other companies use coal. No company operates with a continuous one hundred per cent. load factor, and almost always the peaks are different for different companies. Therefore inter-connections permit the use of the maximum water power and also allow an increase in the average load factor. In its hydro-electric work the bureau has had the assistance of the geological survey and much work of permanent value to the country has been effected along these lines. Another similar activity is the possibility of closing down an uneconomical central station where, in the same territory, a more efficient power plant is able to give the same service. It is estimated that there are, throughout the country, nearly 500 instances

*The Hydro-Electric Power Commission of Ontario recently issued two valuable papers by A. S. L. Barnes, namely, "Report on the Rate of Coal Consumption in Various Electric-Generating Stations and Industrial Establishments in Canada and the United States;" also, "Report on the Heating of Houses—Coal and Electricity Compared." (The same discussion is published by the Honorary Advisory Council for Scientific and Industrial Research as Bulletin No. 6).

†"Electrical World," New York, December 21st, 1918.

of such duplication, and several consolidations have been effected. The savings which have resulted from this work have been estimated to be some 540,000 tons of coal in the calendar year 1918. In general, we feel that this has not been a particularly profitable field for emergency conservation work, the projects involved requiring far too much time for their consummation for immediate benefit. Over a ten year period perhaps, important coal economies could be effected by this means.**

Efficiency of Entire Systems

Heretofore, efforts have been concentrated to secure the efficiency of the unit apparatus of power-generating stations, such as turbines, generators, transformers, etc., but now efforts are being directed to increase the efficiency, not only of units as such, but of the systems of which the units are an integral part. In this connection such questions as the load factors of generators and of systems, the diversity factor, etc., are being subjected to scientific analysis. The creation of super-power stations suitably located with respect to cheap and reliable supplies of coal, of water, of raw materials, for shipment and other purposes, will receive increasing attention. In connection with all these matters greatest care should be taken not to disturb ruthlessly existing organizations and installations, but rather to seek out ways and means by which they may be adapted in some ready and efficient manner to the new general scheme.

It will be profitable for those interested in this subject of co-ordination to study what has been accomplished by the fuel administration of the state of New York in the capitol district of the state; also by the Pennsylvania administration with regard to power generating stations in the mining districts; also by the inter-connection of plants in Eastern Massachusetts and elsewhere; and the extensive work of co-ordination by the Chicago, Milwaukee and St. Paul electric systems.

Co-ordination of Power Systems in Canada

The general trend of such work, however, will be quite clear from the following illustration respecting work in hand by the Hydro-Electric Power Commission of Ontario. This commission, in the extension of its various power installations has also been seeking greater efficiency by inter-connecting and co-ordinating several of its systems until in effect they form one comprehensive unit.

By way of illustration, inter-connection has been arranged between the Wasdell's Falls system, taking power from the Severn River, with a head of about 14 feet and an installation of 1,200 h.p.; the Orillia system, with development at Swift rapids on the Severn River, under a head of about 50 feet and with 5,000 h.p. installed; the Eugenia system, developing at Eugenia Falls on the Beaver River, under a head of 550 feet and with a machinery installation of 8,800 h.p.; and the Severn system, with development at Big Chute on the Severn River, under a head of about 58 feet, with an installation of 5,600 h.p. It may just be mentioned that the steam plant at Owen Sound has been kept in commission, and at times is used to help on the Eugenia system, and the steam plant at the C.P.R. elevator at Port McNicoll is correspondingly used on the Severn system.

It is under consideration to have the Muskoka system, which develops at South Falls on the south branch of the Muskoka River under a head of 106 feet with installed capacity of 1,750 h.p.—a capacity of about 6,000 h.p. is possible—also co-ordinated to this group.

The commission has also proposed a new development at Port Elgin on the Saugeen River, under a head of 80 feet, with an estimated complete development of from 10,000 to 15,000 h.p. This, when constructed, will supply some twelve to fifteen municipalities which at the present time are utilizing coal for the production of their light and power.

It may be explained that at the Muskoka and proposed Saugeen developments, largely increased power may be obtained at times of flood flow. The Eugenia plant, on the other hand, is essentially a storage proposition, and can, therefore, at times of flood flow impound waters which sub-

**From letter to A. V. White, 3rd of January, 1919.