EUROMECH
European Mechanics Society

Newsletter 21
June 2002

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President's Introduction

I am pleased to be able to report on the proceedings of the Prague Council meeting in April 2002. There were three main topics: Organisation (*Council and Committees*), EUROMECH *Conferences and Colloquia in 2003 and later, and the* EUROMECH *Prizes.*

In order to make for a smooth succession of EUROMECH *Officers in the year 2004, I did not wish to stand for re-election for 2003. The Council therefore elected P. Huerre* (*Paris*) *as President, with M. Okrouhlík and E. Hopfinger continuing as Secretary General and Treasurer for 2003. B. Schrefler* (*at present Chairman of the* ESMCC) *was co-opted as a member for 2002.*

L .van Wijngaarden will retire as Chairman of the EFMCC *on 31 December 2002 and the Council appointed G.J. van Heijst as his successor for a period of six years. The Council further appointed four new members of* ENOCC: *B. Brogliato, K. Popp, M. Valášek and F. Vestroni. H. Andersson was appointed as a member of the* EUROMECH ETCC. *The full list of members will be published in the next Newsletter.*

In addition to the two EUROMECH *Colloquia for 2003 already approved in 2001, we received 15 further proposals for the consideration of the Council. Nine Colloquia were accepted for 2003* (*3 Solids and 6 Fluids*) *and two for 2004. The full list of Colloquia in 2003 and 2004 is published in this Newsletter. The Colloquia are spread over six European countries.* (*A wider distribution over the countries of Europe would be very desirable.*)

The Council decided on the final protocol for the Fluid and Solid Mechanics Prizes and on the rules and dates of application. The Council also appointed a Prize Committee for each prize consisting of five members (*including the Chairperson*), *respectively. The first members of these Committees will be the five standing members of the Council in each field with myself* (*Fluids*) *and F.G. Rammerstorfer* (*Solids*) *as Chairmen. The period of office will be 1 January 2002 to 31 December 2004, with the possibility of reappointment for a second time.*

Hans-Hermann Fernholz
President, EUROMECH

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CONTRIBUTION OF ERNST MACH TO GAS DYNAMICS

Rudolf Dvořák [1]

Ernst Mach (born 18.2.1838 in Chrlice-Tuřany, now a part of Brno, died 19.2.1916 in Vaterstetten near Munich) was from 1867 to 1895 Professor of Experimental Physics of the Carolo-Ferdinand University in Prague, and from 1985 to 1901 Professor of Natural Philosophy in Vienna.

In the university record[2] for the academic year 1894/95 we read:

MACH Ernst, Doctor der Philosophie, Ehrendoctor der Medizin an der Universität Tübingen, k.k. Regierungsrath, ordentlicher Professor der Physik, wirklicher Mitglied der kaiserlichen Akademie der Wissenschaften in Wien, Mitglied der Leopoldinisch-Carolinischen Akademie, der Societé francaise de physique, Correspondent der Akademien zu Göttingen und München, des Instituto de Coimbra, Mitglied der k.k. wissenschaftlichen Prüfungscommission für Gymnasial- und Realschul-Lehramts-Candidaten, ordentliches Mitglied der Gesellschaft zu Förderung deutscher Wissenschaft, Kunst und Literatur in Böhmen, 1873 Dekan der philosophischen Fakultät, 1880 und 1884 Rector der Universität.[3]

Among the great variety of problems he investigated, gas dynamics must have been an interest throughout his life. He was engaged on it for all the 28 years of his active life in physics, and likewise, for the whole period he spent in Prague.

After his early experiments in acoustics, and experimental proofs of the Doppler effect, he concentrated on experimental investigations of the propagation, attenuation and interaction of waves of finite amplitude (shock waves), development of various flow visualisation techniques, the supersonic flow past bodies, and supersonic jets.

In 1873 Vincenc Dvořák, one of Mach´s assistants and later Professor of Physics in Zagreb, called his attention to a paper by a Hungarian physicist, Karol Antolik (1843 – 1905), who visualised waves generated by electric spark discharges by their traces on a sooted glass plate. Mach did not take much interest in Antolik's research but thought of using the same method for measurements of small time intervals. The idea behind it was as follows: acoustic waves from two point sources generate a symmetrical pattern of concentric wave fronts which pass through each other without being affected. Should one of the sources be delayed

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This article was presented at the international conference *Ernst Mach and the Development of Physics* (Prague, Sept., 1988). Some changes have been made to the first few pages, with minor linguistic alterations by the EUROMECH editor throughout.

[2] Personal-Stand der k.k. Deutschen Carl-Ferdinands-Universität in Prag zu Anfang des Studien-Jahres 1894/95, pp.20-21

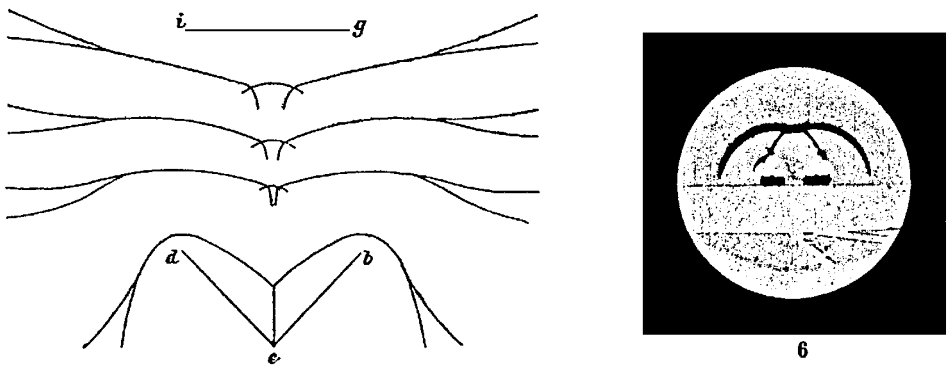
[3] This list does not mention that in 1871 Mach was elected Member of the Royal Czech Society of Sciences.

by a small time interval, the intersection point of these waves would be shifted by a distance which, together with the known sound velocity, gives the time interval.

However, in the first experiments Mach already noticed that some of these waves interacted in an unexpected way, forming a new wave bridging the original waves (Fig. 1).

Mach correctly concluded that the waves generated by the spark discharges could not be infinitesimal acoustic waves but rather must be finite amplitude (Riemann) waves, whose intersection or reflection might be different. In a series of papers (see, e.g. Mach & Sommer, 1887; Mach & Simonides, 1879; and especially a survey paper by Mach, 1878), he studied and analysed various interactions of these waves:- he discovered the irregular reflection and suggested a criterion for its appearance.

At present it is known that there exist two possible ways in which a shock wave reflects from a wall or in which it interacts with another wave, one being a regular reflection occurring when the turning angle through the shock is not too large or when the initial velocity is not too small. However, for either excessively large turning angles or excessively small initial velocity, an irregular reflection occurs. In 1944, in an article by Keenan and Seeger, this reflection was given the name *Mach reflection*.



Nach den Originalnegativen vergrössert und in Lichtdruck vervielfältigt von Carl Bellmann in Prag.

Sitzungsberichte d. kais. Akad. d. Wiss. math.-naturw. Classe. Bd. XCVIII. Abth. IIa. 1889.

Fig. 1

The heuristic criterion for its appearance, allowing a calculation of the limiting angle α (see Fig. 2), still has its validity, and we must admit that none better has been obtained since.

Parallel with these studies Mach, with his assistants, carried out a series of measurements of the propagation velocity of spark explosion waves. Mach and Gruss developed a device enabling them to follow a cylindrical wave between two parallel plates and its development into a plane wave. This was a forerunner of what today we would call a discharge-driven shock tube.

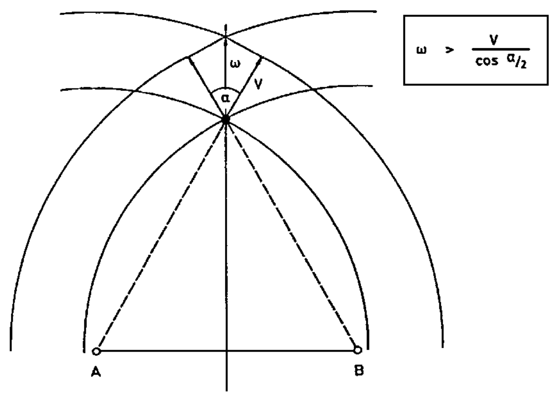


Fig. 2

The paper by Mach, Tumlirz & Kögler (1878) decribes measurements of the gradual decrease of the propagation velocity with increasing distance from the source. The device used in these measurements is quite interesting (see Fig. 3). The distance at which the wave velocity was measured was adjusted by changing the length of the channel through which the wave propagated. This was done by changing the thickness of a wooden block with channels bored-in from the electrodes generating the spark. The wave arrival time was measured by a rotating disc chronograph, i.e., by rotating a sooted glass plate underneath the block, the revolutions of which were set to a certain value by a tuning fork.

