In physics, Fourier's theorem enables us, from certain measurements of temperature, to determine what will be the probable heat of the earth some time in the future. What we need in psychology is a psychical theorem, retrogressive in its character. The surroundings of man daily grow more varied; and his resemblances to his animal ancestors, it is claimed, are fast disappearing. Now is the time to sound a warning note. Our original psychical sources are disappearing. Instead of weighing a lusty African who will tip the scales at a hundred kilograms, we shall soon be reduced to weighing 'veridical phantasms' which we suppose must be below a fraction of a milligram. Back to the original sources, say we! This is the cry of all scholars, and psychists can form no exception to the general rule.

LETTERS TO THE EDITOR.

*** *Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The functions of experiment-stations.

REFERRING to the editorial comments on this subject in the issue of *Science* of Dec. 5, I cannot omit to interpose a demurrer to what appears to me to be a somewhat narrow view of the proper functions of experiment-stations in this country, and one which, if understood to be the prevailing one, would quickly put an end to the popular demand for the establishment of such stations, especially in the newer states.

If it is not one of the essential and primary objects of agricultural experiment-stations to render to the agricultural population the scientific aid which they so sorely need when brought face to face with new and untried conditions and factors in a new country, in order to afford them relief from the slow tentative process of blind experimenting by which the solution of practical questions is commonly approached, then, indeed, the *raison d'être* of such establishments will be seriously questioned in all but the older states, where the *otium cum dignitate* of purely scientific investigations can be indulged in without leaving undone things that ought first to be done.

If the experiment-stations do not do this work for the farmer, who is to do it? It is not certainly the function of the agricultural colleges as such, although in very many cases their greatest present usefulness assuredly lies in that direction; since their direct influence through the few students who hasten through a superficial course in their halls will long remain insensible, unless supplemented by such practical demonstration of the usefulness of agricultural science as the experiment-station work can afford. From both the practical and the educational point of view, then, those functions to which the article in question allots a second place, should, in my view, be placed first.

Again: it is said that to unite the two functions of an experiment-station — the scientific and the practical — in one institution and under one management is of doubtful propriety. So far from admitting this, I hold that nowhere can scientific investigation be more fruitful than where, in this direct connection with practice, it is brought face to face with new conditions, and therefore with new phases and aspects of old problems. I think it would be a grave mistake to segregate the two branches of the work, whether in space or time, and most especially to intrust the solution of practical problems to persons of inferior qualifications, as is too commonly done, to the detriment of the cause of science, and to the disgust of those engaged in pushing it in the face of the difficulties it naturally encounters in a new country. There is a limit to the usefulness of differentiation, when each of the segregated branches is thereby trimmed down to narrowness, and want of proper co-ordination with the other. In our widely varied domain, each location affords peculiar advantages for the prosecution of some branch of both pure and applied agricultural science; and those in charge of the several stations should know, or carefully consider, in which direction their greatest usefulness (in the widest sense of the word) lies.

No one narrow definition of the proper duties and functions of agricultural experiment-stations can apply to all cases alike. Each station will have to adapt its mode and scope of operations to the surrounding circumstances; and the good judgment exercised in determining these points will in a great measure determine also the scientific as well as the practical usefulness of such an establishment. With any thing like an adequate endowment, the two branches are not only compatible, but will fertilize each other, as does the combination of investigation and instruction in the case of teachers. The abstract investigator will rarely shape and express his ideas as clearly as the one who is habitually compelled to put them into the proper form for the understanding of others; and the same is measurably true of the experiment-stations, in which scientific work, and that intended for the direct instruction of the contemporary population, should go hand in hand. It does so even in Europe, where the practical questions needing determination are much fewer and less intricate; and, if it be contended that a different policy should be adopted in this country, the *onus* of showing the reasons therefor certainly devolves upon the advocates of the new doctrine. E. W. HILGARD.

University of California.

The most economical size of electric-lighting conductors.

In *Science*, No. 97, p. 524, Professor Carhart points out an oversight of mine (No. 94, p. 477) in leaving out the cost of waste heat in the conductors as a part of the economy in the Edison three-wire system, and also a mistake in estimating its amount; in both of which I am glad to be corrected. But Professor Carhart has not, I think, quite reached the most economical result, for the reason that we have the interest on n conductors, but heat developed in *only two* of them; and, as it seems worth while to develop the complete solution for this interesting system, I further submit the following: —

Suppose the size of conductors in the two-wire system to be such that the interest on their cost equals that of the heat-energy developed in them (C^2R, using Professor Carhart's nomenclature), which, for simplicity, we will take equal to unity. The general expressions for the various constant~ (in terms of those of the two-wire system), when the same plant of lamps is divided up (with n conductors, each of whose cross-sections is k times that of one of the first) into $n-1$ equally-balanced circuits, with $n-1$ dynamos in series, as in the Edison system figured on p. 477, vol. iv. (the same energy being developed in the lamps as at first), will then be: —

$(n-1)^2 \,.\, r =$ the resistance of the lamps.

