Rapid Transit Arithmetic

The Principle of the Economic Unit Applied To Large Cities' Utilities

By John Lathrop

WERE the statement printed broadcast in the United States or in Great Britain that "the principle of the economic unit, as applied to construction costs and operation of transit lines in large cities, entailed an inevitable increase of passenger fares," the mass of the people would not understand the meaning of it. And yet, by open and frank discussion—by interpreting this well-known engineering principle so that "the men in the street" could understand it, Lord Ashfield, managing director, and Mr. Frank Pick, assistant managing director, of the London County tram, underground and bus lines, achieved that which might have been regarded as impossible.

The increasing of base fares in the Zone system there from one penny (two cents) to one and one-half pennies (three cents) with virtually no complaint by the people. That this was an achievement, that the one-penny base fare was almost so sacred a tradition in England as Magna Charta, the parchment of the original of which rests in the British Museum, must be freely conceded. Post-war burdens had been piled on the British people until they staggered under the colossal whole.

When, therefore, the suggestion was advanced that transit fares must be increased fifty per cent, else the companies would be compelled to retain the Government guarantee, or be insolvent, loud protest was registered by certain writers who seize every opportunity to prejudice public opinion on all matters in respect of the people's utilities.

However, before these protests assumed considerable volume, the managing director, Lord Ashfield, who is American-trained in railway science, asked his assistant managing director, Mr. Pick, who also is American-trained, to take up the frank discussion with the people, through legitimate advertising channels, of the precise situation of the companies, explain why increased fares were necessary, and that, unless they were granted, it would be necessary to continue to

find financial backing from the Government, in order to carry on the service and new commitments essential to continued operation and the supplying of the people's service needs.

Mr. Pick called in his publicity experts, laid before them the scientific principles involved, and told them to go to the people with their arguments. Preliminary objections publicly expressed had been, as expected, among the line of "watered stock," "selfish corporationists," and so forth.

The publicity men proceeded, first, to elucidate to the understanding of the average person the practical out-working of the principle of the economic unit. They showed how, as a city grows toward a certain magnitude, the economies are preserved, and costs of public utility in construction and operation are reduced per unit. They went on to show that, after the city has grown beyond the limit of economic size, costs, instead of being lessened per unit, are inevitably increased; that it costs more per passenger to build and operate in a city of a million population than in one of a hundred thousand; and that, when population mounts to the six millions of London or New York, the economic limit has long since been passed, and costs per unit are vastly more than when the city was small. The involvement of the mechanical works—the intricate network of pipes, conduits, sewers, watermains, telegraph and telephone wires, the heavy and permanent pavements—entailed inseparably higher costs. The growing congestion in the streets, especially after the popularization of the automobile, likewise prevented the economies which the mass of the people believed were possible in a larger city, and added to the passenger-mile costs of operation. The general increase of cost of supplies and materials, they showed, was 150 per cent. For instance, cars which cost two thousand pounds pre-war now cost seventy-five hundred pounds—an increase of 275 per cent. And so on *ad finitum*.

The arrangement was effected with the Minister of

Transport that on September 20, 1920, the Government guarantee should be abandoned, the fares be increased from one-penny base to one and a half pennies, and the companies would stand on their own footing financially, meeting their charges from their own revenues, and asking no aid from the public treasury.

I talked with Mr. Pick at the companies' headquarters in Electric House, Westminster, after the report had been prepared by Lord Ashfield for submission to his stockholders. "How extensive was the volume of protest?" I asked.

"We have here," he answered, pointing toward the letter files, "every written protest which we received. I should be glad to show them to you. There are six millions of persons in London district served by our lines. And we received exactly forty-two letters of protest!"

That, of course, was negligible, especially when the total volume of traffic be taken into account as revealed in Lord Ashfield's report:

Car-miles of the entire system, 179,000,000; an increase of 19,000,000 during the year.

Trackage, 753; underground, 105; trams, 124; omnibuses, 524. Passengers carried, 1,487,000,000; underground, 404,000,000; trams, 210,000,000; omnibuses, 873,000,000; total increase over previous year, 110,000,000.

These increases were forced upon the transit lines by the conditions of city life there which were duplicated in every large city, and in many smaller cities, in all countries during and after the war. And, with fares remaining at the traditional one-penny base, so Lord Ashfield observed in his annual report, "the very success of transport companies in attracting and creating passenger traffic was a burden to them. Since then (the increasing of the fares) the situation has changed radically for the better."

