of the vastly greater constructions which would be needed in any attempt to control floods. There is special insecurity necessarily inhering in the foundations of hydraulic work such as this, constructed in the bed and banks of running streams. Besides this, mention may be made of the interference which such reservoirs would cause in vested interests, such as mills, factories, railroads, canals, and rafting.

The latter portion of Col. Merrill's letter advises the city of Cincinnati to appoint a commission to define the lines of the river-front for high and low water, and to make it the duty of some public officer to prosecute in case of infringement on the free waterway, so that there may be no future obstruction of the river-channel. He shows that to the present time there has been no perceptible obstruction at this point. He further advises that the lower part of the city, next to the river, be filled by continuing the present slope of the river-banks upward to high-water mark; and then that those squares of the city which stand on the slope be devoted to business alone, and be so solidly built as not to be seriously damaged by an occasional flood, while the houses of the laboring population be removed to other parts of the city.

In conclusion, Col. Merrill says, in reply to the question which has frequently been put to him as to what the government is going to do to try to stop these floods, that, if the government be guided by his advice in this matter, it will do nothing, as the undoubted cause of the flood was the excessive fall of rain and snow; and no means of controlling this has yet been discovered.

AN EXPLANATION OF HALL'S PHENOMENON.[1]

MR. E. H. HALL's original experiment was as follows. A strip of gold-leaf was cemented to a plate of glass, and placed between the poles of an electro-magnet, the plane of the glass being perpendicular to the magnetic lines of force. The current derived from a Bunsen cell was passed longitudinally through the gold; and, before the electro-magnet was excited, two equipotential points were found by trial near opposite edges of the gold-leaf, and about midway between the ends. When these points were connected with a galvanometer, there was, of course, no deflection. A current from a powerful battery being passed through the coils of the magnet, it was found that a galvanometer-deflection occurred, indicating a difference of potential between the two points, the direction of the current across the gold-leaf being opposite to that in which the gold-leaf itself would have moved across the lines of force, had it been free to do so. On reversing the polarity of the magnet, the direction of the transverse electromotive force was reversed; and, when the magnet was demagnetized, the two points reverted to their original equipotential condition. Subsequent experiments showed that the direction of the effect differed according to the metal used. This effect was attributed by Mr. Hall to the direct action of the magnet on the current.

Mr. Bidwell claims that Hall's phenomenon might be completely explained by the joint action of mechanical strain and certain thermo-electric effects. The strain is produced by electro-magnetic action. It will be convenient to refer to the metallic plate or strip as if it were an ordinary map, the two shorter sides being called respectively west and east, and the two longer, north and south. Let the south pole of an electro-magnet be supposed to be beneath the strip, and let the strip be traversed by a current passing through it in a direction from west to east: then the strip will tend to move across the lines of force in the direction from south to north. Since, however, it is not free to move bodily from its position, it will be strained; and the nature of the strain will be somewhat similar to that undergone by a horizontal beam of wood which is rigidly fixed at its two ends, and supports a weight at the middle. Imagine the strip to be divided into two equal parts by a straight line joining the middle points of the west and east sides: then in the upper or northern division the middle district will be stretched, and the eastern and western districts will be compressed; while in the lower division the middle part will be compressed, and the two ends will be stretched. If, now, a current is passing through the plate from west to east, the portion of the current which traverses the northern division will cross first from a district which is compressed to one which is stretched, and then from a district which is stretched to one which is compressed; while in the southern division the converse will be the case. And here the thermo-electric effects above referred to come into play.

Sir William Thomson, in 1856, announced the fact that a stretched copper wire is thermo-electrically positive to an unstretched wire of the same metal, while a stretched iron wire is negative to an unstretched iron wire. From this it might be inferred, as Sir William Thomson remarks, that a free copper wire is positive to a longitudinally compressed copper wire, and that a free iron wire is negative to a longitudinally compressed iron wire; and experiment shows this to be the case. *A fortiori*, therefore, a stretched copper wire is thermo-electrically positive to a compressed copper wire, and a stretched iron wire is negative to a compressed iron wire. If, therefore, a current is passed from a stretched portion of a wire to a compressed portion, heat will (according to the laws of the Peltier effect) be absorbed at the junction if the metal is copper, and will be developed at the junction if the metal is iron. In passing from compressed to stretched portions, the converse effects will occur.

It follows from the above considerations, that, if the metal plate (which is subjected to a stress from south to north, and is traversed by a current from west to east) be of copper, heat will be developed in the western half of the northern division, and absorbed in the eastern half; while heat will be absorbed in the western half of the southern division, and developed in the eastern half. But the resistance of a metal increases

[1] Abstract of a paper read at the meeting of the Royal society, Feb. 21, 1884, by SHELFORD BIDWELL, M.A., LL.B.

with its temperature. The resistance of the north-western and south-eastern districts of the plate will therefore be greater, and that of the north-eastern and south-western districts smaller, than before it was subjected to the stress; and an equipotential line through the centre of the plate, which would originally have been parallel to the west and east sides, will now be inclined to them, being apparently rotated in a counter-clockwise direction.

