

## **Expert Opinion about the Value of Patent Rights Held by**

**Dr. Schapiro, Prof. Levitin and Mr. Kruk (“RKM”)**

**Relating to “Rotary Piston Machines“**

This opinion is given in good faith and according the best of my knowledge. The opinion is based on more than forty years experience in the patent field and numerous license agreements negotiated during this time, as well as some technological expertise in the field of hydraulic and pneumatic machines. It should, however, be understood that I cannot accept any liability for the statements made in this opinion.

### **I. Rotary Piston Machines**

Rotary piston machines are machines, wherein, unlike conventional motors in which a cylindrical piston makes a reciprocating movement in a cylindrical chamber, an appropriately shaped piston carries out a rotary movement in a correspondingly shaped chamber, working chambers being defined between the piston and the wall of said chamber, the volumes of the working chambers being cyclically varied. There are various types of such rotary piston machines. These rotary piston machines can be designed and used as pumps or as hydraulic or pneumatic motors, but also as internal combustion engines. In the present case, the inventions relate specifically to rotary piston machines in which a piston the cross section of which is an “oval” rotates in a chamber the cross section of which is also an oval, though of different order. Such rotary piston machines are particularly advantageous with regard to sealing, wear and noise. Hereinafter, they will be called “oval” rotary piston machines.

## II. The Patent Situation

At present, there are four inventions for which patents or patent applications to be evaluated exist. These are the following inventions:

1. A rotary piston machine has a chamber of, for example, tri-oval cross section in which a piston of bi-oval cross section is rotatable. Cylinder chambers are formed thereby, the volumes of which are cyclically increased and decreased again. The pistons make a rotary motion.. During this motion, each time when a stop position is reached, the instantaneous axes of rotation jump between two positions fixed with respect to the piston. According to the invention, the rotary motion (of a motor) is transmitted, in particularly simple and advantageous way, by means of a shaft. This shaft extends through a bi-oval aperture of the piston, a pinion on the shaft meshing with an internal gear of the aperture.

According to my opinion, only this invention, makes rotary piston machines of this type feasible in practice.

A German patent has already been granted on this invention.

2. This invention relates to a kinematic problem, which plays an essential part also in connection with the transmission of the rotary motion in the invention described under (1). The problem is, to provide, with concave gears as, for example, in a bi-oval internal gear, a cinematically correct transition between the gear sections having different radii of curvature, meshing between pinion and internal gear being ensured in each position. According to the invention, linear or convex intermediate gear sections are provided between the concave gear sections having different radii of curvature. Thereby, also movement of the pinion axis along a trajectory having a singularity, for example a point, can be realised.

This invention is essential for the practical realisation of the transmission of motion which is the subject matter of the invention described under (1), thus provides a far-reaching protection of the invention described under (1) and, thereby, for the “ovals”-rotary piston machines as such. In addition, the invention described under (2) can be

used also in connection with numerous other designs, for example in machine tools, where a machine part is to move along a trajectory having a point.

Patent applications for the invention described under (2) have been filed in Germany and, through an international patent application under the Patent Cooperation Treaty (PCT) also in the following countries: EP (European patent), US (USA), JP (Japan), CN (Peoples Republic of China) KR (South Korea), RU (Russia), IN (India), MX (Mexico), CN (Canada), IL (Israel). The search carried out by the European Patent Office in connection with the international patent application revealed no pertinent prior art which could be a bar to the patentability of the invention.

3. A problem arises with the “ovals”-rotary piston machine to which the invention described under (1) relates, namely that, in the stop positions, in which the instantaneous axes of rotation jump between the piston-fixed axes, the kinematics is not “closed”. The piston, instead of continuing to rotate about the new instantaneous axis of rotation, might make a transverse motion under the influence of a pressurised working medium and might jam. In order to counter-act this risk, according to the invention, an instantaneous axis of rotation is forcibly determined for a short time.

Also this function is essential for the correct operation of the rotary piston machine. When practically realising the rotary piston machine, this invention will be needed, whereby also this patent right will provide patent protection covering the practical realisation of an “ovals”-rotary piston machine.

There is a German patent application. Furthermore, patent applications have been filed, through an international patent application under the Patent Cooperation Treaty (PCT) also in the following countries: EP (European patent), US (USA), JP (Japan), CN (Peoples Republic of China) KR (South Korea), RU (Russia), IN (India), MX (Mexico), CN (Canada), IL (Israel). The search carried out by the European Patent Office in connection with the international patent application revealed no pertinent prior art which could be a bar to the patentability of the invention.