This improvement in the financial status of the
(Continued on page 190)

Correspondence

The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

Old Thought and New

To the Editor of the SCIENTIFIC AMERICAN:

Professor Eddington appears to assert that there are absolute things as matter, and that force is purely relative; and also that matter is merely a symptom, and the reality is the field of force. (Space, Time, and Gravitation, pp. 42, 76, 165, 191, *et passim*.) Doubtless by a universal theory of relativity, as distinguished from the special and the general theory, these discordant positions could be harmonized. But it is difficult for the "exoterikoi" to penetrate to the underlying verity.

It is vastly amusing to see the materialists (of whom I am one) giving up matter as an ultimate reality. In taking perhaps a final leave of this supposititious and degraded entity, it is interesting to consider some of the views entertained of it by men preeminent for power of thought throughout the ages.

Plato called a material object a shadow of the real. Gorgias of Leontinum went him one better, and asserted it to be a particular instance of that which is not. Heraclitus before him, an example of generation and corruption, of a passing from not-being through being to not-being again. Democritus, a fortuitous, or necessitated, or self-determined concourse of atoms. St. Augustine, harking back to Heraclitus, a temporality of the Eternal. The schoolmen, a group of transitory, varying accidents inhering in a perdurable, unchanging hypostasis. Berkeley, a group of visible and tangible phenomena not manifested by an underlying substance. Descartes, an extended, inert entity occupying space. Leibnitz, a congeries of unextended, energizing monads. Spinoza, a modification of the divine substance. Kano, a manifold of intuition. Hegel, a figment of the consentient. Hamilton, a mode of the unconditioned. Mill, a permanent possibility of sensation. Spencer, a manifestation of the unknowable. Emerson, a projected phenomenon of the intellect. Francis Bowen, a locally limited portion of space endowed with the principle of

causation. This last would seem to include the latter day view, the nucleus of a gravitational field.

Present opinion seems to be that our notions of space and time are derived from our experience, personal and ancestral, of material objects. Of space and time all possible views have been held, none of them free from very grave difficulties. They are things, objective realities, conditioning all other realities. They are relations between things. They are relations between things and states of consciousness (forms of intuition). They are *entia rationis*, figments of the reason as distinguished from figments of the imagination. I should think some of the absolute idealists must hold them to be relations between states of consciousness.

It is very early to predict that the latest theory will give the final victory to a modification of one of these views. It seems to me that the space-time continuum is needed, not as a relation, but as a correlative of the discretum, the changing material universe.

Ashland, Mass.

W. C. ROSE.

An X-Ray Innovation

To the Editor of the SCIENTIFIC AMERICAN:

While experimenting in an effort to X-ray or radiograph documents and objects of a like nature, we have made a rather interesting discovery, the product of which we have designated as "Fluorographs."

The original negatives were made by placing the check or other document between two fluorescent screens while in contact with an unexposed X-ray film. An X-ray exposure of this combination which was tightly clamped in a light-proof cassette was then made with the resulting negatives. Development of the exposed film was the routine development for X-ray exposures as made in the medical laboratory.

At first it was thought that a true radiograph had been made of the exposed document but further experiment demonstrated that the best negatives were made by means of an X-ray exposure entirely too intense and penetrating for such a slight object as a sheet of paper. Endeavors to X-ray documents without the use of the double fluorescent screens, which in medical work are used simply to intensify the action of the X-ray and thus shorten the time of exposure, were entirely without result. We finally came to the conclusion that these negatives were produced entirely by the action of the fluorescent light set up in the intensifying screens

which were in turn activated by the recognized action of the X-rays upon their structure.

Blurring of certain portions of the samples submitted is due to our inability as yet to obtain a holding cassette with sufficient compression to secure perfect apposition of the document and the film. Contrast between the paper and the printing can be further intensified by refinement of the technic of X-ray exposure. These films were taken with an exposure of 20 milliamperes, an intensity of current represented by an air spark-gap of $4\frac{1}{2}$ inches, distance of 36 inches and time of $\frac{1}{4}$ second.

Practical uses of this process may include commercial reproduction of documents and other papers, the detection of changes in checks and bank notes and a means of measuring and standardizing the fluorescent action of intensifying screens.

Portland, Ore.

DR. J. A. VAN BRAKLE.

Poles and Miles

To the Editor of the SCIENTIFIC AMERICAN:

In your Correspondence for August 27, a writer mentioned timing a train with a watch and it occurred to me that the rule for obtaining the speed of a train direct from the watch without any calculation would probably be of interest to your readers.

This rule is very simple and still very accurate. Note the spacing of the telegraph poles. They are usually 34 to the mile. Watch for a straight stretch. Count the poles that you pass in 106 seconds, the number of poles will be the number of miles per hour that you are going.