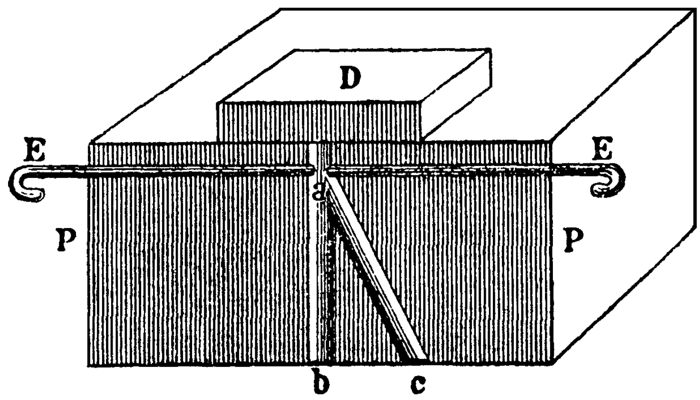


Fig. 3

Mach also suggested to Tumlirz a method for indicating the wave propagation velocity mechanically. On a rotating drum they recorded a signal from two mechanical pick-ups, one of which was connected to the source by a longer tube (Fig. 4). The velocity was determined by this length together with the time interval recorded. The timing marks on the drum were again produced by a tuning fork.

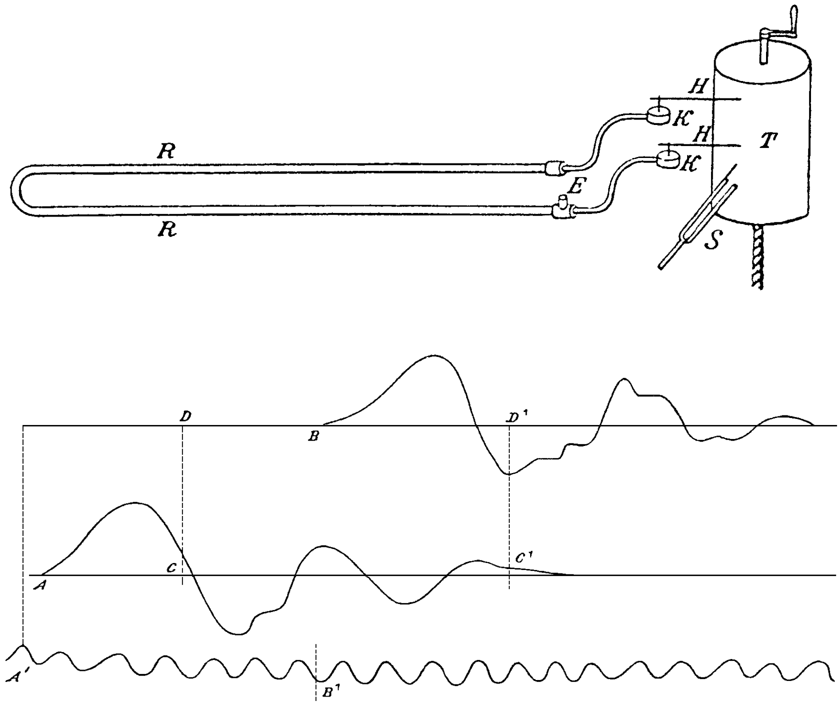


Fig. 4

There is an interesting point in all the Mach´s experiments with spark-generated waves, as well as in his later ballistic experiments. Although Mach knew that the waves studied were not acoustic waves, and although he clearly expressed that …."*we deal in our experiments with waves as described by Riemann*" (Mach & Sommer, 1887), he did not call them "shock waves" (as Riemann had already). He used the names *Schallwelle, Funkenwelle, Explosionswelle,* or simply a *"wave"*. It was not until his later ballistic experiments that he first used the term shock wave. This may be the reason why so many of his findings were later ignored in favour of other papers by Prandtl, Kármán and others.

Mach knew Riemann´s paper and all its weak points in the thermodynamic assumptions. He therefore asked his assistant Tumlirz to repeat the whole calculation using new assumptions. In point of fact I have never come across a reference to this remarkable paper, published in 1887 under the same title as the Riemann paper.

Nevertheless, to prove Riemann´s theory of shock wave propagation, Mach decided to obtain more detailed information on velocity and density profiles in a propagating wave of finite amplitude. He wrote: "*The theory will be proved only after we have succeeded in visualising one wave in two successive time intervals*."

There were already two methods of flow visualisation available - the direct shadow method developed by Mach´s assistant Vincenc Dvořák (published in 1889), and the schlieren method developed by Augustin Toepler in 1864, originally used to distinguish fields of different indices of refraction (inhomogeneities) in glass. Toepler himself also used it to visualize weak explosion waves generated by electric sparks for the first time, and Mach developed this device further in 1872 into an instrument suitable for optical measurements (Mach, 1872).

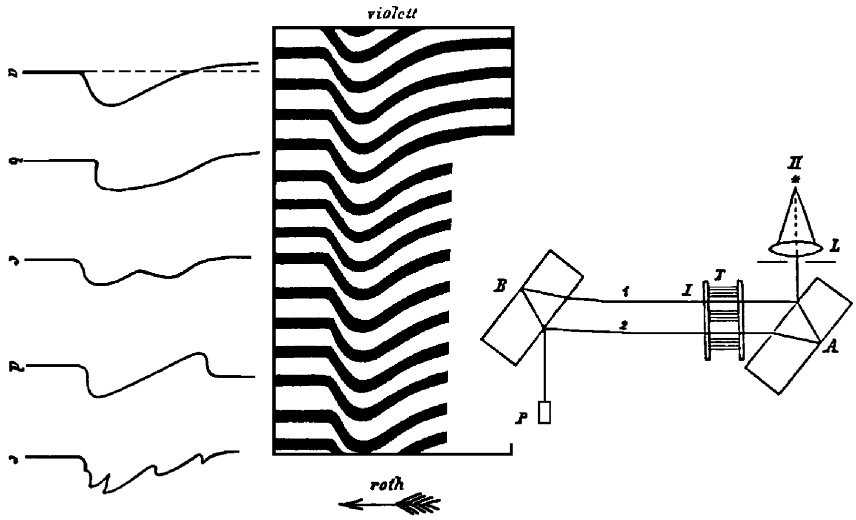


Fig. 5

As early as 1876 Mach and Rosický used an interferometer for the first time. In 1878 Mach and Gruss developed a wave generator together with the spark light source necessary for optical measurements. In 1878 Mach and his student Weltrubsky used a Jamin interferometer (Fig. 5) for the first quantitative optical measurements of aerodynamic phenomena ever made. It was not the Mach-Zehnder interferometer often attributed to Mach´s son Ludwig that we use today (L. Mach, 1896), however, the main idea had already been incorporated in it. The Mach-Zehnder interferometer divides the thick optical glass of the Jamin interferometer into a semitransparent mirror and a full mirror to make the distance between the measuring and reference light beams greater (Fig. 6).

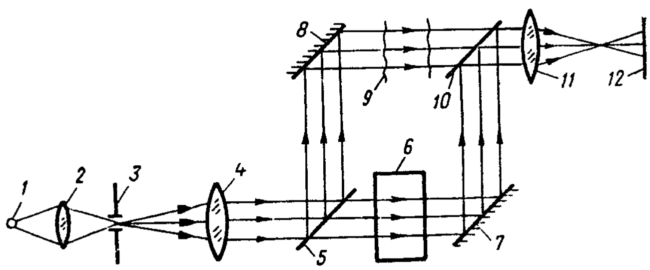


Fig. 6

Already, during the first visualization experiments, Mach realized that to obtain high resolution he had to use very short exposure times (typically 0.8 x 10^{-6}s) then attainable only by using an electric spark, perfectly triggered at the right moment.

Mach and Gruss developed numerous and varied delay circuits required for producing an exact time delay between a spark used as a wave generator and a discharge used as a light source.

It may be of some interest to recall several of these delay circuits.

In the first (Mach & Gruss, 1878) two spark gaps were used, the first (I) for generating the blast wave, the second (II) as a light source. The capacitor *A* (a Leyden jar) was charged by an influence machine. The necessary delay was obtained by the resistance between *B* and *C*. A thin water-filled glass tube was used as a resistor and Mach changed the resistance by varying the immersion depth of the electrode. Fig. 7 shows a diagram of the circuit as well as the original drawing.