- 4a A further design of an “ovals”-rotary piston machine provides that the cross section of the chamber is an oval the order of which is smaller by one than the order of the oval

which forms the cross section of the chamber. Then, two working chambers are formed, which, during the rotary motion of the piston, alternately increase and decrease their volumes. Here, the motion is transmitted (or to or from the piston) by two stationary shafts, of which alternately one runs faster and the other one runs slower. These two shafts can be coupled with a common driving shaft (with pumps) or driven shaft (with motors) through a differential gear.

A patent application has been filed in Germany. In this patent application, a favourable Office Action with suggestions of allowable claims has been issued by the German Patent and Trademark Office, so that grant of the patent can be expected in near future. Furthermore, an international patent application under the PCT has been filed. In this application, at first, all member states of the PCT have been designated. When entering the national phases, the prosecution is likely to be limited to the essential manufacturing countries and markets.

- 4b Disclosed and claimed, independently of a particular type of rotary piston machine, is also a particular design of a pre-combustion chamber of an internal combustion engine into which chamber fuel is injected. This invention will be prosecuted in a divisional application in near future.

The inventions relate to a particular type of rotary piston machine, which offers considerable advantages over rotary piston machines presently on the market. The patents and patent applications mentioned above protect essential features of such rotary piston machines, such that these rotary piston machines will practically not be operative without using the patents. Therefore, practically a monopoly with respect to the rotary piston machines of the present type is achieved by the patents. These rotary piston machines offer essential advantages over the prior art. Patent applications have been filed for the inventions in all essential countries. The present course of the examination procedure, as far as such examination has already been carried out, and the searches carried out by the European Patent Office permit the grant of the patents substantially in the claimed scope to be expected.

### **III. Value Estimation Concept**

Estimation of the value of the of the patent portefolio described above is based on the business plan elaborated by the inventors. This business plan provides, that the rotary piston machine of the invention, at first, is to be developed by a development company, within a time interval of about two years, up to the state of an operative model. As a rule, such a model is not yet in the production stage, can, however, for example be tested on a testing stand and permits proving the usefulness of the rotary piston machine. The operative model, at first, is to be a hydraulic pump or a hydraulic motor. Such unit is simpler to realise technologically than, for example, an internal combustion engine operating after the same principle.

During the development, additional patent rights and further technical know-how can be expected to come up.

With such an operative model, licensees are to be looked for, which lead the rotary piston machine to production stage in accordance with their needs and specifications. The licensee, preferably, should be active in the field of hydraulic pumps or motors, and should have conventional technologies and marketing facilities at their disposal. A license would, probably, be granted as a non-exclusive license (with the possibility that the inventors or the development company is permitted to grant also licenses otherwise) or as an exclusive license with limitations as to regions or certain fields, thus, for example, limited to certain countries or to pumps for certain applications. **In view of the advantages of the principle of the invention, it appears certain that licensees will be found.**

With such a concept of exploitation of the invention, the value of the patent rights is determined by the royalties which can be obtained.

### **IV. Estimation of the Value of the Patent Rights**

On the basis of the concept of exploitation of the invention by licensing and with the realistic assumption innovative and potent licensees will be found to make full use of the inherent capacity of the invention, the following result is obtained:

As royalty, a percentage of 5 percent to 10 percent of the net turnover appears to be realistic. The height if the royalties can depend on whether merely a non-exclusive license is granted or whether the licensee gets an exclusive right with, maybe, regional or technological limitations, or depends on to which extent know how can be transferred to the licensee. In the following, cautiously, a royalty percentage of 5 percent is assumed.

In accordance with figures provided by the Statistische Bundesamt (Federal Authority of Statistics) the turnover of hydraulic pumps and hydraulic motors *per annum* in Germany is substantially constant € 4.5 billions (10<sup>9</sup>).

The worldwide market (remaining Europe, USA, Canada, Russia, East Asia and South East Asia) is a multiple of this figure, cautiously calculated twenty times this turnover, thus € 90 billions.

Hydraulic pumps and motors of the present type will, predominantly, be used as high pressure pumps and motors, respectively, where the sealing between the working chambers guaranteed by the RKM-technology is important. Another field of use are heating and water pumps, where it is important that the pump operates with little noise.