This rule was developed from the old "count the rails" method that is absolutely useless for taking high speeds. The germ of the idea is the same, however, though it is much easier to see the poles than to hear the "clicks."

Both methods depend on a knowledge of the lengths of the elements. Where mile posts are marked the spacing is easily and quickly found. Should the spacing be other than 34 the number 106 must be changed accordingly. This is easily done by finding the number of poles in two miles, and then finding the number of seconds it will take to pass 60 poles at a speed of 60 miles per hour. For example, 30 poles per mile, 60 poles in 2 miles. It will take 120 seconds to pass 60 poles at 60 miles per hour, therefore use 120 instead of 106 and read the poles as miles as before.

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Rapid-Transit Arithmetic

(Continued from page 185)

London transit lines was wrought by the increased fares, as shown by the following condensation of Lord Ashfield's report:

During the first three months of 1920 the underground carried 108,000,000 passengers, receiving an average per passenger of 2.5 pence (five cents). During the last three months of the year, 98,000,000 passengers for an average of 3 pence (six cents).

In the first three months, the omnibuses carried 217,000,000 passengers for an average fare of 1.75 pence (three and one-half cents). In the last three months, 199,000,000 passengers for an average of 2.5 pence (five cents).

In the first three months the trams carried 51,000,000 passengers for an average of 1.5 pence (three cents). In the last three months, 47,000,000 passengers for an average of two pence (four cents).

It worked out that, although on the total year's traffic there was an increase of 110,000,000 passengers, the traffic in the last three months was less by 32,000,000 than in the first three months. A two per cent decrease in these three months as related to the year's total haulage, plus the fare increase, lifted the companies from necessary Government aid to financial independence. The people were bound to pay the extra charges in any event, whether indirectly in the form of Government subsidy, or directly in the form of increased fares. It was not arbitrary action, nor was it corporate manipulation which wrought to produce those increased fares in London. It was the Median and Persian law of economics—the law of the economic unit—which compelled that result.

It is not suggested herein that this reports to be an exhaustion of this subject, or even to be a complete syllabus. It is merely to descant on the scientific phases of the interesting situation of transit in London, it being true that principles fundamental there must be and are fundamental everywhere, principles being universal.

The point of scientific interest in these figures and facts is that there is a general misapprehension by the popular mind of the science of the economic unit—a misapprehension not at all surprising. Not only the "mass" of the people, but hosts of otherwise well educated men and women, labor under the delusion that the larger the city the smaller the construction and operation costs per unit of public utilities.

This delusion was cited to me by the late Mr. Theodore N. Vail, President of the American Telephone and Telegraph Company, one day, in his offices in New York headquarters. Going to a window, and pointing downward to workmen engaged in tearing up a street and laboring among the net work of utility accessories, he said:

"You are right in applying the principle of the economic unit to this problem. It is difficult to explain to the people why the cost of installing and maintaining a telephone increases as the city grows beyond a given economic size. Just what that economic size is, we cannot precisely define. But it is obvious that New York City with its six millions of population has passed it. Every movement by workmen is hindered by the presence in the street of the other utility works. Every act costs more for that reason. Yes, it is the principle of the economic unit that explains it—but it is hard to make the people understand it."

The President of the Society of Mechanical Engineers of Great Britain, delivering his annual address before that body early this year, declared that the cost per passenger-mile on the London 'buses was more than one hundred per cent higher than the cost per passenger-mile on the underground. Although he did not minutely analyze the statement,

(Continued on page 192)

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Rapid-Transit Arithmetic

(Continued from page 190)

it was obvious from the context that it was the intense involvement of the street traffic—the maze of 'buses, trams, automobiles, horse-drawn vehicles and pedestrians in a congested state which entailed the added per-passenger-mile charges for operation.

I submit that until these scientific truths be elucidated to the people there will be no intelligent public consideration of public utilities. So long as there be unenforced comment, there will be unfortunate prejudice. And so long as unscientific ideas prevail among the people, the politician with public-favor axes to grind will befoe the issue.

If, however, anyone will take the trouble to find the true answer in his own experiences as he moves about in a crowded, congested city, he will easily understand this apparently obscure meaning of the principle of the economic unit.

His delay at street corners when traffic is flowing past; his extra time required to get from his office to call at another office, the constant toll of time which he must pay in going from point to point.

If he, then also the public utility workman, must pay that toll of time; if he, then the public utility itself, must constantly pay the super-charge of time and money in doing business in a very large city; and if so, then charges must advance—as a general proposition, and under existing forms of mechanical procedure.

