more elevated point, the apparent colour of the spray became
bluish.　　　　　　　　　　　　　　　　　　　G. H.

September 5

Circular Rainbow seen from a Hill-top

NOTICING a communication in NATURE (p. 361) regarding
the phenomenon of a circular rainbow, I thought it worth while
to mention a case which lately came under my observation.
Standing on a point of rock just opposite the beautiful falls of
Montmorenci, Quebec, I was surprised to see a rainbow in the
form of a circle passing through my feet. The spray from the
falls was being blown into a deep cove in front of me, and the
sun was high in the heavens behind. The primary was well
defined and very beautiful; the secondary was faint. I un-
derstand that the conditions for seeing this circular rainbow are
not often favourable at Montmorenci; still it may not be amiss
to advise intending visitors *not* to stop at the bottom of the steps
which lead down below the falls, but to clamber over the rocks
as near the water as possible.　　　　　W. L. GOODWIN

Montreal, August 28

Intelligence in Frogs

A FRIEND in Scotland has a small lake in his grounds, which
are surrounded by a high wall. At the bottom of the lake is a
sluice by which the water can be let off into a burn below the
grounds. A few weeks ago the lady of the house was walking
down the road outside the wall towards the burn when, to her
astonishment, she met a multitude of frogs making their way up
the road, which makes a considerable detour, to the gate leading
into the grounds. On inquiry she found that the lake had that
morning been emptied through the sluice, and it was plain that
these were frogs which, having been carried down with the water
to the burn, were now making their way back to their old home.
By what instinct did they know that the long road led to the
point from which the short one had started?　　　B. W. S.

September 3

THE TEMPERATURE OF THE SOLAR SURFACE

THE power developed by the sun motor, recorded in
NATURE, vol. xxix. p. 217, has established relations
between diffusion and energy of solar radiation, which
prove that the temperature of the surface of the sun is
extremely high. I have, therefore, during the summer
solstice of 1884, carried out an experimental investigation
for the purpose of demonstrating the temperature of the
solar surface corresponding with the temperature trans-
mitted to the sun motor. Referring to the illustrations
previously published, it will be seen that the cylindrical
heater of the sun motor, constructed solely for the purpose
of generating steam or expanding air, is not well adapted
for an exact determination of the amount of surface ex-
posed to the action of the reflected solar rays. It will be
perceived on inspection that only part of the bottom of
the cylindrical heater of the motor is acted upon by the
reflected rays, and that their density diminishes *gradually*
towards the sides of the vessel; also that owing to the
imperfections of the surface of the reflecting plates the
exact course of the terminal rays cannot be defined.
Consequently, the most important point in the investiga-
tion, namely, the area acted upon by the reflected radiant
heat, cannot be accurately determined. I have accordingly
constructed an instrument of large dimensions, a polygonal
reflector (see Fig. 1), composed of a series of inclined
mirrors, and provided with a central heater of conical
form, acted upon by the reflected radiation in such a
manner that each point of its surface receives an equal
amount of radiant heat in a given time. The said reflector
is contained within two regular polygonal planes twelve
inches apart, each having ninety-six sides, the perimeter of
the upper plane corresponding with a circle of eight feet
diameter, that of the lower plane being six feet. The cor-
responding sides of these planes are connected by flat
taper mirrors composed of thin glass silvered on the out-

side. When the reflector faces the sun at right angles, each
mirror intercepts a pencil of rays of 32·61 square inches
section, hence the entire reflecting surface receives the
radiant heat of an annular sunbeam of 32·61 × 96 = 3130
square inches section. It should be observed that the
area thus stated is 0·011 less than the total foreshortened
superficies of the ninety-six mirrors if sufficiently wide to
come in perfect contact at the vertices. Fig. 2 represents
a transverse section of the instrument as it appears when
facing the sun; the direct and reflected rays being in-
dicated by dotted lines. The reflector and conical heater
are sustained by a flat hub and eight radial spokes bent
upwards towards the ends at an angle of 45°. The hub
and spokes are supported by a vertical pivot, by means of
which the operator is enabled to follow the diurnal motion
of the sun, while a horizontal axle, secured to the upper
end of the pivot, and held by appropriate bearings under
the hub, enables him to regulate the inclination to corre-
spond with the altitude of the luminary. The heater is
composed of rolled plate iron 0·017 inch thick, and pro-
vided with head and bottom formed of non-conducting
materials. By means of a screw-plug passing through the
bottom and entering the face of the hub the heater may
be applied and removed in the course of five minutes, an
important fact, as will be seen hereafter. It is scarcely
necessary to state that the proportion of the ends of the
conical heater should correspond with the perimeters of the
reflector, hence the diameter of the upper end, at the in-
tersection of the polygonal plane, should be to that of the
lower end as 8 to 6, in order that every part may be
acted upon by reflected rays of equal density. This con-
dition being fulfilled, the temperature communicated will
be perfectly uniform. A short tube passes through the
upper head of the heater, through which a thermometer
is inserted for measuring the internal temperature. The
stem being somewhat less than the bore of the tube, a small
opening is formed by which the necessary equilibrium of
pressure will be established with the external atmosphere.
It should be mentioned that the indications of the thermo-
meter during the experiment have been remarkably
prompt, the bulb being subjected to the joint influence of
radiation and convection.

The foregoing particulars, it will be found, furnish all
necessary data for determining with absolute precision the
diffusion of rays acting on the central vessel of the solar
pyrometer. But the determination of temperature which
uninterrupted solar radiation is capable of transmitting to
the polygonal reflector calls for a correct knowledge of
atmospheric absorption. Besides, an accurate estimate of
the loss of radiant heat attending the reflection of the rays
by the mirrors is indispensable. Let us consider these
points separately.

Atmospheric Absorption.—The principal object of
conducting the investigation during the summer sol-
stice has been the facilities afforded for determining
atmospheric absorption, the sun's zenith distance at
noon being only 17° 12' at New York. The retardation
of the sun's rays in passing through a clear atmosphere
obviously depends on the depth penetrated; hence—
neglecting the curvature of the atmospheric limit—the
retardation will be as the secants of the zenith distances.
Accordingly, an observation of the temperature produced
by solar radiation at a zenith distance whose secant is
twice that of the secant of 17° 12', viz. 61° 28', determines
the minimum atmospheric absorption at New York. The
result of observations conducted during a series of years
shows that the maximum solar intensity at 17° 12' reaches
66°·2 F., while at a zenith distance of 61° 28' it is 52°·5 F.;
hence, minimum atmospheric absorption at New York,
during the summer solstice, is 66°·2 − 52°·5 = 13°·7 F., or
$\frac{13·7}{66·2}$ = 0·207 of the sun's radiant energy where the rays
enter the terrestrial atmosphere.

In order to determine the loss of energy attending the