If the plate were of iron instead of copper, the Peltier effects would clearly be reversed, and the equipotential line would be rotated in the opposite direction.

The peculiar thermo-electric effects of copper and iron, discovered by Thomson, are thus seen to be sufficient to account for Hall's phenomenon in the case of those metals. It became exceedingly interesting to ascertain whether the above explanation admitted of general application; and the author therefore proceeded to repeat Thomson's experiments upon all the metals mentioned by Hall. The results are given in the following table, where those metals which in Hall's experiments behave like gold are distinguished as negative, and those which behave like iron as positive.

Metals.	Forms used.	Direction of current.	Hall's effect.
Copper	Wire and foil, pure.	S. to U.	Negative.
Iron	Wire and sheet, annealed.	U. to S.	Positive.
Brass	Wire, commercial.	S. to U.	Negative.
Zinc	Wire and foil.	U. to S.	Positive.
Nickel	Wire.	S. to U.	Negative.
Platinum	Wire and foil.	S. to U.	Negative.
Gold	Foil, purity 99.9 %.	S. to U.	Negative.
Gold	Wire, commerc. pure.	U. to S.	Negative.
Gold	Jeweller's 18-ct. wire and sheet.	S. to U.	Negative.
Gold	Jeweller's 15-ct. sheet.	S. to U.	Negative.
Silver	Wire and foil.	S. to U.	Negative.
Aluminium	Wire and foil, pure.	U. to S.	Negative?
Cobalt	Rod, 8 mm. diameter.	U. to S.	Positive.
Magnesium	Ribbon.	S. to U.	Negative.
Tin	Foil.	S. to U.	Negative.
Lead	Foil (assay).	No current.	Nil.

S. means stretched. U. means unstretched.

It will be seen that in every case excepting that of aluminium, and one out of five specimens of gold, there is perfect correspondence between the direction of the thermo-electric current and the sign of Hall's effect. With regard to the aluminium, a piece of the foil was mounted on glass, and Hall's experiment performed with it. As was anticipated, the sign of the 'rotational coefficient' was found to be positive, like that of iron, zinc, and cobalt. Either, therefore, Mr. Hall fell into some error, or the aluminium with which he worked differed in some respect from that used by the author. The anomalous specimen of gold, being in the form of wire, could not be submitted to the same test: it probably contained some disturbing impurity.

[To the foregoing article, Dr. Hall has favored the editor of *Science* with the following reply.]

Mr. Bidwell's table is certainly very suggestive, but his 'explanation of the Hall phenomenon' cannot stand.

He makes this phenomenon to be an incidental result of the manner in which the metal strip is attached to the plate of glass. It is, he says, like a beam rigidly fastened at both ends, and weighted in the middle. Without discussing the closeness of this analogy, one can see, that if we fasten the strip by its middle, and leave it free at both ends, the conditions upon which Mr. Bidwell supposes the phenomenon to depend are quite changed.

After reading Mr. Bidwell's paper, I took a strip of soft steel, about one-tenth of a millimetre thick, and made the usual connections, but, instead of fastening the strip to glass with cement, so arranged it that it could at will be clamped across its middle or across the ends to a sheet of hard rubber. The end-clamps were about three centimetres apart, and the width of the magnetic poles between which the strip was placed was considerably greater than three centimetres. Now, when the strip was clamped across its middle and left free at the ends, and was made to conduct a current of electricity across the magnetic field, it was like a beam supported at the middle, and with a load distributed from end to end; but when the strip was clamped at its ends and left free in the middle, it was like a beam supported at both ends, and with a load distributed from end to end. Experiment shows that the effect is positive, as I have always found it in iron and steel, whether the strip be clamped in the middle, or at the ends.

There is one other consideration to be urged. Mr. Bidwell would, I suppose, account for the fact that the observed effect is proportional to the magnetic force by saying that the strain would be proportional to this force. But how will he explain the fact that the effect is nearly or quite proportional to the current, as was shown in my first paper upon the subject? Let us see what his theory leads to. Doubling the current, the magnetic force remaining unchanged, would double the strain. But a doubled strain, with a doubled current, would make the heating and cooling from the Peltier effect four times as great as before. This would deflect the equipotential lines four times as much as before; and, as these lines are only half as far apart as before, the transverse current would be eight times as great as before the direct current was doubled. The transverse effect, then, would be proportional, not to the current, but to the cube of the current. EDWIN H. HALL.

Cambridge.

THE CREVAUX EXPEDITION.

E. MILHÔME writes from Corumba, Sept. 24, 1883, to the Société de géographie in regard to the possible survivors of the Crevaux expedition. He believes that several survived for a time, but were afterward put to death by the savages. Information of any sort could hardly be obtained; as the Tobas had made ready for war, and retired to the interior, holding no further communication with the neutral tribes from whom the previous vague news had been derived by the whites. The Indian survivors, from their terror and sufferings, can afford little help. It is known that Branco, one of the party, in his capacity of soldier, was preserved alive by the natives to instruct them in the use of the fire-arms which they captured; and it is possible he may be still living, but, if so, has