the statical and dynamical effects of friction have been confounded together; whereas they are the same in amount only when the body is put in motion by gravity; but not when it is urged down an inclined plane by an extraneous force. In the latter case these effects are no longer comparable; friction being a force which, in an infinitely small time, is proportional to the velocity, while that of gravity is constant at all velocities; or, in other words, the retardation from friction is proportional to the space described, while that from gravity has reference only to the time of acting, whatever space the body may pass over in that time. It is an error to assume that the mechanical power of the plane is equivalent to a reduction of so much friction; for the friction down the inclined plane is the same as on a horizontal plane of the same length, rejecting the trifling difference of pressure; and the whole retardation in passing over the plane, or the whole force required to overcome it, is the same at all velocities, and by whatever force the motion is produced; but the assisting force from gravity is quite independent of the space or of the velocity.

In the investigations which the author has prosecuted in this paper, he assumes that equal quantities of steam are produced in the same time at all velocities; and he adopts for his other data, those given by Mr. Pambour in his Treatise of Locomotive Engines. He deduces a formula from which, the speed on a level being given, we may compute the relative and absolute times of a train ascending a plane; and consequently also the ratio of the forces expended in the two cases; or the length of an equivalent horizontal plane; that is, of one which will require the same time and power to be passed over by the locomotive engine as the ascending plane.

The next objects of inquiry relate to the descent of trains on an inclined plane, and comprise two cases: the first, that when the power of the engine is continued without abatement; and the second, that when the steam is wholly excluded, and the train is urged in its descent by gravity alone. The author arrives at the conclusions, that in the first of these cases, when the declivity is one in 139, the velocity, on becoming uniform, will be double that in a horizontal plane: and that for a declivity of one in 695, the uniform velocity of descent will be one fifth greater than on the horizontal plane; and this, he observes, is perhaps the greatest additional velocity which it would be prudent to admit. A plane of one in 695 is therefore the steepest declivity that ought to be descended with the steam-valve fully open; all planes with a declivity between this and that of one in 139 require to have the admission of steam regulated so as to modify the speed, and adjust it to considerations of safety; and lastly, all planes of a greater slope than this last require, in descending them, the application of the brake.

A paper was also read, entitled, "On the application of Glass as a substitute for metal balance-springs in Chronometers." By Messrs. Arnold and Dent. Communicated by Francis Beaufort, Esq., Captain R.N., F.R.S., Hydrographer to the Admiralty.

In their endeavours to determine and reduce the errors arising from

the expansions of the balance-spring of chronometers consequent on variations of temperature, the authors came to the conclusion that there exist certain physical defects in the substances employed for its construction, beyond the most perfect mechanical form that can be given to it, which interfere with the regularity of its agency: so that however exquisite may be its workmanship, and however complete its power of maintaining a perfect figure when in different degrees of tension, yet the imperfect distribution of its component parts may give rise to great incorrectness in its performance. Hence the balance-spring not only should be made of a substance most highly elastic, but its elasticity should not be given to it by any mechanical or chemical process: as a body in motion, it should be the lightest possible; and, as far as the case admits of, it should be free from atmospheric influence. Glass suggested itself as the only material possessing, in the greatest degree, all these desirable properties. Its fragility, although apparently a great objection to its employment, was found, on trial, to constitute no obstacle whatever; for it was found to possess a greater elastic force than steel itself, and thus to admit of greater amplitude in the arc of vibration.

It was first proposed to ascertain how far a glass balance-spring would sustain low temperatures; and it was found by experiment that it resisted completely the effects of a cold as great as that of + 12° of Fahrenheit's thermometer; thus satisfactorily removing any objection which might be brought against its use from its supposed fragility in these low temperatures. The next object of solicitude was to determine whether it would withstand the shock arising from the discharge of cannon in the vicinity; and its power of resisting concussions of this nature was fully established by experiments made with this view on board H.M.S. Excellent at Portsmouth.

On comparing the performance of glass balance-springs with metallic ones, when the temperatures were raised from 32° to 100°, it was found that while the loss in twenty-four hours in the gold spring was $8^m\ 4^s$, that of steel $6^m\ 25^s$, and that of palladium $2^m\ 31^s$, that of a glass spring was only 40^s. These differences the authors ascribe principally to the different degrees in which the substances had their elasticity reduced by an increase of temperature. As glass was thus found to suffer a much smaller loss of elasticity by this cause than metals, they proceeded to construct a glass balance suited to the correction of the small error still occasioned by this cause, employing a glass disc for this purpose. The compensation being completed, they next tested the isochronism of the glass spring, and it proved to be as perfect as any metallic spring. Chronometers thus constructed are now in course of trial at the Royal Observatory. In common with all other instruments of the same kind they have shown a disposition to progressive acceleration, the cause of which is but little known, but which appears to be influenced by the action of the air.

The Society then adjourned over the Whitsun week, to meet again on the second of June next.