ELECTRIC DELAY CIRCUIT

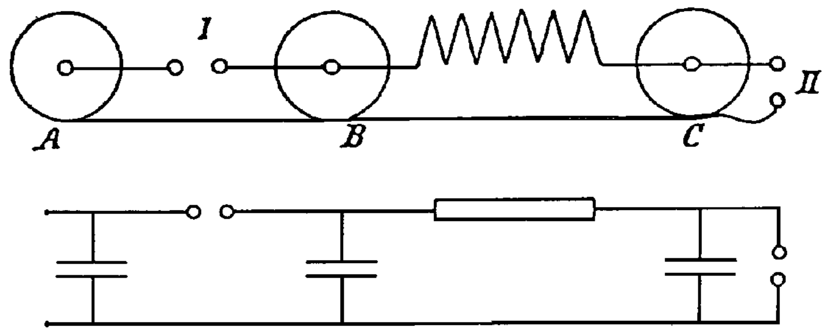


Fig. 7

Fig. 8 shows the original drawing and circuit diagram of a more sophisticated circuit used by Mach in Meppen (Mach, 1881) and by Mach and Salcher in Pola (1889). Here again a Leyden jar *L* is charged by the influence machine J_-J_+.

To minimize the electrical losses, having reached the required voltage the charged capacitor must be disconnected from the influence machine. Immediately afterwards the camera shutter must be opened and both the gun and the light source triggered. The required voltage is set by an adjustable contact *A* in the vane electrometer in which the vane *C* is attracted to *A* as the voltage of *A* rises. The other switches (e.g. the mercury switch *n*) are connected mechanically by a sophisticated system of levers.

The whole device was designed to survive not only transport, but even almost open air operation conditions (in Meppen it was installed in a wooden hut and only the influence machine was placed near an oven so as to be kept in a dry place).

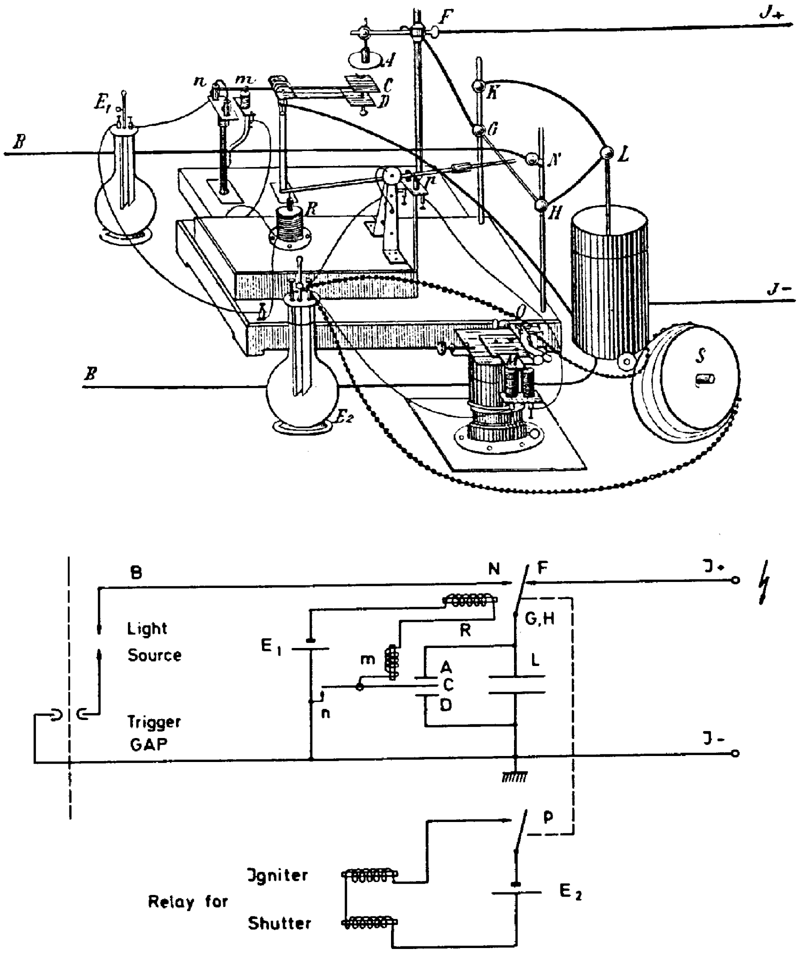


Fig. 8

The trigger for the light source in this arrangement consisted of two parallel wires in series with the capacitor and the spark gap. These wires were short-circuited by the flying bullet. Unfortunately, they disturbed the picture. Therefore, Mach substituted them by an arrangement as shown in Fig. 9 (Mach, 1895).

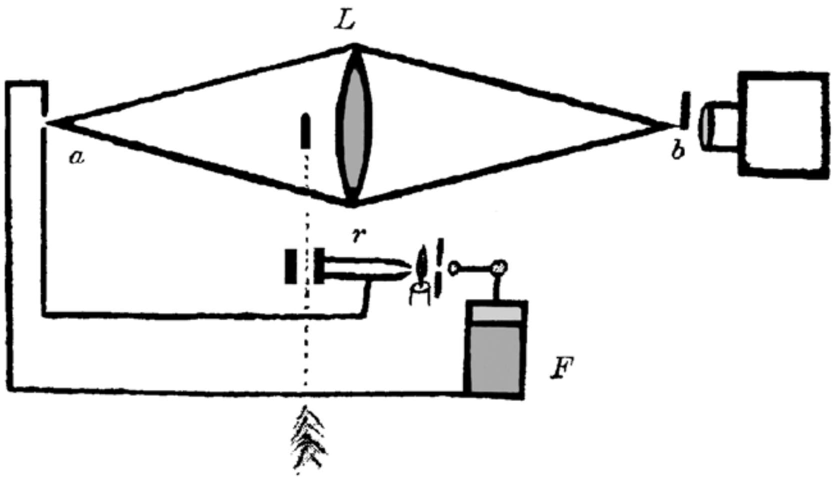


Fig. 9

The necessary time delay was set by changing the length of a tube transmitting the pressure disturbance (in a form of a jet) from the passing projectile to the burning candle. The jet blows the flame through the orifice in a metal plate electrically connected to the tube and the spark gap. The ionized candle flame forms a conducting path and discharges the capacitor through the light source.

Mach also developed an electric delay circuit (Fig. 10), even today called Mach´s delay circuit. In the diagram, F_0 is switched on by the flying projectile, the signal delayed in *CL, C* switches on the light source F_1. The necessary delay is adjusted by varying L_1.

Mach´s interest in shock wave studies is an excellent example of his methodology, of a concentrated effort to grasp and understand the physical phenomena observed, as well as of great inventiveness and skill in experimental work. In a paper written in 1885 (Mach & Wentzel, 1885) he summarised some of his experience. He admitted that he had already acquired sufficient experience and a good instinct as regards flow phenomena at velocities lower than the speed of sound. At velocities higher than this …"*we meet surprising phenomena for which we have not yet developed our feel*". They opened new and challenging fields and also lead to "*a new class of mechanical problems needing a new analytical treatment*". The last eight years of Mach´s work in physics were thus wholly devoted to shock wave studies.

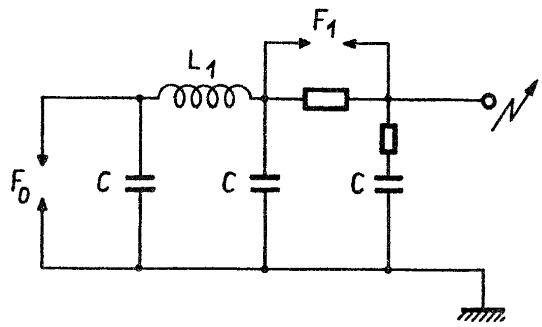


Fig. 10

By about 1878 Mach already had almost everything at hand to study and visualise all the phenomena mentioned above. One obvious problem continued to worry him (as is evident from several of his papers) – the bad quality and reproducibility of the discharges.

In 1881 Mach got a new impetus for his gas dynamic studies. In Paris he heard a lecture by Melsens, a Belgian ballistician. Later, in his own lecture "Über Erscheinungen an fliegenden Projectilen" of 10th November 1897, he wrote:

"*In 1881 Melsens, a Belgian ballistician, expressed an idea in a lecture delivered in Paris, namely, that high speed projectiles push a great mass of compressed air ahead of them; on striking a body this mass of air should – according to Melsens – bring about an explosion-like effect. Having heard this lecture I felt a strong* *desire to prove this idea experimentally and demonstrate this phenomenon if it does exist. This desire was even stronger because everything I needed to perform this experiment had been at my disposal and I had already used or tested it.*"

A further reason for this decision was that it could give him a better source of the disturbances he needed for his experiments with shock waves.