$\frac{R}{k} =$ the resistance of the two outside conductors.

$\frac{C}{n-1} =$ the current in the same.

$\frac{CR}{(n-1)^2 \,.\, k} + Cr = E_{n-1} =$ difference of potential at terminals of each of the $n-1$ dynamos.

$\frac{C^2R}{(n-1)^2 \,.\, k} =$ heat-energy wasted in two outside conductors.

$\frac{C^2}{(n-1)^2} \,.\, (n-1)^2 \,.\, r = C^2r =$ energy developed in the lamps.

$\frac{n}{2} \,.\, k \,.\, C^2R = \frac{n}{2} \,.\, k =$ interest on cost of n conductors.

The energy consumed in the lamps (C^2r) is the same as at first, as shown by Professor Carhart, and, being constant for the plant of lamps, need not be further considered. The total running-expense, then, *due to conductors* (including interest on their cost), is

$$\frac{n}{2} \,.\, k + \frac{1}{(n-1)^2 \,.\, k}$$

in terms of C^2R. This should be a minimum. Its first differential coefficient with reference to k, placed equal to zero, gives

$$k = \frac{1}{n-1}\sqrt{\frac{2}{n}}$$

as the most economical section. This gives, for the minimum value of the total running-expense,

$$\frac{1}{n-1}\sqrt{\frac{n}{2}} + \frac{1}{n-1}\sqrt{\frac{n}{2}} = \frac{1}{n-1}\sqrt{2n},$$

the interest and heating-cost being equal, as they should. The same value of k gives

$$E_{n-1} = \frac{1}{n-1}\sqrt{\frac{n}{2}} \,.\, CR + Cr$$

as the corresponding difference of potential at the terminals of each of the $n-1$ dynamos.

Substituting now in these different expressions, and also in corresponding ones for the Edison system and for Professor Carhart's plan, values of n from 2 to 6, we have the various data given in the following table.

No. of conductors.	Cross-section of each.	Difference of potential at terminals of each dynamo.	Interest on conductors.	Heat-waste in conductors.	Running-expense of conductors.

EDISON'S SYSTEM.

n.	$\frac{1}{(n-1)^2}$	$\frac{(n-1)^2}{(n-1)(n-1)} CR + Cr.$	$\frac{n}{2(n-1)^2}.$	$\frac{(n-1)^2}{(n-1)^2}.$	$\frac{n}{2(n-1)^2}+1$
2	1.000	1.000 $CR + Cr$	1.000	1.000	2.000
3	0.250	1.000 " "	0.375	1.000	1.375
4	0.111	1.000 " "	0.222	1.000	1.222
5	0.062	1.000 " "	0.156	1.000	1.156
6	0.040	1.000 " "	0.120	1.000	1.120

PROFESSOR CARHART'S PLAN.

n.	$\frac{1}{n-1}.$	$\frac{1}{n-1} \,.\, CR + Cr.$	$\frac{n}{2(n-1)}.$	$\frac{1}{n-1}.$	$\frac{n+2}{2(n-1)}.$
2	1.000	1.000 $CR + Cr$	1.000	1.000	2.000
3	0.500	0.500 " "	0.750	0.500	1.250
4	0.333	0.333 " "	0.667	0.333	1.000
5	0.250	0.250 " "	0.625	0.250	0.875
6	0.200	0.200 " "	0.600	0.200	0.800

THE MOST ECONOMICAL PLAN.

n.	$\frac{1}{n-1} \,.\, \sqrt{\frac{2}{n}}$	$\frac{1}{n-1} \,.\, \sqrt{\frac{n}{2}}\, CR + Cr.$	$\frac{1}{n-1} \,.\, \sqrt{\frac{n}{2}}$	$\frac{1}{n-1} \,.\, \sqrt{\frac{n}{2}}$	$\frac{1}{n-1} \,.\, \sqrt{2n}$
2	1.000	1.000 $CR + Cr$	1.000	1.000	2.000
3	0.408	0.612 " "	0.612	0.612	1.225
4	0.236	0.471 " "	0.471	0.471	0.943
5	0.158	0.395 " "	0.395	0.395	0.791
6	0.115	0.346 " "	0.346	0.346	0.693

Some very interesting comparisons of relative advantages might be noted, did space permit. The most important is the rapid increase in the ratio of heat-energy to capacity of conductor in the Edison system, which might make it necessary to lay the wires so as to admit of pretty free radiation of heat.

This question of temperature of electric-lighting conductors promises to protrude itself the more they are laid underground. The desideratum for an insulating covering would seem to be a non-conductor of electricity and good conductor of heat, — apparently inconsistent qualities. Perhaps the eventual solution will be in bare or loosely covered wires on highly insulated points of support, thus admitting of free radiation of heat, like aerial lines. H. M. PAUL.

Washington, Dec. 15.

Sun-spots.

Mr. Todd, in a recent number of *Science*, speaks of Sept. 23, 1883, as the last day of that year on which