No one may foretell what will be true in the distant future. It may be that ingenuity will devise methods of overcoming the resistance of intense large-city involvement. But that it has not yet been done must be conceded by all who can see the fact when presented, and apply to the utility the principles which he himself applies, perforce, every day he lives in and does business in one of the world's metropolises.

From Star to Chronometer via Radio

(Continued from page 186)

Cavite (P. I.), North Head (Wash.), Eureka (Cal.), Point Arguello (Cal.), San Diego, San Francisco, Great Lakes (Ill.), and Pearl Harbor (T. H.). Some of these stations send spark, some are signals, and four send both. Where two or more stations can be heard simultaneously a large variation in wave length is arranged; thus, Washington sends 2500 meters and Annapolis 1700 meters; Balboa 7000 meters arc and Colon 1500 meters spark.

The accuracy of the time signals as sent and received by radio is of course of extreme importance. Determinations of this accuracy are carried out constantly. Any navigator assumes, on receiving a radio time signal, that he is getting true time, or time which varies from the true time by an amount of which he has been previously warned. Washington signals lag behind true time nine hundredths of a second; the lag in Annapolis time is 0.07 second. These are known errors, which are practically constant. They are caused mechanically by the relays which are in the land line circuits. It is true time which starts from the Observatory transmitting clock, but a relay starts the signal over the wires and another receives it and turns it into the automatic machinery which sends out the radio signal. In these relays there is the slight loss of time noted. In the Key West signals there is a lag of twenty-eight one-hundredths of a second, due to the larger number of relays between Washington and Key West.

The lag, however, which is always a plus error . . . that is, the signal was late in starting and so we must have added to it the amount of the lag to get the true time . . . is not the only error. Other causes result in small errors (generally less than a tenth of a second) which are of no real importance to navigators, but

which may be of great importance to those who are using time signals for accurate surveying or longitude determinations. A careful check is made of these errors, which are listed by days and amount plus or minus, and such lists are sent out monthly to all who request them, and regularly to such organizations as the Coast Survey, the Bureau of Standards, several watch companies, the Bureau of Railroad Time Service, etc.

The development of radio time signals to be sent out from the United States has reached its maximum as regards the number of sending stations—it is even possible that one or two might be omitted without material injury to the service. There is no need to add other stations within the radius in which existing stations can be heard. But the radio time service is making constant strides forward in accuracy and in research. At present, experiments are being conducted with a view to the elimination of long land lines, such as from Washington to Key West, and sending Key West a radio signal which will there be picked up and automatically be sent out from the Key West Radio Station. Such an accomplishment will reduce the present large lag to a very small one.

Another development of great interest is the comparison of the radio time signal with the apparatus which sends it. At the Naval Observatory electrical apparatus has been installed which permits a received radio signal to operate a chronograph. This results in the most accurate determination of error in a time signal. Thus, Washington sends out a time signal, over the wire; it is received at Great Lakes and sent out there by radio; Washington receives the radio time signal, and puts it on the chronograph side by side with the record of the same signal as it was sent. The comparison is exact, and the error can be analyzed and the proper values assigned to lag in relay, and error in signal. Signals have been sent to Australia in connection with longitude determinations, and for such a distance the time required for the transmission of the radio wave must be taken into account. Radio travels at the speed of light, roughly 186,000 miles a second. Australia, half way round the world is roughly 12,000 miles away. The signal, then, requires about 1/15 of a second plus, to travel the distance.

The reader with an imagination is asked to recall the fact that the astronomer at Washington is at one point upon a ball which revolves once in twenty-four hours. The ball itself travels about the sun once in a year through a path which is some six hundred million miles in length. The sun and all its train of satellites, of which the earth is one, is moving through space toward an unknown destination. Yet in spite of these complicated movements, at tremendous speeds, the astronomer reaches a star with an arm of light, determined an instant of time for a single place and calls it noon, and then, with an arm of unseen radio wave in an unknown medium he calls the ether, sends that instant broadcast to all the world, for all the world to pick up and use and depend upon for everything it does, from going to breakfast to going to war, or deciding the boundary between states or the exact and accurate location of those who go down to the sea in ships.

Using Cadmium to Galvanize Iron

WHILE it has long been known that so-called galvanized iron could be made with cadmium in place of zinc, its high price prevented such use. A writer named Grès states in the *Bulletin des Inventions* that this difficulty has been overcome since it has been found possible to galvanize 1 square meter of sheet iron with the use of only 34 grams of cadmium. The coating thus produced is more resistant than zinc to acids, salt water and damp air. In spite of its thinness it clings to the iron with great tenacity, not cracking even when the latter is bent.

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