The first laboratory experiments on visualizing the bullet shot from a pistol were made together with Wentzel in 1884 (Fig. 11)

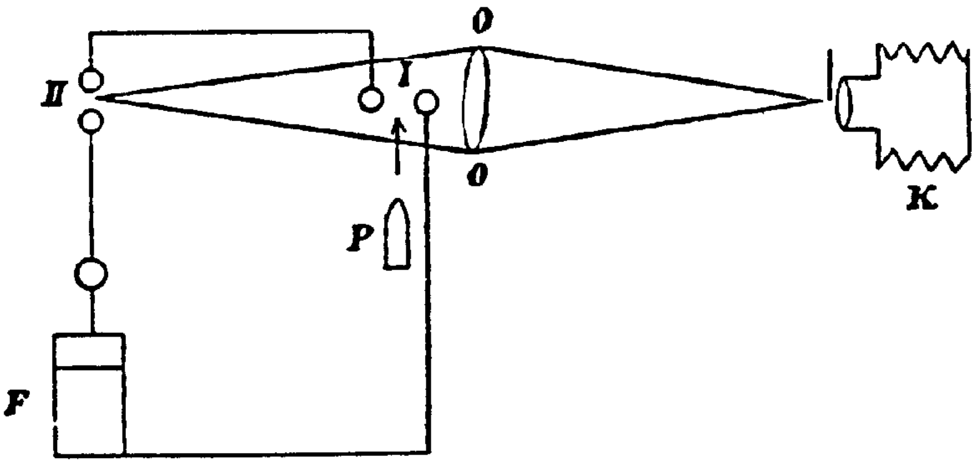


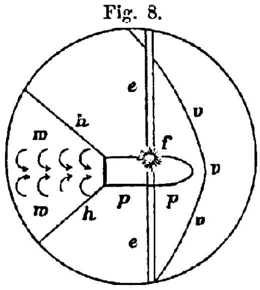
Fig. 11

Although they got a sharp picture of the flying bullet and some acoustic disturbances could be identified, Mach concluded correctly that the velocity of the bullet was too low (they measured it by another device to be 240m/s) for the supersonic phenomena to develop fully. Therefore, in 1885 Mach asked T. Salcher and A.L. Riegler , two professors of the Naval Academy in Fiume, to repeat the experiments with a better gun, using Mach´s visualization technique. They used a Werndl rifle whose bullet, 11 mm in diameter, had an initial velocity of 440m/s. The results were remarkable, and in a preliminary announcement note to the Academy of Sciences in Vienna of 10th June 1886, (Über die Abbildung der von Projectilen mitgeführten Luftmasse durch Momentphotografie), Mach could for the first time display a picture of an object flying at supersonic velocity with all the shock waves. On 21st April 1887 he published – together with Salcher – a full account of the experiment and its results in a paper entitled "Photografische Fixirung der durch Projectile in der Luft eingeleiteten Vorgänge" (see, e.g., Fig. 12).

Not only was this the first picture of a real shock wave, but in fact up to this date nobody had ever heard of the existence of a front shock wave or the whole shock wave pattern typical of a supersonic flow past a body. Mach also pointed out that the same shock pattern might appear in astrophysics around flying meteorites.

Erklärung der Abbildungen.

Fig. 8.



Um die Figuren der Tafel nicht durch eingesetzte Buchstaben zu stören, geben wir eine schematische Abbildung: Fig. 8, *pp* Projectil, *ee* Elektroden, *f* Funke *f*, *vv* vordere Wellengrenze, *hh* hintere Wellengrenze, *ww* Wirbel.

Die Figuren 1—3 der Tafel stellen Versuche mit dem Werndl-Infanteriegewehr $\left(438\frac{m}{sec}\right)$, 4—6 solche mit dem Guedes-Infanteriegewehr $\left(530\frac{m}{sec}\right)$ dar. In allen Bildern der Tafel geht das Projectil von links nach rechts durch das Gesichtsfeld. In 1, 2, 3, und 5 ist die Kopfwelle, in 4 und 6 die Erscheinung **hinter** dem Projectil (Achterwelle und Wirbel) dargestellt. Um den Auslösungsfunken *f* ist meist noch ein Stück einer kreisförmigen Funkenwelle sichtbar.

Fig.3. *Fig.4.* *Fig.5.* *Fig.6*

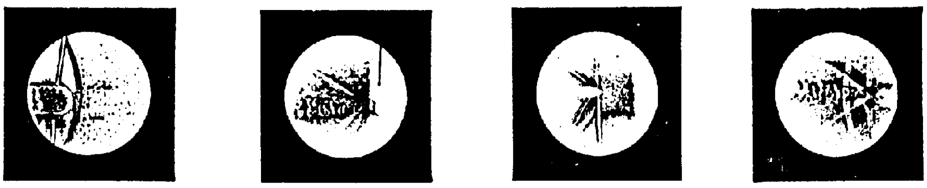
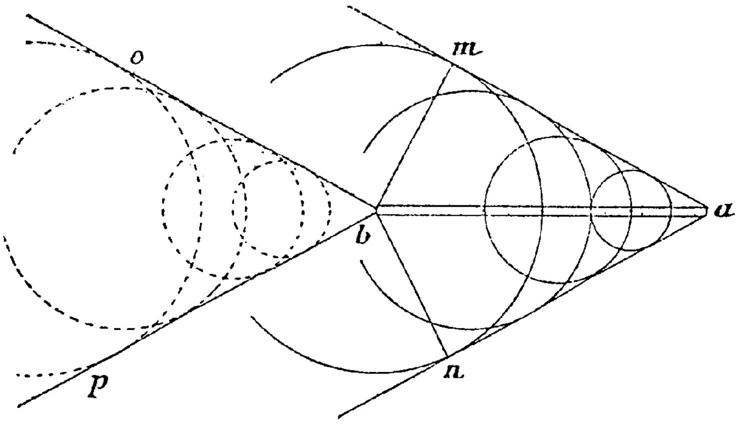


Fig. 12

In the same paper he described the development of the detached front shock wave and discussed the behaviour of the stand-off distance with flight velocity and bullet shape. There is a slight lack of exactness in the explanation of the oblique shock wave angle – Mach´s description concerns the propagation from a point source moving at a supersonic velocity (Fig. 13), so that he actually describes the so called Mach wave and the Mach angle (α = arcsin 1/M), which is the angle of the asymptote to the front shock wave. However, he very precisely described even the near wake, and noticed a symmetrical array of vortices (in contrast to the asymmetrical vortex street behind an airfoil, which was described by Kármán fully 40 years later, see, e.g. Fig. 14).

The fundamental value of this pioneering paper makes it the real beginning of the field of supersonic aerodynamics.

The analysis of the schlieren picture on its own enabled Mach to discover the wave drag of bodies moving at supersonic velocities. After Mach, the bullet drag consists of "drag due to the wave production (i.e. the wave drag), due to vortices in the wake and due to skin friction". He thus even predicted the drag maximum which appears at moderate supersonic velocities.



die Schallgeschwindigkeit übersteigenden Geschwindigkeit in der Luft bewegt wird. Derselbe wird bei *a* unausgesetzt unendlich kleine Verdichtungen erzeugen, welche sich als Schallwellen ausbreiten. Die betreffenden Huyghens'schen Elementarwellen werden als Enveloppe einen Kegel bilden, dessen Schnitt mit der

Fig. 13

This success inspired Mach to have the experiments confirmed by two professional shooting ranges – at Pola (subsidized by the Austro-Hungarian Ministry of War) and in Meppen, (belonging to the Krupp Company – no wonder the company immediately recognized the practical effect of a good knowledge of bullet aerodynamics!). These experiments were made with guns of 90 mm and 40 mm in diameter, and velocities 448 m/s and 670 m/s, respectively. Mach took part in person in the experiments at Meppen.

It is interesting that the cooperation with Salcher took place by mail. According to Reichenbach (1983), the archive of the Ernst Mach-Institute in Freiburg i.Br. holds about 140 letters from Salcher, who reported weekly to Mach on new results. Unfortunately, none of Mach´s letters to Salcher have ever been found. Even the archive of the Charles University in Prague, which has several pieces of Mach´s correspondence, does not have any letter from this period. We can only judge that Mach must have suggested the programme and interpreted Salcher´s description of the photographs (see, e.g., Fig. 15, after Reichenbach, 1983).

For a researcher this was on too large a scale, so Mach preferred to continue with a laboratory experiment, this time, however, using a more efficient rifle and individually produced and checked bullets. With reference to Froude´s experiments he was sure of the similarity between small and large bullets, if only a similarity parameter (*w/c*) is retained. It is this parameter that was named the *Mach number* by Jacob Ackeret in 1929. The laboratory experiments were conducted together with his son Ludwig Mach (1868-1951), who was then a medical student in Prague, and contributed mainly to the flow visualization technique. These experiments yielded the best pictures of shock waves (Fig. 16).