Realistically, it can be assumed that, within the next years after the development of the model, 1 percent of the world market will be covered by pumps or hydraulic motors protected by the patent rights to be valued. This would be a turnover of € 900 millions *per annum*. With a royalty percentage of 5 percent, this would yield annual royalties, from the application in hydraulic pumps and motors alone, of € 45 millions. With an estimated mean lifetime of a patent of 15 years, this yields, alone from the sector of hydraulic pumps and motors, a value of the patent rights of € 675 millions.

The turnover in Germany of pneumatic pumps (compressors) and pneumatic motors amounts, according to the same source, annually about € 2 billions. Analogously, a total turnover for the worldwide market can be estimated as € 40 billions. If 1 percent of this turnover is covered by licensing, this yields a turnover of € 400 millions. With a royalty percentage of 5 percent, this would result in further royalties of annually € 20 millions. For the assumed patent life of 15 years, this yields an additional value of the patent rights of € 300 millions.

This yields, for the area of pneumatic and hydraulic pumps or motors which can be exploited in relatively near future, a value of the patent rights in the form of royalties to be expected of about **€1 billion** (number A).

When estimating the value of the patent rights, the field of internal combustion engines has not been taken into account for the following reasons:

- long-time development strategies of the engine manufacturers,
- development costs in the amount of billions in combination with only long-time depreciation.

These reasons prevent short-time change of technology in the internal combustion engine industry.

If, however, only one automobile manufacturer changed a type of automobile to a rotary piston machine of the present type, then very high turnovers would result. Royalties from such turnovers could lie in the same order of magnitude as the royalties calculated for the pneumatic and hydraulic pumps and motors of **about another €1 billion** (number B).

Further high-potential applications exist, in particular for invention (2), in the field of machine tools. The corresponding potential royalties have not yet been investigated and will not be taken into account here (number C).

Eventually, the patent application filed for invention (4) contains an independent invention, namely the construction of a “pre-combustion chamber”, into which the fuel is injected. This pre-combustion chamber can be used in internal combustion engines in general, independently of the rotary piston machines with ovals discussed here. This invention could have considerable importance. The corresponding royalties have not yet been investigated and will not be taken into account here (number D).

These potentials of additional royalties are present and large but cannot be quantified at present.

## V. Summary

Summing up, the following can be stated:

- The RKM-technology as such is defined by pending or granted patents and is scientifically substantiated.
- The grant of the patents on the pending patent applications is almost certain because of the official patent searches.
- The patent applications were filed in the essential production and market countries: EP (European patent), US (USA), JP (Japan), CN (Peoples Republic of China) KR (South Korea), RU (Russia), IN (India), MX (Mexico), CN (Canada), IL (Israel). Further patent applications have, at present, been filed in all PCT-countries.
- RKM as pump, compressor and hydraulic or pressurised air motor are comparatively easy to develop and can be brought on the market within short time.
- The pump market is huge and diversified and, therefore, is able to easily absorb the new products with better quality and better price-performance ratio.
- The RKM pumps, compressors, hydraulic and pressurised air motors offer decisive advantages with regard to sealing of the working chambers, wear and noise.
- The RKM internal combustion engines offer decisive advantages, among others, with regard to power density, torque and wear.
- Manufacturing the RKM machines is feasible with the conventional manufacturing equipment available on the market.
- **Number A.** The value of the patent rights in the form of royalties to be expected for field of hydraulic and pneumatic pumps and motors, which can be exploited within rather short time, is estimated to amount to **about €1 billion**.
- **Number B.** The value of the patent rights for the field of internal combustion engines, which is to be exploited on medium or long term, is estimated, merely speculatively, to

be in the same order of magnitude as number A, i.e. amounting also to **about €1 billion**.

- **Number C.** The value of the patent rights in the high-potential field of machine tools has not been investigated and, therefore, is **not taken into account**.
- **Number D.** The value of the patent rights in the field of engines having an improved pre-combustion chamber has not been investigated and, therefore, is **not taken into account**.

## **VI. Result**

Alone from the royalties to be expected in the field of hydraulic and pneumatic pumps and motors, the **value of the RKM patent rights, cautiously estimated, amounts to about €1 billion**.

Purely speculatively, the **value of the RKM patent rights in the field of internal combustion engines** can be estimated to amount to **a further billion €**

**Further potential applications were not taken into account.**

Thus the **total estimated value of RKM patent rights is clearly above €1 billion and most likely also above €2 billions**.

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