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PROCESS OF MANUFACTURE OF CELLULAR RUBBER HAVING FLUID-TIGHT CELLS

Louis Emile Henri Pagnon, Paris, France; vested in the Alien Property Custodian

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The present invention relates to a process for manufacturing cellular rubber having fluid-tight cells filled with a gas under pressure. It is known that, in all the present known processes, the mass of rubber, to which may optionally be added waxy or resinous materials and various fillers, is subjected in the hot state, in a fluid-tight receptacle, to the action of a gas at a high pressure, the value of which may reach 500 to 600 kg. at the end of the operation, said mass of rubber being thus simultaneously subjected to vulcanization and to the penetration of the gas which, so to speak, dissolves in the rubber and subsequently forms, at the instant when the free or controlled expansion takes place of the mass that has issued from the treating chamber, very fine cells which do not communicate with each other and are kept expanded by the residual pressure of the gas. This process offers the drawback of being very long and very expensive, and furthermore it does not produce sufficiently uniform products. In fact, on the one hand owing to the very high pressures at which it is necessary to make the gas penetrate into the mass of rubber, the fluid-tight receptacles in which this operation is effected have to have very thick walls, so that the heating of said receptacles (which is effected by means of an external circulation of steam), and also their subsequent cooling, takes a long time and involves a large consumption of heat; on the other hand, the mass of rubber being treated, which is enclosed in said receptacle, is not raised to a uniform temperature despite a very long duration of the treatment, so that the outer layers of the mass are vulcanized too much, whereas the central parts are not vulcanized enough. This in turn makes it impossible to treat a large quantity of rubber at one time, for example in the case of the manufacture of cellular rubber in slabs, the slabs of crude rubber are wound into rolls and treated in a cylindrical "shell", on a likewise cylindrical core of sufficiently large diameter to reduce the radial thickness of the layer of rubber through which the heat has to pass. Furthermore, in order to separate the convolutions which are wound on each other and to facilitate the propagation of the heat, it is necessary to wind a sheet of metal at the same time as the slab of rubber. For all these reasons, it is impossible in practice to treat more than 400 kg. of cellular rubber in slabs in the same apparatus; the treatment of such a weight requires about 24 hours, inclusive of cooling, and in spite of this duration and of the large consumption of heat, the slab obtained is not uniform, since its degree of vulcanization varies substantially from one end to the other.

It has been proposed to overcome these drawbacks by previously subjecting the mass of rubber to heating, optionally accompanied by prevulcanization, and introducing the mass thus raised to the treating temperature into the fluid-tight receptacle, the walls of which have been previously raised to the requisite temperature. However, this process which above all offers the advantage of a more economical prevulcanization, does not enable the above drawbacks to be radically overcome, in particular the duration of the treatment and the consumption of heat to raise the apparatus to the required temperature and to maintain said temperature during the injection of the gas, and furthermore it is still difficult to obtain a homogeneous product owing to the difficulty of maintaining a uniform temperature throughout the entire mass. The duration of the treatment likewise remains long owing to the necessity of allowing the mass to cool in the fluid-tight receptacle.

The present invention has for its object a process which enables perfectly uniform products to be obtained, while considerably reducing the cost of manufacture and increasing the capacity of output of the apparatus. Said process is characterized by the fact that the prevulcanized mass of rubber is cooled and then subjected in the cold state to the action of the gas under pressure in the fluid-tight apparatus.

The inventor has in fact discovered that the penetration and the diffusion of the gas under pressure into a mass of rubber were in practice to a large extent independent of the temperature, and that the essential condition for the manufacture of a cellular rubber consists in the fact that, before being subjected to a free or controlled expansion, the mass of rubber containing the dissolved gas must be partly vulcanized, it being possible for such vulcanization to be effected before or during the injection of the gas.

The degree of prevulcanization effected before the injection of the gas under pressure is substantially the same in the process according to the invention as the degree of final vulcanization obtained in the usual processes, after the gas injection in the hot state.

The process according to the invention offers the very considerable advantage of not requiring any other supply of heat than that used for the prevulcanization, which is effected by the processes that are usual in the rubber industry and outside the fluid-tight apparatus for the

treatment with the gas at high pressure, and which can therefore be effected at small cost and with all desirable regularity. On the other hand, since the injection of the gas into the mass of rubber is effected in the cold state, the duration of this operation is reduced by the fact that it no longer necessitates heating the mass right through, or cooling after such heating. Similarly, the absence of heating during the injection enables the winding of a metal sheet with the slabs of rubber to be eliminated (a simple hooping with an outer metal sheet surrounding the roll is sufficient) and, furthermore, the diameter of the core on which said slabs are wound can be considerably reduced, thereby increasing the capacity of the apparatus. As a result of all these favorable factors, instead of producing 400 kg. of cellular rubber after a treatment of 24 hours, the process according to the invention enables 500 to 600 kg. of rubber to be treated in 12 hours in the same apparatus, while producing a final product of better quality. When it has been removed from the gas treatment chamber, the rubber is expanded in the usual manner, optionally in a finishing mould, with or without complementary vulcanization.

According to another feature of the present invention, the duration of the treatment with the gas under pressure is considerably decreased by the fact that the mass of prevulcanized and cooled rubber is successively or simultaneously treated with two gases under pressure, one of which has a great power of penetration and of diffusion, such as carbon dioxide, and is intended to act as a temporary inflation agent before leaving the mass by exosmosis owing to its great power of diffusion, and the other of which has a smaller power of penetration, such as nitrogen, and is intended to remain in the mass.

It is known in fact that the nitrogen that is generally used for the manufacture of cellular rubber is absorbed rather slowly by the rubber and in a quantity which does not exceed ten times the volume of the rubber at a fairly high pressure, of the order of 200 to 300 kg., and for a period which is compatible with industrial working. It is moreover this very difficulty of the diffusion of nitrogen in rubber that justifies its use, since when it has penetrated into the mass and after its pressure inside the cells has been reduced by the expansion of the vulcanized rubber, the nitrogen has no tendency to escape therefrom. It is known, on the other hand, that carbon dioxide diffuses very readily in rubber, which can absorb in a few hours up to thirty five times its volume thereof, at a pressure of about 40 kg: on the other hand, owing to the ready manner in which it diffuses, carbon dioxide escapes from the rubber by exosmosis, so that after a few days, the cellular rubber obtained with this gas is completely deflated.

By making carbon dioxide and nitrogen act according to the invention, successively or simultaneously, each at a pressure which is best suited to it and the orders of magnitude of which have been stated above, on the one hand by means of the carbon dioxide a quick swelling at high pressure of the rubber mass is obtained which subsequently permits efficient expansion and efficient moulding, whereas on the other hand the nitrogen ensures a durable filling at low pressure of the cells that are expanded by the carbonic acid.

Furthermore, the time of absorption of the necessary volume of gas is thus reduced, the carbon dioxide appearing to favour the diffusion of the nitrogen that follows it, and furthermore this novel method of treatment requires substantially lower final pressures (200 to 300 kg. instead of 5 to 600). Although it can also be used in the known processes of gas injection in the hot state, this injection of two different gases is particularly advantageous in the case of the injection in the cold state according to the present invention, since in the first case, the total duration of the treatment chiefly depends on the duration of the heating and of the cooling, and not on the duration of the injection of the gas. The figures for the pressure have only been given by way of example; the pressures will be proportional to the dimensions of the work-pieces to be treated, to the nature of the mixtures (these being similar to the formulae acquired by experience of the usual processes), to the densities to be obtained, and to the periods of injection.

LOUIS EMILE HENRI PAGNON.