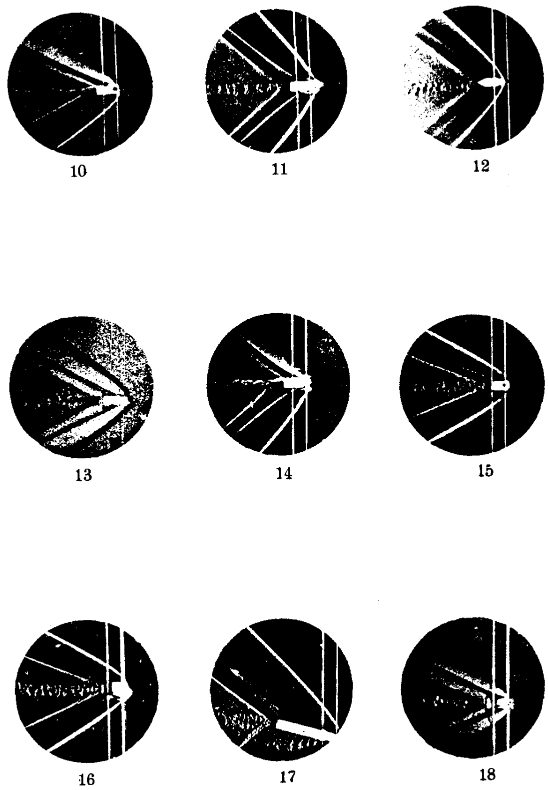
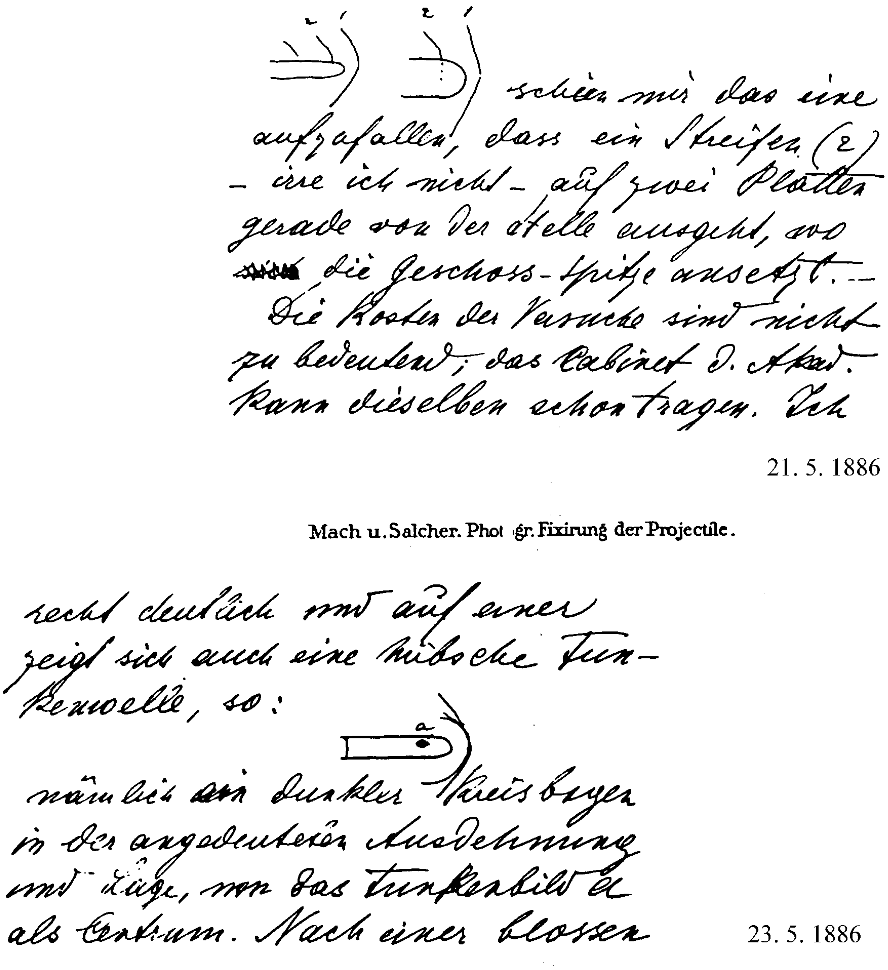


Fig. 14

Nowadays we are used to powerful electronics, laser techniques, and various sophisticated optical methods which all provide us with a lot of data, mostly treated by computers. We have to admire Mach´s analysis of the limited experimental results, from pictures 5 mm in diameter, which nevertheless provided all the important data.

How many of the results hidden in Mach´s articles were step by step and one by one redisovered half a century later! Some of them could not then have been known – e.g. the secondary (lip) shock, apparently noticed and mentioned by Salcher in his letter of 21st May 1886.

It was not until 1947 (the first supersonic flight) that scientists rediscovered the sonic boom and started to investigate it. Fifty years earlier in a lecture on the 10th November 1897, presented to the Wiener Verein zur Verbreitung naturwissenschaftlicher Kenntnisse, Mach had already mentioned and explained it. He even mentioned the double boom, though its interpretation concerning a projectile was different (but correct) from the present theory concerning an aircraft.


schien mir das eine aufzufallen, dass ein Streifen (2) – irre ich nicht – auf zwei Platten gerade von der Stelle ausgeht, wo die Geschoss-Spitze ansetzt. — Die Kosten der Versuche sind nicht zu bedeutend; das Cabinet d. Akad. kann dieselben schon tragen. Ich

21. 5. 1886

Mach u. Salcher. Phot. gr. Fixirung der Projectile.

recht deutlich und auf einer zeigt sich auch eine hübsche Funkenwelle, so:

nämlich ein dunkler Kreisbogen in der angedeuteten Ausdehnung und Lage, von das Funkenbild als Centrum. Nach einer blossen

23. 5. 1886

Fig.15

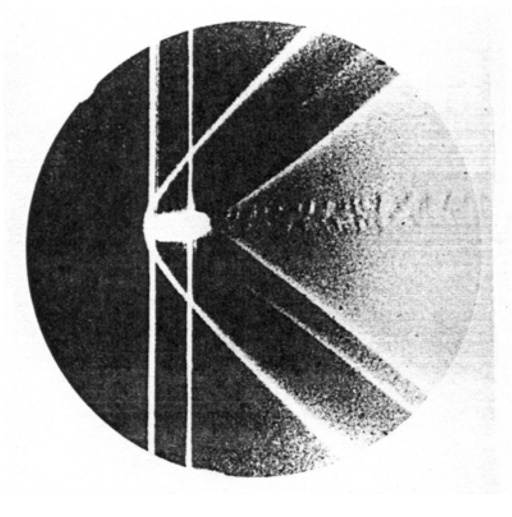


Fig. 16

The account of Mach´s achievements in the field of gas dynamics, i.e. in shock waves and supersonic aerodynamics, would hardly be complete without mentioning the experiments on supersonic jets. They also resulted from the cooperation with Salcher, whom, moreover, Mach inspired to a further theoretical analysis of supersonic jets (see, e.g., Salcher & Whitehead, 1889).

Let me quote the first sentence and a footnote from an article by Mach and Salcher (1889):

"*During the experimental investigation of bullet aerodynamics Salcher had the idea that we should try the inverse case of studying a flow past a body, fixed in a supersonic stream and thus confirm our previous results.*"

In footnote No 2 they add:

"*When the stream had a large enough area in relation to the inserted fixed body we could observe an analogue of a front shock wave.*"

This experiment was made in a torpedo factory in Fiume (Rjeka) by Salcher and John Whitehead.

The test rig was very modest (see Fig. 17) – the axially symmetrical nozzles had diameters of 1.2 – 5.1 mm. The pressure ratio was 60 or 70 to 1. Mach´s former experience with pictures of flying bullets enabled him even to analyse the shock wave structure in the jet properly (Fig. 18). This is, to my knowledge, the first description of the wave reflection and the periodical structure of the so-called Mach disc (Salcher and Mach referred to it as Lyra, see Fig. 19, which is a part of a letter by Salcher to Mach, after Reichenbach, 1983).

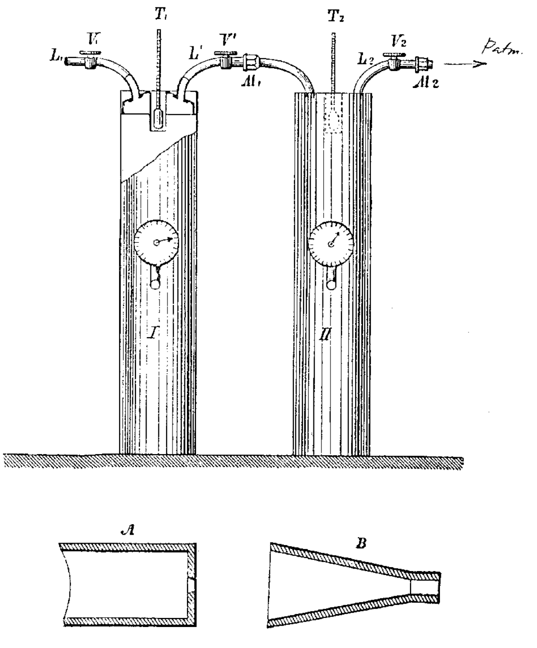


Fig. 17

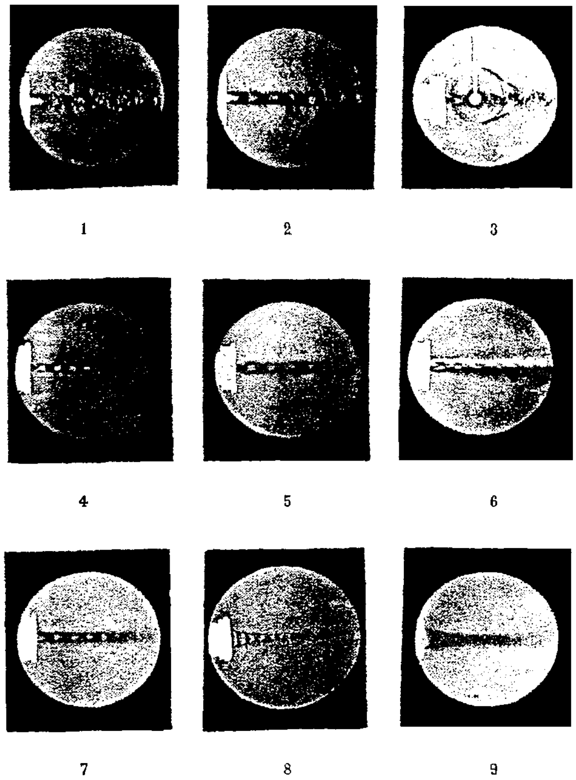
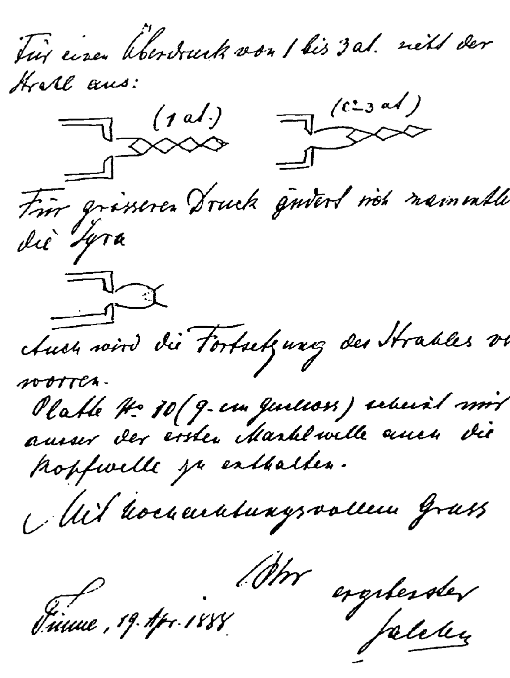


Fig. 18



Für einen Überdruck von 1 bis 3 at. sieht der Strahl aus:

(1 at.) (c. 3 at.)

Für grösseren Druck ändert sich namentlich die Form

Auch wird die Fortsetzung des Strahles verworren.

Platte No. 10 (9-cm Geschoss) scheint mir ausser der ersten Machwelle auch die Kopfwelle zu enthalten.

Mit hochachtungsvollem Gruss

Ihr ergebenster Salcher

Fiume, 19. Apr. 1888

Auszug aus einem Brief P. Salchers an Ernst Mach vom 19. April 1888

Fig. 19

Mach explained its appearance correctly in the same way as he did for his (several years earlier) experiments with the irregular interaction of weak explosion waves.

Mach also measured the ejection effect of the jet by producing a disturbance outside the jet, and observed how it became distorted due to the surrounding air flowing along the jet boundary (picture No 3 in Fig. 18).

All these results were laid aside, along with many others, and we usually refer to Prandtl´s experiments from the year 1904 as giving the first pictures of a supersonic jet, as well as the first description of the shock waves in the jet (Fig. 20).

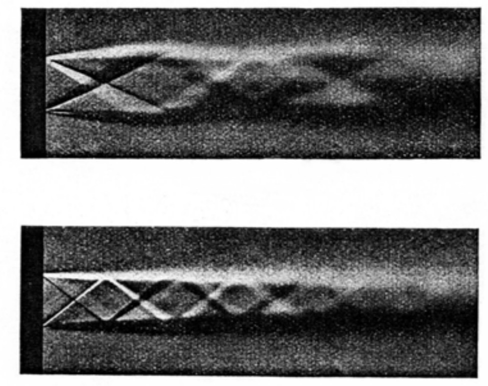


Fig. 20

This cannot be due to the mistake in nomenclature, as already mentioned. In this case Mach called these waves compression waves (Verdichtungswelle) and expansion waves. The only objection that can be raised here is against the erroneous assumption that the jet boundary behaves as a solid body boundary.

The idea of using a jet source of supersonic flow past a body as quoted above was even successfully verified by Salcher by placing a bullet in the jet. Thus, this was the first supersonic wind tunnel ever built!

Concluding remarks.

From the preceding remarks it is evident how much of Mach´s activity was devoted to gas dynamics.

His contribution to gas dynamics was fundamental and it is quite difficult to understand why it was not utilized more fully earlier and why we had to wait so many years to see it rediscovered. Moreover, unlike many of his other contributions to physics and philosophy, his contribution to gas-dynamics has needed no substantial changes and deserves its full appreciation even from the present point of view.

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Regulations and Call for Nominations

EUROMECH FLUID MECHANICS PRIZE

EUROMECH SOLID MECHANICS PRIZE

The *Fluid Mechanics Prize* and the *Solid Mechanics Prize* of EUROMECH, the *European Mechanics Society*, shall be awarded every three years for outstanding and fundamental research accomplishments in Mechanics.

Each prize will consist of 5000 Euro. The recipient is invited to give a Prize Lecture at one of the European Fluid or Solid Mechanics Conferences held every three years.

Nomination Guidelines :

A nomination may be submitted by any member of the Mechanics community. Eligible candidates should have made a significant portion of their scientific career in Europe. Self-nominations cannot be accepted.

The nomination documents should include the following items:

- a presentation letter summarizing the contributions and achievements of the nominee in support of his/her nomination for the Prize,
- a curriculum vitae of the nominee,
- a list of the nominee's publications,
- at least two letters of recommendation.

Five copies of the complete nomination package should be sent to the Chair of the appropriate Prize Committee, as announced in the EUROMECH Newsletter and on the Society's Web site www.euromech.org Nominations will remain active for two selection campaigns.

Prize committees :

For each prize, a Prize Committee, with a Chair and four additional members shall be appointed by the EUROMECH Council for a period of three years. The Chair and the four additional members may be re-apppointed once. The committee shall select a recipient from the nominations. The final decision is made by the EUROMECH Council.

Nomination Deadlines for both prizes : November 30, 2002.

The members of the *Fluid Mechanics Prize Committee* are :

- D. Abrahams
- P. Blondeaux
- H.H. Fernholz (Chair)
- E.J. Hopfinger
- P. Huerre

The members of the *Solid Mechanics Prize Committee* are :

- A. Benallal
- E. van der Giessen
- I. Goryacheva
- M. Okrouhlik
- F.G. Rammerstorfer (Chair)
-

The period of office is January 1st, 2002 to December 31st, 2004, with the possibility of reappointment for a second period of office.

Chairmen's Addresses:

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EUROMECH Colloquium 422
Pattern Formation by Motile Micro-organisms and Cells

Chairpersons: Prof. N.A.Hill (Glasgow); Dr. M.A.Bees (Surrey)

EUROMECH 422 was hosted by the Department of Applied Mathematics at the University of Leeds (UK) from 3rd – 5th December, 2001. The meeting was recognised as a satellite meeting of the programme "From Individual to Collective Behaviour in Biological Systems" at the Isaac Newton Institute (INI, UK). The 58 participants contributed a total of 45 presentations, including a lively poster session. Prizes for the best student posters were awarded to Rachel Bearon (Cambridge) and Richard Hillary (Surrey).

A notable feature of the workshop was the bringing together of mathematical modellers in plankton population dynamics, where dispersion is mainly caused by oceanic currents, and those in bio-convection, with theorists in the growth of bacterial colonies and the behaviour of slime moulds. Mechanics plays a fundamental role in all these biological problems. The standard of the talks was excellent, and there was much energetic discussion enhanced by keynote experimental and biological presentations. The vigorous state of mechanics applied to biology in Europe and worldwide was demonstrated by the wide range of new experimental results, theoretical models and mathematical results which were presented, e.g. on travelling waves, Taylor dispersion in suspensions of swimming micro-organisms, angiogenesis and the fluid dynamics of swarming bacterial colonies.

The very successful theme of a workshop devoted to the application of mechanics to biology was a timely new venture for EUROMECH, and points a way forward for future developments of the Society's interests.

EUROMECH Colloquium 423
Boundary Layer Transition in Aerodynamics

Chairpersons: S.Wagner, M.Kloker and U.Rist (IAG Universität Stuttgart)

EUROMECH 423 was held in the Stuttgart Bildungszentrum Südwest of German Telekom AG from April 2nd – 4th, 2001. There were 68 participants from 8 countries. About a third of those attending were Ph.D. students. There were 41 spoken contributions, limited to 30 minutes including discussion, except for 5 keynote lectures lasting 45 minutes. Session chairmen were encouraged to keep tight control over speakers, and contrived to maintain a lively atmosphere allowing for discussion which was much appreciated – in contrast to the more usual *speak as fast and short as possible* conferences. The success of a previous meeting, EUROMECH 359 (1997) at the same venue resulted in over-subscription, a further 18 contributions having to be declined. The colloquium was divided into nine sessions treating the different stages and aspects of transition.

The first topic was "receptivity", the filtering process bringing disturbances from the free stream into the boundary layer, with four contributions including a keynote lecture by W.Saric (USA). A main topic was the separation of superposed sound and instability waves.

This was succeeded by "two-dimensional boundary layers", nine contributions dealing mainly with late stages – formation/dynamics/breakdown of flow structures– and so-called bypass mechanisms, which lead to turbulence without wave-like instabilities. These "streak instabilities" were considered in a keynote lecture by H.Alfredsson (S) and three other papers.

The main session of the second day treated receptivity, linear and nonlinear instability, and disturbance control in swept-wing boundary layers with cross-flow. The seven contributions definitely showed that the secondary instability of saturated steady or unsteady cross-flow vortices is of convective and not absolute nature; also the secondary mechanisms work equivalently for both steady and unsteady primary disturbances. The primary cross-flow instability can be strongly influenced by a so-called three-dimensional upstream flow deformation by vortices with a smaller spanwise spacing than the most unstable modes. The day concluded with three papers on transition control.

The third day started with three papers on the industrial application of transition prediction methods, including a keynote lecture by D.Arnal (F). The exp(N)-method is still routinely used despite its flaws for 3D boundary layers – a more physically sound prediction based on the parabolised stability equations requires accurate initial disturbance amplitudes which can not yet be reliably provided. The "prediction" session was followed by three contributions dealing with aspects of measuring techniques, including supersonic flows.

The third day treated super- and hypersonic flow, a principal topic of EMC423. A survey by A.Maslov (RU) was followed by eight contributions. The necessity for, and difficulties of, "controlled" transition experiments were underlined, and a measurement method based on the constant-voltage hot-wire anemometer for high frequencies was presented. A DNS study showed that for fundamental resonance associated with a primary acoustic disturbance, the secondary mode must also to be of acoustic type if resonance is to set in effectively. H.Fasel (USA) concluded the symposium with a lecture on a new methodology for flow simulations which is an alternative method to traditional LES simulations. It continually switches, dependent on local criteria, between DNS and the solution of the Reynolds-averaged equations (RANS). The examples shown were encouraging.

Informal discussion benefited greatly from accommodation and working sessions occupying the same site. On the second day wine supplied with a buffet dinner at the University's international centre, the Eulenhof, "purified" the conversation. A video "*A Nose Ahead*" on flight experiments with boundary layer suction provided an informative entertainment (G.Schrauf, EADS Airbus).

EUROMECH Colloquium 428
Transport by Coherent Structures in Environmental and Geophysical Flows

Chairpersons: A.Provenzale (Torino); A.J.Hogg (Bristol)

EUROMECH 428 took place in Torino, Italy, on 26 – 29 September 2001. There were forty participants from more than eight countries.

The workshop was devoted to the study of the dynamics of coherent structures in environmental and geophysical flows. I particular, three main topics were addressed:

1. The role of mesoscale coherent structures in the ocean and the atmosphere. The invited and contributed talks of this session discussed the dynamics of coherent vortices and their effects on transport, as well as the role of coherent convective plumes in geophysical flows. The contributions ranged from analytical approaches through high-resolution numerical simulations to laboratory experiments and field observations.

2. The role of coherent turbulent motions near the erodible bottom of rivers and coastal flows. The focus of this session was the dynamics of near-wall flow structures and their effects on material transport.

3. The dynamics of fully developed turbulence and the behaviour of passively advected particles in turbulent flows, with specific emphasis on the role of coherent structures.

The workshop ended with a general discussion on the role and the dynamics of coherent structures in environmental and geophysical flows, and on the possibility of developing a unified approach to the study of coherent structures in turbulence.

EUROMECH Colloquium 429
Computational and Experimental Mechanics of Advanced Materials

Chairpersons: H.J.Böhm (Wien), V.Silberschmidt (Loughborough), E.Werner (München)

Euromech 429 took place at the TU Wien on September 19th & 20th 2001. There were 23 participants (plus the three chairmen) from 10 European countries. A total of 22 contributions were presented in 7 themed sessions and the meeting was closed by a discussion session.

A considerable percentage of the contributions pertained to continuum modelling of the mechanical and thermodynamic behaviour of inhomogeneous materials, such as composites, cellular and polycrystalline materials, and layered systems, under static and dynamic conditions. Fields of special interest in this context were damage and failure, debonding and interfacial effects, microstructure property relations, microscale–macroscale transitions and the evolution and reconstruction of microstructures. Other focal points of the meeting were the modelling of material inhomogeneites such as domain structures, multi-field studies of active (piezoelectric and ferroelectric) materials, constitutive models and parameter identification for advanced materials, and experimental methods for resolving microscopic elastoplastic strain fields. Among the materials specifically targeted in the presentations were perovskites, ferroelectric and piezoelectric ceramics, textile reinforced concrete, wood, superalloys, metallic foams, metal matrix composites and special steels.

A noteworthy aspect of EC429 was the wide range of subject fields represented by the participants, ranging from experimentally orientated materials science *via* mechanics to applied mathematics. This breadth of scope was also evinced by the high proportion of non-members of EUROMECH amongst the participants.

All contributions were given as scheduled and were followed by lively discussions. Features of special interest during the final discussion were comparisons between different numerical approaches for continuum-level simulations of inhomogeneous materials. An important feature of the colloquium was the high proportion of young researchers among the attendees, which, together with the participation of established and recognised experts in the field, stimulated an intensive exchange of ideas and experiences of a broad spectrum of topics. An additional impetus for discussion was provided by the high percentage of presentations describing ongoing work.

Publication of selected contributions to EC429 is planned within the framework of a special issue of the ASME *Journal of Engineering Materials and Technology* dedicated to European research efforts in the mechanics of advanced materials.

The chairmen feel that the level of interest in this and related subjects is such as to justify a further colloquium covering this field in the next 3 – 5 years.

EUROMECH Colloquium 430
Formulations and Constitutive Laws for Very Large Strains

Chairpersons: J.Plesek (Prague); L.Nilsson (Linkoping)

EUROMECH 430 was held at the Institute of Thermomechanics, Prague, on 3rd – 5th October, 2001. There were 42 participants from 14 countries. Each presentation lasted 30 minutes, which was considered the optimum time for a small conference of this type.

The meeting brought together researchers interested in the theoretical development and experimental assessment of constitutive models capable of describing finite strain situations, as well as those who were concerned with their computer implementation. Research groups presented their views of existing formulations, proposed new approaches, and discussed important results obtained from their analyses.

The following topics were addressed: Total versus rate formulations, hyper-elasticity, finite strain plasticity, computational procedures, localisation and experimental identification/verification. In summary, most talks dealt with the problems involving inelastic strains: The reconciliation of the Lagrangian formulation for stress evaluation with Eulerian systems, suitable for modelling inelastic flows was recognised as the main challenge to be tackled.

Post-conference proceedings to be published in 2002 will contain full-length papers.

List of Colloquia in 2003 and 2004

442. Computer-Aided Optimization of Mechanical System

Chairman: Prof. Dr.-Ing. Peter Eberhard
Institute of Applied mechanics, University of Erlangen-Nuremberg,
Egerlandstr. 5, D-91058 Erlangen, Germany
E-mail: eberhard@ltm.uni-erlangen.de
WEB: www.ltm.uni-erlangen.de/euromech442
Co-chairman: Prof. Dr.-Ing. habil. Dieter Bestle, BTU Cottbus, Germany
Euromech contact person: Prof. Werner Schiehlen
Date and location: 23 - 27 February 2003, Erlangen - Germany

443. High Rayleigh Number Thermal Convection

Chairman: Prof. Dr. D. Lohse
P.O.Box 217, 7500 AE, ENSCHEDE
The Netherlands
E-mail: lohse@tn.utwente.nl
Co-chairman: Prof. Dr. F. Busse, Univ. of Bayreuth, Germany
Euromech contact person: Prof. H.H. Fernholz, Prof. L. van Wijngaarden
Date and location: June 10 - 18, 2003, University of Twente,
The Lorentz-Center, Leiden, The Netherlands

445. Mechanics of Material Forces

Chairman: P. Steinmann
Chair of Applied Mechanics
University of Kaiserslautern. P.O.Box 3049, D-67653 Kaiserslautern, Germany
E-mail: ps@rhrk.uni-kl.de
Co-chairman: G.A. Maugin, Université Pierre et Marie Curie, Paris VI, France
Euromech contact person: Prof. A. Benallal
Date and location: March 2003, Kaiserslautern, Germany

446. High-order methods for the numerical simulation of vortical and turbulent flows

Chairman: Prof. Dr. rer.nat. Michael Schäfer
Fachgebiet Numerische Berechnungsverfahren im Maschinenbau, Technische Universität Darmstadt, Petersenstr. 30, D-64287 Darmstadt, Germany
E-mail: schaefer@fnb.tu-darmstadt.de

Co-chairman: Dr. Patrick Bontoux, Laboratoire de Modélisation et Simulation Numérique, CNRS/MSNM, unité 2405, IMT Château-Gombert, La Jetéee, 38 Rue Frédéric Joliot-Curie, 13451 Marseille Cedex 20, France
Euromech contact person: Professor Patrick Huerre
Date and location: March 2003, Seeheim, Germany

447. Interaction phenomena in turbulent gas-particle flows

Chairman: Professor Martin Sommerfeld
Fachbereich Ingenieurwissenschaften, Martin-Luther-Universität Halle-Wittenberg D-06099 Halle (Saale), Germany
E-mail: martin.sommerfeld@iw.uni-halle.de
Co-chairman: Dr. Ph. Ülo Rudi, Director of Estonian Energy Research Institute of the Tallinn Technical University, Paldiski Rd. 1, 10137 Tallinn, Estonia
Professor Leonid Zaichik, Head of laboratory of Mathematical Modelling Russian Academy of Sciences Institute for High Temperatures,
Kasnokazaarmennaya 17a, 111250 Moscow, Russia
Euromech contact person: Prof. J. Engelbrecht
Date and location: May 2003, Tallinn, Estonia

448. Vortices and field interactions

Chairman: Dr. Maurice Rossi
Laboratoire de Modélisation en Mécanique, Université Pierre et Marie Curie (Paris 6)
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Co-chairmen: Dr. Andrew Gilbert, Lecturer in Applied Mathematics,
School of Mathematical Sciences, University of Exeter, Exeter, EX4 4QE, UK
Dr. A. Maurel, CNRS, Lab. Ondes et Acoustique,
ESPCI – 10 rue Vauquelin, Paris, France
Euromech contact person: Professor Patrick Huerre
Date and location: September 2003, Paris, France

449. Computational Aeroacoustics: from acoustic sources modeling to far-field radiated noise prediction

Chairman: Pierre Sagaut
ONERA, DSNA/ETRI, 29 av. Division Leclerc, 92 Châtillon, France
E-mail: sagaut@onera.fr
Co-chairman: Eric Manoha, ONERA, DSNA/BREC
Euromech contact person: Professor Patrick Huerre
Date and location: September-December 2003, Paris, France

450. Studies on Splashes, a Century after A.M. Worthington

Chairman: Clanet Christophe
IRPHE, Technopole de Château Gombert
49 rue Frédéric Joliot-Curie, 13 384 Marseille, France
E-mail: clanet@irphe.univ-mrs.fr
Co-chairman: Jean-Marc Chomaz, LADHYX, Ecole Polytechnique, 91 128 Palaiseau
David Quéré, Physique de la Matiere Condensée,
College de France, 75 231 Paris, France
Euromech contact person: Professor Patrick Huerre
Date and location: Septembre 2003, Carry le Rouet, France

451. Sea Wave Boundary Layer

Chairman: Associate Professor Enrico Foti
Department of Civil and Environmental Engineering, University of Catania
V. le A. Doria, 6, 95125 Catania, Italy
E-mail: efoti@dica.unict.it
Co-chairman: Professor Jorgen Fredsoe, Department of Mechanical Engineering, Technical University of Denmark, Building 115, DK-2800 Lyngby, Denmark
Euromech contact person: Professor Paolo Blondeaux
Date and location: October 2003, Catania (or nearby), Sicily, Italy

452. Advances in Simulation Techniques for Applied Dynamics

Chairman: Dr. M. Arnold
DLR German Aerospace Center, Vehicle System Dynamics Group
Oberpfaffenhofen, P.O.Box 1116, D – 82230 Wessling, Germany
E-mail: martin.arnold@dlr.de
Co-chairman: Prof. Dr.-Ing. Dr. h.c. W. Schiehlen, Institute B of Mechanics, University of Stuttgart, Germany
Euromech contact person: Prof. W. Schiehlen
Date and location: October 6-10, 2003 at DLR Oberpfaffenhofen, Germany

453. Internal Stresses in Polymer Composite Processing and Service Life

Chairman: Professor Alain Vautrin
Mécanique et Materiaux, Ecole Nationale Superieure des Mines de Saint-Etienne
158, cours Fauriel, 42023 Saint-Etienne Cedex 2, France
E-mail: vautrin@emse.fr
Co-chairman: Professor Luigi Nicolais, Materials and Production Engineering, University of Naples Federico II, Naples, Italy

Euromech contact person: Professor Ahmed Benallal
Date and location: 2003 December, Ecole des Mines de Saint-Etienne, France

2004

454. Large Eddy Simulation (LES), Coherent Vortex Simulation (CVS) and Vortex methods for incompressible turbulence

Chairman: Kai Schneider
L3M & CMI, Universite de Provence (Aix-Marseille I)
39, rue Joliot-Curie, 13453 Marseille Cedex 13, France
E-mail: kschneid@cmi.univ-mrs.fr
Co-chairman: Marie Farge, LMD-CNRS, Ecole Normale Superieure, Paris,
Joel Ferziger, Department of Mechanical Engineering,
Stanford University & visiting professor, LM3, CNRS-Universite Aix-Marseille II
Euromech contact person: Professor Patrick Huerre
Date and location: April, 2004, Syracuse (Sicily, Italy)

455. Semi-active Vibration Suppression

Chairman: Professor Michael Valášek
Department of Mechanics, Faculty of Mechanical Engineering, Czech Technical University, Karlovo nám. 13, 121 35 Prague 2, the Czech Republic
E-mail: valasek@fsik.cvut.cz
Co-chairman: Professor Andre Preumont, Active Structures Laboratory
Department of Mechanical Engineering and Robotics, Faculty of Applied Sciences
Universite Libre de Bruxelles, Bruxelles, Belgium
Euromech contact person: Asoc. Professor Miloslav Okrouhlík
Date and location: July 2-4, 2004, Prague, the Czech Republic

Information for prospective chairpersons of EUROMECH colloquia

a) EUROMECH will give three grants of 200 EURO each (total 600 EURO), for the support of young participants. The recipients should not be from the chairperson's institute. The Chairperson can either request the amount, in a letter addressed to the Treasurer, or deduct it at the end of the Colloquium from the amount of additional registration fees collected from non-members, then due to be sent to the Treasurer. The names and addresses of the grant recipients should appear in the final report.

b) EUROMECH members will be allowed a 32 EURO reduction in the registration fee. Their identification is their membership number, which may be requested by the chairperson. Non-member participants who have paid the full registration fee can become members by sending a completed membership application form to the President, (available from the chairperson or on www.euromech.cz). The 32 EURO will in this case be credited as membership dues for the year of the Colloquium.

c) After the Colloquium or Conference the Chairperson should transfer to the Treasurer (within about 1 month after the meeting) an amount corresponding to the 32 EURO collected from the non-member participants, together with a list of participants, indicating members and non-members.

The EUROMECH account is:

EUROMECH -E.J. Hopfinger, Banque Populaire DA, Grenoble University Campus Agency, Bank Code: 12807; Agency: 00015; Account number: 01519068782; Key: 20; SWIFT: CCBPFRPPGRE

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